SOUTHERN CALIFORNIA EDISON
TRANSMISSION AND DISTRIBUTION

Distribution Design Standards (DDS)

2013—FIRST QUARTER ISSUE
January 25, 2013

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SOUTHERN CALIFORNIA EDISON®
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Distribution Design Standards (DDS) Manual

Revision Summary

2013 — First Quarter Issue

Effective Date: January 25, 2013

Overview

The main purpose of this revision summary is to describe notable revisions for the current quarter (Table 1–3). In addition, this revision summary provides:

- A list of the items in the revision package (Table 1–1)
- A link to a Web site giving instructions for ordering and printing additional copies of revision packages or complete manuals
- Contact information

Note: *Some or all of the information in this revision summary may have been previously communicated to field personnel by other means.*

Table 1–1: List of Items in Revision Package

Item	Description
1	Title Page
2	Revision Summary (this document)
3	Table of Contents
4	DDS-2: Feeder Systems
5	DDS-5: Street-Lighting Subsystems
6	DDS-10: Overhead Systems

Ordering Information

For instructions on ordering the manual through the Edison Portal, visit Transmission & Distribution> Standards and Publications, and click the appropriate link under “Place an Order.”

Standards-approved revisions are identified with **change bars** and can be “Admin” (Administrative), “New,” or “Technical” revisions. These three types of revisions are defined below in Table 1–2, followed by the revisions themselves in Table 1–3.

Table 1–2: Definitions of Revision Types

Type	Definition
Admin	Admin revisions do not significantly affect design, construction, maintenance or operation of the electrical distribution, substation, and transmission systems. These revisions do not require Standards Review Team (SRT) or management approval; however, these revisions have been approved by other organizations as appropriate. Admin revisions may include updates to material codes, updates to references, updates to standards for clarity, or deletions of outdated information.
New	Refers to a new standard. New technical standards require SRT and management approval.
Technical	Technical revisions are engineering changes to existing standards. These revisions affect the design, construction, maintenance or operation of the electrical distribution, substation, and transmission systems. These revisions require SRT and management approval.

Table 1–3: DDS Manual Revisions

Chapter	Page	Description	Type
DDS-2		**Feeder Systems**	Admin
	21	Revised the branch-fuse design requirements in Section 5.9 B., “Branch-Fuse Design Requirements,” for clarity.	
	39	Revised the table reference in Subsection 5.15 B., “Pole-to-First Underground Structure,” for clarity.	
DDS-5		**Street-Lighting Subsystems**	Technical
	12	Subsection 5.10 B. was developed to provide design and procedure criteria for non-SCE AMI equipment to be installed onto 28-foot SCE LS-1 marbelite poles and customer-owned streetlights served from SCE's unmetered LS-2 schedule.	

Table 1–3: DDS Manual Revisions — *Continued*

Chapter	Page	Description	Type
DDS-10		**Overhead Systems**	
	16	Added notes in Table 10-1 (Single-Phase Transformer Pole Mounting and Weight Limitations on Wood Poles) to reflect the new equipment weight tables in DDS-10 and application of 10 kVA and 15 kVA overhead transformers. 10 kVA and 15 kVA overhead transformers are not available and not approved for use on new installations or replacements.	Technical
	17	Revised the transformer weights in Table 10-2 (Weight Limitation of Three-Phase Transformers — Crossarm or Bracket Mounted on Wood Pole) to reflect the transformer weights shown in DDS-10, Table 10-4; and AP 108 of DOH.	Technical
	18	Revised the transformer weights in Table 10-3 (Weight Limitation of 2-Single Phase Transformers — Open Delta Bracket on Wood Pole) to reflect the transformer weights shown in DDS-10, Table 10-4; and DOH AP 108.	Technical
	19	Revised the transformer weights in Table 10-4 (Single-Phase OH Transformer Weight and Dimensions) to reflect the transformer weights shown in DOH AP 108.	Technical
	19, 20	The weights and dimensions for capacitors, voltage regulators, automatic reclosers, power control transformers, and overhead switches were removed from Table 10-4. The weights and dimensions for various equipment are outlined in Table 10-5, Table 10-6, Table 10-7, Table 10-8, and Table 10-9.	Technical
	19, 20	Table 10-5, Table 10-6, Table 10-7, Table 10-8, Table 10-9 are new tables describing the revised weights and dimensions for capacitors, voltage regulators, automatic reclosers power control transformers, and overhead switches.	Technical
	53	Removed reference to PO 147 of DOH from Subsection 5.6 P. for clarity.	Admin
	73	Revised Subsection 5.7 H., “SmartConnect Communication Devices,” to allow the installation of the Broadband Global Area Network (BGAN) and Cell Relay devices on distribution wood poles.	Admin
	88	Added conductor sizes for aerial cable and telephone cables in Table 10-21, “Conductor Pole Loading.”	Technical

Getting Help

Technical Revisions

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TRANSMISSION AND DISTRIBUTION

DISTRIBUTION DESIGN STANDARDS

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INTRODUCTION

DDS-1

Southern California Edison
Transmission and Distribution Business Unit

Chapter DDS–1: Introduction

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1.0 Introduction

The Distribution Design Standards are about to undergo many exciting and significant changes to design concepts reflecting a revolution in technologies for the 21st century.

Edison is "Leading the Way in Electricity" exploring and implementing benefits from innovations such as Circuits of the Future, Smart Grids, Smart Meters, space age technologies such as GPS and Satellite Communications, advancements in Information Technologies, and other as of yet, undefined opportunities. The environment in which SCE operates is also rapidly changing. Electric vehicles, photo voltaics, smart appliances, environmental regulations, to name a few, will bring challenges and changes to the way Distribution systems are designed.

In 2009, SCE embarked on an ambitious project to completely re-evaluate existing Standards, examine challenges of the future, and develop plans to effectively move forward into the 21st century with improved Standards and processes. This project is called the 'Wires Investment Strategy Efficiency Review' (WISER). Over 900 employees in craft and technical organizations were surveyed regarding changes required to existing Standards and needs for additional Standards. Approximately 100 Standards issues were prioritized and at the time of this writing, waves of teams of craft and technical subject-matter experts have been launched to find the best solutions. It will take several years to come up with all the answers, so the Distribution Design Standards can be expected to change significantly with each new edition.

Your job will be challenging: remain constantly alert to design changes, learning and understanding them, and providing input from your own observations to help improve future editions of the *DDS Manual*. But you will be rewarded in that the Distribution Systems you design will safely effectively meet the challenges of the future while serving our customer's needs today.

One of the first major changes in the 2010 *DDS Manual* is Above-Ground Equipment (AGE) Initiative. Field employees who build and operate our distribution system every day recognized certain hazards and reliability concerns with subsurface equipment installations and worked with management to convince the California Public Utilities Commission (CPUC) to allow SCE to discontinue the use of underground equipment. The following AGE policy change was implemented into the Design Standards:

> Pad-mounted, aboveground equipment is the standard design for the SCE system. The use of below ground, subsurface equipment, except in limited situations, is no longer allowed.

Engineering and Technical Services has made the commitment that all new equipment implemented in the field will have appropriate Standards and Training in order that it can be safely and correctly designed, installed, operated, and maintained. In order that this commitment can be achieved, all system additions and rebuilds will be designed in accordance with these standards. Deviations from the standards may be made when approved and documented as described in the TDBU Standards Process Manual. This deviation documentation will be used as a source for improving these standards in the future.

The uniform application of this design manual will assure consistent design practices among all of our regions and with Applicant Designers.

2.0 Manual Format

This manual is organized in a *design process format* rather than the typical *reference document*. The contents are arranged in the same order that a typical project would be prepared. The design criteria for 6.9 kV, 9.4 kV, 12 kV, and 16 kV applications are addressed. Some 4 kV and 33 kV design criteria have also been included in this edition.

3.0 Description of Chapters

The manual consists of chapters described below:

3.1 Feeder Systems (Chapter DDS–2)

A. The Feeder Systems Chapter provides the design criteria for the portion of the distribution system utilizing 1/0 and larger conductors.

B. The utilization of surface-operable switches of lowest installed cost to provide appropriate loadblock switching. This criteria requires that switches be installed based on the following order of preference:

1. PME switch (For large transformers, 1,500 kVA and above, with fault duty greater than 10 kA, a three-phase switch position will be used to de-energize the load-break elbow positions before closing them.)
2. SF_6 pad-mounted switch (space constraints)
3. SF_6 switch in vaults - This type of installation is no longer allowed except in installations where it is not technically feasible to install pad-mounted equipment or in the public property and public rights-of-way where the local governments create insurmountable obstacles for pad-mounted equipment. Refer to DDS–6, Section 1.1, for definition of technically feasible.

C. A reduction in switches accomplished by limiting the number of ties provided to adjacent circuits.

D. Branch-line fusing on overhead 4 kV, 12 kV and 16 kV tap lines is primarily to improve reliability.

3.2 Commercial/Industrial Subsystems (Chapter DDS–3)

The Commercial/Industrial (C/I) Chapter provides the design criteria for the majority of C/I installations. Some of the design criteria included in this chapter are:

A. A methodology for more accurate demand estimating, resulting in estimated loads that are closer to those actually experienced, allowing better transformer sizing. These criteria consider the effect of new energy-efficient construction and equipment technology as outlined in the California Energy Commission's Title 24.

B. A reduction in the number of switch installations is achieved by the establishment of 1,500 kVA loadblocks. Commercial subsystems up to 1,500 kVA of multiple-transformer installations can be served from a feeder switch position or T-tapped off the feeder cable between switches.

C. Load-break elbows have been included in the subsystem design. In these approved applications, planned outages can be avoided and still allow planned maintenance activities.

3.3 Residential Subsystems (Chapter DDS–4)

The Residential Chapter provides the design criteria for residential developments. Some of the significant design standards included in this chapter are:

A. The number of switch installations is reduced by the establishment of 1,500 kVA loadblocks. Residential subsystems up to 1,500 kVA of transformation can be served from a feeder switch position or T-tapped off the feeder between switches.

B. Pad-mounted surface-operable equipment is the standard installation. Buried Underground Residential Distribution (BURD) equipment is no longer allowed except in the following situations:

- Installations where it is not technically feasible to install pad-mounted equipment. Refer to DDS–6, Section 1.1, for definition of technically feasible;
- Installations in the public property and public rights-of-way where the local governments create insurmountable obstacles for pad-mounted equipment; or
- When replacing existing failed BURD equipment.

C. Minipads will be standard installation on all residential, single-phase, fused radials on 6.9 kV and 9.4 kV systems.

Dead-end minipad-mounted transformers (minipads) and looped pad-mounted (standard sized) transformers shall be the standard installation for all residential, single-phase, fused radials on the 12 kV and 16 kV systems. The minipads shall be used for dead-end applications and looped pads shall be used for looped applications.

As an exception for new installation and when approved by management, dead-end minipads can be configured for looped applications, and looped pads can be utilized for dead-end applications. Management approval is not required when replacing like for like.

D. Load-break elbows are included in residential subsystem design. In approved applications, planned outages can be avoided and still allow planned maintenance activities.

3.4 Streetlight Subsystems (Chapter DDS–5)

This chapter provides the design criteria for CIC and conventional streetlight subsystems.

3.5 Underground Structure Applications (Chapter DDS–6)

This chapter provides criteria to be used in selecting the proper size structures that will adequately accommodate equipment planned for new installations and also to help determine equipment that may be installed in existing structures.

3.6 Transformer Loading (Chapter DDS–7)

This chapter provides loading criteria for transformers serving residential and commercial/industrial loads.

3.7 Voltage Drop/Flicker (Chapter DDS–8)

This chapter provides criteria and methods to be used to evaluate allowable voltage drop and flicker for both overhead and underground systems. Also included in this chapter are the criteria and methods for calculating short-circuit duty.

3.8 Cables/Conductors (Chapter DDS–9)

This chapter provides standards for economic cable/conductor loading, duct bank loading, and cable pulling.

3.9 Overhead Systems (Chapter DDS–10)

This chapter provides design criteria for overhead systems. The key criteria included in this chapter are:

A. Pole-strength/pole-loading criteria discussed with reference tables and examples.

B. Guying criteria are provided with reference tables and examples, including new information addressing sidewalk anchors.

C. New criteria are provided for evaluating the use of unguyed spans where guying is not possible.

D. General construction practices are outlined with references to appropriate construction standards.

3.10 EMF Management Program (Chapter DDS–11)

This chapter explains the Southern California Edison's policy regarding Electromagnetic Field (EMF) and outlines measures for minimizing EMF exposure.

3.11 Plug-In Electric Vehicles (Chapter DDS–12)

This chapter contains items that address providing service to enable customers to charge Plug-In Electric Vehicles (PEVs), and includes requirements and processes associated with PEV charging equipment.

3.12 Rebuild Strategy (Chapter DDS–13)

This chapter provides the criteria for evaluating existing facilities and determining the replacement needed for rebuilding and redesigning existing distribution facilities.

3.13 Generation Interconnection (Chapter DDS–14)

This chapter provides the criteria for evaluating generation connected to the SCE distribution system.

3.14 Customer-Owned Transformer Room (Chapter DDS–15)

This chapter provides the criteria for designing a new customer-owned transformer room (walk-in vault) located inside a building.

3.15 Metering and Applications Types (Chapter DDS–16)

This chapter provides the application and design criteria for metering and associated equipment (for example, meters, current transformers, and voltage transformers).

3.16 Formulas (Chapter DDS–17)

This chapter contains useful formulas and helpful rule-of-thumb factors.

3.17 Glossary (Chapter DDS–GL)

This chapter contains a glossary including the definition of key terms used in this manual.

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Southern California Edison
Transmission and Distribution

Chapter DDS–2: Feeder Systems

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DDS—2
Feeder Systems

1.0 Scope

This chapter establishes the design criteria to be used in designing feeder systems.

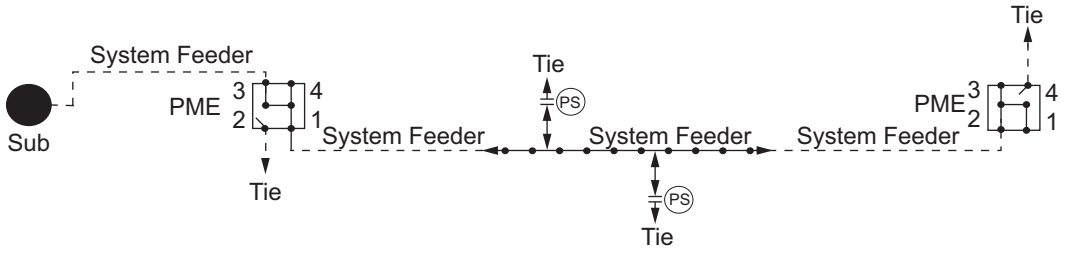
The distribution system is made up of three main components: feeders, loadblocks and subsystems. There are three types of feeders: System Feeder, Future System Feeder, and Dead-End Feeder. The intent of this section is to focus on how these feeders form a circuit.

1.1 System Feeder

The System Feeder uses 600 A components and switches, and contains paralleling points to other circuits and/or itself. It is recommended to consider installing circuit tie switches approximately every 1/3 of the system feeder for reliability purposes.

The Underground System Feeder is designed with cables ranging in size from 350 to 1,000 kcmil for 12 kV to 16 kV, and 4/0 to 1,500 kcmil for 33 kV. The Overhead System Feeder is designed with 336 to 653 Aluminum Conductor Steel Reinforced (ACSR). In some cases, it may be appropriate to use 1/0 CLP and 1/0 ACSR for the System Feeder in accordance with planned future system requirements.

Figure 2–1: System Feeder Example

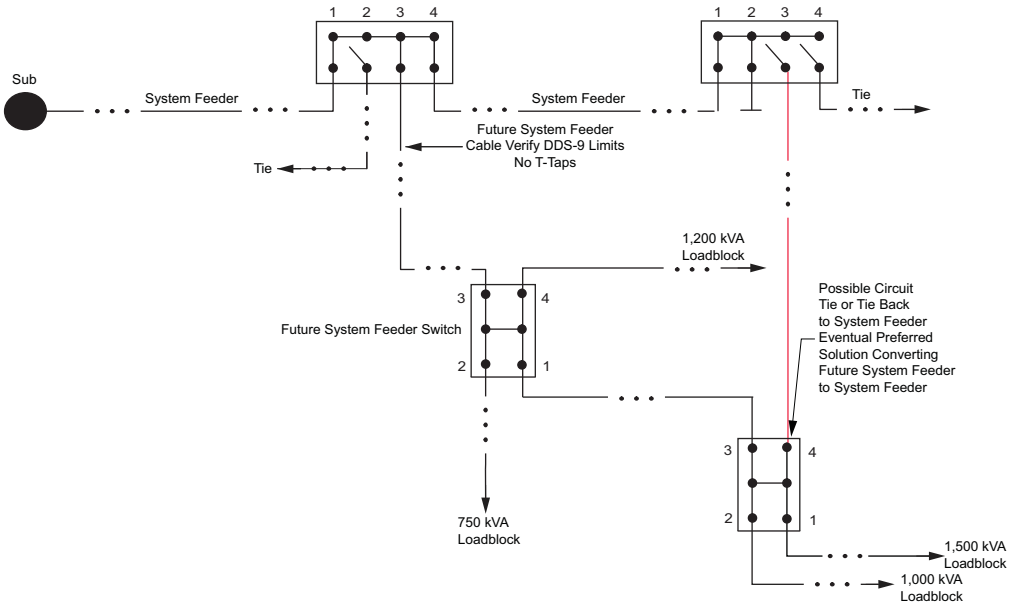


1.2 Future System Feeder

A Future System Feeder uses 600 A components and switches without a paralleling point. It consists of 600 A cable between two switches and has the potential to expand. Eventually, these systems may expand and make a paralleling point to create a System Feeder. Therefore, the conduit and structures are to be designed as a System Feeder.

On Future System Feeders, T-taps are not allowed. This will prevent outages impacting multiple loadblocks. The only allowable exception is automation transformers may be T-tapped off the Future System Feeder switch position. Planners must work with Field Engineering to make appropriate provisions for capacitors as needed. When Future System Feeders exceed 4,500 kVA, Field Engineering must be notified to determine if a System Feeder needs to be created.

Figure 2–2: Future System Feeder Example

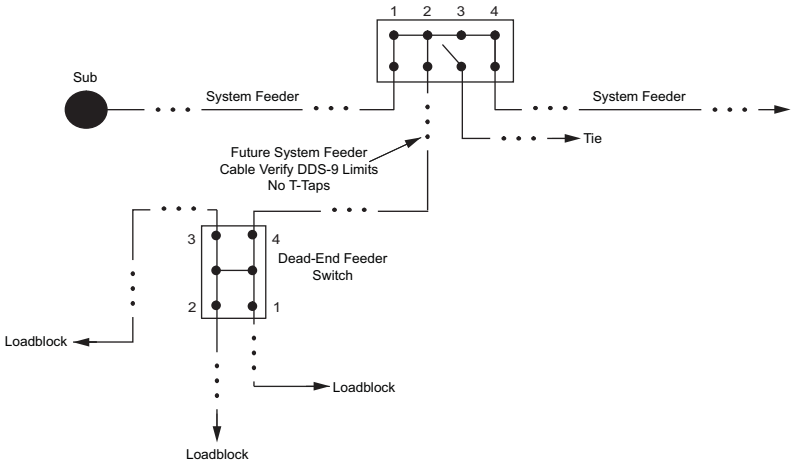


1.3 Dead-End Feeder

A Dead-End Feeder is a section of cable that originates from a switched position on the System Feeder and extends to another switch with no intent to create a paralleling point. The combined total of all the loadblocks on the Dead-End Feeder will not exceed 4,500 kVA without consulting Field Engineering. On Dead-End Feeders, T-taps are not allowed. This will prevent outages impacting multiple loadblocks.

The Dead-End Feeder is intended for situations that are typically a few large commercial/industrial loads on a cul-de-sac. Consideration must be taken of this load as it increases since this limits the ability to switch load between circuits. Planners must work with Field Engineering to make appropriate provisions for capacitors as needed.

Figure 2–3: Dead-End Feeder Example



The activity that creates the need to design a new feeder system can be identified through internal activities such as circuit planning, the Distribution Substation Planning (DSP) process, or external influences, that is, Rule 20 projects, and large new developments. The design process begins by reviewing the region's master electrical distribution plan. Appropriate design criteria are then applied to arrive at a specific economical design. A flowchart shown in Appendix (Page 2–38) outlines the design process for feeder systems.

The following design criteria for the feeder systems are covered:

5.1 Cable Selection on Page 2–8
5.2 Duct Bank Loading on Page 2–9
5.3 Switch Selection on Page 2–9
5.4 Structure Selection on Page 2–12
5.5 Feeder/Subsystem Interface on Page 2–14
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2.0 Key Definitions

Chapter DDS–GL contains a glossary which includes the definition of key terms. A review of the glossary will assist in understanding the discussion in this standard.

3.0 Design Concept

The feeder system design criteria applies to the planning of new distribution circuits, the undergrounding of an existing section of an overhead feeder, or the installation of a new section of a feeder. These criteria also apply to the rearrangement of an existing feeder section.

Based on economics, the design of feeder systems should result in capital expenditures, installation of plant, being deferred when the actual need for equipment is not required for five years; and conduits/substructures are not required for ten years.

A feeder should be planned for peak-load conditions. *Distribution Design Standards* (DDS) will minimize the number of switches and subsystem connections to the feeder in accordance with the following strategies:

A. Plan for circuit ties to provide the required switching (planned and emergency)

B. Plan subsystems for commercial/industrial (C/I) and residential developments as radial designs

C. Group subsystems into loadblocks

Due to the operating limitations and increased loading in the 4 kV circuits, further expansion of these systems should be avoided. If load needs to be added, to an existing 4 kV circuit, Field Engineering needs to be consulted. Cutting over a 4 kV circuit to SCE's more typical 12 or 16 kV systems should strongly be considered as the preferred alternative to expanding the 4 kV system.

33 kV circuits are primarily used as source lines to small substations. They are used more often as a subtransmission system than a distribution system. Occasionally, it is necessary to connect a single-phase or three-phase transformer to a 33 kV circuit in order to feed a single or three-phase load.

Use of the 33 kV primary as a distribution system is dependent on economics and availability of other distribution voltages in the area. When serving large motor loads, it is appropriate to consider the benefits and economics of serving the load from a nearby 33 kV circuit rather than from an adjacent 12 kV circuit. Consult Field Engineering for any such application.

3.1 Loadblocks and Subsystems

A Loadblock is a single subsystem or a grouping of subsystems, and can be any combination of C/I and/or residential load up to 1,500 kVA. When possible, commercial/industrial and residential load should not be combined on a single loadblock/subsystem without providing means of disconnecting the C/I separately from the residential load. This will help avoid long or frequent outages for residential customers caused by equipment upgrades for commercial/industrial customers.

Loadblocks shall be designed in a manner that allows each loadblock to be switched and isolated from the feeder without interrupting service to any other loadblock.

On overhead circuits, 1,500 kVA (one loadblock) shall be connected to the System Feeder between two overhead switches.

Subsystems are three-phase and/or single-phase components serving C/I developments and/or residential developments. Subsystems will generally be 200 A systems utilizing 1/0 CLP cable, and 200-amp-rated equipment.

3.2 T-Tap Connections

T-taps may be connected between two switch positions on the System Feeder based on the following criteria:

A. One T-Tap

A single T-tap may be located on a switch position or in any structure between two switch positions on a System Feeder.

B. Two T-Taps

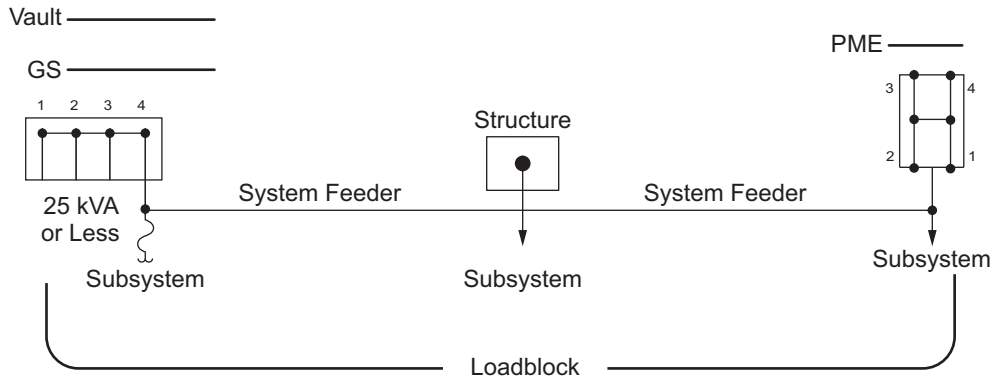
One of the T-taps shall be located on a switch position in the switch structure. The second T-tap may be located on a switch position or in any structure between two switch positions on a System Feeder.

C. Three T-Taps

Two of the T-Taps shall be located on switch positions in the switch structures. One of the T-Taps serves single-phase load which does not exceed 25 kVA.

Note: It is intended that each loadblock will contain 1,500 kVA of fully-loaded transformation. Based on recommended loading criteria, each transformer can be loaded to 120 percent or 130 percent of the nameplate. Therefore, a C/I loadblock can consist of a total of more than 1,500 kVA of actual peak load. Planners shall consult Field Engineering when transformation exceeds 1,500 kVA and when transformers are being upgraded due to loading. If the growth requires system upgrades, the Planner and Distribution Engineer shall identify options to split the load into smaller loadblocks.

Figure 2–4: Loadblock



3.3 Best Practices for Design and Construction

A. Avoid T-taps when installing a new switch to allow for future expansion.

B. T-taps are not allowed on Future System Feeders or Dead-End Feeders due to loadblock definitions (for example, de-energizing a loadblock may not affect any other loadblock). Automation transformers are the only exception and may be tapped off the Future System Feeder switch position if there is a means to avoid ferroresonance such as use of load-break elbows, phase to neutral transformers, etc. (See DDS, Section 5.13 B).

C. T-taps are not allowed to be connected to the System Feeder between the substation and the first switch position.

4.0 Prerequisite Information

A Planner must have the following specific knowledge and information to design an economically viable feeder system:

A. Planners should consider the City/County/Municipality's ultimate zoning master plan that includes main arterial roadways.

B. Master Duct Plan, Distribution Substation Plan (DSP), circuit loading, and circuit emergency operating plans (consult Field Engineering).

C. Developer/Governmental Agency Project Plans as appropriate

D. Knowledge of Distribution Construction Standards

5.0 Design Criteria

5.1 Cable Selection

Primary cable for a new 12 kV and 16 kV feeder will be jacketed 1/0 AWG or, 350 kcmil, or 1,000 kcmil stranded aluminum with 220 mil of Cross-Linked Polyethylene (CLP) insulation in a conventional conduit system.

Underground cable will be sized in accordance with Table 9–1. The cable loading table ensures that cable installations on the feeder system are sized adequately for future load requirements while also providing the lowest long-term cost to SCE ratepayers.

In order for a cable size to be determined, the following information must be known:

- Whether the installation requires any new infrastructure
- Whether the proposed cable size can be supported by the existing conduit size and/or structure spacing

Exceptions to Table 9–1:

Due to equipment bushing limitations, certain transformer sizes and protective equipment require installation of 1/0 AWG JCN. The affected equipment includes the following:

- Equipment associated with a loadblock
- At 12 kV, both 1,500 kVA and 2,500 kVA transformers
- At 16 kV, both 2,500 kVA and 3,750 kVA transformers

For these installations, 1/0 AWG JCN will be installed between the protective equipment and the next upstream structure, and from the protective device to the primary of the transformer.

Loading standards are to be used for all new cable installations including:

- New substation getaways
- Feeders through new residential or C/I developments
- Replacement of overhead feeder with underground
- Replacement of cable due to cable overload
- Addition of cable to accommodate load transfers and emergency or planned switching

Overhead conductors will be sized in accordance with Table 9–2 and Table 9–3.

5.2 Duct Bank Loading

Circuits shall be planned so that loads do not exceed the ampacity of the cable. For underground cables, the ampacity is affected by the loading of all the circuits in a common duct bank. The critical portion of most circuits is the getaway cable as it leaves the substation carrying the entire circuit load in a duct bank common to other loaded cables.

Circuits shall be planned so that the loading of individual cables in a duct bank will not exceed the normal operating *planned* loading limits. Circuits shall also be planned so as to support substation N-1 contingency plans without exceeding the emergency operating ratings.

See Chapter DDS–9 for tables, diagrams, and a discussion of how to determine acceptable duct-bank loading.

5.3 Switch Selection

A. Pad-mounted switches are the standard when designing a new feeder system. Sub-surface equipment in vaults is no longer approved except in the following situations:

- Installations where it is not technically feasible to install pad-mounted equipment. Refer to DDS-6, Section 1.1, for definition of technically feasible;
- Installations in the public property and public rights-of-way where the local governments create insurmountable obstacles for pad-mounted equipment; or,
- When replacing existing failed sub-surface switches in vaults.

B. An overhead pole switch shall be installed ahead of an underground dip when a ferroresonant condition exists between the riser pole and a switch in the underground system.

C. There are five types of switches approved for use on the feeder system:

1. Omni-Rupter® and Alduti-Rupter® Overhead Load-break Switch

   The Omni-Rupter® and Alduti-Rupter® overhead load-break switch is the preferred standard for new switch installations where switching can be performed from the overhead system. The Omni-Rupter® switch may be used on riser poles to switch underground systems.

Refer to the *Distribution Overhead Construction (DOH) Manual*, AP 336, for Omni-Rupter® switch installation details.

2. Pad-Mounted Elbow-Connected (PME) Switchgear

   The PME dead-front switchgear replaced the Pad-Mounted Housing (PMH), live-front switchgear as the recommended standard for new underground fed installations. PME switchgear must be fused with current-limiting fuses, unless the installation requires fusing of more than 100 A (two 50 A fuses). PME switchgear is available with two, three or four positions. The switchgear is available with stainless steel cabinets which should be used in areas with severe corrosion. Refer to the *Distribution Underground Construction (DUG) Manual*, Section PD 337, for detailed description of PME switchgear and fuses and PME switchgear installation details.

3. Pad-Mounted Gas Switch

   The pad-mounted gas switch can be used in lieu of the PME switch for new installations. Pad-mounted gas switches are available in two through six positions. Refer to DUG, SE 260, for pad-mounted gas switch installation details.

4. RA-Type Ground (RAG) Switch

   These standards are not intended to remove a switch from service that has not yet met the end of its useful life. These standards are for the installation of new switches or replacement of switches that are deteriorated, have failed, or been identified for replacement through the Infrastructure Replacement Program.

   The RAG switch allows remote grounding and reduces the time devoted for grounding activities required when work is being performed in the field. These benefits need to be balanced with the cost differential over the RAM switch. Therefore, it is recommended that the RAG switch be installed strategically. Strategic locations include, but are not limited to the following:

   - The 1st switch outside of the substation before any load
   - Three or more 600 A mainline connections, excluding loadblocks and pad-mounted equipment gear

   Presently, a RAG switch cannot be automated. If automation is required, install a RAM switch.

   Refer to DUG, SE 259, for RAG switch installation details.

5. RAM Switch

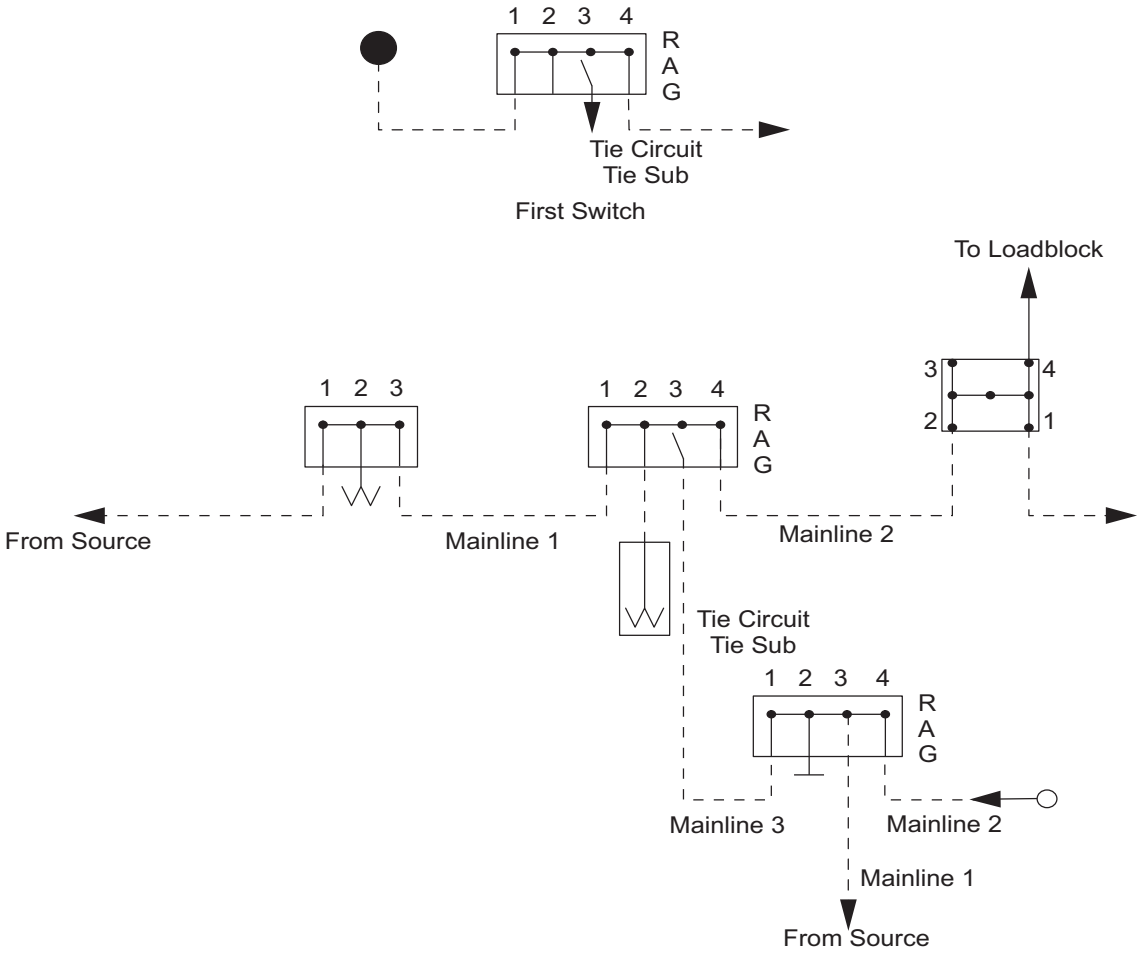
   The gas-filled RAM switch can be used on mainline circuits at the following locations:

   - Switches that require automation
   - Feeders with two or fewer 600 A mainline connections
   - Radials with only 200 A connections
   - Structures not large enough to accommodate a RAG switch, for example, a 6' x 12' x 7' Vault

   Refer to DUG, SE 258, for RAM switch installation details.

   The specific project requirements and site conditions must be considered in making the most economical selection of switches. Refer to Figure 2–5 for potential feeder switch applications:

Figure 2–5: Switch Applications



Three or More Mainline Positions

5.4 Structure Selection

A master plan for duct, circuitry, and cabling should be developed for growth areas and reviewed periodically. Plans for the installed substructure system should anticipate area growth and system needs for the next ten years.

A. Structure Type and Size

Pad-mounted or surface-operable equipment and structures are the standard structure type to be used in the Edison Underground System. When sub-surface structures are allowed per the AGE Initiative, tub-type structures are standard for vaults, manholes, surface-operable enclosures, and PME structures used for feeder and C/I systems. Tunnel or poured-in-place structures shall be installed on an ***exception*** basis only.

Pad-mounted or surface-operable equipment and structures should be utilized where conditions permit. Vaults should normally be used to house transformers, switches, and/or protective devices in full-traffic areas only.

B. Structure Spacing

Underground manholes and vaults for mainline installation shall be laid out based on the **pulling length** for the largest size cable identified in Table 9–1. For all other non-mainline structure installations, the structures shall be laid out to accommodate the maximum **pulling** length of the cable currently being installed.

EXAMPLE 1:

Scenario: Load justifies installing 350 kcmil mainline cable between two new vaults on a 12 kV circuit.

Question: What size cable should be used to determine the structure spacing?

Answer: Since the circuit voltage is 12 kV, the pulling length for 1,000 JCN (largest size) should be utilized when determining the spacing between the two structures.

C. Structure Location

The preferred location for structures is in the parkway or other non-traffic areas with good vehicle access. The second choice would be in light-traffic areas (parking lot or driveway not subject to truck traffic). Full-traffic locations are least desirable.

In all cases, consideration must be given to the following items when determining structure locations:

1. Clearance from other utilities' substructures
2. Maintain a 36-inch minimum clearance, if space permits or can be provided at no additional cost or low cost minor work to accommodate the Americans with Disabilities Act of 1990 (ADA) and pedestrian right-of-way access requirements (Avoid structure placement in wheelchair ramp locations).

3. Traffic patterns
4. Traffic control requirements as established in the *California Joint Utilities Traffic Control Manual (CJUTCM)* and the *Pedestrian Traffic Control Manual (PTCM)*
5. Visibility for vehicles when using pad-mounted equipment
6. Aesthetics in relation to development plans
7. Whenever possible, place pad-mounted structures and equipment away from areas with frequent irrigation to help prevent future corrosion.

   Install NEW stainless steel pad-mounted equipment only if every effort has been made to locate the pad-mount away from high-corrosion areas and the pad-mount is expected to be changed out within 15 years due to corrosion. Contact Field Engineering for approval.

   Existing mild steel pad-mounted equipment may be upgraded to stainless steel if the existing equipment has failed due to corrosion within 15 years of installation. Contact Field Engineering for approval.

   Note: All pad-mounted transformers purchased after 2004 are designed with stainless steel bottoms.

D. Riser Cable Runs

Cable should be fed from the structure up to the riser. Cable should not be fed from the top of the riser or from the base of the pole.

E. Duct Bank Planning

For substation getaways and feeder structures, design for a maximum of six circuits in each duct bank. Reduce to four, two, or one five-inch duct as loading requires. Install six-inch ducts in areas with 33 kV. If there are more than two, five-inch ducts will be justified by need and included in the **Master Duct Plan** for the area.

The preferred location for ducts is parallel to curbs and in the parkway. The existing location of other utility facilities must be researched and plotted on a base map to properly plan Edison duct banks. Normally, a ten-foot separation is required for transmission and distribution ducts. Requirements for communication cable must be considered in the initial installation. Rear property lines are the least desirable locations.

F. Joint Trench

Joint trench construction (with telephone, cable television (CATV), or other utilities) should be planned according to good engineering practices and *G.O. 128* clearance requirements. Joint trench provides a means to share trenching and paving costs. It can provide savings to Edison, other utilities, and the customer, depending upon the tariff rule application. Formulas for allocating joint trench costs are included in Chapter DDS–17, "Formulas" (Page 17–1).

5.5 Feeder/Subsystem Interface

Loadblocks comprised of one or more subsystems will be connected to the feeder using any of the options shown in Figure 2–6.

In addition to loadblocks, cogeneration or small power projects may be connected to the feeder. All primary feeder connections to either a cogeneration or small power producer will be made from a dedicated switch position as illustrated in Figure 2–6, Diagram 1. Methods of Service and necessary project and metering packages are to be coordinated through Field Engineering.

Figure 2–6: Feeder/Subsystem Interface ***(Sheet 1 of 2)***

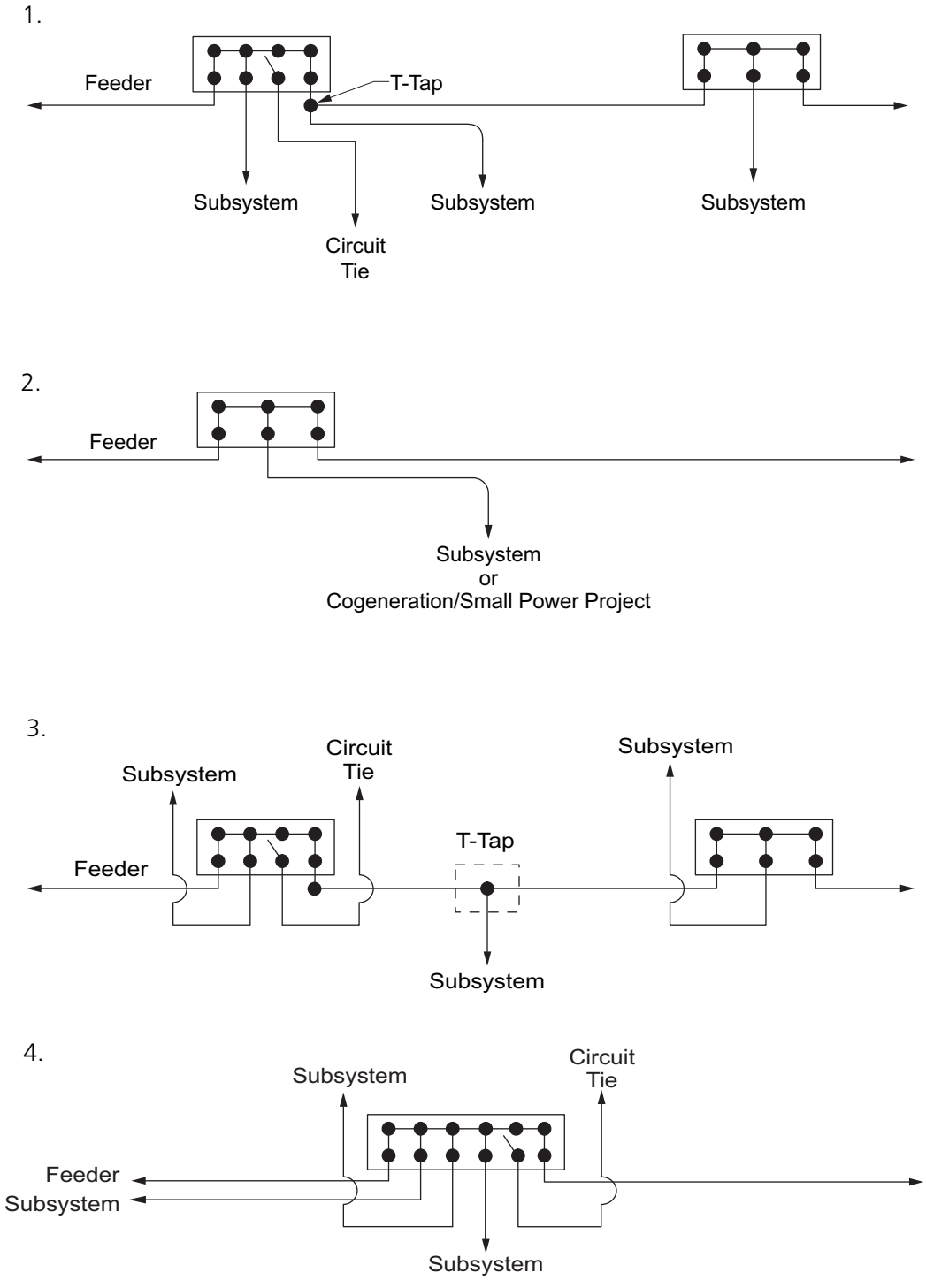
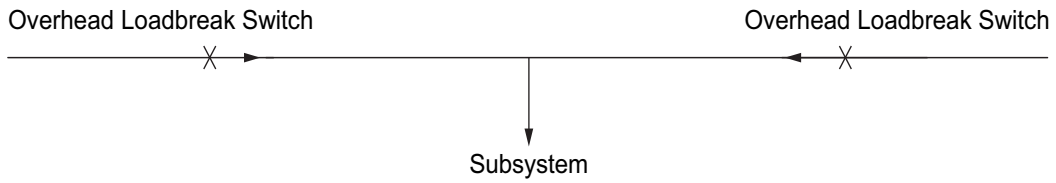
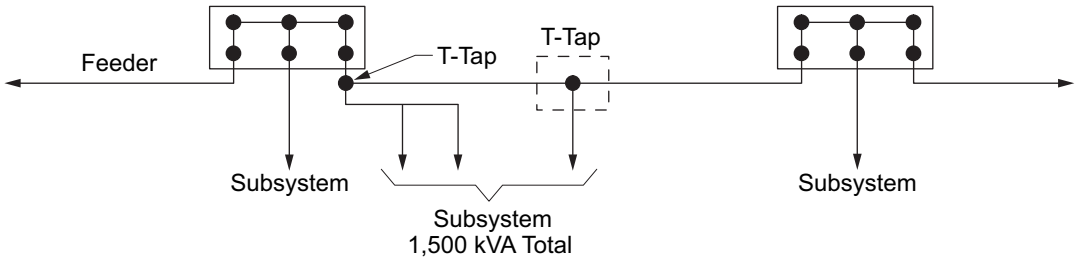


Figure 2–6: Feeder/Subsystem Interface *(Sheet 2 of 2)*

5.



6. MULTIPLE-TAPS



Notes:

1. It is cost-effective to T-tap at the switch location and run 1/0 CLP cable up to a distance of approximately 900 feet to the load (Diagram 2, Page 2–15). If the distance is more than 900 feet, (Diagram 3, Sheet 1, Page 2–15), is the preferred method for a T-tap. The economics of a specific project may result in a breakeven distance other than 900 feet.
2. No T-taps are to be connected to the feeder between the substation and the first switch.
3. For new PME installations, the addition of a switch position (up to four positions) may be more economical than to T-tap off a feeder position of 350-1,000 kcmil cable.
4. T-taps may be installed on feeder cables to form subsystem loadblocks of approximately 1,500 kVA of transformation provided:
   a. T-taps are installed in no more than two locations, totaling approximately 1,500 kVA, and
   b. One of the two locations is tapped off a switch position in the switch enclosure.

5.6 Circuit Ties

Feeder designs, including circuit ties, must be site-specific and designed in accordance with a master plan. Three properly located circuit ties are sufficient to satisfy required planned and emergency operations. However, geographic conditions such as mountains, flood control channels, freeways, or operating constraints such as Bulletin 22 areas, PE equipment, and protection requirements, may require that circuits be designed with more than three circuit ties.

These ties should allow circuit loadings after load transfers that are below circuit relay minimum trip settings and emergency cable loading limits. The cable size of the circuit ties should be determined by:

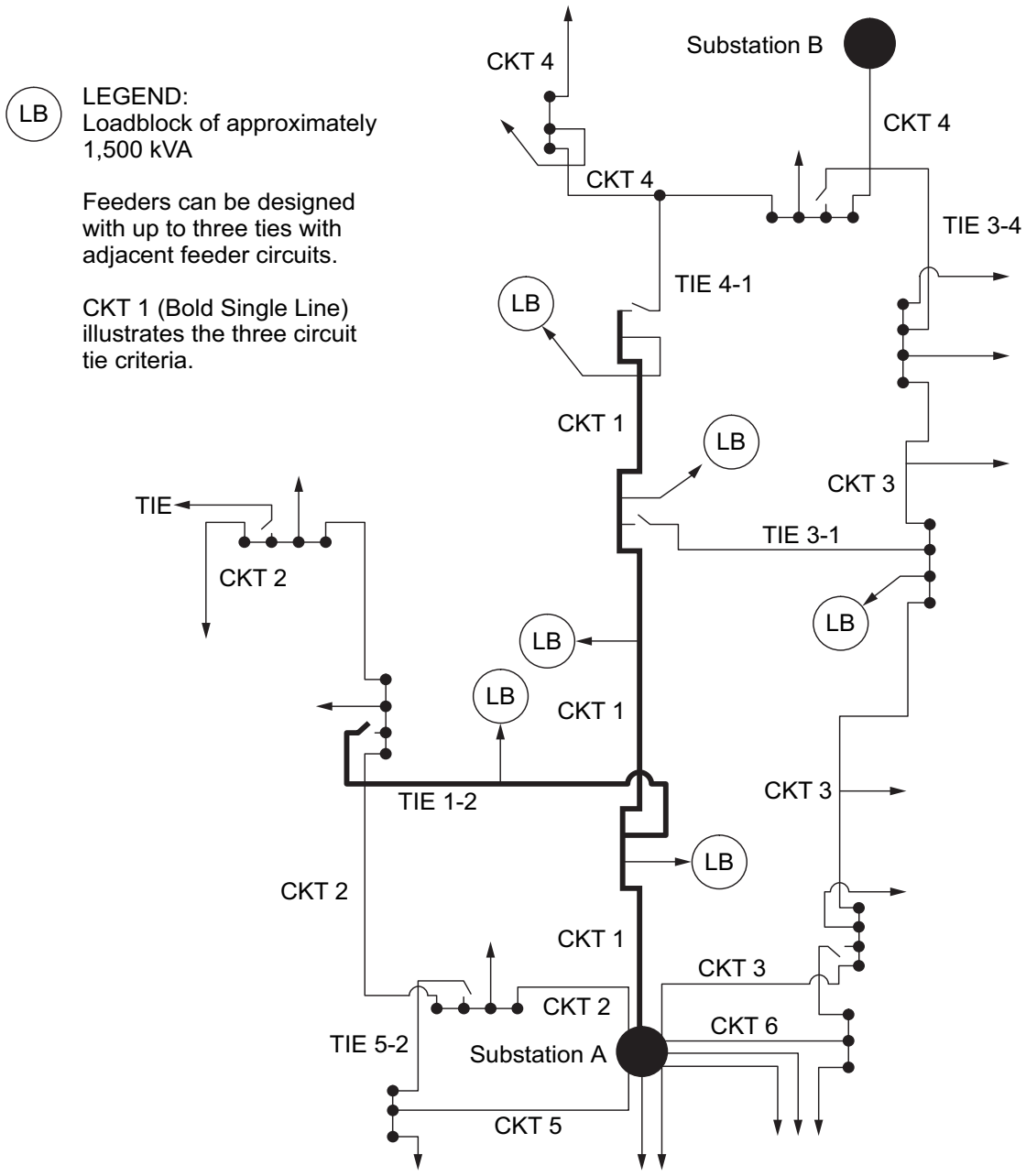
1. Cable Sizing Guide in Chapter DDS–9, Section 2.0 for normal loading conditions; and
2. Duct bank loading criteria in Table 9–5 for both normal operating *planned* and emergency loading conditions.

The number of ties with circuits out of the same substation versus circuits out of another substation must be considered in order to satisfy N-1 DSP criteria.

Generally, subsystems will be designed as radial systems rather than loop systems; however, existing 200 A loop systems do not constitute a circuit tie for the application of these standards.

Figure 2–7 schematically illustrates the circuit tie criteria.

Figure 2–7: Circuit Tie Criteria



5.7 Fault Indicators

A. Description

Fault indicators (FIs) are placed on a cable to indicate that fault current has passed through that point. When it senses a fault, it displays a flashing red Light Emitting Diode (LED), or a red flag. Starting at the substation, the troubleman can trace the path of the fault by following the flashing fault indicators.

Overhead FIs are installed directly on the bare conductor (refer to DOH AP 600). Underground units mount on insulated conductors, but not on Paper-Insulated Lead-Covered Cable (PILC) (refer to DUG, Section TD I00). Underground units include extension fiber-optic cables for remote indication at convenient locations (refer to DUG sections TD 100.3 to TD 100.7).

Fault indicators are phase-current sensing devices which are highly reliable. However, FIs are very much dependent on the fault magnitude and duration, which varies from each and every location in the circuit. Therefore, they may not work in some situations where fault duties are not high enough and/or long enough to trip the FI unit.

B. Operation

A tripped circuit breaker or a blown fuse is the first evidence that a fault has occurred. If the circuit breaker tripped due to a fault, then the fault indicators installed on the breaker's associated circuit would trip if the fault current passed through them. The FIs are then used to indicate the path to the fault location.

In general, the segment of the circuit between the farthest downstream flashing FI and the next non-flashing FI indicate the segment where the fault has occurred. The troubleman then opens the appropriate switch or switches to sectionalize and isolate the faulted segment of the circuit. After verifying that no other source paths to the faulted segment exist, the troubleman re-energizes other unfaulted parts of the circuit to restore power to as many customers as possible.

The FIs are commonly made an integral part of the circuit's emergency switching procedures. Their locations are marked on the circuit maps in accordance with *Distribution Operation and Maintenance Policy and Procedures (DOM) Manual*, Section CO-2.

C. Selection

Fixed-trip FIs are selected based on twice the circuit's five-year projected peak load determined by Field Engineering. Four discrete trip-ratings are available for both overhead and underground applications: 200 A, 400 A, 600 A, and 800 A.

Automatic, self-adjusting FI units — There are two approved self-adjusting FIs:

- The Load Tracker with Load Memory is available in both overhead and underground applications.
- The Navigator is only available for overhead applications.

The Load Tracker with Load Memory has a very low (50 A) minimum trip that can be used in applications where fault duties are extremely low. Both the Load Tracker with Load Memory and the Navigator are self-adjusting types FIs that sample the load current every 72 hours and adjust the setpoint accordingly based on the peak load current.

D. Placement

Fault Indicator locations will be selected to cost-effectively reduce the switching time to isolate a fault based on the established emergency switching procedures. Special circumstances, such as problem circuits (circuits with a history of frequent or lengthy outages), and circuits with critical loads, may warrant additional FI locations.

Avoid installing FIs at the following locations:

- On any normally open tie line
- On any normally de-energized circuit section
- On minor circuit tap sections and single-phase laterals
- Immediately beyond fuses
- Circuits that are looped
- Downstream of an AR if ground device is enabled

The FIs will be placed in a readily visible and accessible (for resetting) location, at or near a circuit sectionalizing point, on overhead conductors, in selected subsurface locations, or in pad-mounted equipment. FIs may be placed on overhead conductors near underground risers to indicate faults on underground portions of the circuit.

5.8 The GridSense Line Monitoring System

The purpose of the GridSense Line Monitoring System (GridSense System) is to wirelessly monitor overhead circuits by capturing data on the circuit performance and condition of the lines, thereby allowing Engineering and Field Personnel to respond to equipment-related outages, over-load conditions, troubleshooting, and reliability issues. The time-stamped data it captures include load, maximum demand, line current, line voltage, fault waveform and direction, conductor temperature, ambient temperature, power factor, phase angle, and switch operations for each of the three phases.

The GridSense System has built-in wireless communication for onsite (non-remote) or remote data download via the Distribution Center Monitoring System (DCMS).

Due to the cost of the GridSense System, **it is not normally specified equipment for new or existing distribution lines**. Although this system is to be normally specified by Grid Ops, Field Engineering, and District Managers, **Planners may consult with Field Engineering for deployment of the GridSense System** on long distribution lines or difficult-to-patrol areas, for example, areas where air patrol is required.

Refer to DOH, AP 610 for further information.

5.9 Overhead Branch-Line Fusing

The application of overhead branch-line fusing on 4 kV, 12 kV, and 16 kV circuits shall be limited to selected locations and requires Field Engineering approval.

A. Branch-Fuse Applications

Branch-line fusing may be considered for the following applications:

1. To improve circuit performance by reducing average Customer Minutes of Interruption (CMI):

   The application of branch-line fusing is available to improve the average CMI of circuits having a history of poor performance. The circuits selected should be poorly performing circuits having a recorded history of high CMI and having known interruptions due to faults on overhead branch lines. The branch line to be fused should be limited to five percent or fewer of the total circuit customers.

2. To provide end-of-line protection as an acceptable economic alternative to automatic reclosers:

   The application of branch-line fusing for end-of-line protection is recommended for cases when branch-line fusing will be an acceptable alternative to purchasing an AR, for example, branch-line fusing will satisfy protection and operating requirements.

B. Branch-Fuse Design Requirements

Branch fuses will be sized to meet the criteria shown in Table 2–1, Table 2–2, and Table 2–3. These tables were developed to meet the following design requirements:

1. Coordinate with existing ground relay setting at the substation circuit breaker.
2. Accommodate anticipated normal loads of the branch line.
3. Accommodate cold-load pick-up requirements.
4. Coordinate with the individual transformer.

C. Branch-Fuse Restrictions

For all of the recommended applications, the following restrictions apply to the installation of branch fuses:

1. Branch fuses are **not** to be installed in series with another branch fuse such as fused underground subsystem.
2. Branch fuses planned to be installed ahead of nonfused underground subsystems shall require an engineering review for potential ferroresonance.
3. Branch fuse sizes shall meet the design criteria in Table 2–1, Table 2–2, and Table 2–3.
4. Any rearrangement or installation of load to a fused branch line requires an engineering review of the branch fuse.
5. Branch fuses shall not be installed if a capacitor bank is downstream of that branch.

Table 2–1: Fuse Application Guide for 4 kV Overhead Branch Lines

For selection information, see Section 5.9 (Page 2–21). Application of branch line fusing requires Field Engineering approval.

Branch Fuse (SMU-20/ Link) (See Note 4)	MAX Load on Branch			Largest Transformer on Branch (See Note 1)			MIN Ground Relay MIN Trip (Amps) (See Note 3)
	MAX Load Current (Amps)	Connected Load Total kVA (See Note 2)		Transformer Equipment Fuse Size (SMU/ Link)	1Ø 2.4 kV Transf. (kVA)	3Ø Transf. (kVA)	
		1Ø Branch (2.4 kV)	3Ø Branch				
15E/15	11	25	75	10K/10	10	30	30
25E/25	17	40	120	10K/15	15	45	60
40E/40	32	75	225	25E/25	25	75	120

Notes:

1. The largest transformer on the branch is determined by the maximum equipment fuse that will coordinate with the branch fuse. However, high-duty faults (within one-half mile of the substation) occurring at the equipment bushings may still interrupt both the equipment fuse and the branch fuse.
2. For three-phase branch lines, the total kVA includes both single-phase and three-phase transformation, and assumes that the single-phase loads are balanced for all three phases.
3. Branch fuses installed within one mile of the substation may not coordinate with the substation ground relay Instantaneous Trip (IT) settings, where applicable.
4. See DOH PR 107-1 for fuse link SAP numbers. See DOH PR 107-2 for SMU-20 SAP numbers.

EXAMPLE 1:

Using Table 2–1, consider the following scenario and determine what action, if any, is required:

- Existing 4 kV branch-line fuse = 15E
- Existing connected load = 25 kVA single-phase
- New addition load to be connected = two 10 kVA single-phase transformers

What action is required?

Answer: Due to 45 kVA connected load on radial, 40E branch-line fuse is required.

Table 2–2: Fuse Application Guide for 12 kV Overhead Branch Lines

For selection information, see Section 5.9 (Page 2–21). Application of branch line fusing requires Field Engineering approval.

Branch Fuse (SMU-20 Slow) (See Note 3)	MAX Load on Branch			Largest Transformer on Branch (See Note 1)			MIN Ground Relay MIN Trip (Amps)
	MAX Load Current (Amps)	Connected Load Total kVA (See Note 2)		Transformer Equipment Fuse Size (SMU/ Link)	1Ø 12 kV Transf. (kVA)	3Ø Transf. (kVA)	
		1Ø Branch	3Ø Branch				
15E	11	130	225	10K/10	50	75	30
25E	17	200	360	10K/10	50	75	60
40E	32	380	690	25E/15	100	225	100
50E	40	480	860	30E/30	100	225	120
80E	62	740	1,400	50E/50	250	500	180

Notes:

1. The largest transformer on the branch is determined by the maximum equipment fuse that will coordinate with the branch fuse. However, high-duty faults (above 2,500 A) occurring at the equipment bushings may still interrupt both the equipment fuse and the branch fuse.
2. For three-phase branch lines, the total kVA includes both single-phase and three-phase transformation, and assumes that the single-phase loads are balanced for all three phases.
3. See DOH PR 107-2 for SMU-20 SAP numbers.

Table 2–3: Fuse Application Guide for 16 kV Overhead Branch Lines

For selection information, see Section 5.9 (Page 2–21). Application of branch line fusing requires Field Engineering approval.

Branch Fuse (SMU-20 Slow) (See Note 3)	MAX Load on Branch			Largest Transformer on Branch (See Note 1)			MIN Ground Relay MIN Trip (Amps)
	MAX Load Current (Amps)	Connected Load Total kVA (See Note 2)		Transformer Equipment Fuse Size (SMU/ Link)	1Ø 16 kV Transf. (kVA)	3Ø Transf. (kVA)	
		1Ø Branch	3Ø Branch				
15E	11	175	300	10K/10	75	112.5	30
25E	17	270	470	10K/10	75	112.5	60
40E	32	510	880	25E/15	167	300	100
50E	40	640	1,110	30E/30	167	300	120
80E	62	990	1,700	50E/50	333	500	180

Notes:

1. The largest transformer on the branch is determined by the maximum equipment fuse that will coordinate with the branch fuse. However, high-duty faults (above 2,500 A) occurring at the equipment bushings may still interrupt both the equipment fuse and the branch fuse.
2. For three-phase branch lines, the total kVA includes both single-phase and three-phase transformation and assumes that the single-phase loads are balanced for all three phases.
3. See DOH PR 107-2 for SMU-20 SAP numbers.

EXAMPLE 2:

Using Table 2–2, consider the following scenario and determine what action, if any, is required:

- Existing 12 kV branch-line fuse = 25E
- Existing connected load = 100 kVA single phase
- New additional load to be connected = one 75 kVA single-phase transformer

What action is required?

Answer: 40E branch-line fuse is required due to the addition of a 75 kVA transformer. The largest single-phase transformer allowed with a 25E fuse is only 50 kVA.

D. Additional Branch Fuse Considerations

Branch-line fusing, even when correctly applied, will probably increase average CMI to customers on the branch experiencing faults. Under the current system for some faults, for example, lightning, trees in line, and so forth, the cause will clear itself and result in a momentary interruption. For these types of faults, branch-line fusing will cause an extended outage on the branch. Even for faults on a branch that would cause a circuit to lockout, the CMI to branch customers may increase. For this reason, it is extremely important that sensitive customers not be served from lines having branch fuses.

There are some additional secondary benefits to branch fusing. Branch fusing can act as an indicator and direct appropriate overhead line maintenance to reduce the frequency of troublesome fuse interruptions. Where, as before, no cause was found on a circuit patrol and repeated interruptions occurred before the trouble was determined. It is important to recognize that branch fusing is not to be used as a substitute for good overhead maintenance.

E. Branch-Line Fuse Application Approval

Request for a proposed branch-line fuse application shall be sent via e-mail to Field Engineering for approval. The proposed branch-line fuse application must conform with the design requirements and restrictions outlined above, and must include the reason for branch fusing and the following data:

1. Number of customers on branch
2. Number and size of all transformers on branch
3. Number and size of any capacitors on branch
4. Size and distance of all conductors on branch
5. Size and distance of all conductors from substation to branch fuse location
6. Circuit ground relay setting
7. Proposed branch fuse size
8. Circuit map reference

When a branch fuse is installed, the Distribution Operation Center (DOC) shall revise the circuit map to include the fuse size and location.

5.10 Capacitor Planning

Power factor correction and voltage support are provided by the installation of a combination of fixed and switched capacitor banks. Fixed capacitor banks provide for off-peak minimum load Voltage-Amperes Reactive (VAR) requirements. Switched capacitor banks provide the balance of the peak-load VAR requirements and provide voltage support.

Although Field Engineering is responsible for determining system VAR requirements, knowledge of the distribution capacitor planning process is essential so that the Planner can ensure adequate space and structures are provided for future capacitor requirements. Capacitor requirements need to be considered in conjunction with the design of new business projects, or the rearrangement of an existing capacitor installation due to rebuilding work or circuit rearrangement. For the design criteria of new and replacement capacitor banks, refer to DDS-13, Section 5.9.

The Transmission and Distribution (T&D) is implementing the Distribution Capacitor Automation Project (DCAP). DCAP helps to improve customer voltage regulation and increase transmission line and substation capacity by improving system power factor. The system uses two-way packet radios and Programmable Capacitor Controllers (PCCs). The radios transmit line voltage information and capacitor status to head-end computers. The PCCs can be monitored and controlled from the head-end computers.

The following represents the capacitor planning design criteria:

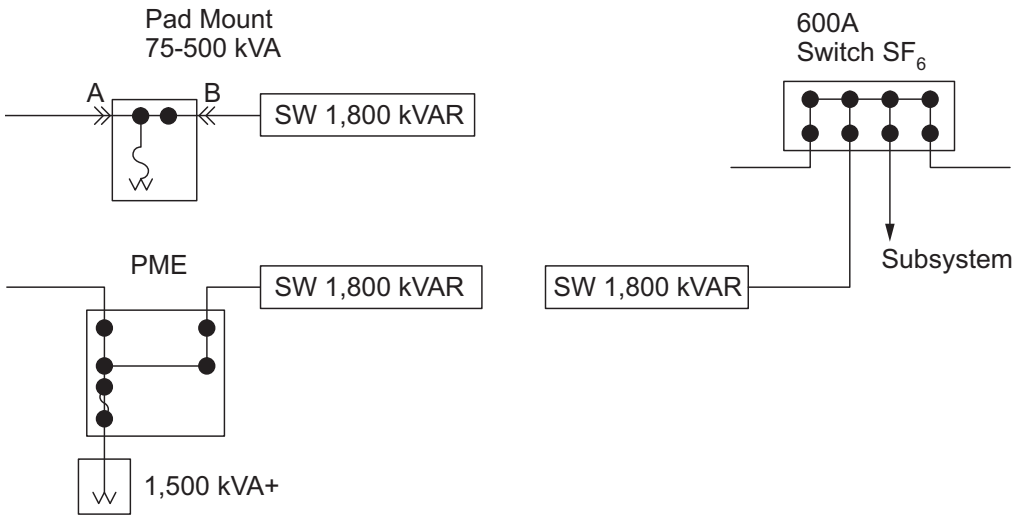
A. Structure space for a pad-mounted capacitor must be included in the design of subsystems to serve residential and commercial/industrial developments when the accumulated kVA of transformation is approximately 2,500 kVA for one or more adjacent subsystems. The actual decision to provide structure space depends on the following:

   1. Annual VAR requirements for the particular substation/circuit as determined by Field Engineering. All capacitor installations must be approved by Field Engineering.
   2. Available space (present and future) for overhead capacitor installations for the particular substation/circuit.

   The installation of a pad-mounted capacitor bank must be planned in accordance with the Annual Capacitor Program.

B. Pad-mounted capacitors shall be electrically connected to the system as shown in Figure 2–8.

Figure 2–8: Pad-Mounted Capacitor Connections



C. Table 2–4 and Table 2–5 may be used to determine the approximate total kVAR requirements for a circuit or for a new loadblock being added to a circuit. For a new loadblock, the capacitor location shall be designed and incorporated into the design of the new business project. Capacitors shall be connected to the electrical system according to Figure 2–8 above. Field Engineering should also be consulted and the Annual Capacitor Program reviewed prior to planning new capacitor bank installations.

D. Overhead capacitor banks shall be installed whenever feasible rather than pad-mounted units because of the large cost difference per kVAR.

Table 2–4: kVAR Requirements for New Load

kW Load	kVAR Required at 12 kV or 16 kV		
	VAR/Watt Ratio		
	0.5	0.6	0.7
1,000	500	600	700
1,500	800	900	1,100
2,000	1,000	1,200	1,400
2,500	1,300	1,500	1,800
3,000	1,500	1,800	2,100
3,500	1,800	2,100	2,500
4,000	2,000	2,400	2,800
4,500	2,300	2,700	3,200
5,000	2,500	3,000	3,500

Table 2–5: kVAR Requirements for Circuits

Circuit Peak (Amps)	kVAR Required at 12 kV			kVAR Required at 16 kV		
	VAR/Watt Ratio			VAR/Watt Ratio		
	0.5	0.6	0.7	0.5	0.6	0.7
50	500	700	800	700	900	1,000
100	1,100	1,300	1,500	1,500	1,800	2,100
150	1,600	2,000	2,300	2,200	2,600	3,100
200	2,200	2,600	3,000	2,900	3,500	4,100
250	2,700	3,300	3,800	3,700	4,400	5,100
300	3,300	3,900	4,600	4,400	5,300	6,200
350	3,800	4,600	5,300	5,100	6,200	7,200
400	4,300	5,200	6,100	5,900	7,100	8,200
450	4,900	5,900	6,800	6,600	7,900	9,300

Notes:

1. The kVAR required represents the total capacitor requirement to correct the circuit or portion of circuit to unity power factor.
2. The VAR/Watt ratio represents the uncorrected power factor of the load on a circuit/substation. The actual ratio to be used is location sensitive and determined by Field Engineering.

VAR/Watt Ratio	0.5	0.6	0.7
Uncorrected Power Factor	89.4%	85.7%	81.9%

E. Field Engineering's Annual VAR Program identifies by system or substation the net VAR requirements. The approximate location to place distribution capacitors on individual circuits out of a selected substation can be determined using the information below:

1. Determine the circuit(s) requiring additional kVAR by comparing the total kVAR required, Table 2–5, to the existing capacitor inventory.
2. Divide the circuit into loadblocks.
3. Determine the total kVAR required for each loadblock according to Table 2–4 or Table 2–5.
4. Compare existing capacitor inventory to the estimated kVAR requirements for each loadblock and identify loadblocks requiring additional and/or new capacitor installations.
5. Generally, fixed overhead capacitor banks should be installed within the first half of the circuit and represents between 15-20 percent of the total kVAR requirement. Refer to Field Engineering for the specific recommended ratio between fixed and switched capacitors.
6. Switched capacitor banks should be located as close to the loadblocks as practical to facilitate switching capacitors with the load during circuit rearrangement.
7. Capacitor banks shall not be installed downstream of branch-line fusing.

F. Generally, capacitor installations should be located on a distribution circuit such that the voltage rise will not exceed 2-3 percent. The voltage rise increases as the distance from the substation to the capacitor location increases. The approximate voltage rise can be calculated using the following formula:

$$\% \text{ Voltage Rise} = \frac{\text{kVAR} \times 100}{\text{Short-Circuit Duty}}$$

The percent voltage rise on total underground circuits generally cannot exceed 2-3 percent. If a circuit has a combination of overhead and underground conductors, and the proposed pad-mounted capacitor installation is more than one mile from the substation, the percent voltage rise may be more than 2-3 percent. In those cases, Field Engineering should be requested to perform a site-specific percent voltage rise calculation.

G. Planned capacitor installations should utilize the largest available bank size in the category to be selected, considering voltage rise as determined by Field Engineering. This is most economical because the cost per kVAR decreases as the bank size increases.

H. Capacitor controls shall be voltage with time or temperature bias. For further information on capacitor control, refer to the *Distribution Overhead Construction Standards (DOH) Manual*, Section AP 200, and the *Distribution Underground Construction Standards (DUG) Manual*, Section UC 120.1.

I. See Table 6–8 for pad-mounted capacitor mounting pad structure requirements.

5.11 Economic Planning

Southern California Edison (SCE) pays ownership and operating costs for all plant expenditures over the life of the system. These annual carrying charges are approximately 18 percent. As an example, SCE completed a section of feeder through a residential development that cost $100,000. The annual ownership and operating costs paid by SCE for this project amounts to approximately $18,000 each year over the life of the system (that is, 30 years).

Therefore, it is extremely important to design and install feeder systems that will accommodate anticipated growth, yet minimize capital expenditures. This can be accomplished by installing cable according to projected load in five years as described in the Economic Loading Table in Chapter DDS–9, Section 2.0,. Deferring installation of switches when not required within five years, and deferring the installation of conduit and substructures when not required within ten years will accommodate anticipated growth, yet minimize capital expenditures. The decision made by the service Planner, that the installation of plant is not required, means that the load can be adequately served meeting all other appropriate design and operating standards.

This economic planning criterion can be applied on the following typical projects:

A. Residential Feeders — Install 1/0 200 A component system initially and replace with a larger conductor 600 A component feeder system after five years.

B. Rule 20 Projects — For a section of feeder loaded to 150 A, install 350 kcmil CLP in a conventional system rather than 750 kcmil CLP even though the existing overhead conductor to be removed is 653 Aluminum Cable (Conductor) Steel Reinforced (ACSR). It is economical to plan to replace the 350 kcmil CLP with the larger size cable after five years or later if load growth requires replacement. For 25 kV and 33 kV underground cable applications, contact Field Engineering.

5.12 Switch Automation Planning

The purpose of Switch Automation is to install a Remote Control Switch (RCS) to improve radial feeder circuit performance by reducing Average Customer Minutes of Interruption (ACMI). Transmission and Distribution is implementing the Distribution Control and Monitoring System (DCMS) for Remote Control and Status monitoring of each RCS. The system uses two-way packet radios and Remote Terminal Units (RTUs) to interface with the switch operator controls and read real-time switch status.

An RCS is a remotely-operated distribution switch near the midpoint of a radial feeder circuit or at a tie-point between two feeder circuits. An RCS at a midpoint feeder location is also intended to automatically open and isolate a permanent, load-side fault when it occurs. If a line or source-side fault occurs, an RCS is still intended to open automatically and isolate that portion of the feeder between the substation and the RCS so that load can be restored by closing a tie switch, either manually or remotely. To provide coordination of the RCS with the feeder substation circuit breaker, Grid Operations and Maintenance must be contacted during the planning stage and requested to set the station breaker for two tests.

When required on an overhead feeder circuit and overhead load-break switches (Omni-Rupter®) on 4 kV, 12 kV, 16 kV, and 33 kV systems can be retrofitted with a switch operator for remote control operation. Likewise, when required on an underground feeder circuit, pad-mounted and submersible switchgear on 4 kV, 12 kV and 16 kV systems can be retrofitted with a switch operator and controls for remote control operation.

An RCS can be manually operated at the switch location by a handle provided with the operator. Also, the RCS can be electrically operated at the switch location with the switch operator controls in the LOCAL mode. Remote control of an RCS requires the switch operator controls to be set in the REMOTE mode. An RCS can open automatically on loss of AC providing switch operator controls are in REMOTE and AUTO. When in both the AUTO and REMOTE modes, line voltage will be monitored by the RCS and an automatic open operation of the RCS will be initiated on loss of AC power after a predetermined time delay that coordinates with the substation recloser test cycle.

When an underground RCS is fed directly from a riser pole, and the PT is on the line side of the switch, an overhead Omni-Rupter® switch must be installed at the riser pole to prevent a potential ferroresonant condition caused by the Control Power Transformer (CPT).

The following criteria should be used to select locations for switch automation.

A. Switches should be on circuits that have high CMI as defined by system-wide distribution circuit interruption analysis.

B. Switches shall be gang-operated disconnects on 4 kV, 12 kV, 16 kV, or 33 kV circuits suitable for fault closing and being retrofitted with a switch operator. No single-blade disconnects are acceptable.

C. Switches should be on circuits with substation circuit breakers capable of being set for two test operations. Field Engineering should notify Grid Operations and Maintenance of the need to set substation circuit breakers on circuits with an RCS to two tests, the first at 15 seconds, and the second at 55 seconds.

D. Switches located on the load side of Automatic Reclosers (ARs) should not be placed on Loss of Voltage Automatic (LVA should be in NON-AUTO mode), unless AR can be set to two tests, and the AR operation can be coordinated with the substation circuit breaker.

E. Switches located on circuits that are fed from substations equipped with supervisory (SUPY or ATTEND) control cannot be placed on Loss of Voltage Automatic (LVA must be in NON-AUTO mode).

F. Overhead switches should be on poles where both pole condition and congestion have been verified as acceptable and meeting *G.O. 95* requirements.

G. Switch locations should be reviewed with IT NetComm as to RF connectivity and potential economic analysis of installation at any given site. Planners should complete the Netcomm Device Installation Form prior to contacting IT NetComm to identify the latitude and longitude positions for each proposed RCS location.

H. Midpoint switches should be located at or beyond critical load areas on a circuit.

I. Midpoint switches should be located so 30 percent to 70 percent of load is on the *down-stream* side of the circuit, that is, on the load side from midpoint switch location.

J. Midpoint switches should be located, where possible, before the highest fault activity area on a circuit.

K. All midpoint and tie-point switches shall each have a dedicated potential transformer to provide 120 VAC control power, and this transformer's primary shall be connected to the same circuit as the RCS it is serving. No other load than the RCS devices shall be served from this transformer.

L. The primary of the dedicated control power transformer for a midpoint switch shall be connected to the line or source-side of the RCS.

M. The primary of the dedicated control power transformer for a tie-point switch may be connected to either side of the switch; although during design of the installation, consideration shall be taken to connect the potential transformer on the side most likely to be used as the source of parallel or load transfers.

N. Tie-point switches should be capable of carrying peak load on the "down-stream" or load side of the midpoint switches.

5.13 Guidelines for Elimination of Ferroresonance

A phenomenon, known as ferroresonance, can result when energizing or de-energizing one phase of primary cable and transformer that are connected in series and the primary cable capacitance is equal to or greater than the transformer's coil inductance. This can occur on transformers with phase-to-phase connected primaries or floating wye connected primaries when switched one phase at a time with no secondary load connected. Ferroresonance typically results in high primary phase-to-ground voltages and low energy capacitive current spikes accompanied by unusually loud transformer buzzing.

Ferroresonance will not produce high currents. Maximum current and energy are limited by the amount of charge the cable capacitance can store, which is very small.

The unusual conditions caused by ferroresonance can cause surge arresters, cable, components, and transformers to fail. Arcing can occur when de-energizing with fuse cutouts, line taps, or load-break elbows. For these reasons ferroresonance should be avoided.

A. Identification of a Potentially Ferroresonant Installation

Four conditions are required to create a situation where ferroresonance might occur. Unless <u>all</u> four are present ferroresonance will not occur:

1. The transformer or bank has phase-to-phase primary connections, or a wye primary with an ungrounded neutral (floating wye); and,
2. Phases are energized or de-energized one phase at a time; and,
3. Combined secondary load on the radial is insignificant relative to the primary cable lengths being switched (refer to *Distribution Operation and Maintenance Policy and Procedures (DOM) Manual*, Procedure TR-8, for identifying load); and,

4. If the primary cable being energized or de-energized, one phase at a time, is of a length greater than or equal to the critical cable length Table 2–6 a ferroresonant condition may exist. Cable length is the total length (not the sum of all phases) of all cable being energized/de-energized and is measured from the connection point to the end of the radial.

The critical cable length is the total cable length per phase that is just enough to make ferroresonance a possibility when switched with unloaded transformers.

For unloaded transformers, Table 2–6 presents the critical cable lengths. For installations involving transformers purchased after January 1, 2010, Table 2–7 shows the critical cable lengths. For multiple transformers being switched on a radial, the critical cable length is based on the total kVA being switched; for instance 150 kVA if switching three 50 kVA units.

Table 2–6: Critical Cable Lengths for Existing Transformers (See Note 1)

Critical Cable Length (in Feet)												
Transformer Size - kVA		#2 CLP (See Note 2)		1/0 JCN		4/0 JCN	350 JCN	750 JCN (See Note 3)	1 Cond - #2 PILC (See Note 2)		3 Cond - #2 PILC (See Note 2)	
1 Ø Size	3 Ø Size	12 kV (See Note 4)	16 kV	12 kV (See Note 4)	16 kV	33 kV	33 kV	33 kV	12 kV (See Note 4)	16 kV	12 kV (See Note 4)	16 kV
25	75	70	30	60	30	10	5	5	45	25	40	25
37.5	112.5	90	50	80	45	15	10	10	55	35	50	35
50	150	100	60	90	50	15	10	10	65	40	60	40
75	225	150	80	130	70	20	15	10	90	55	85	55
100	300	190	100	170	90	25	20	15	120	75	110	70
165	500	320	170	280	150	40	35	25	200	120	185	115
250	750	470	250	420	225	65	50	40	300	185	275	175
333	1000	630	340	560	305	85	70	55	395	250	365	235
500	1500	890	480	790	430	120	100	75	560	350	520	330
833	2500	1500	810	1330	720	205	165	130	945	585	870	550
1250	3750	2130	1150	1890	1025	290	235	180	134	835	1240	785
1666	5000	2840	1540	2520	1365	385	315	240	1790	1110	1650	1045

Notes:

1. These lengths apply to transformers purchased after 1980. For older transformers, use four times the table length.
2. Not approved for use on new installations.
3. 750 JCN cable (33 kV) will only be utilized as specified in DDS-9, Table 9–1.
4. For 4 kV transformers, use ten times the lengths shown for 12 kV.

Table 2–7: Critical Cable Lengths for New Transformers Installations

Critical Cable Length (in Feet)												
Transformer Size - kVA 1 Ø Size 3 Ø Size		#2 CLP (See Note 2)		1/0 CLP (See Note 2)		4/0 CLP (See Note 2)	350 CLP (See Note 2)	750 CLP (See Note 2)	1 Cond - #2 PILC (See Note 2)		3 Cond - #2 PILC (See Note 2)	
1 Ø Size	3 Ø Size	12 kV	16 kV	12 kV	16 kV	33 kV	33 kV	33 kV	12 kV	16 kV	12 kV	16 kV
25	75	46	12	70	31	0	—	0	—	—	—	—
37.5	112.5	57	32	94	51	—	—	—	—	—	—	—
50	150	69	27	95	39	13	—	8	—	—	—	—
75	225	82	52	128	43	13	—	8	—	—	—	—
100	300	132	44	204	49	15	—	10	—	—	—	—
165	500	243	122	265	136	20	—	13	—	—	—	—
250	750	270	137	448	233	66	—	42	—	—	—	—
333	1000	339	155	527	240	82	—	53	—	—	—	—
500	1500	354	198	550	307	127	—	82	—	—	—	—
833	2500	730	415	1134	644	180	—	116	—	—	—	—
1250	3750	1127	629	1750	977	376	—	241	—	—	—	—
1666	5000	—	—	—	—	528	—	339	—	—	—	—

Notes:

1. These lengths apply to transformers purchased after January 1, 2010. For older transformers or cable, use Table 2-6 above.
2. Some cable equipment and transformer combinations no longer available.

B. Eliminating Ferroresonance

Ferroresonance is eliminated by removing any one of the four conditions listed under "A." above which together make a potentially ferroresonant situation. The following considerations in design will eliminate ferroresonance in operation.

1. Phase-to-ground primary connections prevent ferroresonance. Ferroresonance is not a consideration in design.
2. Energize/De-energize transformers and cables separately.
   - In general, new installations will be pad-mounted with load-break elbows. In this way a means is provided to energize/de-energize cable separate from transformers (refer to the *Distribution Operation and Maintenance Policy and Procedure* (*DOM) Manual*, Section TR-8). These installations with load-break elbows remove the need for separate switches for ferroresonance control.
   - 12 kV and 16 kV dead-front, three-phase, fused, pad-mounted transformers should all be installed with load-break elbows.
   - Mitigation of Customers Control Power Transformers (CPT) Potential Ferroresonance Conditions

     If the CPT is connected to the SCE system on the supply side of the customer's main service disconnect (or customer's main breaker) within the primary switchboard, SCE under a line extension order shall install a three-phase, loadbreak gang-operated switch ahead of the primary switchboard to avoid any potential ferroresonant condition that may occur while energizing/de-energizing the primary switchboard.

     In the cases where the panels have CPTs that can be racked out, panel and secondary run should be marked with a ferroresonance sign.
   - If an existing panel is served by a transformer with no gang-operated switch or way to rack out the CPTs, the service may be de-energized one phase at a time on the primary side of the transformer and a switch is not needed. Planners should contact their field engineer on any of these installations to verify ferroresonant condition and design requirements.
3. Use secondary load as a means to eliminate switches.
   - Single-phase radials will almost always have sufficient load so that they may be sectionalized without regard to ferroresonance. A simple rule-of-thumb is a maximum of 250 feet of primary cable per customer if cable is being sectionalized with transformers for 12 kV radials, for instance, a radial with four customers can have up to 1,000 feet of cable per phase. For 16 kV, it is 200 feet of primary cable per customer being switched.
   - For new tracts/services a means of energizing the transformers is needed when no load is present. Load-break elbows on pad mounts will work, but a separate switch will be needed for 12 kV and 16 kV BURD installations.

- Single phasing C/I customers (by single-phase switching with the customer main closed) may damage customer equipment. This is not a preferred way to avoid ferroresonance for C/I customers.

4. Sectionalize using gang-operated switches, when necessary.

   a. Single-phase radials (12 kV and 16 kV) with transformers where the cable lengths exceed those given in Table 2–6 or Table 2–7. Fuse the radial with a 2W-2P fused switch or pad-mounted switch or an Omni-Rupter® switch and fuses on a pole.

   b. All potential transformers connected to primary cable shall be considered potentially ferroresonant and means shall be provided to energize or de-energize them separate from cable or with a gang-operated switch.

   c. Three-phase live-front, pad-mounted transformers with cable lengths to the switching point in excess of those given in Table 2–6 or Table 2–7. Fuse the pad mount with a PME-4 adjacent to the transformer when the designed or actual measured distance of cable is less than the critical cable length in Table 2–7, or use a PME-5 if the switching device cannot be located closer than the critical cable lengths in Table 2–6.

   d. Three-phase underground transformer banks shall have a gang-operated switch such as a three-phase, fused BURD switch or be fed from an underground switch position.

C. Marking Ferroresonant Conditions

When a fused riser pole is serving a potentially ferroresonant cable and transformer system, it should be clearly marked on the circuit maps with ferroresonance symbol and marked out in the field using a ferroresonance sign to assist crews sectionalizing in the future. Signs must be installed at the fused riser pole so that the crews will be sure to sectionalize using the transformer switch or transformer load-break elbows rather than the fuse cutout on the pole. Also, install a decal on each transformer downstream of the riser pole. This applies to three-phase, commercial/industrial transformers fused at underground riser poles and to single-phase radials with one or two customers. Signs are not required for residential tracts with three or more customers since customer load will prevent ferroresonance once customers move into the homes.

5.14 Distribution Automatic Recloser Guidelines

The distribution system Automatic Recloser (AR) can be used in substations as well as in the distribution system. There are application limitations for ARs as with any apparatus application. This section describes the electrical and construction limitations of ARs when applied to distribution circuits and substation lines and banks.

Table 2–8 below lists the specific types of ARs to be ordered for distribution and substation applications.

Table 2–8: Automatic Reclosers for Distribution and Substation Applications

Distribution and Substation Applications	AR Type	SAP (Recloser)	SAP (Controller)
4 kV, 12 kV, and 16 kV overhead applications	Viper-S	10106580	10106579
4 kV, 12 kV, and 16 kV pad-mounted applications	Viper-S	10106587	10106590
25 kV and 33 kV overhead applications	Viper-S	10106595	10106579
25 kV and 33 kV pad-mounted applications	Viper-S	10173375	10106590

A. Automatic Reclosers for Distribution Applications (Outside Substation Fence)

Note: Field Engineering should be consulted prior to planning new ARs, replacing old ARs, or making circuitry changes influencing ARs.

1. For overhead circuits, the AR can be installed on wood poles. Refer to *Distribution Overhead Construction Standards (DOH) Manual*, Section AP 505, for installation details. If two ARs are required for two adjacent distribution feeders, H-frame construction can be considered.
2. For underground circuits, a pad-mounted recloser can be installed. A bypass switch shall be installed with the pad-mounted recloser.
3. The Distribution Control and Monitoring System (DCMS) shall automate the recloser.
4. Distribution Planning and Field Engineering shall determine the circuit electrical loading and available fault currents. They shall not exceed the following electrical ratings and limits:
   a. The maximum anticipated fault current at the recloser location shall not exceed 10,000 A for 4 kV, 12 kV, and 16 kV applications, or 8,000 A for 33 kV applications.
   b. The maximum continuous current shall not exceed 560 A.
   c. The maximum cable-charging current shall not exceed 25 A.

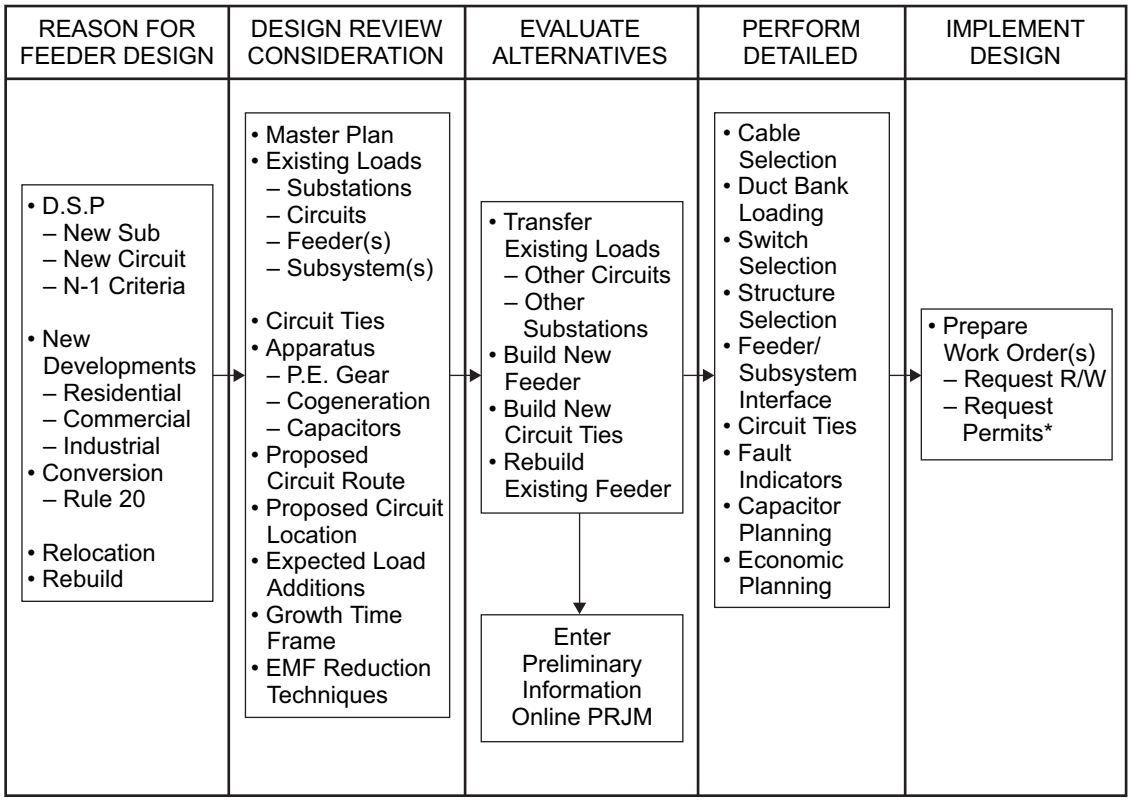
B. Automatic Reclosers for Substation Applications (Inside Substation Fence)

Note: Field Engineering and Projects Engineering should be consulted prior to planning new AR installations in substations.

1. **High Side —** When using a single transformer bank, the ultimate substation capacity is limited to 28 MVA.
2. Circuit electrical loading and available fault currents shall not exceed the following electrical ratings and limits:
   a. The maximum anticipated fault current at the recloser location shall not exceed 10,000 A for 4 kV, 12 kV, and 16 kV applications, or 8,000 A for 33 kV applications.
   b. The maximum continuous current shall not exceed 560 A.
   c. The maximum cable-charging current shall not exceed 25 A.

3. **Construction —** The project engineer shall determine the final method of installation of the AR, based on the following choices:
   a. The AR can be frame mounted.
   b. For overhead circuits, the AR can be installed on wood poles. Refer to *Distribution Overhead Construction Standards (DOH) Manual*, Section AP 505, for installation details. If two reclosers are required for two adjacent distribution feeders, H-frame construction can be considered.
      - Wood poles shall be guyed according to Distribution Design Standards.
      - Ground wires shall be tied in with the ground grid according to Electrical Construction Standards (ECS).
      - Line and bus disconnect shall be required.
   c. For underground circuits, pad-mounted ARs can be installed. A bypass switch shall be installed with the pad-mounted recloser.
4. The DCMS shall automate the recloser unless other means of automation is determined to be more effective.

Appendix 2–1: Feeder System Design Process



* SCE should only apply for excavation permits when facilities are to be constructed by SCE-approved contractors working directly for SCE.

5.15 Bare Copper Neutral Installation

A. Substation-to-First Structure (Overhead or Underground)

1. New Construction

a. A 4/0 bare copper neutral conductor shall be installed in the trench with all conduit banks from the substation cable trench to the first distribution structure.

2. Existing Substations without Existing Bare Copper Neutral

a. Concentric neutrals will continue to be utilized as the neutral conductor.

b. If trenching is required from the substation to the first distribution structure, a 4/0 bare copper conductor should be installed (direct buried into the earth). Trenching for the sole purpose of installing 4/0 bare copper conductor is **NOT** allowed.

B. Pole-to-First Underground Structure

1. 3-Wire Systems

Not Required.

2. 4-Wire Systems

a. New Construction

New 4-wire feeder risers shall be designed and constructed utilizing a bare copper conductor from pole-to-first structure. This bare copper will be the neutral current carrying conductor and shall be sized according to Table 2–9. For detailed construction standards on how to construct this design, refer to DUG, TP 209 and CR 140.

Exception: Bare copper conductor installation is **NOT** required from pole-to-first structure where the riser serves a single three-phase pad-mounted transformer.

b. Cable Replacement in Existing Feeder Riser

When replacing CLP (non-jacketed) with JCN (jacketed) cable and the existing bare copper conductor is adequate (see Table 2–9), continue to use the existing bare copper conductor as the neutral current carrying conductor.

When replacing CLP (non-jacketed) with JCN (jacketed) cable and the existing bare copper conductor is NOT adequate (see Table 2–9), concentric neutral can be used as an alternative. Refer to DUG, TP 209.

c. 3-Wire to 4-Wire Conversion
When converting 3-wire to 4-wire, the JCN cable concentric neutrals can be used instead of the bare copper ground as the neutral current carrying conductor. If trenching is required for reasons other than adding the bare copper conductor, then DUG, CR 140 should still be used. If trenching is *not* required for reasons other than adding or replacing the bare copper conductor, then design and construct the pole as shown in DUG,TP 209.

Table 2–9: Bare Copper Neutral Sizing

Conductor Size	Bare Copper Neutral Size
1/0	#2
350 and Larger	4/0

SOUTHERN CALIFORNIA EDISON
TRANSMISSION AND DISTRIBUTION

Chapter DDS–3: Commercial and Industrial Subsystems

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DDS—3
Commercial and Industrial Subsystems

1.0 Scope

This standard provides the design criteria for designing commercial/industrial (C/I) underground distribution facilities. This includes demand estimating, service points, transformer selection, cable selection, substructure selection, feeder interface, and subsystem design. A flowchart outlining the design process is included as Appendix 3–1 (Page 3–31).

2.0 Key Definitions

Chapter DDS–GL contains a glossary that includes the definition of key terms. A review of the glossary will assist in understanding the discussion in this standard.

3.0 Design Concept

The C/I subsystems are generally designed using 1/0 Cross-Link Polyethylene (CLP) cable Jacketed Concentric Neutral (JCN), 200 A components, and pad-mounted equipment as radials off the feeder forming loadblocks of approximately 1,500 kVA of transformation. Subsystems may be served from a switch position or T-tapped off the System Feeder between switch positions.

A Future System Feeder uses 600 A components and switches without a paralleling point. It consists of 600 A cable between two switches and has the potential to expand. Eventually, these systems may expand and make a paralleling point to create a System Feeder. Therefore, the conduit and structures are to be designed as a System Feeder.

On Future System Feeders, T-taps are not allowed. This will prevent outages impacting multiple loadblocks. The only allowable exception is automation transformers may be T-tapped off the Future System Feeder switch position. Planners must work with Field Engineering to make appropriate provisions for capacitors as needed. When Future System Feeders exceed 4,500 kVA, Field Engineering must be notified to determine if a System Feeder needs to be created.

A Dead-End Feeder is a section of cable that originates from a switched position on the System Feeder and extends to another switch with no intent to create a paralleling point. The combined total of all the loadblocks on the Dead-End Feeder will not exceed 4,500 kVA without consulting Field Engineering. On Dead-End Feeders, T-taps are not allowed. This will prevent outages impacting multiple loadblocks.

The Dead-End Feeder is intended for situations that are typically a few large commercial/industrial loads on a cul-de-sac. Consideration must be taken of this load as it increases since this limits the ability to switch load between circuits. Planners must work with Field Engineering to make appropriate provisions for capacitors as needed.

Refer to DDS-3, Figure 3–4 for further details.

Facility sizing shall comply with the following loading criteria:

Item	Loading Criteria
Substructures	Anticipated need for ten years
Primary Cable	Anticipated peak loading in five years (according to Chapter DDS–9)
Transformers	Expected demand
Secondary and Service Cable	Expected ampacity, including voltage and flicker standards

4.0 Prerequisite Information

The following information must be incorporated into designing a C/I subsystem:

1. CPUC Tariff Rules 15, 16, 20B, and 20C
2. SCE Construction Standards
3. *Electrical Service Requirements* (ESR)
4. *Distribution System EMF Guide*
5. Knowledge of the existing distribution system in the area, including the following:
   A. Nearest primary circuits
   B. Distance from substation
   C. Possible feeder interface points, overhead (OH) or underground (UG)
   D. Existing substructures in the area
   E. Loading on existing feeders or subsystems
   F. Master plans for circuits in the area
6. Information from the customer/developer for new load to be served, including:
   A. Plot plan showing buildings, parking areas, driveways, landscape areas, and so forth
   B. Connected load schedule and main switch size
   C. Requested service voltage
   D. Building square footage
   E. Type of occupancy and type of operation
   F. Other plot plan data as required, for example, elevations, grading, sewer and storm drains, and so forth
   G. Motor size and motor-starting characteristics
   H. Unusual loads
   I. Occupancy plans for EMF reduction considerations

5.0 Design Criteria

5.1 Demand Estimating

To verify that an accurate estimate has been made, *use two of the three methods outlined below whenever possible and compare the results*. The three methods of demand estimating are listed below. They are listed in the order in which they should be applied.

The three methods of demand estimating are as follows:

1. Customer Load Schedule and Operational Need
2. Estimate Demand of Similar Customer
3. Estimate Demand per Square Foot

Note: When demand estimates are different, always use the highest calculated demand.

Method One, Customer Load Schedule and Operational Need, is the preferred method when the information is available. Methods Two and Three are based on historical demands, but the error for Method Three can be as much as 25 percent for an individual customer.

A. Method One: Estimate Demand Based on Customer Load Schedule and Operational Need

Obtain the electrical plans and panel schedules from the customer or electrical contractor. A written commitment should be obtained from the customer requesting the desired service voltage and indicating the connected load.

With industrial customers, it is particularly important to determine the types of operation, hours of operation, and how they plan to use their equipment. This information is essential to determine their estimated load factor.

B. Method Two: Estimate Demand Based on Historical Demand of Similar Customer

This method uses Customer Service System (CSS) in determining the measured maximum demands that can be used to calculate power factor and load factor for similar existing businesses. Often the customer, or their electrical engineer, can provide names of customers with similar operations and information on relative size (square footage) so that the service Planner can relate the billing information to the proposed customer's plans.

Appendix 3–3 provides an example of using this method to estimate the demand for a new restaurant using historical demand of a similar customer.

C. Method Three: Estimate Demand Based on Historical Demand per Square Foot

Table 3–1 provides typical historical demands in volt-amperes per square foot for different types of occupancies and climate zones. Also included are typical power factors and load factors for each type of occupancy. Use the values from Table 3–1 for the applicable type of occupancy and square footage to determine the estimated demand.

As mentioned above, there may be a bandwidth of variation between customers which may vary as much as 25 percent from the Table 3–1 values. This variation is primarily due to differences in operations.

Appendix 3–3 provides an example of using method three to estimate the historical demand per square foot.

Appendix 3–2 provides the description of the building types shown in Table 3–1.

Appendix 3–3 provides an example of using this method to estimate the demand and load factor for a new restaurant.

Table 3–1: Historical Demand per Square Foot by Type of Occupancy

Bldg. Type No.	Building Type (See Appendix 3–2 for Building Description)	All Climate Zones		CZ 1	CZ 3,5,7	CZ 9
		Percent Power Factor	Percent Monthly Load Factor	Avg. Peak Volt-Amps per Sq-Ft	Avg. Peak Volt-Amps per Sq-Ft	Avg. Peak Volt-Amps per Sq-Ft
1	Large Office Building (> 30 K ft^2)	85	44	4.6	5.4	5.5
2	Small Office Building (< 30 K ft^2)	86	34	14.2	14.5	14.5
3	Restaurants (< 3 K ft^2)	88	44	20.5	20.5	25.6
4	Restaurants (> 3 K ft^2)	87	49	13.2	14.5	17.9
5	Large Retail (> 30 K ft^2)	89	49	8.7	11.0	21.4
6	Small Retail (< 30 K ft^2)	90	37	8.6	10.0	12.3
7	Large Food Store (> 30 K ft^2)	89	79	10.0	10.0	13.7
8	Small Food Store (< 30 K ft^2)	88	58	13.8	13.9	15.6
9	Refrigerated Whse.	79	54	8.1	17.8	17.8
10	Non-refrigerated with A/C Whse	83	34	5.1	8.0	9.6
11	Large Electronic Retail (> 30 K ft^2)	91	59	9.4	9.4	12.2
12	Small Electronic Retail (< 30 K ft^2)	90	54	8.0	10.7	11.8
13	Nonrefrigerated, non A/C Whse.	85	28	0.7	0.7	0.7
14	Elementary and Secondary School	79	25	7.1	10.1	17.5
15	Colleges and Universities	84	35	20.4	21.6	24.3
16	Hospitals	85	55	4.8	6.7	14.5
17	Health Clinics	85	45	8.4	16.4	16.4
18	Hotels and Motels	86	45	4.7	4.8	9.3
19	Auto Repair Shops	81	28	6.5	9.4	11.5
20	Misc. Repair (TV, and so on)	80	30	7.3	7.3	14.3
21	Movie Theatres (indoor)	93	37	12.7	12.7	16.1
22	Bowling Alleys	83	48	9.1	9.1	9.1
23	U.S. Post Offices	82	47	5.7	6.7	8.4
24	Meat Packing	82	48	15.6	15.7	20.4
25	Fruit and Vegetable Processing	78	40	5.4	6.9	9.0
26	Bakery Products	74	48	10.0	10.0	13.0
27	Apparel Manufacturing	82	31	4.9	6.0	7.8
28	Furniture Manufacturing	77	33	4.7	8.4	10.9
29	Paper Production (containers, and so on)	75	46	5.7	7.5	9.8
30	Printing/Publishing	81	31	8.5	9.1	9.1
31	Plastic Products	85 (See Note 2)	46	16.8 (See Note 2)	16.8 (See Note 2)	21.8
32	Metal Fabrication	77	37	9.0	11.9	15.5
33	Telephone Communications Center	85 (See Note 2)	61	12.0 (See Note 2)	12.0 (See Note 2)	15.6
34	Churches (< 3 K ft^2)	88	34	3.7	4.4	6.7
35	Churches (> 3 K ft^2)	88	34	4.9	7.7	7.7
36	Gym (< 3 K ft^2)	85	49	4.6	6.3	6.3

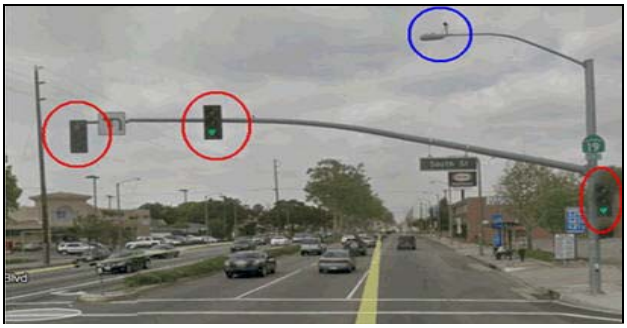
Table 3–1: Historical Demand per Square Foot by Type of Occupancy *(Continued)*

Bldg. Type No.	Building Type (See Appendix 3–2 for Building Description)	All Climate Zones		CZ 1	CZ 3,5,7	CZ 9
		Percent Power Factor	Percent Monthly Load Factor	Avg. Peak Volt-Amps per Sq-Ft	Avg. Peak Volt-Amps per Sq-Ft	Avg. Peak Volt-Amps per Sq-Ft
37	Gym (> 3 K ft^2)	85	49	4.3	5.3	5.3
38	Auto Manufacturing	78	42	5.6	8.0	8.0
39	Aircraft Manufacturing	78	44	7.4	9.8	9.8
40	Machine Shop w/Welding and CNC Equipment	80	39	2.3	3.4	3.4
41	Traffic Signals	72	83	(See Note 4)	(See Note 4)	(See Note 4)

Notes:

1. Power factor is the same in each climate zone for each building type.
2. Power factor estimated at 85 percent; kVA determined from actual kW divided by 0.85.
3. Load factor averaged from the three climate zone groups.
4. One Traffic Signal (LED) = 100 VA
   One Traffic Signal (Halogen) = 100 VA
   One Safety Light (LED) = 1,000 VA
   One Safety Light (Halogen) = 2,000 VA

Figure 3–1: Example Showing 3 Streetlights (Red Circles) and 1 Safety Light (Blue Circle)



In Figure 3-1, the total VA usage (assuming all Halogen lighting) is:

3 Traffic Signals: 3 x 100 VA = 300 VA
\+ 1 Safety Light: 1 x 2,000 VA = 2,000 VA
Total: 2,300 VA

Formula: $kVA = \frac{ft^2 \times VA/ft^2}{1{,}000}$

Volt-amperes is the apparent power (kVA) that is obtained by dividing the real power (kW) by the power factor expressed as a decimal, for example, 0.85.

Table 3–2 provides demand factors, *order of magnitude*, for various types of C/I loads. Use these demand factors with the customer's load schedule to determine the estimated demand.

Table 3–2: Demand Factors by Type of Load

Type of Load	Demand Factor
Lighting	90%
Air Conditioning	100% for one unit, **or** 80% for total of 2 to 5 units, **or** 70% for total of 6 or more units (Climate Zones 7 and 9 should consider all A/C at 100%)
Commercial Cooking	40%
Machine Tools	30% of the total amount for all motors, **or** 100% of the largest motor (whichever of these is greater)
Resistance Welders	60% to 120% per Rule 2-1
Arc Welders	100% of largest unit, plus 10% of balance
Induction/Resistance Heating	100% of largest unit, plus 50% of balance
Receptacles	10%

For customers installing the latest technology equipment for conservation of energy, consult the Engineering and Technical Services Group of the Marketing Division of the Transmission and Distribution (T&D).

5.2 Service Points

The location of the various points-of-service for a C/I development should be established to minimize the number of transformer locations required. Uniform application-of-service points will be established using the following criteria.

A. Single Enterprise

One or more buildings occupied by a single enterprise on a single premise will be provided one point-of-service at a location determined by Edison. However, additional points-of-service may be provided at a location determined by Edison for Edison's operating convenience, or where provided for in tariff schedules, or where required by law or local ordinance. Exceptional cases should be reviewed by management, with consideration given to circumstances such as size of additional load, customer's operation, and distance to new load as well as size and location of Edison facilities.

All facilities installed on the premise will be done under Rule 16. However, where it is known or anticipated that there will be future enterprises on the same or adjacent properties that will be served from the facilities installed, Rule 15 would apply.

B. Multiple Enterprises

One or more buildings in a commercial/industrial development occupied by multiple enterprises may, as determined by Edison, be given one point-of-service per building. Additional points-of-service per building, for single or groups of meters, may be provided for Edison's operating convenience, or where provided for in tariff schedules, or where required by law or local ordinance.

Regional shopping centers, malls, and other unusually large buildings are normally sufficiently large enough to make additional services necessary. They require special engineering considerations to determine the number of service points. Voltage drop, service type/voltage, and transformer utilization will be considered to establish service points consistent with good engineering practices.

All primary and secondary conductors and substructures common to two or more service points will be done under Rule 15. Then, Edison's supply-line facilities from the point where it leaves the Rule 15 distribution system to the service entrance of the customer shall be installed under Rule 16.

C. Service Voltages

The applicable service voltages shall be determined by Edison for any of the service points described above, taking into consideration the customer's load and use characteristics. All terminating enclosures for services for each of the types and voltage classes of load to be served shall normally be grouped at one location as determined by Edison.

D. Edison's Operating Convenience

The provision of additional points-of-service for Edison's operating convenience refers to the utilization of facilities or practices that contribute to the overall efficiency of Edison's operation. It does not refer to customer convenience, nor to the use of facilities or adoption of practices required to comply with applicable laws, ordinances, rules or regulations, or similar requirements of public authorities. See Rule No. 1 for definition of Utility's Operating Convenience.

Edison must be able to substantiate that, when SCE engineers a job based on its operating convenience, the installation is prudent, economical, and in the best interest of all ratepayers. Approval from the Operation and Engineering Manager is required when installing for Edison's Operating Convenience.

E. Added Facilities

For an applicant's convenience, a building may be provided additional points-of-service or transformation for the same voltage, at the applicant's expense where it does not conflict with laws or local ordinance. Additional service points will not be provided for purposes of permitting a customer to circumvent the mandatory applicability requirement based on load of a rate schedule (that is, TOU 8).

1. The added facilities base shall be the difference between a standard system designed by Edison and the requested system to be installed for the applicant's convenience.
2. All added facilities' costs for additional points-of-service will be provided in accordance with Rule 2, Section H, 2.d., on a one-time charge basis.

F. EMF Considerations

Note: Chapter DDS–11 and the "*EMF Design Guidelines for New Electrical Facilities: Transmission, Substation, Distribution*" explain the policy of the Company regarding EMF and outlines measures for minimizing EMF exposure.

5.3 Transformer Selection

A. Transformer Types

Pad-mounted transformer located on the customer's premise is the standard design for serving new loads. The customer will be required to furnish satisfactory rights-of-way for such purposes, and will provide the required physical space for aboveground transformer installation. The required physical space includes the necessary room for structures, perimeter walls or barriers and maintaining the required working clearances around pad-mounted equipment as shown in the *UGS Manual*.

Requirements for transformers on customer's premises are detailed in ESR 3, Section 7.0 and ESR-4. Transformers previously installed in subsurface enclosures and building roofs on customer's premises will be maintained; however, these types of transformer installations are no longer approved for new installations.

Rule 20 conversion and other rebuild projects shall also be designed with pad-mounted transformers on private property.

Use of BURD transformers is no longer allowed except in the following situations:

- Installations where it is not technically feasible to install pad-mounted equipment. Refer to DDS-6, Section 1.1, for definition of technically feasible;
- Installations in the public property and public rights-of-way where the local governments create insurmountable obstacles for pad-mounted equipment; or,
- When replacing existing failed BURD transformers.

If single-phase, fused, BURD transformers are required for the installation, they shall not be used for closed delta service. When it is necessary to build a closed delta bank in a submersible structure, nonfused transformers must be used with a separate fuse device. Fused BURD transformers may be used in open delta banks for serving 120/240 V, three-phase, four-wire loads.

B. Transformer Sizing

Transformer capacity shall be determined based on the sum of all loads to be served. Generally, no diversity should be expected among individual customers in commercial and industrial areas.

The transformer selected shall be the smallest that will handle the expected load within the allowable load limits. Pad-mounted and overhead transformers may be operated at loads above their nameplate rating as shown in Table 3–3.

Table 3–3: Load Limits of Commercial/Industrial Transformers

Customer Load Factor (%)	Transformer Load Limit (% of Transformer Rating)
0 — 64	130
65 — 74	125
75 — 100	120

Existing Customers:

Use the following equation and Table 3–3 above to determine transformer sizing.

Note: A customer's load factor can be determined using Table 3–1 or by calculation as shown below.

$$\text{Customer Load factor} = \frac{\text{Billing Period kWh usage} \times 100}{\text{kW demand} \times \text{billing period days} \times 24 \text{ hours}}$$

New Customer:

Get monthly load factor from Table 3–1 and estimated kW demand calculated in Section 5.1 and use both values and Table 3–3 to determine transformer sizing.

Three-phase, pad-mounted transformers are available in the following sizes:

Transformer Voltage	Transformer Size (kVA)
120/208 V and 277/480 V	75
	150
	300
	500
	750
	1,000
277/480 V	1,500
	2,500
	3,750

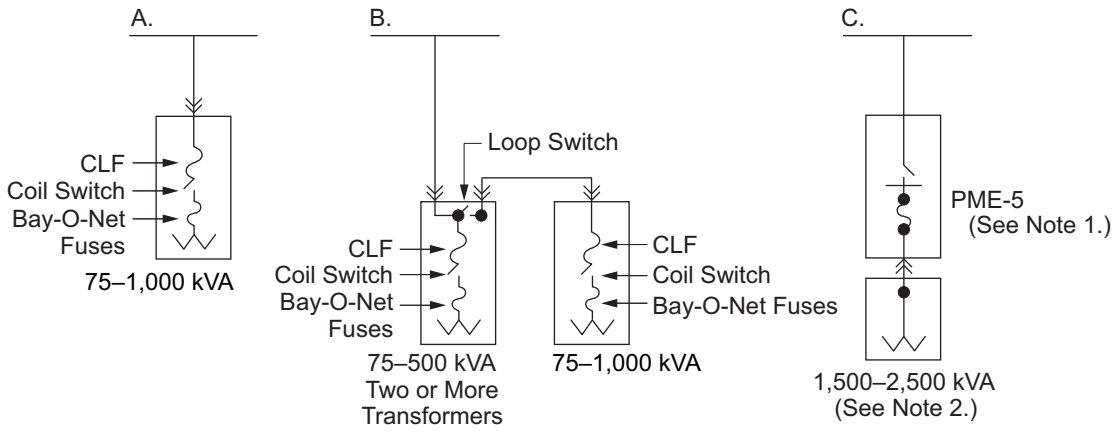
C. Transformer Source and Fusing Requirements

Note: Refer to the *Distribution Underground Construction Standards (DUG) Manual*, Section PD 337 for a detailed description of Pad-Mounted, Elbow-Connected (PME) switches and fuse choices and DUG, Section PD 318 for a description and details of Vacuum Fault Interrupter (VFI) equipment.

1. Three-phase, pad-mounted transformers sizes 75 kVA through 1,000 kVA are equipped with load-break "A" (coil) switches, Bay-O-Net-type fuses, and internal (nonfield replaceable), current-limiting fuses (CLF). These are dead-front design with universal high-voltage bushing wells and are to be used with load-break elbows. Transformer sizes 75 kVA through 500 kVA may be ordered with a "B" (loop) switch for looping through each unit in a multi-transformer installation. See Figure 3–2 and Figure 3–3 for examples of subsystems.
2. Three-phase transformer sizes 1,500 kVA through 3,750 kVA will be equipped for dead-front cable connections. The 1,500 kVA and 2,500 kVA units will come with 200 A bushing wells, and the 3,750 kVA units will come with 600 A bushings for 12 kV applications and 200 A bushings for 16 kV applications.
3. When 12 kV or 16 kV, three-phase, pad-mounted transformer sizes 1,500 kVA through 2,500 kVA are connected from an underground source, a PME-5 with either SMU-20 or SM-type power fuses shall be used. The three-phase switch position in the PME shall be used to de-energize the fuse positions before closing the associated load-break elbows. See Figure 3–2.

4. When 12 kV or 16 kV, three-phase, pad-mounted transformer sizes 1,500 kVA through 2,500 kVA are connected from an overhead source, fusing shall be provided on the riser pole when possible. If a ferroresonant condition exists, an Omni-Rupter® switch shall be used in combination with the overhead fusing. In applications where an Omni-Rupter® switch cannot be installed, a PME-5 with power fuses can be used instead of the Omni-Rupter®/overhead fuse combination. A three-phase switch position in the PME shall be used to de-energize the fuse positions before closing the associated load-break elbows. See Figure 3–3.
5. Consult Field Engineering for fusing/protection for transformer 1500 kVA and larger. Providing fusing tables for transformers 1500 kVA and larger is not feasible. Fusing large transformers depends on the specific installation, system characteristics, and customer switchgear. For this reason, fuse size selection for large transformers is done on a case-by-case basis.
6. Vacuum Fault Interrupters (VFI) are used to protect 12 kV transformers above 2,500 kVA, 16 kV transformers above 3,750 kVA, and most 33 kV pad-mounted transformers (Figure 3–4). Contact Field Engineering for design configuration and the proper coordination of fault interrupter curves in the VFI equipment or fuse curves in the PME equipment.

Figure 3–2: Feeding an Underground System — Underground Source

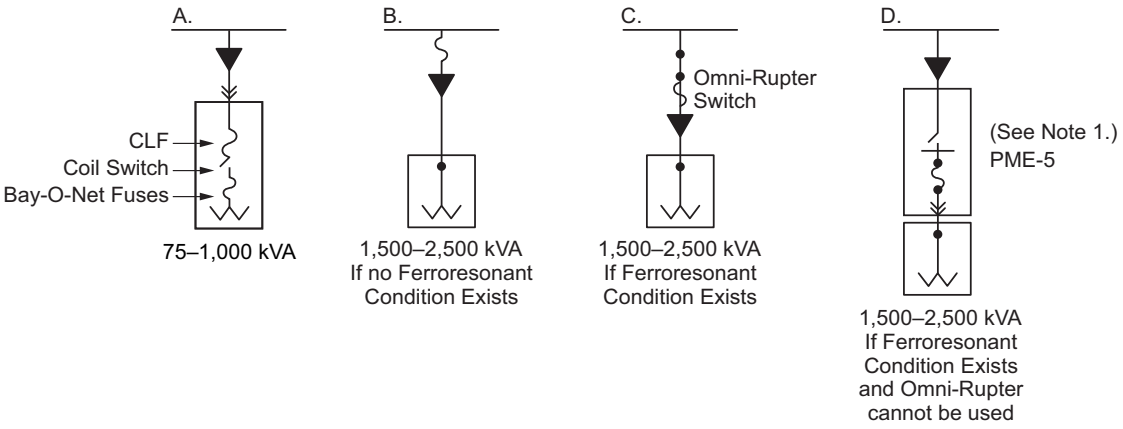


Notes:

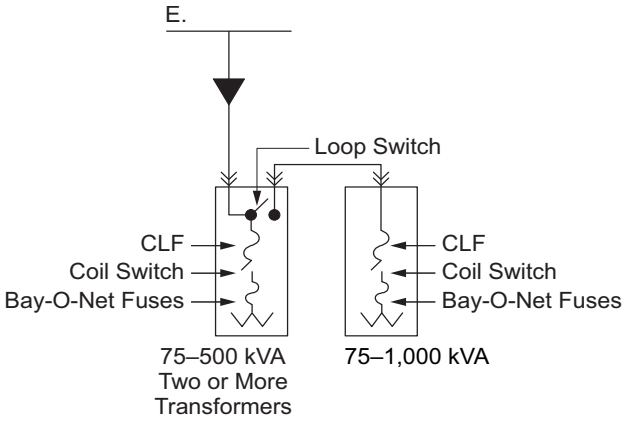
1. A PME-5 can be used when one transformer is feeding a single customer.
2. Two transformers can be served from one fused position. However, consider 1,500 kVA load-block criteria.
3. For 1,500 kVA and 2,500 kVA transformers, contact Field Engineering to determine fuse size.
4. For Bay-O-Net fuse selection, refer to the *Distribution Operations and Maintenance Policy and Procedures (DOM) Manual*, TR-2.

Figure 3–3: Feeding an Underground System — Overhead Source

One Pad-mounted Transformer



Two or More Pad-Mounted Transformers (75–500 kVA)

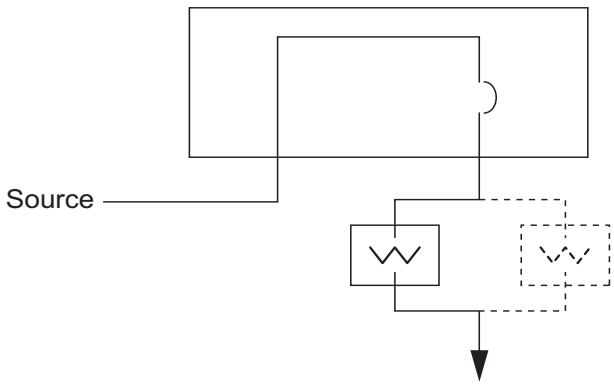


Notes:

1. A PME-5 can be used when one transformer is feeding a single customer.
2. 12 kV or 16 kV, loop-fed transformers shall be connected with load-break elbows and bushing inserts.
3. Refer to *Distribution Operation and Maintenance Policy and Procedures (DOM) Manual*, Section CC-5, for operation of load-break elbows.

Figure 3–4: Protecting Large Power Transformers

A. VFI-4



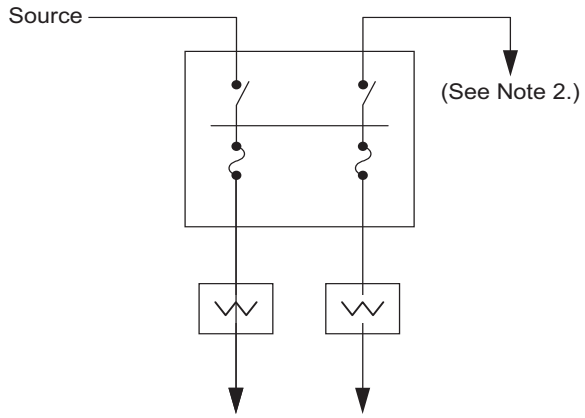
Source	MAX Transformer (kVA)
12 kV and 16 kV (See Note 1, Note 2, and Note 3.)	7,500
33 kV (See Note 3.)	20,000

Notes:

1. For 2,500 kVA and 3,750 kVA units having a 12 kV or 16 kV source, include structure space for a pad-mounted capacitor bank (if needed for VAR requirements of source substation/circuit). If no nearby idle switch position is available for the capacitor bank, use a PME-9/VFI-9 instead of a PME-4/VFI-4.
2. Two, 2,500 kVA or 3,750 kVA units operated in parallel can be fed from a single switchgear.
3. Capacitor planning not considered for 33 kV source.

Figure 3–4: Protecting Large Power Transformers *(Continued)*

B. PME-9 SML (See Note 1.)



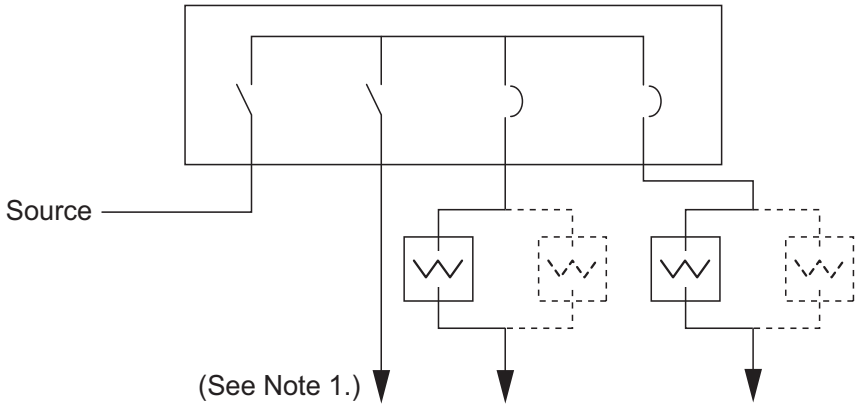
Source	MAX Transformer (kVA) per Fused Position
12 kV (See Note 3)	2,500
16 kV (See Note 3)	3,750

Notes:

1. A PME-9 can be used when multiple transformers are serving one customer. The entire switch can be de-energized when required.
2. Reserved for future capacitor bank.
3. Include structure space for a pad-mounted capacitor bank (if needed for VAR requirements of source substation/circuit) and use idle position of VFI-9 or PME-9.

Figure 3–4: Protecting Large Power Transformers *(Continued)*

C. VFI-9



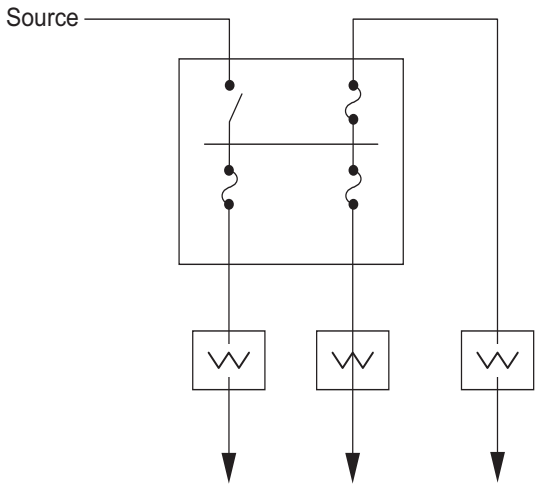
Source	MAX Transformer (kVA) per Source
12 kV	7,500
16 kV	10,000
33 kV (See Note 2)	20,000

Notes:

1. Reserved for future capacitor bank.
2. Capacitor planning not considered for 33 kV source.

Figure 3–4: Protecting Large Power Transformers *(Continued)*

D. PME-12 SML (See Note 1)



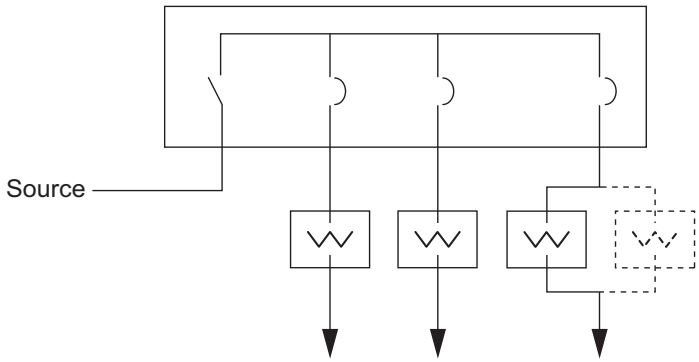
Source	MAX Transformer (kVA) per Fused Position
12 kV (See Note 2)	2,500
16 kV (See Note 2)	3,750

Notes:

1. A PME-12 can be used when multiple transformers are serving one customer. The entire switch can be de-energized when required.
2. Include structure space for a pad-mounted capacitor bank, if required. Install additional switch, as required, to accommodate capacitor bank.

Figure 3–4: Protecting Large Power Transformers *(Continued)*

E. VFI-12



Source	MAX Transformer (kVA) per Source
12 kV	7,500
16 kV	10,000
33 kV	20,000

Note: Include structure space for a pad-mounted capacitor bank, if required. Install additional switch, as required, to accommodate capacitor bank.

D. EMF Considerations

Chapter DDS–11 and the "*EMF Design Guidelines for New Electrical Facilities: Transmission, Substation, Distribution*" explain the policy of the Company regarding EMF and outlines measures for minimizing EMF exposure.

5.4 Cable Selection

A. Primary Cable

Primary cables for a C/I subsystem radial shall be 1/0 JCN in a conventional duct system. Primary cable shall be sized in accordance with Table 9–1. As a consideration of high-fault duty within one-half mile of a substation, 1/0 JCN will be the minimum size cable installed.

B. Secondary or Service Cable

Secondary or service cables shall be 600 V Al CLP sizes 1/0, 4/0, 350 kcmil, and 700 kcmil. The cable shall be installed in a conventional duct system or in a cable trench. The cable shall be selected and installed to meet expected demand in accordance with Chapter DDS–9, Table 9–4 and Table 9–5.

C. Voltage Drop

Voltage drops through secondaries and services to the new service point shall not exceed three percent. Chapter DDS–8 contains the constants, formulas, and examples necessary to calculate voltage drop.

D. Voltage Flicker

Flicker may be a concern when customers have large air-conditioning equipment, motors (over 100 hp), arc welders, arc furnaces, or other types of equipment with high-starting currents. Consult Field Engineering to evaluate service to these customers.

E. Cable Splicing

Various cable splicing methods may be used depending on space and operating requirements. Chapter DDS–9 shall be used when designing splicing methods.

5.5 Substructure Selection

Substructures should be installed to accommodate anticipated growth and system needs for the next ten years.

A. Equipment Structure Location

1. Equipment structures should be located so that vehicle access adjacent to structures will be provided for initial construction and future operation and maintenance needs.
2. Structures for pad-mounted transformers shall be located a minimum distance from building or other structures in accordance with Appendix 3–4.
3. Pad-mounted equipment must be protected from vehicular traffic. Usually, designated landscape areas or parking lot islands provide protected and accessible structure locations.
4. When locating pad-mounted equipment, care must be taken to avoid placing equipment where it might create a safety hazard by obstructing the vision of vehicular traffic.

5. Whenever possible, place pad-mounted structures and equipment away from areas with frequent irrigation to help prevent future corrosion.

   Install NEW stainless steel pad-mounted equipment only if every effort has been made to locate the pad-mount away from high-corrosion areas and the pad-mount is expected to be changed out within 15 years due to corrosion. Contact Field Engineering for approval.

   Existing mild steel pad-mounted equipment may be upgraded to stainless steel if the existing equipment has failed due to corrosion within 15 years of installation. Contact Field Engineering for approval.

   Note: All pad-mounted transformers purchased after 2004 are designed with stainless steel bottoms.

B. Transformer Structure Requirements

1. Transformers should be located so as to minimize the length of service runs to all appropriate service points.
2. Transformer structures shall be sized in accordance with Chapter DDS-6, Table 6–12. Determine the structure size using the maximum size transformer that might be expected considering the installed switchboard capacity.

C. Duct and Conduit Requirements

1. Normally, only one, five-inch duct will be provided for the primary cable to a radial C/I subsystem.
2. A minimum of two, five-inch ducts will be required for all primary feeder systems. Within the C/I loadblock primary systems, may be fed using a single five-inch conduit.
3. For lot sales or speculative C/I developments, one, four-inch primary duct will normally be provided to every other property line.
4. The equivalent straight pull footage of each primary conduit run should not exceed the maximum allowable straight pull footage for the cable being used as shown in Chapter DDS–9, Section 5.0.
5. Service conduits will normally be four-inch and will be installed to accommodate the expected main switch or pull section capacity in accordance with Table 6–6.
6. Use five-inch conduit when pulling 700 CLP further than 100-feet straight length equivalent.
7. For commercial and industrial installations (including speculative buildings), size all conduits and structures to the main switch or pull section capacity. However, if the main switch or pull section capacity used for strip or retail commercial building(s) exceeds the normally expected ultimate peak demand by 200 percent, the number of ducts from the transformer and the structure size may be reduced. The main switch or pull section capacity will be considered excessive when it is equal to or greater than 200 percent of the calculated demand using one of the three methods for determining demand as shown in the Section 5.0 Design Criteria (Page 3–5).

8. The number of bends along the service conduit route should be kept to a minimum to facilitate pulling of cable and to minimize the need for pulling structures. A 90 degree bend located within five feet of the opening where the cable is fed may be ignored for applying the following criteria:

   a. Service conduit runs up to 250 feet in length are acceptable if they contain no more than two, 90 degree bends.

   b. Service conduit runs up to 500 feet are acceptable with one, 90 degree bend.

   c. A cable dolly or a pulling truck may be used to pull cable at each end.

   d. Use 12.5-foot radius sweeps when pulling 700 CLP cable in excess of 100-feet straight length. The bend(s) into the bottom of the pull section may be five-foot radius bends. See Chapter DDS-6, Table 6–5 for details.

   Where the number of bends or length of conduit run exceeds this criteria, the equivalent pulling length should be calculated per Chapter DDS–9, Section 5.0 and compared to the maximum allowable. If the maximum allowable is exceeded, an intermediate pull box will be required.

D. Capacitor Structure Requirements

Structure space requirements for future pad-mounted capacitor banks should be reviewed with Field Engineering when:

1. An individual customer will require 2,500 kVA or more of installed transformer capacity; or

2. Development in an area will cause total installed transformer capacity to reach or exceed 2,500 kVA.

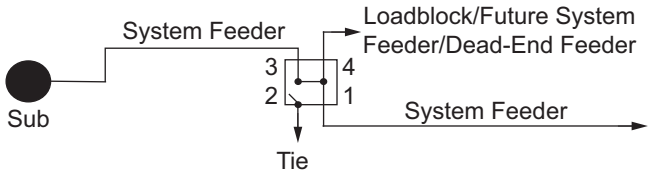
   See Chapter DDS–2, Section 5.10, for a discussion on capacitor planning.

5.6 Feeder Interface

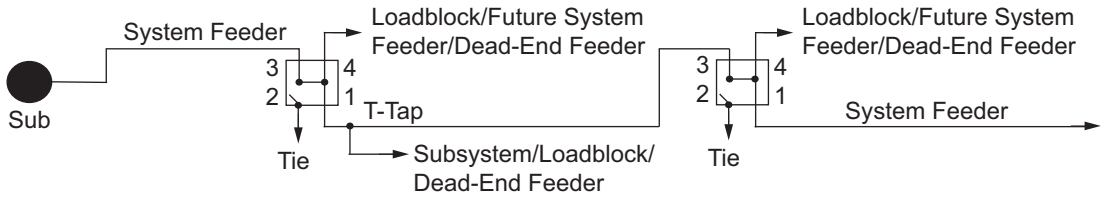
The number of C/I subsystem connections to the feeder should be kept to a minimum. Generally, groups of transformers should be connected as radial subsystems forming loadblocks served from switch positions or T-tapped off the feeder between switch positions. Figure 3–5 provides examples.

Figure 3–5: System Feeder Interface Design

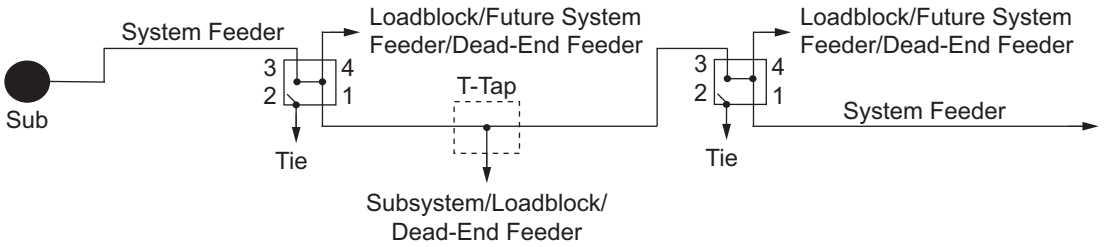
A. Feeder System Position



B. T-Tap off System Feeder between Switch Positions in same Structure as Switch



C. T-Tap off the System Feeder between Switch Positions in a Separate Structure if the T-Tap Structure: 1) Is Required for Pulling; and, 2) Already Exists



D. T-Tap may be Installed between Switch Positions at Two Locations Provided One of the Two is Tapped off A Switch Position in the Switch Enclosure

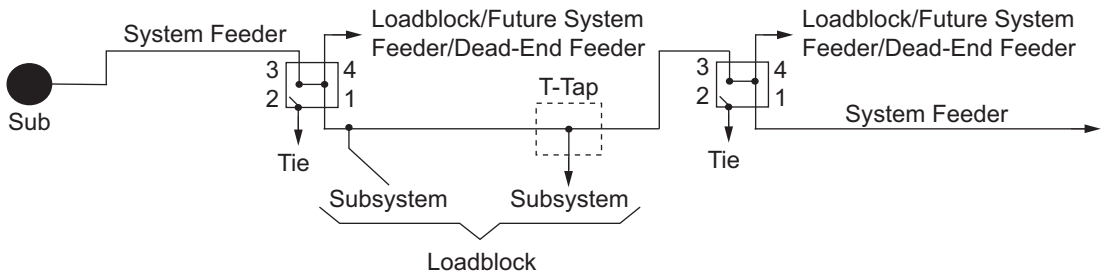


Figure 3–5: System Feeder Interface Design *(Continued)*

E. System Feeder or Dead-End Feeder Systems

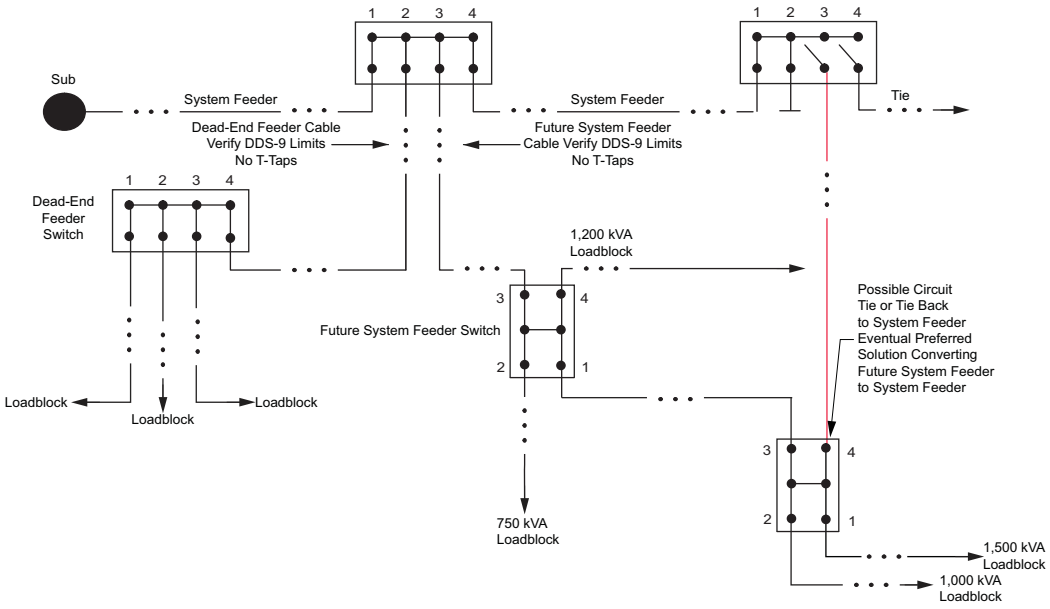


Figure 3–5: System Feeder Interface Design *(Continued)*

F. BURD Switches are for example only and cannot be installed or replaced without Field Engineering approval. BURD switches cannot be looped back to the mainline due to cable and switch ampacity limitations. Fused BURD switches shall never be installed between two sources to create a boxed loop. Fused BURD switches contained a single switch that isolates ONLY the line side of the switch. In the event that this BURD switch is connected in a boxed loop, the fuses would be energized at full phase voltage from the second source instead of being completely de-energized. This situation is a potential "trap" to field personnel in the event of replacing the fuse(s).

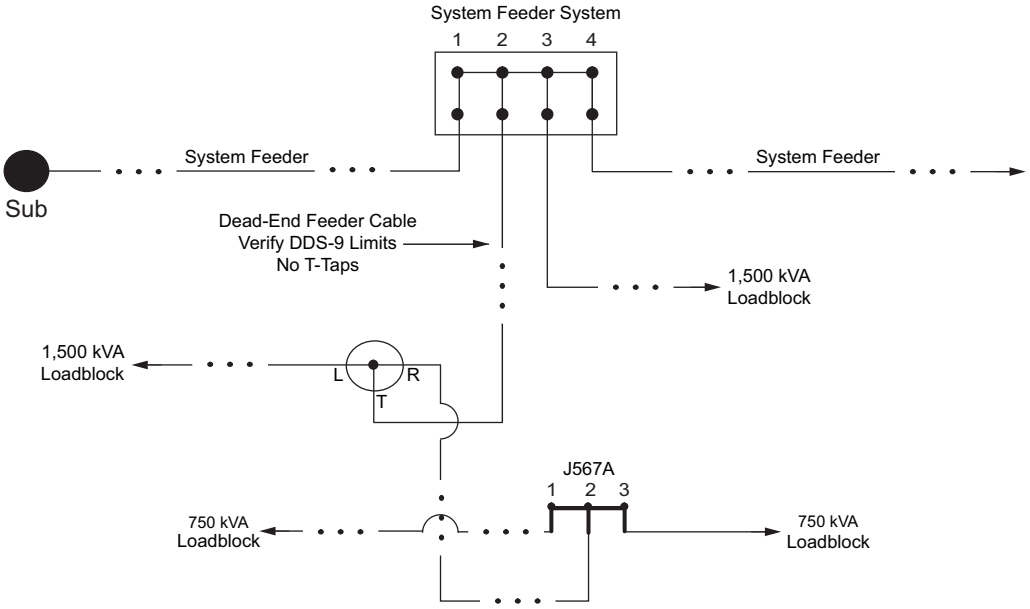
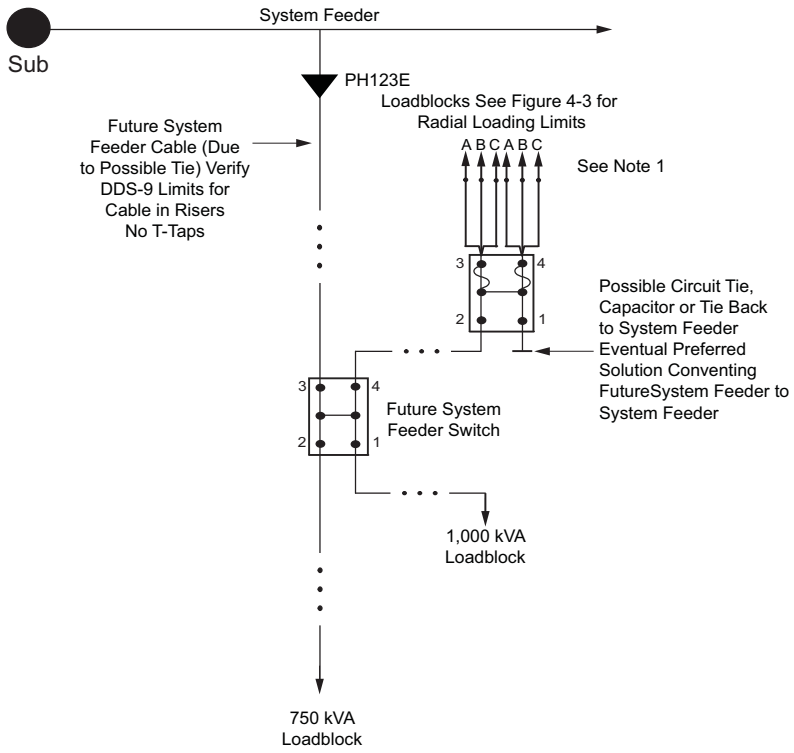


Figure 3–5: System Feeder Interface Design *(Continued)*

G. For single-phase to ground radials, loadbreak elbows can be used to isolate the subsystems. This is an exception to the loadblock rule of isolating from the feeder by opening a dedicated switch position.

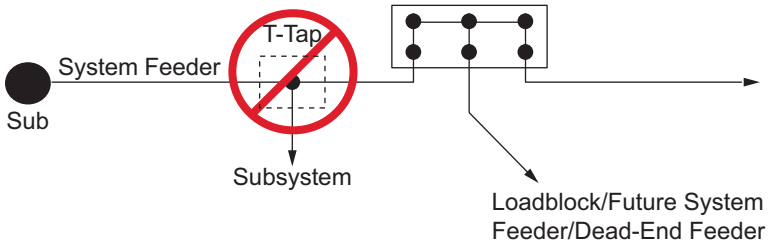


Note:

1.This is an exception to the loadblock rule of isolating from the System Feeder by opening a dedicated switch position. For single phase-to-ground radials, loadbreak elbows can be used to isolate the subsystems.

NOT ACCEPTABLE

H. Do not T-Tap off Feeder between substation and first switch or on the correlating first switch position.



5.7 Loadblocks

Each multiple-transformer loadblock shall be designed to contain approximately 1,500 kVA of transformation.

It is intended that each loadblock will contain 1,500 kVA of fully-loaded transformation. Based on recommended loading criteria, each transformer could be loaded to 120 percent or 130 percent of nameplate, and therefore a C/I loadblock can consist of a total of more than 1,500 kVA of actual peak load.

Planners shall consult Field Engineering when transformation exceeds 1500 kVA and when transformers are being upgraded due to loading. If the growth requires system upgrades, the Planner and Distribution Engineer shall identify options to split the load into smaller loadblocks.

System wide, C/I pad-mounted transformers are loaded to an average of less than 70 percent of nameplate. When adding to a system where under-loaded transformers exist, loadblocks may be designed with more than 1,500 kVA of transformation. Planners must take into consideration the potential load growth and design a system that provides the greatest degree of flexibility for future expansion.

Individual three-phase transformer installations of 1,500 kVA or larger will normally be considered as complete loadblocks and will interface directly with the feeder. Single customers with multiple transformers are the exception and may exceed 1500 kVA of transformation.

5.8 Subsystem Design

The following items use the design criteria outlined above to select and incorporate transformers, cable, and substructures into recommended subsystem designs.

A. Pad-mounted transformers located on the customer's premises is the standard installation for serving C/I customers. Transformers installed on available overhead poles, with overhead-to-underground service, are to be designed when economical.

B. Subsystems will be designed to form loadblocks of approximately 1,500 kVA of transformation. The use of Bay-O-Net-fused transformers will reduce the need for external switches.

C. Subsystems are fed from a switch position or a T-tap between switch positions. A T-tap shall not be made between the substation and the first switch. Figure 3–5 provides examples of this design.

D. Subsystems will be fed by Dead-End Feeder/Future System Feeder out of the System Feeder. Looped subsystems are deviations that must be approved by the Design Manager or Planning Supervisor.

E. Radial subsystems with multiple transformers may be designed with two-circuit transformers or with 200 A junctions and one-circuit transformers. The economic and operating considerations of each specific job should determine the design to be used. Figure 3–6 provides examples of these designs.

F. All new 12 kV and 16 kV, three-phase, dead-front, radial transformers (75–1,000 kVA) and loop-fed transformers (75–500 kVA) shall be connected using load-break elbows and bushing inserts.

G. Subsystems will be designed to provide the system of least cost, consistent with the appropriate application of Rules 15 and 16.

H. Subsystems fed from an overhead source must be designed considering potentially ferroresonant conditions, in accordance with Section PD 100 of the *Distribution Underground Construction Standards (DUG) Manual*. Figure 3–2 provides examples of design.

I. Design of subsystems should include capacitor-planning requirements as described in Chapter DDS–2, Section 5.10.

J. Class 200 A (15 kV and 25 kV) load-break elbows (LBEs) shall be installed in all new installations. Existing 200 A dead-break elbow (DBE) installations should be retrofitted to LBEs during apparatus replacement due to failure, end of life, or upgrade of equipment.

1. Applications

   Load-break Elbows:

   - Load-break junctions may be installed on the 12 kV and 16 kV systems for splice locations requiring an operational capability (Chapter DDS–9, Section 6.0) only if point of application is within the design rating of the load-break components (possible fault-duty magnitude and duration is equivalent to a fault of 10,000 A for 10-cycle duration). This can be accomplished by the following:

     1. Installing downstream of current-limiting fusing or
     2. Installing downstream of power-fusing and it has been determined by Field Engineering that the point of application will remain under 10,000 A

   - New 12 kV and 16 kV, three-phase, fused, pad-mounted transformers are equipped for LBE usage.
   - The load side of the fuse compartments of PME-CL and PME-SML are equipped for LBE cable connections.

2. Conditions

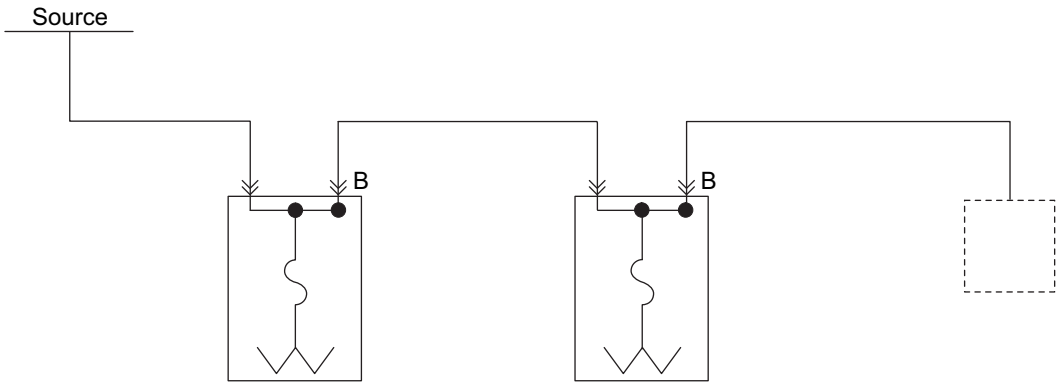
   All LBE installations are restricted by the following conditions:

   - Must have ferroresonance signs installed if there is the potential for a ferroresonant condition.
   - The 15 kV Class LBEs are to be used only on 12 kV systems; only 25 kV Class LBEs shall be used on 16 kV systems.
   - Do not operate LBEs to energize or de-energize capacitor banks.

   The above conditions must be followed in the design and operations of all LBEs.

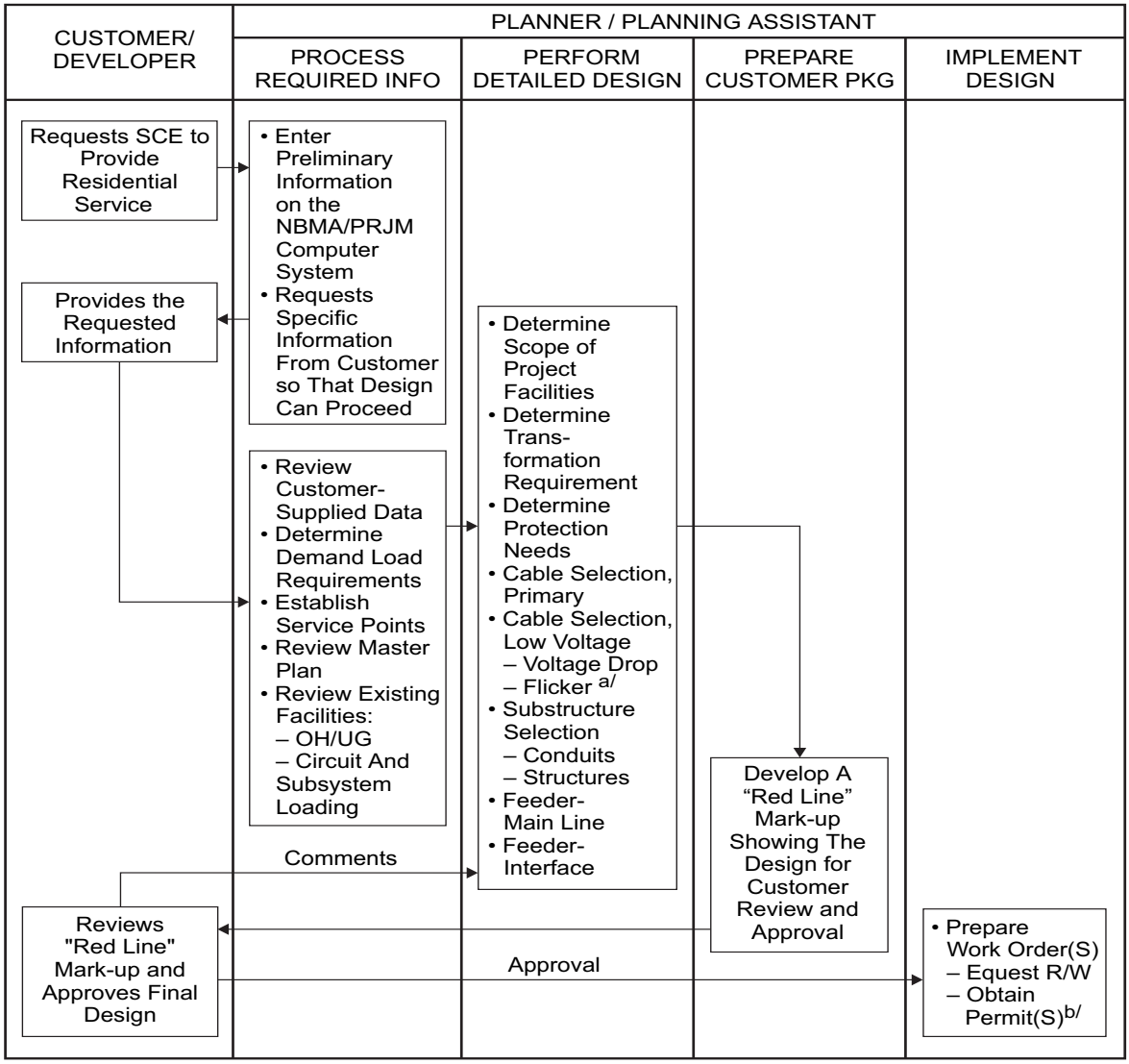
Figure 3–6: Radial Subsystem Design Using Multiple Transformers

A. Two-Circuit Transformers except Last Transformer One Circuit



Note: The decision to use design "A" above should be based on the economic and operating considerations of each specific job. See Chapter DDS–9, Section 6.0.

Appendix 3–1: Commercial/Industrial Design Flowchart



a/ Flicker is only evaluated when dealing with special demand requirements. Contact Field Engineering for assistance.

b/ SCE should only apply for excavation permits when facilities are to be constructed by SCE-approved contractors working directly for SCE.

Appendix 3–2: Building-Type Descriptions *(Sheet 1 of 3)*

A sample of 25,863 service accounts was used to develop this table. Each extracted record was classified according to the TDBU building type occupancy, matched to available InfoUSA data, assigned a square footage range where possible, and the maximum annual electrical demand (kW) recorded.

The following table lists the Standard Industrial Classification (SIC) grouping for each building type presented in Table 3–1. In general, this grouping is consistent with SCE's System Planning and Research and the California Energy Commission's aggregations of groups of SIC codes into building type.

BUILDING NO.	TYPE	BUILDING DESCRIPTION
	COMMERCIAL	
1	Large Office (> 30,000 ft^2)	Depository Institutions, Insurance Carriers/Agents, Real Estate, Business Services, Medical Clinics/Offices, Legal Services, Social Services, Business/ Labor/Political Organizations, Courts
2	Small Office (< 30,000 ft^2)	Same as above
3	Restaurant (< 3,000 ft^2)	McDonalds, Chipotle, Panda Express, and Subway
4	Restaurant (> 3,000 ft^2)	Claim Jumpers, Outback, Steak House, and Applebees
5	Large retail (> 30,000 ft^2)	Building Materials and Garden Supplies, Department Stores, Auto Dealers, Clothing Stores, Furniture/Appliance/Home Furnishing Stores, Miscellaneous Retail (Drug, Sporting Goods, Bicycle, Stationery, Gift)
6	Small Retail (< 30,000 ft^2)	Same as Above
7	Large Food Stores (> 30,000 ft^2)	Grocery, Dairy Products, Fruit and Vegetable, Meat and Fish, Retail Bakeries, Liquor Stores
8	Small Food Stores (< 30,000 ft^2)	Same as above, "7-11," "Stop-N-Go"

Appendix 3–2: Building-Type Descriptions *(Sheet 2 of 3)*

BUILDING NO.	TYPE	BUILDING DESCRIPTION
	COMMERCIAL	
9	Refrigerated Warehouse	Refrigerated Warehousing and Storage, Packaged Frozen Foods, Dairy Products, Poultry Products, Fish and Seafoods, Meats and Meat Products, Fresh Fruits and Vegetables
10	Nonrefrigerated with A/C Warehouse	Local Trucking with Storage, Public Warehousing and Storage, Wholesale Trade—Durable Goods (Motor Vehicles/Parts/Supplies, Tires, Furniture, Lumber, Hardware)
11	Large Electronic Retail (> 30,000 ft^2)	Electronic, Computer, Appliance
12	Small Electronic Retail (< 30,000 ft^2)	Electronic Computer, Appliance
13	Nonrefrigerated, Non-A/C Warehouse	Local Trucking with Storage, Public Warehousing and Storage, Wholesale Trade—Durable Goods (Motor Vehicles/Parts/Supplies, Tires, Furniture, Lumber, Hardware)
14	Elementary and Secondary Schools	Elementary and Secondary Schools, Day Care Services
15	Colleges and Universities	Colleges and Universities, Vocational Schools, Schools and Educational Services
16	Hospitals	Hospitals (Surgical/General/Psychiatric), Nursing and Personal Care Facilities
17	Health Clinics	Medical and Dental Laboratories, Outpatient Clinics
18	Hotels and Motels	Hotels and Motels
19	Auto Repair Shops	Auto Body, Glass, Exhaust, Paint, Tire, Transmission, and Repair Services
20	Miscellaneous Repair	Electrical Appliance Repair (Radio, Television, Refrigerator), Reupholstery, Watch and Clock
21	Movie Theaters	Indoor Movie Theaters
22	Bowling Alleys	Bowling Alleys
23	U.S. Post Offices	U.S. Postal Service
24	Meat Packing	Meat Packing Plants, Sausages and Other Prepared Meats, Poultry Slaughtering and Processing
25	Fruit and Vegetable Processing	Preserved, Canned, Dehydrated, Pickles, Sauces, Salad Dressings, Frozen

Appendix 3–2: Building-Type Descriptions *(Sheet 3 of 3)*

BUILDING NO.	TYPE	BUILDING DESCRIPTION
	INDUSTRIAL	
26	Bakery Products	Bread, Cake, Cookies, Frozen Bakery Products (except Bread)
27	Apparel Manufacturing	Clothes, Hats, Belts, Fur, Leather, Curtains
28	Furniture Manufacturing	Wood and Metal Household and Office Furniture, Mattresses and Bedsprings, Wood TV Cabinets
29	Paper Products	Containers, Boxes, Cans, Drums, Bags, Stationery
30	Printing/Publishing	Newspapers, Periodicals, Books, Greeting Cards, Typesetting
31	Plastic Products	Plastic Films and Sheets, Laminated, Profile Shapes, Pipe, Bottles, Foam, Plumbing Fixtures
32	Metal Fabrication	Cans, Shipping Containers, Barrels, Hardware, Doors, Sheet Metal, Screws, Bolts, Nuts, Washers, Stampings, Forgings, Springs
33	Telephone Communications Center	Telephone Communications and Switching Center

Appendix 3–3: Demand Estimating Examples *(Sheet 1 of 4)*

The following example illustrates the three different methods of demand estimating on the same new ©Sizzler Restaurant to be built in Climate Zone 5.

EXAMPLE 1:

Estimating Demand using Customer Load Schedule and Operational Needs

Method 1:

The following provides an example of estimating the demand for the new ©Sizzler Restaurant using the information provided in Example 1 and the following load schedule.

Load Schedule:

Lighting 12.6 kW

Air conditioning 50 kW

Cooking 80 kW

Receptacles 12.6 kW

Spare 17 kW

Customer demand (kW) = Sum of connected load x demand factor (from Table 3–2) for each type of load

Lighting at 90% = .9 x 12.6 kW = 11.3 kW

Air conditioning at 100% = 1.0 x 50 kW = 50 kW

Cooking at 40% = .4 x 80 kW = 32 kW

Receptacles at 10% = .1 x 12.6 kW = 1.3 kW

Total customer demand = 94.6 kW

Spare or future load not considered

Customer demand (kVA:)

$$\frac{kW}{PF} = \frac{94.6\ kW}{0.87^{(a)}} = 108.7\ kVA$$

(a) Power Factor from Table 3–1, "Historical Demand per Square Foot by Type of Occupancy" (Restaurants > 3,000 ft^2)

EXAMPLE 2:

Estimating Demand using Historical Demand of a Similar Customer

Method 2:

The following provides an example of estimating the demand for the new ©Sizzler Restaurant using historical billing information for another ©Sizzler of comparable size in the same Climate Zone, using CSS to determine the peak kW demand for the previous 12 billing periods and the total kWh and number of days for the peak billing period.

Given Data:

kWh 40,380

kW 96.3

Days 31

Customer Demand (kVA):

$$\frac{kW}{PF} = \frac{96.3\ kW}{.87\ PF\ ^{(a)}} = 110.7\ kVA$$

To determine load factor use:

$$\text{Customer Load Factor} = \frac{\text{Billing Period kWh usage} \times 100}{\text{kW demand} \times \text{billing period days} \times 24}$$

Note: The kW demand should be the highest on record and the kWh should correspond to the same month.

$$\text{Load Factor} = \frac{40,380 \times 100}{96.3 \times 31 \times 24} = 56\%$$

(a) Power Factor from Table 3–1, "Historical Demand per Square Foot by Type of Occupancy" (Restaurants > 3,000 ft^2)

EXAMPLE 3:

Estimating Demand using Square Footage

Method Three

The following provides an example of estimating the demand and load factor for the new ©Sizzler Restaurant using historical average demand per square foot by type of occupancy and Climate Zone.

Given data:

800 A Main Switch Board

120/208 V, three-phase, four-wire

7,000 square feet

Climate Zone 5

Customer Demand (kVA)

$$\text{kVA Demand} = \frac{\text{ft}^2 \times (\text{VA}/\text{ft}^2)}{1{,}000} = \frac{7{,}000 \times 14.5^{(a)}}{1{,}000} = 101.5 \text{ kVA}$$

Load Factor = 49%([a])

(a) From Table 3–1, "Historical Demand per Square Foot by Type of Occupancy" (Restaurants > 3,000 ft^2), Climate Zone 5.

COMPARING RESULTS

The three demand-estimating methods in the examples above result in similar estimates, from a low of 101.5 kVA to a high of 110.7 kVA. All three would require a 150 kVA transformer since a 75 kVA transformer is limited to 97.5 kVA for load factors of 0 to 60 percent. If the two methods results in different size transformers, use the larger kVA transformer.

Appendix 3-4: Pad-Mounted Transformer Locations *(Sheet 1 of 2)*

Pad-mounted transformers located on customer's premise are the standard for serving C/I customers. Refer to Sub-section 5.3 A for details.

Pad-Mounted Transformers Installations Shall Conform to the Following:

A. Pad-mounted transformers shall not be located directly in front of doors, stairways, beneath windows that can be opened, or where they will obstruct the vision of vehicular traffic.

B. Pad-mounted transformers shall be located at least the minimum distance, as identified in the figure below, away from buildings or other structures to ensure adequate space for operating, to minimize vibration hums, and to meet fire safety requirements.

C. Whenever possible, place pad-mounted structures and equipment away from areas with frequent irrigation to help prevent future corrosion.

   Install NEW stainless steel pad-mounted equipment only if every effort has been made to locate the pad-mount away from high-corrosion areas and the pad-mount is expected to be changed out within 15 years due to corrosion. Contact Field Engineering for approval.

   Existing mild steel pad-mounted equipment may be upgraded to stainless steel if the existing equipment has failed due to corrosion within 15 years of installation. Contact Field Engineering for approval.

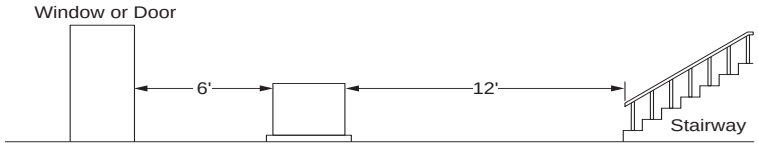
   Note: All pad-mounted transformers purchased after 2004 are designed with stainless steel bottoms.

D. A clear passageway of 12-feet minimum shall be available at all times, immediately adjacent to one side of the transformer to provide an accessible roadway for transformer maintenance. This passageway shall be designed to meet H-20 (20-ton) Construction.

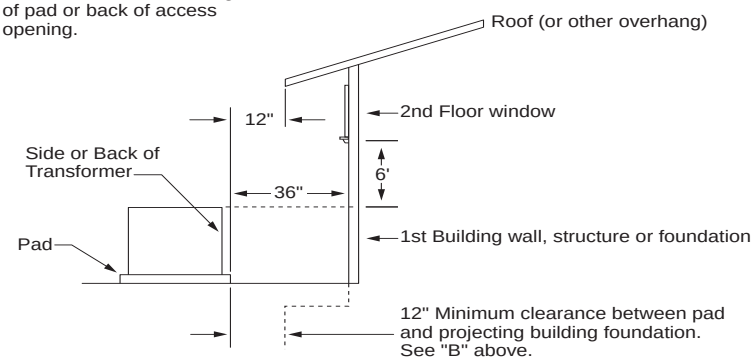
E. If SCE has installed or agrees to install, transformers at locations where SCE cannot use its standard transformer lifting equipment and special lifting facilities are required to install or remove the transformers on the customers premises, the customer shall, at their expense, (a) furnish, install, own, and maintain permanent lifting facilities and be responsible for lifting the transformer to and from its permanent position, or (b) provide (or pay for) portable lifting facilities acceptable to SCE for installing or removing the transformers. Rights-of-way and space provisions shall be provided by Applicant such that access and required clearances from adjacent structures can be maintained.

Appendix 3-4: Pad-Mounted Transformer Locations *(Sheet 2 of 2)*

F. Transformer structures will normally be installed only in nontraffic areas. Transformer protection is required when Company equipment is exposed to traffic. This protection may be in the form of barriers, barricades, or curb. A curb must have a minimum height of six inches and be at least six-inches thick and its front face located 60-inches minimum from the equipment foundation.



NOTE: An 8' minimum clearance is required on the door side of transformer for operation. The 8' clearance shall be measured from the edge of pad or back of access opening.



SOUTHERN CALIFORNIA EDISON
TRANSMISSION AND DISTRIBUTION

Chapter DDS–4: Residential Subsystems

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DDS—4
Residential Subsystems

1.0 Scope

This chapter provides the criteria for designing residential subsystem distribution facilities. This includes demand estimating, service points, transformer selection, cable selection, feeder interface, loadblock, and radial subsystem design.

2.0 Key Definitions

See Glossary, Chapter DDS–GL.

3.0 Design Concept

The preferred design for residential subsystems is 1/0 Jacketed Concentric Neutral (JCN) cable and pad-mounted equipment. Subsystems are to be current-limiting fused radials using pad-mounted fuse equipment and nonfused transformers with load-break elbows. Subsystems may be combined, in accordance with good balancing practices, to form loadblocks of approximately 1,500 kVA of transformation. See Section 5.6 (Page 4–21).

The SCE standard is conventional conduit for the primary voltage system, see Section 5.4, H (Page 4–17), for the required design criteria.

4.0 Prerequisite Information

A Service Planner must have the following specific knowledge and information to design a residential subsystem:

A. Planners should consider the City/County/Municipality's ultimate zoning master plan that includes main arterial roadways.

B. Master Duct Plan, Distribution Substation Plan (DSP), circuit loading, and circuit emergency operating plans (consult Field Engineering)

C. Site, grading, elevation, street improvement plans, as appropriate

D. Connected load schedules

E. Service voltage

F. Square feet per unit

G. Primary source voltage

H. Feeder source structure locations

I. *Distribution Underground Construction Standards* (DUG)

J. *Electrical Service Requirements* (ESR)

K. Meter panel size

L. Distribution Section of the "*EMF Design Guidelines for New Electrical Facilities: Transmission, Substation, Distribution*"

5.0 Design Criteria

5.1 Demand Estimating

Demand Estimating for Non-Custom Homes / Condominiums (less than 5,000 Square Feet) – Use Table 7–1 through Table 7–5and Table 7–7 in DDS-7 to determine "Design Square Footage". Then use Table 4–5 to determine kW demand. kW demand will be used to calculate voltage drop. Table 7–1 through Table 7–7 should be used for residential transformer loading. Table 7–1 through Table 7–5 and Table 7–7 also provide the maximum number of customers with similar demands who can be connected to a given size transformer (includes coincidence). When adding load to an existing transformer or calculating the required transformer size with dissimilar loads, multiply the kW demand from Table 4–5 by the appropriate coincidence factor and convert the result to kVA.

Demand Estimating for Custom Homes over 5,000 Square Feet – Obtain the connected loads (in kW) from the developer's plans for homes larger than 5,000 square feet. Multiply the connected load shown in the developer's plans (in kW) for the applicable categories by the demand factors found in Table 4–1. The total of these demands is the Total Customer Demand of the home.

Demand Estimating for Lot Sales (undetermined home sizes, 5 or more) – Determine whether the development is a load block or a future system feeder, based on load within development and load beyond development. See DDS–2 Feeder Systems.

5.2 Service Points

One service point normally will be provided for each single-family unattached residence, in accordance with Rule 16. The meter location should be on a sidewall near the front of the residence. Every effort should be made to avoid placing the meter panel on normally occupied rooms. Consideration should be given to allow for the use of a joint trench. Multiple-occupancy buildings will have the meters grouped at one location per building. Additional service points may be provided for Edison's operating convenience.

Lot sales may require a secondary system design independent of the residential load to feed streetlight, temporary power, and pedestals.

For high-rise, multi-occupancy, residential buildings seven floors or greater, or 75 feet or more above grade level, the Company may, at its option, establish more than one meter room location for groups of individual metering facilities. Residential high-rise buildings could have a mix of residential loads and commercial loads (for example, retail and/or restaurants, which are typically located at ground level). The Company's service point-of-delivery shall terminate at grade level or first level basement/parking to an underground termination pull section and main-service disconnect. Refer to the *Electrical Service Requirements (ESR) Manual*, ESR-5, Section 8.0, for service requirements.

5.3 Transformer Selection

A. Minipads will be standard installation on all residential, single-phase, fused radials on 6.9 kV and 9.4 kV systems. Exception – Lot sales (5 or more lots) require all transformers to be switched and fused.

Dead-end minipad-mounted transformers (minipads) and looped pad-mounted (standard sized) transformers shall be the standard installation for all residential, single-phase, fused radials on the 12 kV and 16 kV systems. The minipads shall be used for dead-end applications and looped pads shall be used for looped applications.

As an exception for new installation and when approved by management, dead-end minipads can be configured for looped applications, and looped pads can be utilized for dead-end applications. Management approval is not required when replacing like for like.

The same standard concrete or polymer pads are used with the minipad transformer as with the standard height units. Both minipad and standard height pad mounts have the same kVA load range and removal loads. Chapter DDS-7, Table 7–1 through Table 7–5, apply to both types of transformers.

Minipads have "crossover" cable configuration. Primary cable must enter on the right side of the pad and crossover to the primary bushings on the left side of the transformer housing (*Distribution Underground Construction Standards [DUG] Manual*, TX 190, and Underground Structures Standards [UGS], SS 504). Apply decals on drawings to ensure proper conduit placement by developer.

An inverted handhole shall be installed beneath the minipad transformer. The inverted handhole will provide the necessary room to train, route and operate cables and its accessories. Refer to DUG TX 190 and UGS SS 506 for installation details.

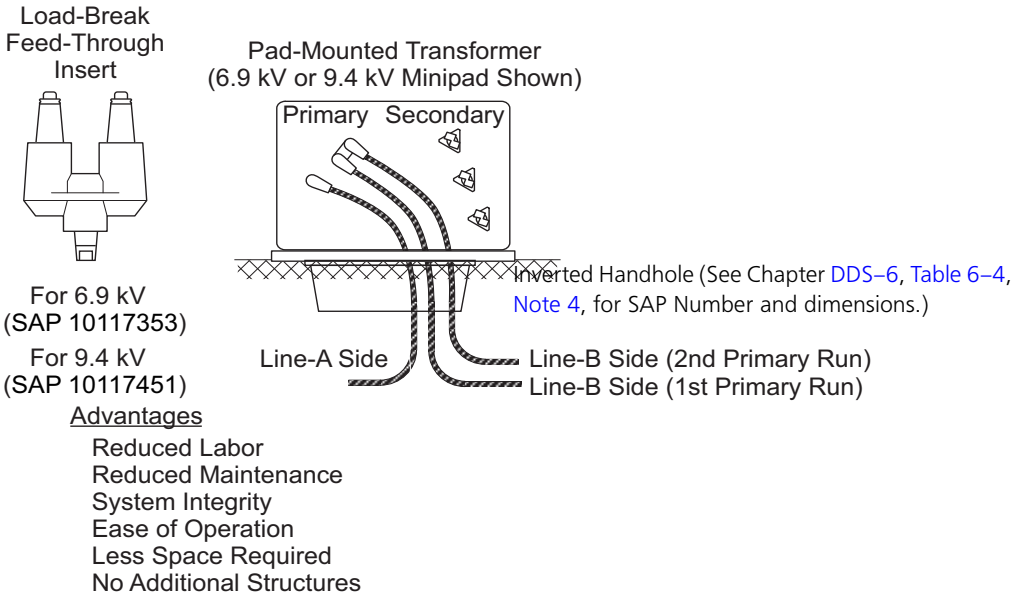
On all 6.9 kV or 9.4 kV residential radials, feed-through inserts at the transformer or load-break fuse cabinet (LBFC) are preferred over a separate pull box installation for providing a second run of cable. See Figure 4–1. The insert is used so that two primary runs may be looped on either the Line-A or Line-B side in the transformer compartment (or LBFC).

When the residential radial is fed from 6.9 kV or 9.4 kV overhead, the pothead must be installed in the buck-arm position whenever possible to allow changing the tap connection in any of the phases should load balancing be required in the future (refer to TP 209 of the *DUG Manual* for the preferred pothead construction).

Use of BURD equipment has been discontinued except in the following situations:

- Installations where it is not technically feasible to install pad-mounted equipment. Refer to DDS-6, Section 1.1, for definition of technically feasible;
- Installations in the public property and public rights-of-way where the local governments create insurmountable obstacles for pad-mounted equipment; or
- When replacing existing failed BURD equipment.

Figure 4–1: Example of Feed-Through Insert



B. Minimize the number of transformer locations by maximizing the number of residential customers per transformer. It is more economical to install 50 kVA or 75 kVA transformers depending on lot sizes and sizes of homes. Site-specific analysis must be performed to arrive at the most economical design.

C. In single-family developments, 100 kVA transformers shall not be used for new installations.

   In multi-family developments, 100 kVA pad-mounted transformers may be used for new installations because load growth is usually not expected.

D. Use the transformer loading tables in Chapter DDS–7 to determine the maximum number of dwellings of a given square footage that can be served by a transformer. The tables apply to single-family and multi-family residential developments up to 5,000 square feet per unit and cover the five climate zones. The tables also apply to single-family residential lot sales developments based on the average square footage of homes determined by the development lot size and restrictions.

E. The tables in Chapter DDS–7 incorporate average residential power factor and residential coincident factors. Chapter DDS–7, Section 2.1, also includes an adjustment to design square feet dwelling size to account for unusually large or small air conditioners. The adjusted design square feet will be used with the transformer loading tables in Chapter DDS–7 and with Table 4–5 in Chapter DDS-4 to determine the residential kW demand for calculating voltage drop per Chapter DDS–8.

F. For multi-family dwellings served by single-phase transformers, the number of customers served per transformer is to be increased by 20 percent above the numbers shown in Chapter DDS–7, Table 7–2 through Table 7–6.

For multi-family dwellings served by three-phase transformers, the number of customers served per transformer is shown in Chapter DDS–7, Table 7–8. DO NOT increase the customers served per transformer by 20 percent for this table.

See Chapter DDS–7, Appendix 7–1, Examples 3 and 4, for sample calculations.

G. If a BURD transformer is used for 12/16 kV applications, then no more than three runs of secondary cable (excluding streetlight service) will be run directly from a BURD transformer. If a BURD transformer is used for 6.9/9.4 kV applications, then no more than four runs of secondary cable (excluding streetlight service) will be run directly from a BURD transformer. If more runs of secondary cable are needed from this location, a handhole will be added next to the transformer enclosure. Refer to Sub-section 5.3 A (Page 2) for BURD equipment applications.

H. Sizing the Transformer

1. If a transformer will serve more than one custom home, calculate the customer demand and multiply the total by the appropriate coincidence factor in Table 4–2 to determine the total transformer demand in kilowatts. Coincidence Factor is defined as the ratio of the simultaneous peak demand of a group of customers on a transformer to the sum of the individual peak demands. The Coincidence Factor takes into account that all customers connected to a transformer do not reach their individual peak demand at the same time.
2. The transformer kilowatts demand is converted to transformer kilo-volt-ampere demand by dividing by the 0.9 Power Factor (PF) for residential load. See Table 4–2 for equations.
3. The transformer size is then selected from the installation range table included in the transformer loading table for the appropriate climate zone. See Chapter DDS–7, Table 7–1 through Table 7–5. Note that pad-mounted transformers are preferred in new residential subsystem construction.
4. When three-phase service is provided to custom homes from a pad-mounted transformer, the transformer size is selected from the installation range in Chapter DDS–7, Table 7–8 for three-phase, pad-mounted transformers. When three-phase service is provided by banks of BURD or overhead transformers that are connected "Y" on the secondary side, divide the transformer bank kilovolt-ampere demand by three and select the appropriate size of single-phase transformer to make up the three-phase bank from the transformer loading tables in Chapter DDS–7, Table 7–1 through Table 7–5 (for BURD) or Table 7–6 (for overhead).

I. See Chapter DDS–4 (Page 4–10), Examples 1–3, for sample calculations.

Table 4–1: Custom Residential Dwelling Demand Factors by Type of Load

Demand Categories	Demand Factor (See Note 1)		Connected Electric Appliances	Typical Connected kW (See Note 2) per Unit
	Summer Peak	Winter Peak		
Lights	10%	30%	Internal Lighting	4-6
Air Conditioning	100%	—	1 or 2 (largest) Units	1.4 kW per Ton
or	70%	—	All other Units	
Heat Pump or	—	70%	Single or Multiple Units	1.4 kW per Ton
Resistant Heating	—	70%	Baseboard Heating (use actual)	Varies
Major Appliances	20% 40%	30% 40%	Range (Use actual unit load.) Clothes Dryer Dishwasher Water Heater Water Heater (quick recovery) Refrigerator	 8–12 ea 5.5 ea 1.2 ea 4.5 ea 9.0 ea 2.5 ea
Exterior Loads	50%	30%	Swimming pool equipment, and so on	Varies
Exterior Lighting Loads	10%	30%	Tennis court and/or other	Varies
Other Loads (use actual connected load)	10%	10%	Convenience outlets Small motor load	Varies Varies
Electric Vehicles	100%	100%	Electric vehicle charging unit	4 kW-19 kW

Notes:

1. **Demand Factor** is the ratio of peak demand to connected load and is found in Table 4–1.
2. **Connected Load** is the total connected load in kW for each appliance category shown in the developer's plans. Some typical connected kW per unit factors are shown in Table 4–1.

Table 4–2: Coincidence Factors for Transformer Sizing

Number of Customers	1	2	3	4	5–6	7–8	9–11	>11
Coincidence Factor	1.00	0.90	0.85	0.80	0.75	0.70	0.65	0.60
Equation for Converting kW to kVA ***(90% Power Factor Assumed)***	$kVA = \frac{kW}{\text{Power Factor}}$ $kVA = \frac{kW}{0.90}$							

Notes:

The following formulas should be used for:

1. New installations:

   New Transformer Demand = Estimated New Load x Coincidence Factor

2. When load is being added to existing load:

   New Transformer Demand = (Estimated New Load x Coincidence Factor) + Existing Load

The following example explains how to use Table 4–1 and Table 4–2 to calculate the estimated demand, (Calculate Estimated Demand (Example 1: [Page 4–10]) how to apply the demand for estimating voltage drop (Example 2: [Page 4–10]), and how to size the transformer (Example 3: [Page 4–11]).

EXAMPLE 1:CALCULATE ESTIMATED DEMAND

Using Table 4–1, and the following load schedule in Table 4–3 below, estimate the kilowatt-customer demand for a customer dwelling that is 6,000 square feet with three, 5-ton air-conditioning units in Climate Zone 9 (summer peak) with the following load schedule:

Table 4–3: Calculate Estimated Customer Dwelling Demand

Air Conditioning	(Two largest units,10 ton total)	14 kW	Using 1.4 kW/ton from Table 4–1
Air Conditioning	(All Other units, 5 ton total)	7 kW	Using 1.4 kW/ton from Table 4–1
Electric Range	Not given, assumed	8 kW	From Table 4–1
Dishwasher	Not given, assumed	1.2 kW	From Table 4–1
Refrigerator	Not given, assumed	2.5 kW	From Table 4–1
Swimming Pool		4 kW	
Tennis Court Lighting		4 kW	
Internal Lighting		5 kW	
Convenience Outlets		7 kW	
Electric Vehicles	Not given, assumed	4 kW	From Table 4–1

Customer Demand = connected load x demand factor (lights)

\+ connected load x demand factor (A/C)

\+ connected load x demand factor (range, pool, and so on)

Solution:

To obtain the estimated demand per customer, multiply each connected load by the appropriate Demand Factor from Table 4–1 and add the products.

Table 4–4: Calculated Estimated Customer Dwelling Demand

	Connected Load (kW)	Multiplied by	Summer Demand Factor	Equals	Demand Per Customer (kW)
Air Conditioning (Two largest units)	14	x	1	=	14
Air Conditioning (Other units)	7	x	0.7	=	4.9
Electric Range	8	x	0.2	=	1.6
Dishwasher	1.2	x	0.2	=	0.2
Refrigerator	2.5	x	0.4	=	1.0
Swimming Pool	4	x	0.5	=	2.0
Tennis Court Lighting	4	x	0.1	=	0.4
Internal Lighting	5	x	0.1	=	0.5
Convenience Outlets	7	x	0.1	=	0.7
Electric Vehicle	4	x	1	=	4

Total Customer Demand = 29.3 kW

EXAMPLE 2: CALCULATE VOLTAGE DROP

Using the estimated customer demand of 29.3 kW from the above example, proceed to Chapter DDS–8 and use the formulas to determine the voltage drop.

EXAMPLE 3: CALCULATE TRANSFORMER SIZE

Calculate the size of a transformer for four customers using the estimated kilowatt-customer demand from the previous examples (29.3 kW per customer).

Size transformers using Table 4–1 and Table 4–2.

When estimating demand for sizing transformers, the following should be done once the total customer demand is determined:

1. Multiply the customer demand (kW) by the number of customers to get the total demand;
2. Multiply the total customer demand (kW) by the appropriate Coincidence Factor from Table 4–2;
3. Convert the kW to kVA by using the conversion equation; and,
4. Select the transformer size from the installation range table included in the transformer loading tables in Chapter DDS–7.

   Note: The table for the appropriate climate zone must be used. See the following example:

Solution:

1. Total Demand = Customer Demand x Number of Customers Total Demand = 29.3 kW × 4 = 117.2 kW
2. The Coincidence Factor for four Customers from Table 4–2 is 0.8

   To get the Transformer Demand (in kW), multiply the total Demand by the Coincidence Factor: Transformer Demand (in kW) = 117.2 kW × 0.8 = 93.8 kW
3. Converting Transformer Demand in kW to Transformer Demand in kVA:

   Transformer Demand (in kVA) = Transformer Demand (in kW) / 0.9
   Transformer Demand (in kVA) = 93.8 kW / 0.9
   Transformer Demand = 104 kVA
4. Using the Installation Range data in Table 7–5, at the estimated Transformer Demand of 104 kVA, the dwellings would be served as new installations by a 100 kVA pad-mounted transformer (the Installation Range for 100 kVA transformer in Climate Zone 9 is 83-104 kVA). However, in Chapter DDS-4, Section 5.3 C., 100 kVA transformers shall not be used for new installations. The above example should be recalculated for two transformers.

   Note: If customer qualifies for three-phase service, provide appropriate transformer(s) to serve three-phase load.

5.4 Cable Selection — Secondary and Service Plan

A. Planning the secondary and service requirements must be designed to produce the most economical design that meets appropriate design criteria. Secondary services will be a minimum of 350 cable and all services will be a minimum of 1/0 cable.

Note: The customer's meter panel size must be known before sizing service cable. Residential 125 A panels can accept #2 to 1/0 AWG cable and 200/225 A panels can accept 1/0 to 4/0 AWG cable. Refer to the *Electrical Service Requirements (ESR) Manual*, Chapter *ESR-3* for details. Larger cable sizes can be placed into panels with the use of adapters. Refer to *TP-100* of the *Distribution Underground Construction Standards (DUG) Manual*. Residential 400 A panels can accept 1/0 AWG to 350 kcmil cable.

B. On a development site plan, make a trial transformer size and location plan showing groups of customers to be served by each transformer. The transformers should be located in the center of the group of customers and adjacent to the property line (P/L) or other locations according to good design practices. Maintenance access, vehicular safety, and aesthetics must also be considered.

C. For lot sales (5 or more lots), consider locating transformer structures at every other property line, with stubouts to adjacent properties. See Appendix 4–2 for an example.

Preferred transformer and trench locations shall be in accordance with the following:

1. When sidewalk is adjacent to curb—NO parkway (see Figure 4–5, Diagram 1.)

Pad-Mounted Equipment

Align back edge of trench with back edge of sidewalk.

In the event the trench location cannot be located as shown, for example, due to streetlight requirements, adjust trench location with consideration for easements, joint trench, and any city requirements.

Equipment placed at the back of the trench may encroach on private property and require easements.

Whenever possible, place pad-mounted structures and equipment away from areas with frequent irrigation to help prevent future corrosion.

Install NEW stainless steel pad-mounted equipment only if every effort has been made to locate the pad-mount away from high-corrosion areas and the pad-mount is expected to be changed out within 15 years due to corrosion. Contact Field Engineering for approval.

Existing mild steel pad-mounted equipment may be upgraded to stainless steel if the existing equipment has failed due to corrosion within 15 years of installation. Contact Field Engineering for approval.

Note: All pad-mounted transformers purchased after 2004 are designed with stainless steel bottoms.

BURD Equipment

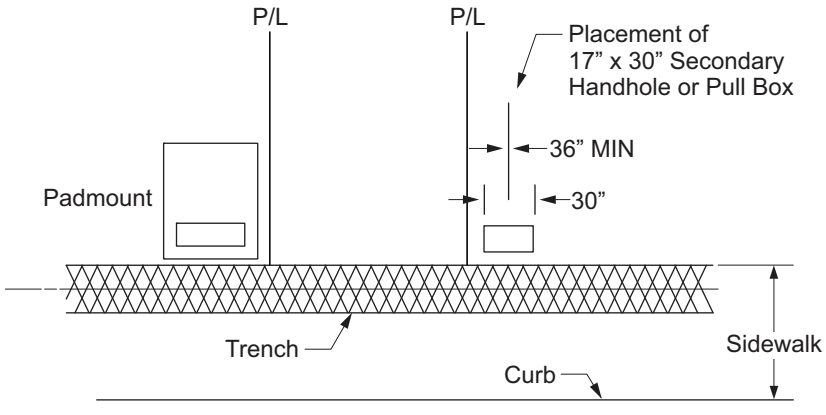
Back edge of trench: at back edge of sidewalk

Equipment placed at the back of the trench may encroach on private property and require easements.

Primary Splice Boxes and Secondary Handholes

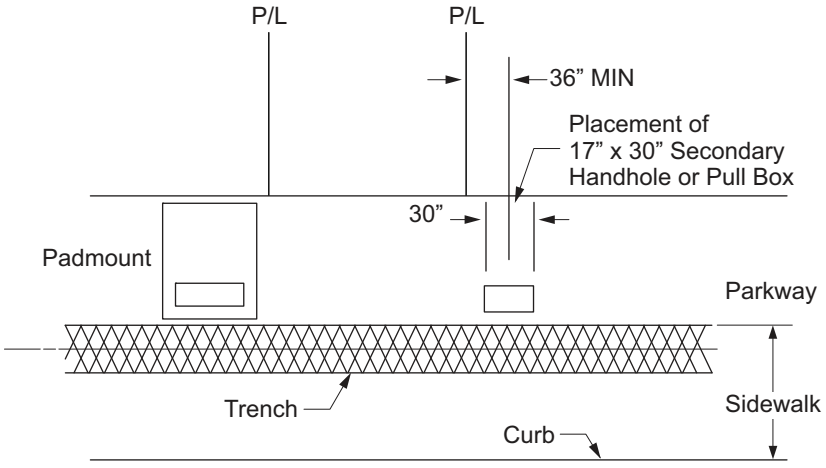
If Primary Splice Boxes and/or Handholes are required, they shall be located behind the trench and sidewalk. The handholes on tract developments and custom lots sales that serve multiple customers must be placed so that they will provide space and clearance requirements to convert to a larger handhole or to install a pad-mounted transformer in case of added load in the future. This may preclude handholes being installed between driveways. The handholes must be placed where conversion will not require any additional civil construction.

Figure 4–2: Preferred Placement of Handholes and Pull Boxes to allow for Future Conversion to a Pad-Mounted Transformer — Scenario 1



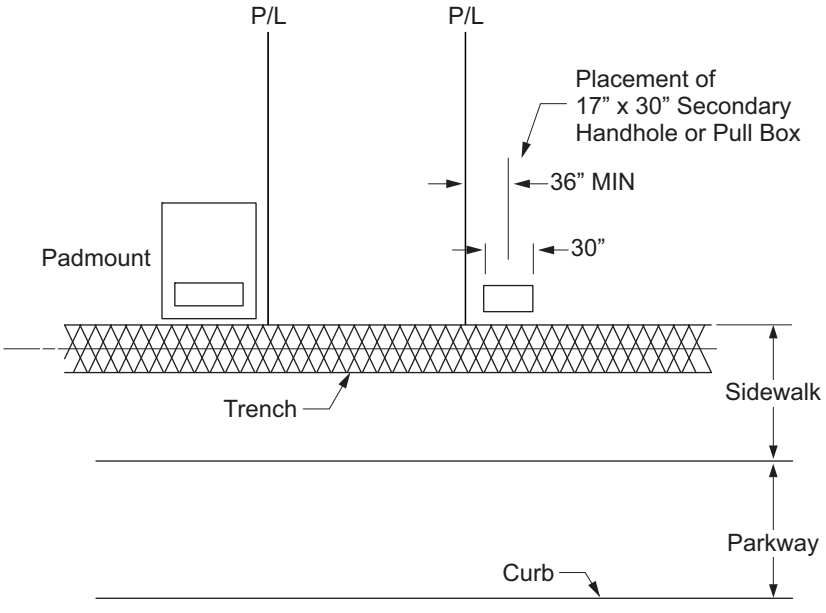
Scenario 1
Sidewalk adjacent to P/L, no parkway.

Figure 4–3: Preferred Placement of Handholes and Pull Boxes to allow for Future Conversion to a Pad-Mounted Transformer — Scenario 2



Scenario 2
Sidewalk adjacent to street, with parkway adjacent to P/L.

Figure 4–4: Preferred Placement of Handholes and Pull Boxes to allow for Future Conversion to a Pad-Mounted Transformer — Scenario 3



Scenario 3
Sidewalk adjacent to P/L, with parkway adjacent to street.

Equipment placed at the back of the trench may encroach on private property and require easements.

The Planner shall request an easement for future transformer installations at each handhole location.

When the customer edge of driveway is six feet or less from the property line, the handhole will need to be centered on the P/L to provide required clearances.

Note: When there is a rolled curb or no curb, refer to UGS, MC 830.

2. When parkway is present—sidewalk is in back of parkway (see Figure 4–5, Diagram 2)

Pad-mounted equipment

Front edge of trench: at front edge of sidewalk, adjacent to parkway

Equipment placed at the back of the sidewalk may encroach on private property and require easements.

Whenever possible, place pad-mounted structures and equipment away from areas with frequent irrigation to help prevent future corrosion.

Install NEW stainless steel pad-mounted equipment only if every effort has been made to locate the pad-mount away from high-corrosion areas and the pad-mount is expected to be changed out within 15 years due to corrosion. Contact Field Engineering for approval.

Existing mild steel pad-mounted equipment may be upgraded to stainless steel if the existing equipment has failed due to corrosion within 15 years of installation. Contact Field Engineering for approval.

Note: All pad-mounted transformers purchased after 2004 are designed with stainless steel bottoms.

BURD Equipment

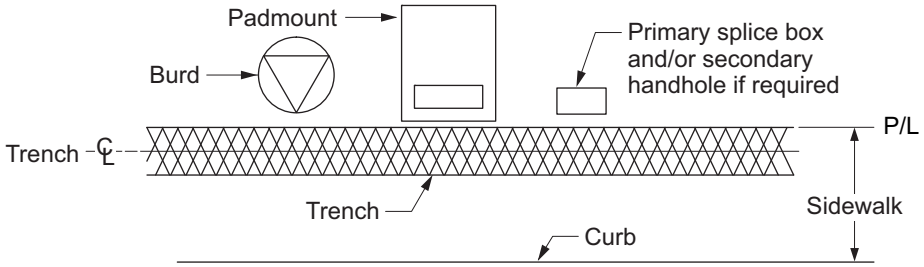
Front edge of trench: at front edge of sidewalk, adjacent to parkway
Equipment in parkway: between curb and sidewalk

Primary Splice Boxes and/or Secondary Handholes

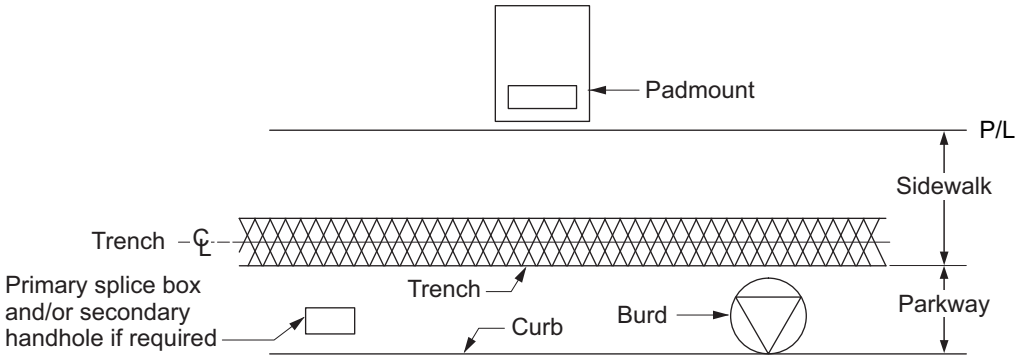
If Primary Splice Boxes and/or Handholes are required, they shall be located in the parkway, between the curb and the sidewalk.

Figure 4–5: Preferred Transformer and Trench Locations

1. Sidewalk adjacent to curb—no parkway



2. Parkway is present—sidewalk in back of parkway



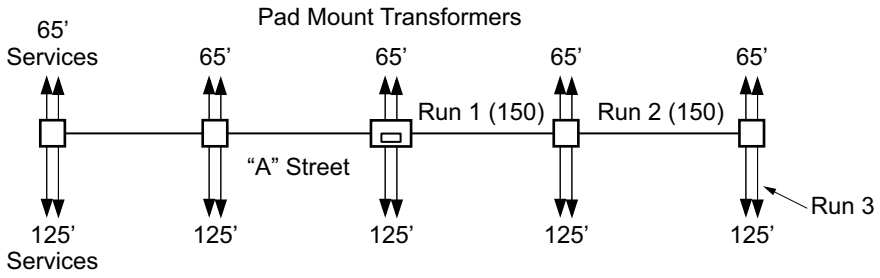
3. Other Substructures

   Refer to other substructure plans (water, sewer, storm drain/flood control, and so on), so that any conflicts in structure location are avoided in the planning stage.

4. Routing trench and cable on private property with proper easements may be allowed when economical.

D. Generally, design secondary and service plans with transformers and handholes on one side of the street, except for lot-sale tracts. A reduced number of subsurface connections (secondary or service connections in handholes or BURD transformer enclosures) will offer a more reliable system and require less maintenance. The following figure shows an example of a residential handhole design.

Figure 4–6: Example of Residential Handhole Design



E. Minimize the number of handholes in the secondary and service design.

F. Locate the transformer and secondary handholes as close as practical to the load centers of the lots they are to serve.

G. The standard installation of residential secondaries and services is cable in a rigid duct.

H. For design criteria when installing conventional conduit systems, see the following:

1. Chapter DDS–6, Table 6–4, Table 6–5 and Table 6–6 for recommended handholes, splice boxes, and pull boxes
2. Chapter DDS–6, Table 6–1 and Table 6–2, for recommended conduit and riser sizes
3. Chapter DDS–9, Section 5.0 and 5.1, for general cable pulling notes and criteria
4. Chapter DDS–9, Table 9–10, for recommended multiplying values for standard conduit angles
5. Chapter DDS–9, Table 9–13, for the maximum allowable equivalent cable pull length for residential single-phase cable pulls.
6. Chapter DDS–9, Section 5.2 Example 1 for residential cable pulling example
7. *UGS Manual*, Section 100.8, for requirements for mandrelling, cleaning, pull rope, and pull tape installations
8. *UGS Manual*, Section 110.1, for recommended conduit type
9. *UGS Manual*, Section 115, for approved conduit vendors and conduit requirements
10. *UGS Manual*, Section 120.2, and various other sections, for proper placement of conduit in trench and structures

I. Develop a secondary and service plan utilizing 350 secondaries and 1/0 cable services. This design must meet the three percent voltage drop and five percent flicker standards in the most cost-effective manner.

J. The service and secondary cables must be sized to comply with the maximum allowable voltage drop and flicker as shown in Chapter DDS–8.

K. Residential Demand for Voltage Drop Determination

Perform voltage drop calculations on the customer's expected kW demand.

To estimate the kW demand needed for determining residential voltage drop, use Table 4–5 for dwelling units with Design Square Feet up to 5,000 square feet. See Chapter DDS–7, Section 2.1 to determine the Design Square Feet dwelling size, including an adjustment to account for unusually large or small air conditioners.

If voltage drop standards are not met, adjust the secondary/service cable size or redesign the transformer locations to ensure voltage drop standards are met.

For larger custom homes or homes above 5,000 square feet, the demand can be determined using the connected load provided in the developer's plans. This method is described in Chapter DDS–4.

Table 4–5: Diversified Residential kW Demand per Unit with Air Conditioning

Dwelling Type	Square Feet	Climate Zone 1 and 3	Climate Zone 5 and 7	Climate Zone 9
		kW Demand	kW Demand	kW Demand
Multi-Family	600	2.0	2.5	3.5
	800	2.5	3.0	4.0
	1,000	3.0	3.5	4.5
	1,200	3.0	3.5	5.0
	1,400	3.5	4.0	5.5
	1,600	4.0	4.5	6.0
	1,800	4.0	4.5	6.0
	2,000	4.5	5.0	6.5
	2,200	5.0	5.0	7.0
	2,400	5.0	5.0	7.0
	2,600	5.0	5.5	7.5
Single-Family	1,000	4.0	4.5	5.5
	1,200	4.0	4.5	6.0
	1,400	4.5	5.0	6.5
	1,600	5.0	5.5	7.0
	1,800	5.0	5.5	7.5
	2,000	5.5	6.0	8.0
	2,200	6.0	6.5	8.5
	2,400	6.0	6.5	9.0
	2,600	6.5	7.0	9.5
	2,800	6.5	7.0	10.0
	3,000	7.0	7.5	10.5
	3,200	7.0	8.0	11.0
	3,400	7.5	8.0	11.5
	3,600	8.0	8.5	12.0
	3,800	8.5	9.0	12.5
	4,000	8.5	9.0	13.0
	4,200	9.0	9.5	13.5
	4,400	9.0	9.5	14.0
	4,600	9.5	10.0	14.5
	4,800	10.0	10.5	15.0
	5,000	10.0	10.5	15.5

Notes:

1. Use this table to determine the kW demand for secondary and service voltage drop calculations given the Design Square Feet dwelling size developed in Chapter DDS–7, Section 2.1.
2. For dwellings having non-air conditioning motor loads of greater than 1-1/2 hp, use the Custom Residential Dwellings Table 4–1 to estimate the demand.
3. For all-electric dwellings, use the Custom Residential Dwellings, Table 4–1 to determine the demand.
4. This table assumes average load coincidence for purposes of cable loading.

The following examples explain how to use Table 4–5 to determine the estimated demand, voltage drop, and the number of customers to be served from a transformer.

EXAMPLE 4: CALCULATE ESTIMATED DEMAND

Calculate the estimated demand for single-family dwellings in Climate Zone 7 with a design square feet of 2,400-square feet (determined as a result of preliminary transformer selection in Chapter DDS–7, Section 2.1.)

SOLUTION:

Table 4–5 indicates that a single-family dwelling with design square feet size of 2,400-square feet in Climate Zone 7 will have a customer kW demand of 6.5 kW.

EXAMPLE 5: CALCULATE VOLTAGE DROP

Using the estimated customer demand calculated in Example 4:, proceed to Chapter DDS–8, Section 3.3, using the procedures there to determine the voltage drop.

L. The maximum allowable flicker through the transformer, secondary, and service, is five percent at end-of-line (EOL) customer. Chapter DDS–8 contains tables that provide percent flicker through the transformer as a function of air conditioning (A/C) size (in tons) and transformer size. Tables are also provided to determine percent flicker through secondary and service cable as a function of A/C size and cable length and size. Examples demonstrating the use of these tables are included in Chapter DDS–8.

5.5 Feeder Interface

The residential subsystem connections to the feeder should be selected to reduce feeder switches/switch positions. Groups of fused radial subsystems forming three-phase balanced loadblocks should be connected to the feeder from a switch position or T-tapped between two feeder switch positions. T-taps may be connected between two switch positions on the System Feeder based on the following criteria:

A. One T-Tap

A single T-tap may be located on a switch position or in any structure between two switch positions on a System Feeder.

B. Two T-Taps

One of the T-taps shall be located on a switch position in the switch structure. The second T-tap may be located on a switch position or in any structure between two switch positions on a System Feeder.

C. Three T-Taps

Two of the T-taps shall be located on the switch position in the switch structures. One of the T-taps serves single-phase load which does not exceed 25 kVA.

T-taps are not allowed on Future System Feeders or Dead-End Feeders due to loadblock definitions (for example, de-energizing a loadblock may not affect any other loadblock). The only exception is that automation transformers may be T-tapped off the System Feeder switch position if there is a means to avoid ferroresonance such as use of load-break elbows, phase to neutral transformers, etc. (See DDS, Section 5.13 B).

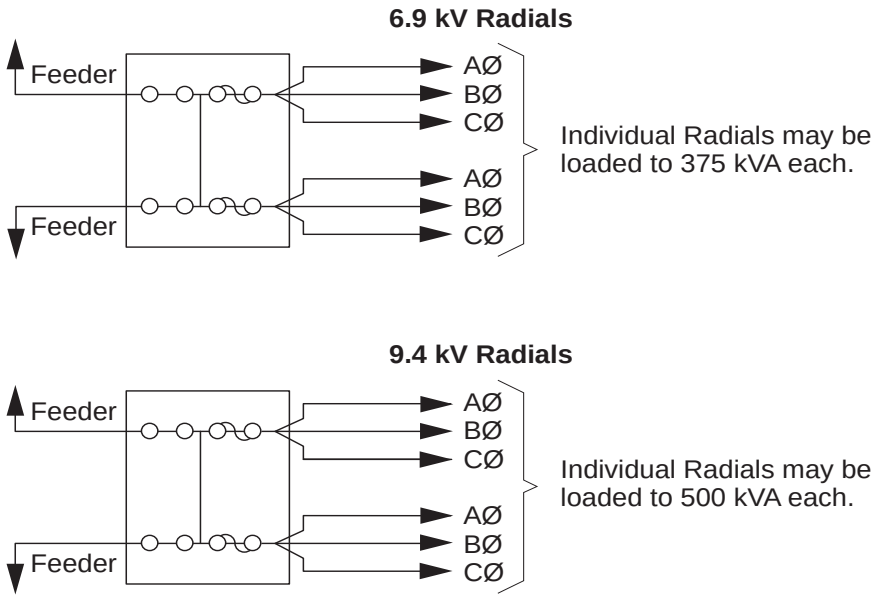
5.6 Loadblock

A loadblock of residential load must be able to be de-energized from the feeder by opening its own dedicated switch position, or by de-energizing the feeder section by opening switch positions on either side of the loadblock.

An overhead pole switch shall be installed ahead of an underground dip when a ferroresonant condition exists between the riser pole and a switch in the underground system.

Figure 4–7 illustrates typical residential radial subsystems served from fused PME switch positions.

Figure 4–7: Residential Radials Served from Fused PME Switch Positions



5.7 Radial Subsystem Design

A. Identify the primary source and voltage to determine the minimum number of radial subsystems required.

The preferred source will be a 6.9 kV or 9.4 kV system. Use12 kV or 16 kV laterals only under the following conditions:

1. It is not economical to install the neutral. Refer to DDS-4, Section 5.8 to determine if installation of the fourth wire is economical.

2. It is not economical to use 16-9.4 kV or 12-6.9 kV isolation transformer until the neutral can be installed.

B. It is essential to plan large residential developments served by 6.9 kV or 9.4 kV radials so that phase balancing is accomplished (refer to TP 209 of the *Distribution Underground Construction Standards (DUG) Manual* for the preferred pothead construction). Each fused radial on each phase of a development is to be phase marked on the work order map according to the overall development master plan.

C. Maximize the kVA per radial by determining the minimum number of radial subsystems required to serve the development according to the criteria outlined in Table 4–6.

Table 4–6: MAX kVA/Radial by Source Voltage

Item	Fuse Device per Phase	6.9 kV (L-G)	9.4 kV (L-G)	12 kV (L-L)	16 kV (L-L)
Riser Pole (See Note 1)	80 A CL	375 kVA	500 kVA	400 kVA	500 kVA
PFC-CL (PME-1) (See Note 1)	2-40 A CL	375 kVA	500 kVA	—	—
Load-Break Fuse (LBFC)	2-40 A CL	375 kVA	500 kVA	—	—
Pad-Mounted (PME-2) (See Note 1)	2-40 A CL	—	—	400 kVA	500 kVA
BURD Switch (See Note 2)	2-40 A CL	375 kVA	500 kVA	—	—
BURD Switch (See Note 2)	1-40 A CL	—	—	325 kVA	450 kVA
PME-CL (See Note 1)	2-40 A CL	375 kVA	500 kVA	400 kVA	500 kVA

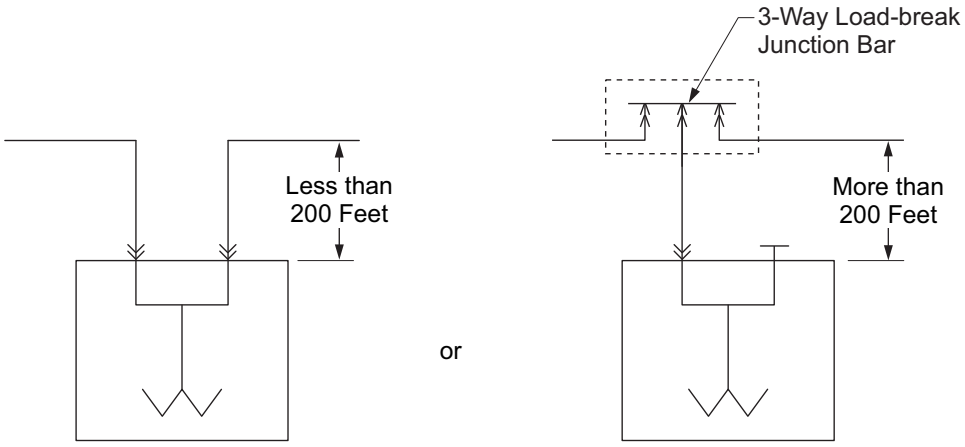
Notes:

1. An 80E SMU-20 fuse may be used in place of a CL fuse(s) for applications where Engineering has determined that the fault duty is under 10,000 A, and will remain under 10,000 A with any foreseeable changes in the future.
2. Pad-mounted equipment is standard design for radial subsystems. BURD equipment should not be used except where allowed in Section 5.0, and DDS-6, Section 1.0.

$$\text{Number of Radials} = \frac{\text{Total Connected Transformer kVA}}{\text{Maximum kVA/Radial}}$$

D. If a lateral is required to run over 200 feet to pick up a single transformer, use one, 3-way load-break junction bar in a 2' x 3' x 3' pull box, or two, 3-way J-bars, if system is 12 kV or 16 kV, in a 2'-6" × 4' × 3'6" pull box instead of doubling the cable back in the same trench. See Figure 4–8.

Figure 4–8: Lateral-to-Single Transformer Design



E. Select a fuse device according to the applications described in Figure 4–14 and Figure 4–15. Alternatives in each figure are listed in order of preference according to least cost and overall operating flexibility.

F. The standard fusing for radials served from an overhead source is a 80 A CL fuse. See Figure 4–14.

G. If a feeder switch is required, use a PME-CL equipped with a 200 A fused position as the source to fuse 6.9 kV or 9.4 kV radials. If a 600 A to 200 A T-tap or an SF_6 switch is to be the source, use a PME-4 CL for multiple radials. For one radial, use an LBFC or a PME-1.

   The recommended method for fusing 12 kV and 16 kV single-phase radials is shown in Figure 4–15. Generally, a single radial with two or more transformers shall be fused from either a riser pole with an 80 A CL fuse or through a 2-way, two-pole fused pad-mounted switch (PME-2) with two 40 A CL fuses. For a single radial with only one transformer, a fused pad-mounted or BURD transformer shall be used. For multiple radials, use either a PME-4 with a 2-40 A CL fuse or a PME-5 with a 2-40 A CL fuse if switching capability is desired. See Table 4–6 for maximum kVA limitations.

   For lot sales (5 or more lots), to reduce the risk of exceeding fuse capabilities, utilize switched fused padmounted transformers for these installations. See Section 5.3 (Page 4–4).

   Check for potentially ferroresonant conditions on 12 kV and 16 kV radials using Chapter DDS–2, Section 5.13. Ferroresonance signs must be installed on all equipment where these conditions exist. Note the need for these signs on the work order map.

H. The LBFC is pad-mounted, uses load-break elbows and up to two 40-A current-limiting fuses. It may be used to fuse single-phase 6.9 kV residential radials of up to 375 kVA, or 9.4 kV up to 500 kVA and is the preferred design alternative to the pad-mounted fuse cabinet current-limiting (PME-1). A PFC-CL should be used if available working clearance is a concern. Refer to the *DUG Manual*, Section PD 420.

I. 15 kV and 25 kV Class 200 A load-break elbows are the standard installation.

1. Conditions

   The following conditions must be met in the design and operations of all load-break elbows:

   a. Must be beyond current-limiting fusing, or if the current-limiting fuse is integral to the single-phase or three-phase transformer. See Figure 4–9 and Figure 4–10.

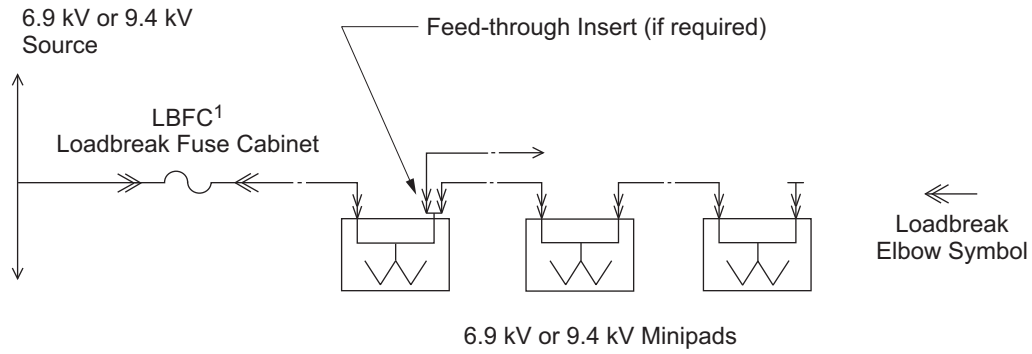
   b. An elbow being installed does not mean it can be assumed to be operable while energized. For operational guidance, refer to the *Distribution Operation and Maintenance Policy and Procedures (DOM) Manual*, Section CC-5, Attachment 2.

   c. Loadbreak elbows must not be operated. A ferroresonance must be installed if there is the potential for a ferroresonant condition.

   d. 15 kV Class LBEs are to be used only on 6.9 kV and 12 kV systems. Only 25 kV Class LBEs shall be used on 9.4 kV and 16 kV systems.

   e. Do not operate load-break elbows to energize or de-energize capacitor banks.

Figure 4–9: Single-Phase Applications



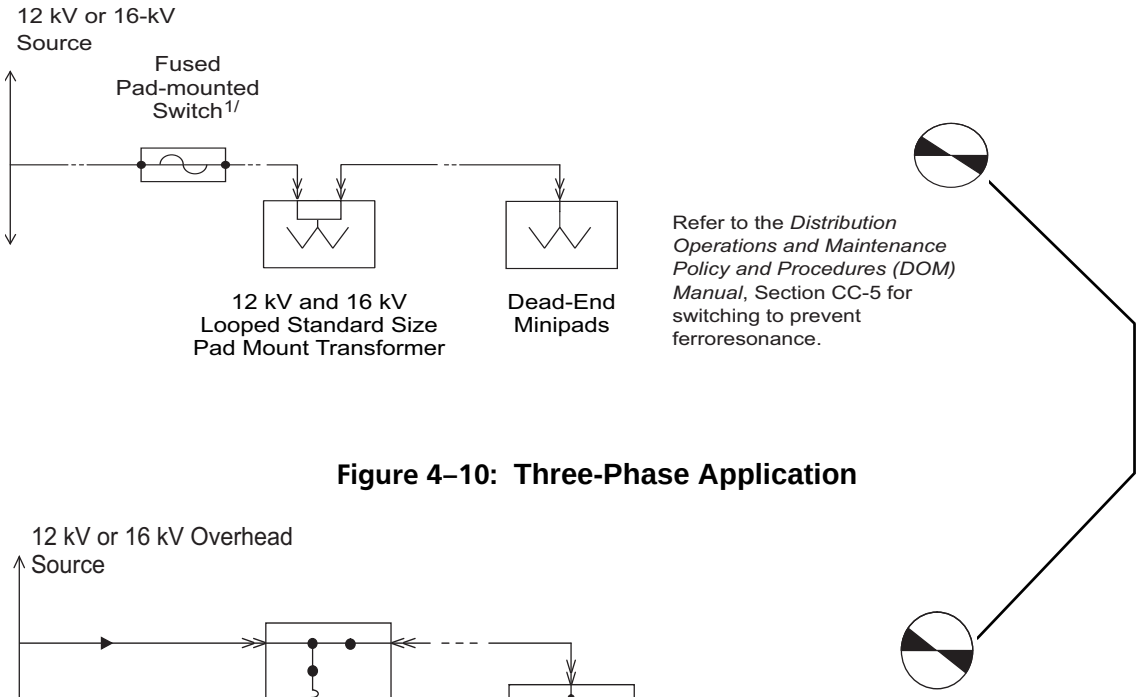
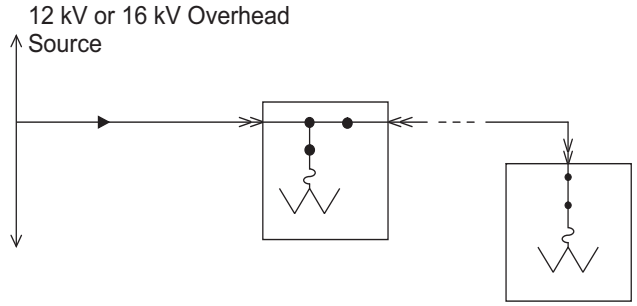


Figure 4–10: Three-Phase Application



[1/]Alternate fusing shown in Table 4–7.

2. Current-Limiting Fusing Options

   The application of load-break elbows requires the use of current-limiting fuses to avoid high-fault duty (greater than 10,000 A). Below are the most common current-limiting fused devices used to facilitate the use of load-break elbows.

   - LBFC (Pad-mounted Load-break Elbow Fuse Cabinet)
   - PME-1 (Pad-mounted Fuse Cabinet with current-limiting fusing)
   - PME–CL (Pad-mounted Enclosure with current-limiting fusing)

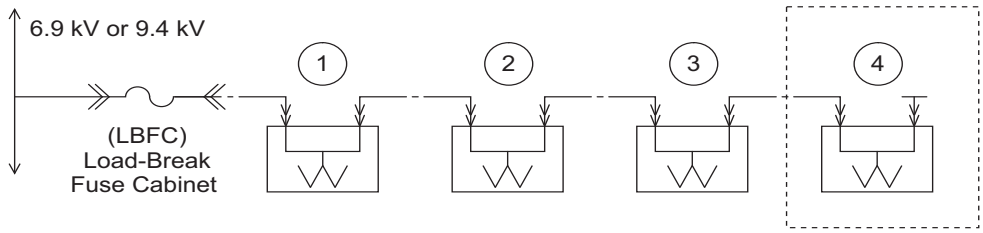
   Detailed descriptions of existing current-limiting options appear on the following pages.

   Selection of the proper equipment will depend on the requirements and conditions of each specific situation. Table 4–7 is an application guide listing advantages and requirements of the above devices. Also included in the table are the CL pad-mounted oil switches and CL BURD switches for reference when needed for three-wire fusing.

3. 6.9 kV or 9.4 kV Pad-mounted Load-break Elbow Fuse Cabinet (LBFC) (SAP 10107391) (ZUFE 035 and 036)

   This cabinet is the preferred design alternative for use on 6.9 kV or 9.4 kV radials. It uses load-break elbows and two 40 A, current-limiting fuses. It can fuse up to 375 kVA on a 6.9 kV residential radial or 500 kVA on 9.4 kV.

Figure 4–11: LBFC on 6.9 kV or 9.4 kV Residential Radial with Load-Break Elbows

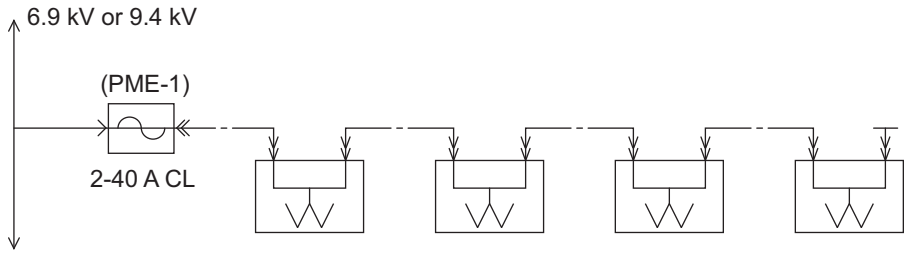


No outage required when adding new transformer (#4).

4. 6.9 kV or 9.4 kV Pad-Mounted Fuse Cabinet with CL Fuses (PME-1) (SAP 10107397) (ZUFE 037 and 038)

   This cabinet has a fused disconnect and may be used to fuse 6.9 kV (375 kVA) and 9.4 kV (500 kVA) residential radials, using up to two 40 A, current-limiting fuses. Refer to the *Distribution Underground Construction Standards (DUG) Manual*, Section PD 420. This cabinet should be used when available working clearance is a concern. The LBFC is the preferred design alternative to the PFC-CL for 6.9 kV and 9.4 kV radials because of lower installation costs and a lower profile.

Figure 4–12: Fusing with a PME-1



5. 15 kV Pad-Mounted Cabinet with Current-Limiting Fuse (PME-4 CL) (SAP 10107421)

   The PME 4 CL is used to fuse two or three 6.9 kV or 9.4 kV residential radials, using up to two 40 A, current-limiting fuses per radial.

Figure 4–13: Fusing with PME-4 CL

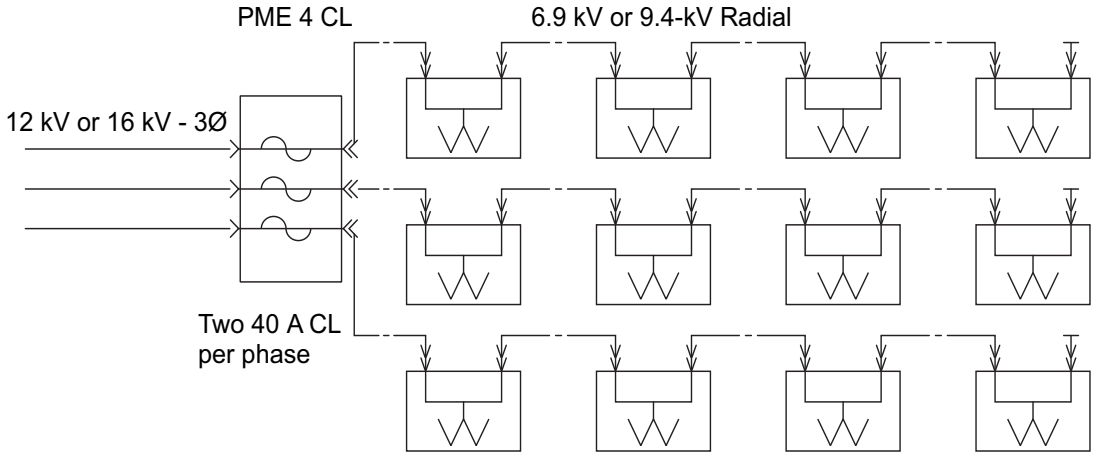


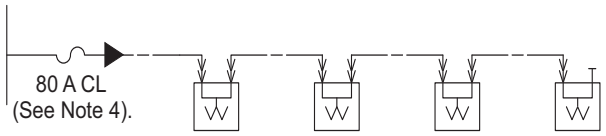
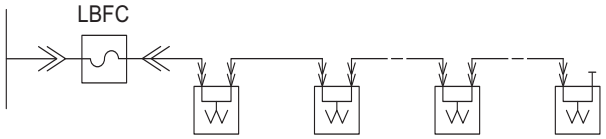
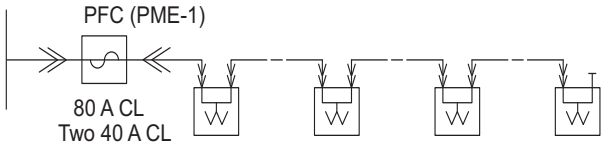
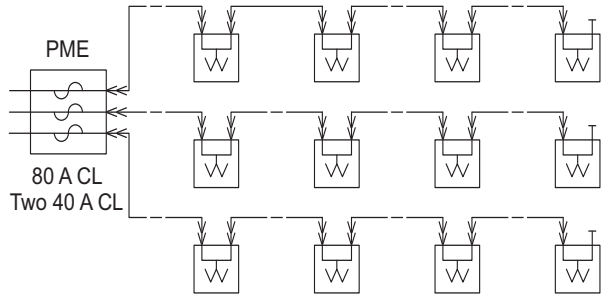
Table 4–7: Current-Limiting Fusing Application Guide for Single-Phase Radials (shown in order of economic preference)

Equipment	Rating kV	Rating Fusing	Application	Req'd Clearances on Door Side of Cabinet (ft) (See Notes 2) Front	Req'd Clearances on Door Side of Cabinet (ft) (See Notes 2) Back	Switch-Handle Side	Considerations
Riser Pole — CL Fuses	6.9 and 9.4	80 A	For fusing underground circuits from an overhead structure	—	—	—	—
Load-break Fuse Cabinet (LBFC)	6.9 and 9.4	Two 40 A	Fuse 1Ø radials (preferred over PFC-CL)	8	8	—	• Low profile
PME-1 (2W-1P, PFC-CL)	6.9 and 9.4	Two 40 A	Alternate to LBFC where 8-foot clearance is not available on two sides.	8	—	—	• Higher cost than LBFC • Dead-front • Rodent resistant • No oil
PME-4 CL	6.9 and 9.4	Two 40 A per Ø	Multiple residential radials	8	8	—	• Dead-front
2W-1P Fused BURD Switch	6.9 and 9.4	80 A	Where subsurface required	DUG Encl.	—	—	See Notes 1
Riser Pole — CL Fuses	12 and 16	80 A	For fusing underground circuits from an overhead structure	—	—	3	
PME-2 (2W-2P, Fused PM Switch)	12 and 16	Two 40 A per Ø	Where switching capability is desired	8	—	—	• Dead-front • Rodent resistant • No oil
2W-2P Fused BURD Switch	12 and 16	40 A	Where gang-operated switch required	DUG Encl.	—	3	See Notes 1
PME-4, -5 CL	12 and16	Two 40 A per Ø	Multiple residential radials where switching capabilities are required	8	8	3	• Dead-front • Can use load-break junctions for individual radials
PM-6, -9, -11, -12, and -14 CL	6.9 and 9.4 12 and 16	Two 40 A per Ø	Multiple residential radials at a main line switch	8	8	4	• 4' clearance required for automation

Note:

1. Pad-mounted equipment is the standard design for radial subsystems. BURD equipment should not be used except where allowed in Section 5.0 and DDS-6, Section 1.0.
2. Eight-foot clearance shall be measured from the edge of pad or back of access opening. Refer to UGS Manual for additional information.

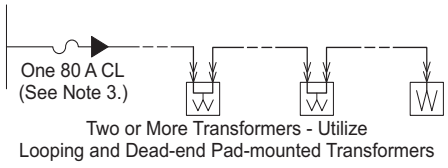
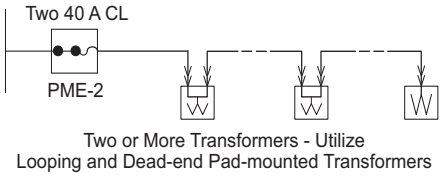
Figure 4–14: Radial Subsystem Design for 6.9 kV and 9.4 kV Radials

Source	No. of Radials	Single-Line Diagram
1. Overhead Feed (Riser Pole) to Underground Dip	1	
2. Underground	1	
3. Underground	1	
4. Underground	2 or 3	

NOTES:

1. Alternatives are listed in order of economic preference.
2. BURD transformers may be substituted for pad-mounted transformers.
3. Diagram "4" represents either a PME-4, PME-9, PME-11, PME-12, or PME-14. It is most economical to use a fused position in an available PME switch rather than a T-tap to a PME-4 switch.
4. X-Limiter is suitable for 80 A CL fuse on a riser pole.

Figure 4–15: Radial Subsystem Design for 12 kV and 16 kV Radials

Source	No. of Radial	Single-Line Diagram
1. Overhead	1	
2. Underground	1	

NOTES:

1. Alternatives are listed in order of economic preference.
2. X-Limiter or equivalent is suitable for 80 A CL fuse on a riser pole.
3. Check for a ferroresonance condition and note on the work order map the need for any ferroresonance signs.

5.8 Extension of Fourth Wire

Extension of fourth wire (primary neutral) should be determined when a new tract development is going to be built on a three-phase, three-wire system. Three-phase, three-wire underground systems are typically more expensive to build and maintain than three-phase, four-wire systems. Four-wire systems typically have lower installation and maintenance costs due to less equipment being needed to serve the development. Four-wire systems also eliminate the potential for ferroresonance and limit the outage exposure to customers.

When determining extension of a fourth wire, factors such as pole loading, adjacent ties, future growth (Residential and Commercial), and cost need to be taken into account. Planners shall use Table 4–8 and consult with Field Engineering to determine if a new development being served off a three-wire system should have a fourth wire extended to serve that new development. Table 4–8 is determined using the Present Value Revenue Requirement (PVRR), which is the cost to SCE ratepayers of an installed piece of equipment over its useful life in present year dollars.

This table helps in determining fourth wire extension when it is unknown how many additional homes will be built for the following years of an initial development and empty land is adjacent to the development. The Planner, with the help of the Field Engineer, should determine if the circuit serving the development has additional growth potential. If the circuit has additional growth potential, use Table 4–8 to determine if a fourth wire should be extended. Determine the amount of additional acreage that can be developed, and use the known housing development density to determine the total number of homes that can be built. If the number homes per acre is unknown, use nine homes per acre.

To use the table, multiply the number of homes being developed by the cost per home difference provided by Table 4–8 and sum up the values for each year of the development. If the cost of the fourth wire extension is less or equal than the total PVRR, a fourth wire should be extended to serve the new tract development.

Appendix 4–1 provides examples of how to determine the PVRR for extension of a fourth wire.

Table 4–8: Determination to Extend Fourth Wire to Serve New Development

Year of Tract Development	Cost/Home Difference 3- Wire verses 4-Wire (See Note 1)	Number of Homes to be Built in Given Year (See Note 2)	PVRR to Extend Fourth Wire
1	$600	Input by Planner	The values determined by multiplying the cost/home difference and number of homes built will determine how much may be spent to extend the fourth wire.
2	$550	Input by Planner	
3	$525	Input by Planner	
4	$500	Input by Planner	
5	$450	Input by Planner	
(6-10)	$375	Input by Planner	
(11-15)	$275	Input by Planner	
(16-20)	$210	Input by Planner	

Notes:

1. After year five, PVRR amount used in an average values for each of the five year increments shown.
2. When the future number of homes is unknown, use zoning average for area or an average of nine homes per acre.

Appendix 4–1: Determination to Extend a 4th Wire to Serve a New Development and Future Growth

EXAMPLE 1:

Estimating PVRR to extend a fourth wire to new tract development (Method One)

Year of the project (Year 1) new track development is being built with 50 new homes. For the following five years, Table 4–9 shows the additional number of homes that will be built each year. Using Table 4–8, determine how much you can spend on the project to pull a fourth wire to serve year one's load and the following year's load.

Table 4–9: Additional Homes Built per Year

Year	Number of Homes
1	50
2	35
3	25
4	35
5	15
6	15

Table 4–10: PVRR to Extend Fourth Wire

Year of Tract Development	Cost/Home Difference 3-Wire verses 4-Wire (See Notes 1)	Number of Homes to be Built in Given Year (See Notes 2)	PVRR to Extend Fourth Wire
1	$600	50	$30,000
2	$550	35	$19,250
3	$525	25	$13,125
4	$500	15	$7,500
5	$450	15	$6,750
(6-10)	$375	15	$5,625
(11-15)	$275	—	—
(16-20)	$210	—	—
		Summation:	**$82,250**

Notes:

1. After year five, PVRR amount used in an average values for each of the five year increments shown.
2. When the future number of homes is unknown, use zoning average for area or an average of nine homes per acre.

Table 4–10 shows that for the initial development of 50 homes and the following year developments, a fourth wire could be extended to serve the initial development if the fourth wire installation cost is $82,250 or less.

EXAMPLE 2:

Estimating PVRR to extend a fourth wire to new tract development. (Method Two)

Year of the project (Year 1) new track development is being built with 50 new homes, and in year two an additional 45 homes will be built. After the development, the 12 kV circuit serving the new tracks still has an additional 75 A of capacity. The average home being built is 7 kW. There is still an additional 10 acres that can be developed and is known to be part of a master plan community. Using Table 4–8, determine how much can be spent to pull a fourth wire to serve the new tract development load and the additional acres that can be developed.

First, determine the number homes that can be built on the 10 acres. Using an average of nine homes/acre and 7 kW/home:

- 10 Acres x 9 Homes/Acre = 90 Homes
- 90 Homes x 7 kW/Home = 630 kW
- 630 kW/1,000 x 46 A / 1 MW = 29 A

Since an additional 90 homes could be built, it is possible that the 10 acres could totally be developed within five years. Assuming the 90 homes will be built in the following years three, four, and five at 30 homes per year, the existing serving circuit is adequate since 29 A does not exceed the available 75 A remaining capacity on the circuit. Work with Field Engineering when determining future growth on a circuit.

Table 4–11: PVRR to Pull Fourth Wire

Year of Tract Development	Cost/Home Difference 3-Wire verses 4-Wire (See Notes 1)	Number of Homes being Built (See Notes 2)	PVRR to Pull Fourth Wire
1	$600	50	$30,000
2	$550	45	$24,750
3	$525	30	$15,750
4	$500	30	$13,500
5	$450	30	$6,750
(6-10)	$375	–	–
(11-15)	$275	–	–
(16-20)	$210	–	–
		Summation:	**$99,000**

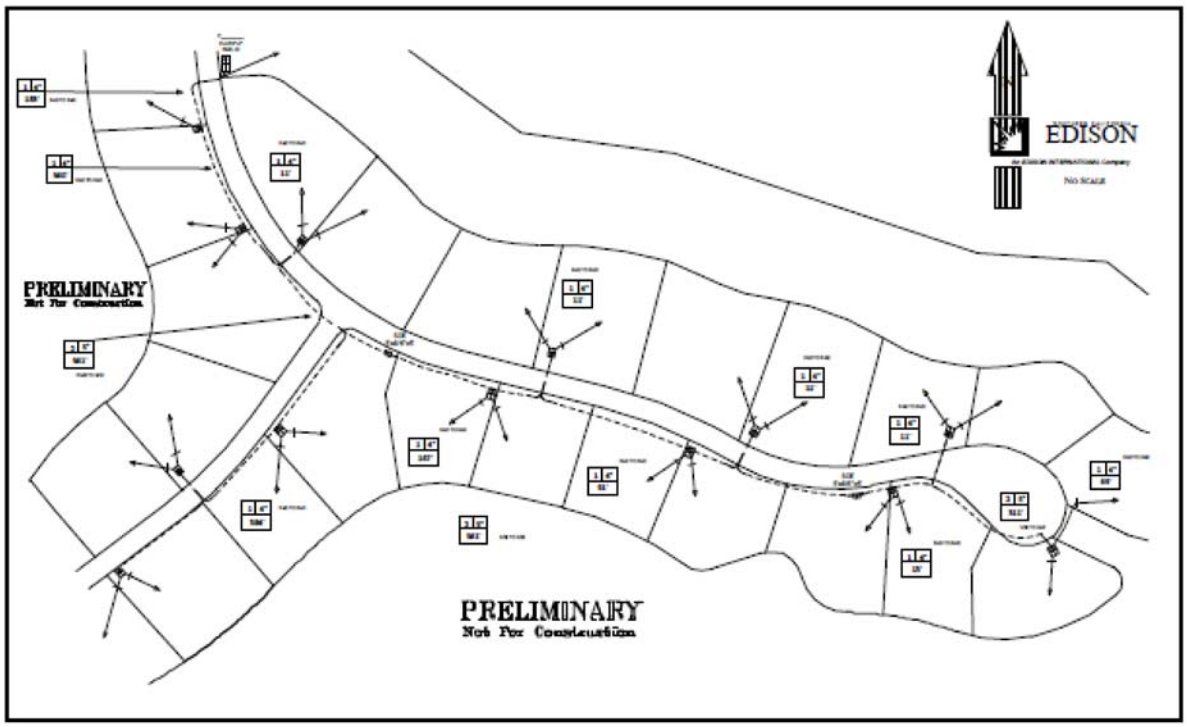
Notes:

1. After year five, PVRR amount used in an average values for each of the five year increments shown.
2. When the future number of homes is unknown, use zoning average for area or an average of nine homes per acre

Table 4–11 shows that for the development of 95 homes plus the additional 90 homes that can be built on the 10 acres, a fourth wire could be extended to serve the initial development if the fourth wire installation cost is $99,000 or less.

Appendix 4–2: Example Design for Lot Sales and Custom Homes

EXAMPLE:



Compared to typical tract developments, there are many unknowns in lot sales, such as house sizes and load requirements. In many cases the actual load is underestimated, which contributes to overloaded load blocks and expensive rebuild projects. To avoid these types of situations, the following example provides considerations for Planners when designing a lot sales and customer homes:

1. Prerequisite information prior to start of design. See Section 4.0 (Page 4–3).
   a. Use surface operable equipment to comply with AGE initiative in the design.
   b. Consider area expansion using the master duct plan and zoning requirements.
   c. Overall of development plans, bridge, railroad, city street improvement.
   d. Master Duct Plan, DSP Plans, circuit loading
2. Use estimates based on the largest size home that could reasonably be placed on the lot to prevent overloaded load blocks.
3. Determine whether the area should be designed as a load block or system feeder (current and future). See Section 5.0 (Page 4–4).
   a. For non-arterial roadways, 1/0 or 350 JCN may be adequate; for aterial roadways, design the subsystems to ultimately accommodate 1000 JCN cable. See DDS–6, Section 2.1.

b. Determine structure spacing by the equivalent length for three-phase conductor.

c. Use 5-inch conduit for distribution-sized structures designed for primary. See DDS–6, Table 6–1.

4. Use switched fused padmounted transformers to reduce the risk of exceeding fuse capabilities. This strategy allows for greater flexibility should the system expand beyond the original load expectations. See Section 5.3 (Page 4–4).

5. For lot sales (5 or more lots), consider locating transformer structures at every other property line, with stubouts to adjacent properties. See Section 5.4, C (Page 4–12) and DDS–6, Table 6–1.

6. Lot sales may require a secondary system design independent of the residential load to feed streetlight, temporary power, and pedestals. See DDS–5, Section 3.0.

Southern California Edison
Transmission and Distribution

Chapter DDS–5: Street-Lighting Subsystems

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DDS—5
Street-Lighting Subsystems

1.0 Scope

This chapter provides the design criteria to determine allowable voltage drop for streetlights, and capacity of constant current street-lighting transformers. It also includes brief descriptions of available streetlight electroliers and luminaires. This chapter also applies to Edison-owned parking lot lighting subsystems in publicly owned and publicly operated parking lots.

2.0 Key Definitions

Chapter DDS–GL contains a glossary which includes the definition of key terms. A review of the glossary will assist in understanding the discussion in this standard.

3.0 Design Concept

Street-lighting subsystems are designed utilizing electroliers, luminaires, and serving conductors. The appropriate governmental agency, for example, lighting district is responsible to provide the streetlight layout design and material requirements. SCE is responsible for the design of the electrical service to the streetlight subsystem and, when requested, the streetlight installation. Lot sales may require a secondary system design independent of the residential load to feed streetlight, temporary power, and pedestals. See DDS–4, Section 5.2.

4.0 Prerequisite Information

A service Planner must have the following specific knowledge and information to design street-lighting subsystems:

4.1 Customer-Provided Information

- Scaled site, streetlight, and street improvement plans, as approved by the appropriate governmental agency (for example, the final customer of record)
- Stationed streetlight locations
- Connected streetlight load schedules
- Type of streetlight luminaires
- Type of streetlight electroliers
- Streetlight pole type and style (for example, OH on wood pole with mast arm, concrete octagonal, specialty pole)
- Streetlight profile (pole location at face of curb, back of sidewalk, parkway) See Figure 5–1
- Required source voltage
- Source structure locations
- Streetlight Authorization Letter (Advance Energy Charges status and Service Account Number)

- Application for Electrical Service — CSD-272 Contract

4.2 Required Knowledge

- Knowledge of *Distribution Construction Standards (DOH/DUG/UGS)*
- Knowledge of *Electrical Service Requirements* (*ESR*)
- Knowledge of Edison Policy & Procedure Central (EPPC) SCE-OPS-STREETLT-PR-55 (Street Lighting Guide ***Pricing)
- Costs for non-standard options and equipment (for example, pole color, anti-graffiti coating, painted arms, traffic control)
- Streetlight tariff schedules (LS-1, LS-2, or LS-3)
- Policies, procedures, and restrictions of Local Governmental Agencies (for example, lighting ordinances, equipment type, spacing)

5.0 Design Criteria

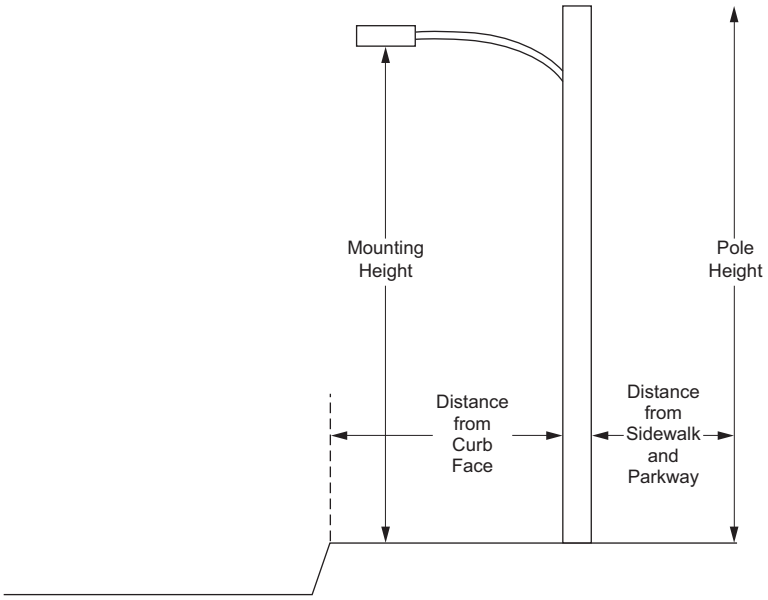
5.1 Streetlight Equipment

Upon receipt of the streetlight request and necessary information, the customer selects the luminaire and electrolier type. Appendix 5–1 illustrates the available standard and optional ornamental streetlight equipment.

5.2 Streetlight Location

Upon receipt of the approved, scaled, and stationed street light plans, the customer should provide the appropriate profile for each new streetlight location. The profile should show the proposed location of the streetlight in relationship to curb face, sidewalk, parkway, property line. See Figure 5–1: Streetlight Location Requirements.

Figure 5–1: Streetlight Location Requirements



5.3 Allowable Voltage Drop

The voltage drop to multiple type HPSV and LPSV luminaires is limited to five percent from the source transformer. The percent voltage drop can be evaluated using any of three separate methods, as shown in Appendix 5–2, Appendix 5–3, or Appendix 5–4 and described below.

All information for looped systems is for reference only; each streetlight must be independently fed.

A. Appendix 5–2 illustrates a method using a formula with constants from Table 5–1 for calculating percent voltage drop for various lamp sizes and types, and conductor sizes and lengths. This method is flexible enough to cover most any system configuration, but is fairly complex for systems with a string of lights. Examples are provided in the appendix.

SUMMARY FOR WHEN TO USE Table 5–1

On street-lighting systems that:

- are 120 V, two-wire (use duplex value) or 120/240 V, three-wire (use single-conductor values)
- and are made up of luminaires with the same or mixed wattages

B. Appendix 5–3 provides a simplified method for determining percent voltage drop for the most common streetlight installations. Table 5–2 through Table 5–5 give percent voltage drop for three HPSV streetlight sizes (5,800 lumen, 9,500 lumen, 16,000 lumen, and 22,000 lumen) with one to five lights served by a given length of #8 Aluminum cable. The voltage drop values for two to five lights are for looped streetlight systems which are not approved for new constructions. Examples are provided in the appendix.

   SUMMARY FOR WHEN TO USE Table 5–2 to Table 5–5 on street-lighting systems that:

   - are 120 V, two-wire
   - use #8 Al duplex
   - utilize luminaries with the same wattages

C. Appendix 5–4 provides an easy method to evaluate voltage drop for HPSV streetlight systems with a large number of equally spaced lights. Table 5–6, in the appendix, may be used to determine the maximum conductor length that will meet the five percent voltage-drop criteria for a given light size, conductor size, and nominal spacing. Examples are provided in the appendix.

   SUMMARY FOR WHEN TO USE Table 5–6 on street-lighting systems that:

   - are 120/240 V, three-wire
   - maintain equal spacing between streetlight poles
   - utilize luminaires with the same wattages

If the source for the streetlight conductor is a secondary handhole, a simple two-step process can be used to determine the percent voltage drop. First, calculate the percent voltage drop on the streetlight conductor using the method shown in Appendix 5–3. If the result is equal to or less than two percent, the design criteria is within allowable limits since the voltage drop to new residential homes must be less than or equal to three percent. Therefore, no further calculations are required.

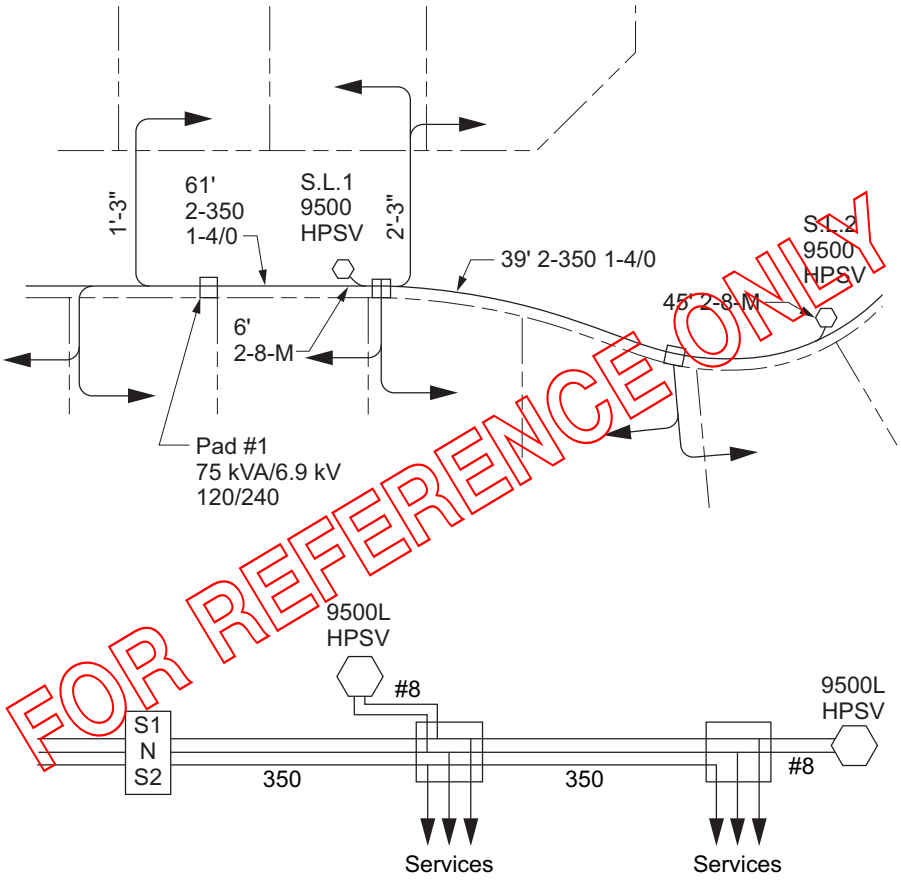
If the voltage drop on the streetlight conductor is greater than two percent, then it is necessary to consider the percent voltage drop (VD) on the secondary system. Voltage drop on the secondary system should be calculated per Chapter DDS–8, Section 2.3. The sum of the voltage drops on the secondary cable plus streetlight cables cannot exceed five percent.

Note: To calculate the voltage drop of a three-wire circuit, it is only necessary to determine the voltage drop in the phase conductor. In practical street-lighting systems, the neutral voltage drop is insignificant.

5.4 Multiple Streetlight Subsystems — Edison-Owned

Typically, Edison-owned streetlight subsystems are designed utilizing conventional construction for the electrical service. Figure 5–2 and Figure 5–3 illustrate these design concepts.

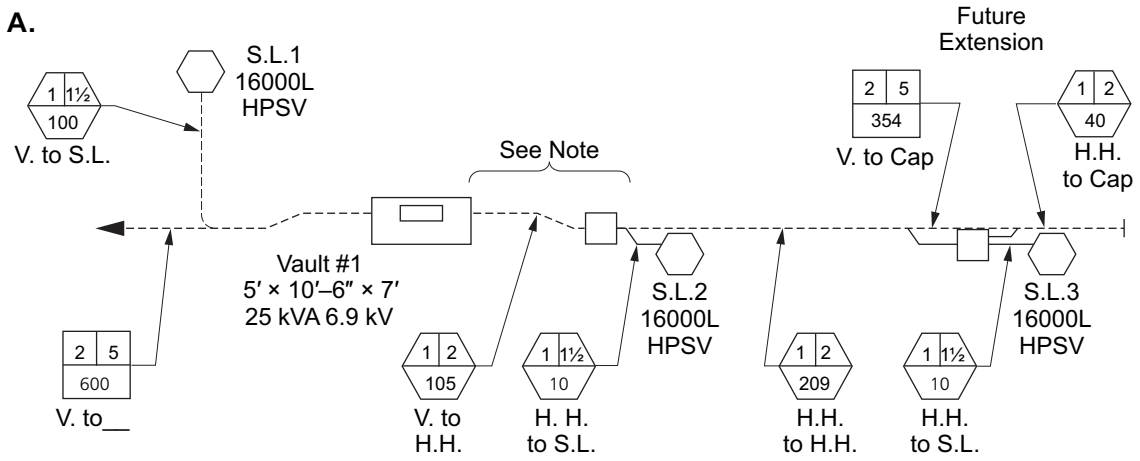
Figure 5–2: Streetlight Design CIC Construction



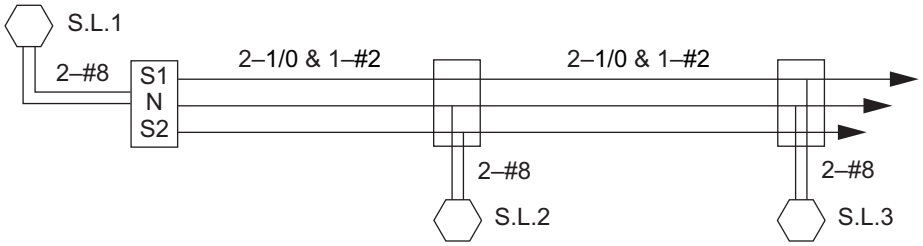
FOR REFERENCE ONLY

A. Streetlight subsystems are typically designed with conventional construction when installed in conjunction with conventional underground systems; Rule 20, residential, feeder, or C/I projects. As Figure 5–3 shows, the electrical source may be a transformer in a vault or a pad-mounted transformer.

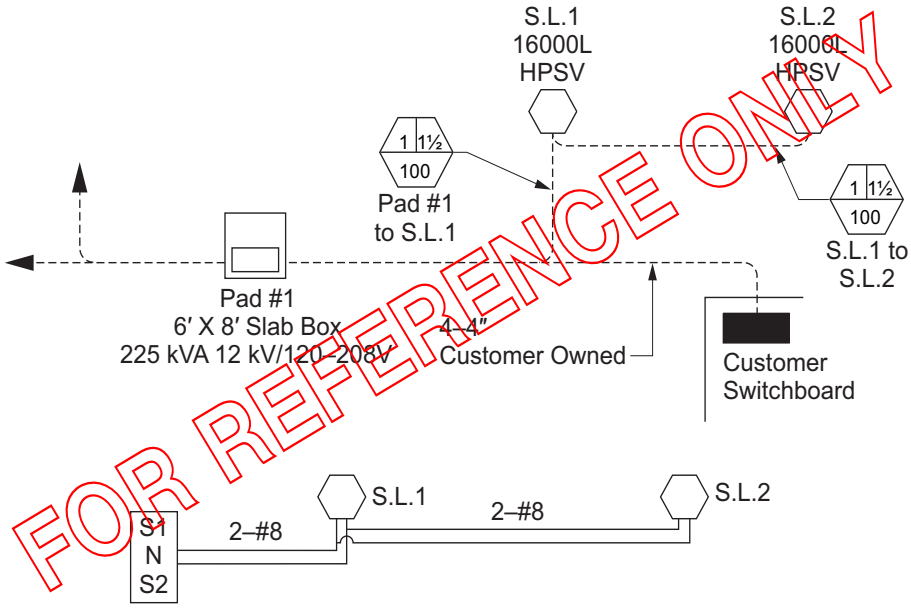
Figure 5–3: Streetlight Design Conventional Construction



Note: When two streetlight conduits parallel each other more than 100 feet, it is more economical to install an additional handhole. Therefore, an additional handhole is installed for S.L.2. This results in a savings, for example, only one conduit is needed to be installed from the vault for the first 105 feet for both streetlights S.L.2 and S.L.3.



B.



FOR REFERENCE ONLY

Figure 5–3, Diagram A, illustrates the 100 Foot Rule" stating that it is more economical to install an additional handhole than to have two streetlight conduits parallel each other more than 100 feet. This rule applies where voltage drop requires streetlight secondary cable larger than 2-#8 Al that cannot be looped in and out of the streetlight base. Looped streetlights systems are no longer valid for new construction.

Section UGS 175 in the *Distribution Underground Structures (DUG) Manual* illustrates the recommended configuration of handhole and conduits for streetlight foundations. Note that the largest size conduits that Edison terminates in the streetlight base is 1.5", and in a streetlight handhole is 2". See Chapter DDS–6, Table 6–4 for the appropriate handhole to use for the specific design. In consideration of permitted conduit sizes and available handholes for streetlight subsystems, typically the maximum size cables used for streetlight subsystems is 1/0.

B. When the only available source is a 277/480-V pad-mounted transformer, a dry transformer (277/120 V) installed in the transformer secondary compartment should be considered. This installation is shown on TX 250 and SL 450 in the *Construction Standards Manual*. This dry transformer is rated 1 kVA and should be used to serve a maximum of two 9,500 lumen or smaller HPSV lights or one larger light. When serving streetlights from a dry transformer, voltage drop on the streetlight cable should be limited to two percent.

5.5 Multiple Streetlight Subsystems — Customer-Owned

Service to customer-owned streetlight systems can be provided to unmetered (LS-2) or metered (LS-3) points of service. Services can also include combination streetlight and safety light requirements. Refer to SL 605-620 in the *Distribution Overhead Construction Standards (DOH) Manual* for material and equipment requirements.

The design criteria for minimum voltage levels for customer-owned streetlight systems are governed by CPUC Rule 2, 114-120 V. Therefore, the maximum percent voltage drop allowed to the point of service is nominally five percent. Typically, customer-owned streetlight luminaires incorporate regulated ballasts that allow for a ten percent voltage swing to properly start and operate the HPSV lamps.

5.6 Series Streetlight Subsystems

Series streetlight circuits are supplied by constant current or Regulated Output (RO) transformers which deliver a constant current of 6.6 A. Although there will be no new LS-1 series subsystems installed, existing subsystems must be maintained and occasionally modified.

According to the LS-2 and LS-3 tariffs, new or modified series installations shall be made only where, in the opinion of the Company, it is practical to supply series service. For new or modified series installations requiring a new RO transformer, the customer shall furnish and maintain the transformer; and service will be delivered at the primary side of the transformer.

It is generally not practical to serve mercury vapor, HPSV, or LPSV series installations. This is because of the high starting requirements of the lamps and the minimum/maximum load requirement for the RO transformer.

The loading of RO transformers is very critical. ROs are generally very inefficient and should not be overloaded or underloaded. A lightly loaded unit will experience excessive tank heating. This is because ROs are not built like normal distribution transformers, they have a movable secondary coil that adjusts its position depending on the load demand.

RO transformers should be loaded to a minimum of 60 percent and a maximum of 100 percent of their nameplate rating. In Appendix 5–5, Table 5–7 contains series streetlight data for various lamp types to be used in determining starting and running loads. Five percent should be added to the total volt-amps load to allow for line loss. Examples are provided in the appendix. The load on an existing series system can be field checked in accordance with the procedure in *Distribution Operation and Maintenance Policy and Procedures (DOM) Manual*, Procedure TR-5.

In the event of a failed RO transformer, contact the Street and Outdoor Lighting Organization (SOLO).

5.7 LS-2 and LS-3 Installations

A. LS-2

All LS-2 facilities installed in conjunction with or without metered traffic signals (TC-1) must be served using a service disconnect switch, a single master photocontroller, and an auxiliary relay when the wattage exceeds 1,000. SCE is responsible to provide the photocontroller and its maintenance for all LS-2 installations, whereas the customer is responsible for any auxiliary relays when required. Whenever LS-2 lights are installed with TC-1 installations, they must be reported to the Street and Outdoor Lighting Organization (SOLO) and be assigned to existing or new customer accounts.

Therefore, the service requirements for basic installation of LS-2 systems are as follows:

1. When the service is fed from an underground source, the customer is required to provide and install, at their expense, the photocontroller receptacle and auxiliary relay (when required) into a meter cabinet and pedestal. The photocontroller and its installation will be at SCE's expense.
2. When the service is fed from an overhead pole and the customer elects to install their safety-socket box or service disconnect switch on the pole, SCE will furnish and install above the safety-socket box or service disconnect switch all necessary material, including the photocontroller. The photocontroller and its installation will be at SCE's expense. All other material, including the photocontroller receptacle, auxiliary relay (when

required), and the necessary service cables and risers, and their installation, will be at the customer's expense. The customer will furnish and install the safety-socket box and/or the service switch box on the wood pole as shown in the *Distribution Overhead Construction Standards (DOH) Manual*, pages SL 605.1 and SL 605.4.

Services for a TC-1 with LS-2 safety lighting, where the safety-socket box is attached to the traffic controller cabinet, are to be installed using only the following two methods:

1. When the service is fed from an underground source, the customer is required to provide SCE with a photocontroller receptacle and auxiliary relay (when required), as shown in the *Distribution Overhead Construction Standards (DOH) Manual*, SL 605.2.
2. When the service is fed from an overhead source, SCE will furnish and install, at its own expense, the photocontroller on a wood pole. At the customer's expense, SCE will furnish and install the photocontroller receptacle, auxiliary relay (when required), and necessary service cable and risers.

When the customer elects to use a pedestal to serve their LS-2 or TC-1/LS-2 lighting system, SCE will furnish the photocontroller, and the customer will furnish, at their expense, the pedestal, complete with a service disconnect switch, photocontroller receptacle, and auxiliary relay (when required). For details and pedestal information, refer to the *Electrical Service Requirements (ESR) Manual,* Chapter ESR-3, Underground Service Connections 0–600 V.

B. LS-3

All streetlight controls for LS-3 services, including photocontrollers and relays, are the responsibility of the customer.

C. LS-2 and LS-3

LS-2 and LS-3 projects are installed to serve street-lighting systems, not single-lighting installations. These projects generally require/utilize pedestals to house the controls, disconnects, and/or metering for the street-lighting circuits. Therefore, for these types of installations, the cost of the pedestals will make LS-1 installations more practical.

References:

- *Distribution Overhead Construction Standards (DOH) Manual*
  T-128.4
  SL 100.4
  SL 605.1,.2, and.4
  SL 620.1 and.2
  SL 720
- Electrical Service Requirements (ESR)
  In ESR Chapter 3, refer to figure titled "Non-Residential Un-Metered Service Pedestal 0-200 amperes, 0-240 V, Single Phase, LS-2, Street-Lighting Systems Only."

5.8 Street-Lighting Modifications

Edison applies the term "street-lighting modification" to the changes made to an existing street-lighting subsystem (installation), when these changes are requested by the customer. The term "upgrade" is generally used when a customer requests Edison to install higher wattage lamps to increase existing light levels. For purposes of tariff application, any customer-requested changes to an existing installation, including upgrades, is a modification of that installation (see examples on the next page).

Examples of street-lighting subsystem modifications are as follows:

- Original Equipment: 70 W HPSV, cobra head luminaire
  Change to: 100 W HPSV, cobra head luminaire
- Original Equipment: 175 W mercury vapor, cobra head luminaire
  Change to: 100 W HPSV, cobra head luminaire
- Original Equipment: 55 W LPSV luminaire
  Change to: 70 W HPSV, cobra head luminaire

5.9 Acquisitions of Customer-Owned Street-Lighting Subsystems

Please refer all inquiries regarding the sale or purchase of a street-lighting subsystem to SOLO.

5.10 Special Conditions

A. Streetlight Structures — Responsible Organizations

- Wi-Fi antennas on streetlight structures
  Contact: IMS
- Streetlight replacements for non-SCE antennas on streetlight structues
  Contact: Edison Carrier Solutions (ECS)
- Non-electrified attachments on streetlight structures
  Contact: SOLO

B. Non-SCE Advance Metering Infrastructure (AMI) Equipment on SCE LS-1 Marbelites and Customer-Owned Streetlights

Non-SCE AMI equipment is only allowed on standard 28-foot SCE LS-1 marbelite streetlight poles or on a customer-owned streetlight served from SCE's unmetered LS-2 schedule. Equipment shall not interfere with the intended illumination pattern. The streetlight pole shall not be altered in order to accommodate the installation of the Non-SCE AMI equipment.

On SCE LS-1 marbelites, or customer-owned LS-2 streetlights, a maximum of 125 watts or less rated consumption attached to any one streetlight secondary circuit may be connected to SCE's transformer. A weather-resistant sign or decal shall be affixed to the equipment identifying the unit number (serial number). The decal must also identify the owner/operator and provide a 24-hour emergency contact number. Install and maintain each sign/decal to allow legible visual reading from ground level.

For installation of Non-SCE AMI equipment, the following is required:

1. In addition to required contracts, applicants must submit documentation as requested by IMS Group to confirm:
   - Radio equipment meets the requirements of 47 CFR Part 15 and IEEE 802.11
   - Radio equipment and Timed Auxiliary Power (TAP) devices are approved by SCE
   - Dimensions and weight of radio equipment is acceptable to SCE
2. Wi-Fi antennas shall only be installed according to clearances described in SCE's Distribution Overhead Construction Standards Manual, Section SL 108.
3. Joint Pole will process the License Agreement and pole space rental fees.

Appendix 5–1: Standard and Optional Streetlight Equipment *(Sheet 1 of 2)*

Standard Streetlight Equipment
High-Pressure Sodium Vapor, Low-Pressure Sodium Vapor, and Metal Halide

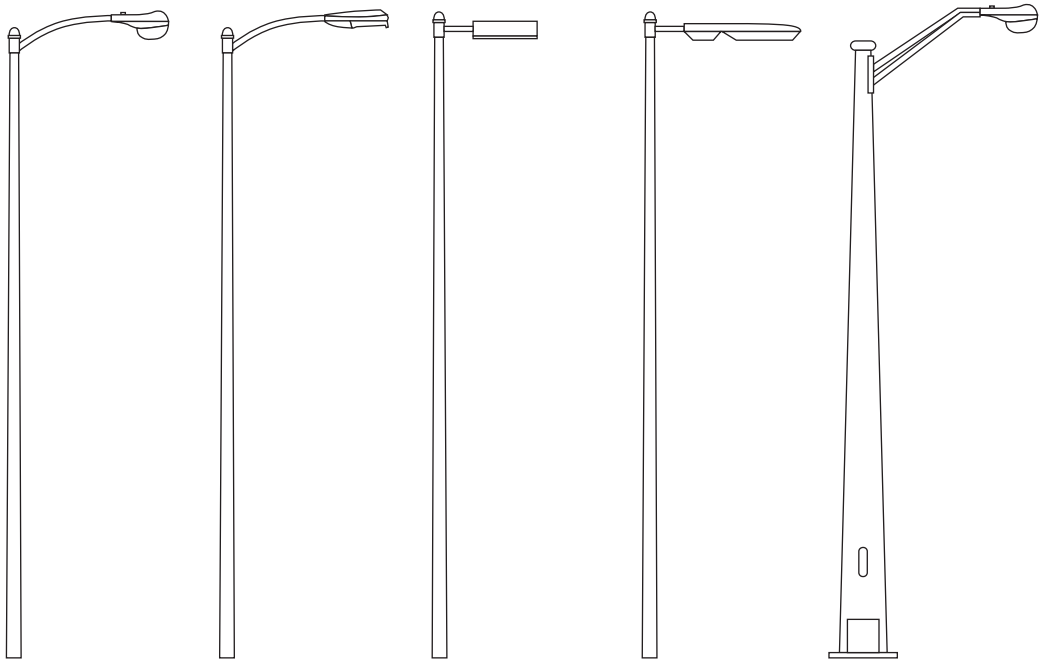


Figure 1 **Figure 2** **Figure 3** **Figure 4** **Figure 5 (Composite Only)**

	Luminaire Data		Concrete Pole Data		Composite Pole Data	
Figures	**Style**	**Wattage Available**	**Mounting Heights (ft)**	**Twin Arms Available**	**Mounting Heights (ft)**	**Twin Arms Available**
1 and 5	Cobra Head (Drop Glass)	50-400	18 25 30	Yes	18 25 30	Yes
2 and 5	Cobra Head (Cutoff)	70-400	18 25 30	Yes	18 25 30	Yes
3 and 5	LPSV (Cutoff)	25-180	18 25 30	Yes	18 25 30	Yes
4 and 5	LPSV (Drop Glass)	35-180	18 25 30	Yes	18 25 30	Yes

Appendix 5–1: Standard and Optional Streetlight Equipment *(Sheet 2 of 2)*

Optional Ornamental Streetlight Equipment
High Pressure Sodium Vapor and Metal Halide Street Lighting

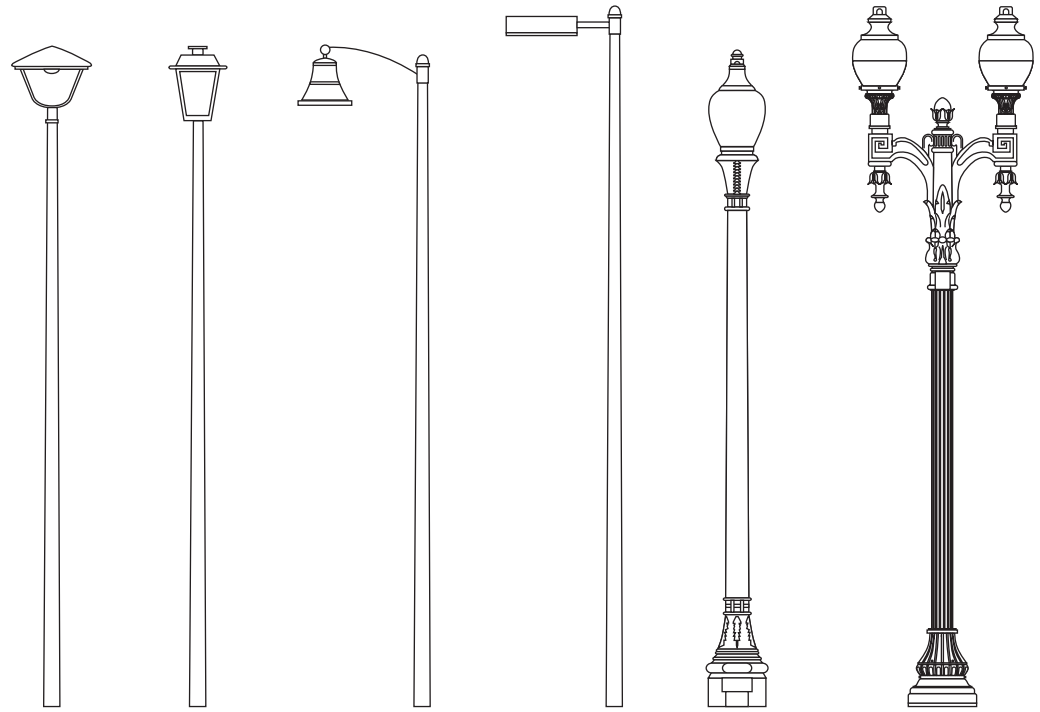


Figure 1 Figure 2 Figure 3 Figure 4 Figure 5 Figure 6

	Luminaire Data		Concrete Pole Data		Composite Pole Data	
Figure	**Style**	**Wattage Available**	**Mounting Heights (ft)**	**Twin Arms Available**	**Mounting Heights (ft)**	**Twin Arms Available**
1	Lawnaire[a/]	50-100	19	No	1 feet	No
2	Colonial	70-250	25 30	No	25 30	No
3	Mission Bell	70-400	25 30	Yes	25 30	Yes
4	Rectilinear	70-400	25 30	Yes	25 30	Yes
5	Nostalgic	50-250	16	No	16	No
6	Nostalgic	50-250	19	Yes	19	Yes

[a/] Luminaire is available for new streetlight installations. Schedule DWL "Residential Walkway Lighting" is available only for replacement maintenance.

Appendix 5–2: Voltage Drop — Table of Constants and Examples *(Sheet 1 of 6)*

Table 5–1: Voltage Drop Constants

Nominal Lamp Watt	Initial Lamp Lumen	120V Running Amps	Lamp Type	Percent Voltage Drop Per 100 Feet (Voltage Drop Constants are Based on an 80% PF)					
				Duplex			Single Conductor		
				#8 Al	#6 Al	#6 Cu	#4 Al	#2 Al	#1/0 Al
		1.00		0.169	0.109	0.067	0.034	0.022	0.015
50	4,000	1.20	HPSV	0.203	0.131	0.080	0.041	0.026	0.018
70	5,800	1.60	HPSV	0.270	0.174	0.107	0.054	0.035	0.024
100	9,500	2.20	HPSV	0.372	0.240	0.147	0.075	0.048	0.033
150	16,000	3.30	HPSV	0.558	0.360	0.221	0.112	0.073	0.050
200	22,000	4.80	HPSV	0.811	0.523	0.322	0.163	0.106	0.072
250	27,500	2.60	HPSV*	0.439	0.283	0.174	0.088	0.057	0.039
400	50,000	4.00	HPSV*	0.676	0.436	0.268	0.136	0.088	0.060
35	4,800	0.70	LPSV*	0.118	0.076	0.047	0.024	0.015	0.011
55	8,000	0.80	LPSV*	0.135	0.087	0.054	0.027	0.018	0.012
90	13,500	1.30	LPSV*	0.220	0.142	0.087	0.044	0.029	0.020
135	22,500	1.70	LPSV*	0.287	0.185	0.114	0.058	0.037	0.026
180	33,000	2.10	LPSV*	0.355	0.229	0.141	0.071	0.046	0.032
100	8,500	1.00	MH*	0.169	0.109	0.067	0.034	0.022	0.015
175	12,000	1.80	MH	0.304	0.196	0.121	0.061	0.040	0.027
250	19,500	2.50	MH	0.423	0.273	0.168	0.085	0.055	0.038
400	32,000	4.00	MH	0.676	0.436	0.268	0.136	0.088	0.060

Notes:

1: The 120 V Running amps are based upon the Line Operating amps using G. E. ballasts. (Resultant values are based on the largest current draw from each ballast type(s) used per lamp wattage.)

2: All of the 120 V Running amps values for LPSV lamps were obtained from American Electric Lighting's chart of Low-Pressure Sodium Lamp data.

3: Asterisk (*) denotes luminaire with HPF ballast.

4: Percent voltage drop based on 120 V = 100%, overhead or underground conductors.

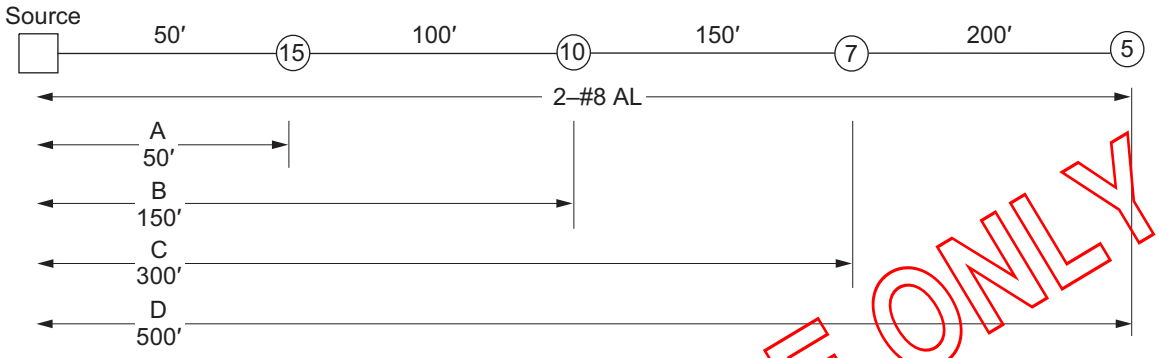
5: The constants are applicable to aluminum multiplex (overhead) or CLP (underground) cable.

6: The resistance of aluminum conductor is at 65 degrees C for the voltage drop calculation.

$$\textbf{FORMULA: \% Voltage Drop} = \frac{\textbf{Conductor Run in Feet}}{\textbf{100}} \times \textbf{Constant}$$

VOLTAGE DROP CALCULATION EXAMPLES

Example 1: 2-Wire, 120 V—Lights of Different Sizes



Problem:

Determine the total voltage drop at the last light.

Solution:

Using Table 5–1 (Page 5–16) in this chapter for #8 aluminum two-wire 120 V, the voltage drops contributed by the various lights are as follows:

For 150 W HPSV at 50 feet on 2 #8 aluminum

$$VD\,(A) = \frac{50}{100} \times (0.558) = 0.28\%$$

For 100 W HPSV at 150 feet on 2 #8 aluminum

$$VD\,(B) = \frac{150}{100} \times (0.372) = 0.56\%$$

For 70 W HPSV at 300 feet on 2 #8 aluminum

$$VD\,(C) = \frac{300}{100} \times (0.270) = 0.81\%$$

For 50 W HPSV at 500 feet on 2 #8 aluminum

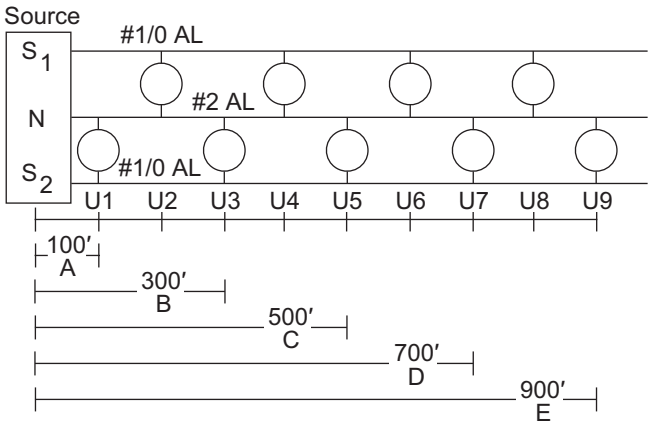
$$VD\,(D) = \frac{500}{100} \times (0.203) = 1.02\%$$

$$\text{Total voltage drop at 50 W HPSV light} = 2.67\%$$

Since this total is less than the allowable 5.0 percent limit, the design is satisfactory.

FOR REFERENCE ONLY

Example 2: 3-Wire 120/240 V—All Lights Same Size, 150 W (16,000 LUMENS) HPSV, 100 FT Nominal Spacing



To calculate the voltage drop of a 3-wire circuit, it is only necessary to determine the voltage drop in the phase conductor. In practical street-lighting systems, the neutral voltage drop is insignificant.

Problem:

Determine the total voltage drop for the phase at the last light.

Solution:

Using Table 5–1 (Page 5–16) in this chapter for #1/0 aluminum single conductor, the voltage drops in phase wire S_2 contributed by the various lights are as follows:

VD (A) = 1 - 150 W HPSV at 100 ft on #1/0 Aluminum = 100/100 × (0.050) = 0.05%

VD (B) = 1 - 150 W HPSV at 300 ft on #1/0 Aluminum = 300/100 × (0.050) = 0.15%

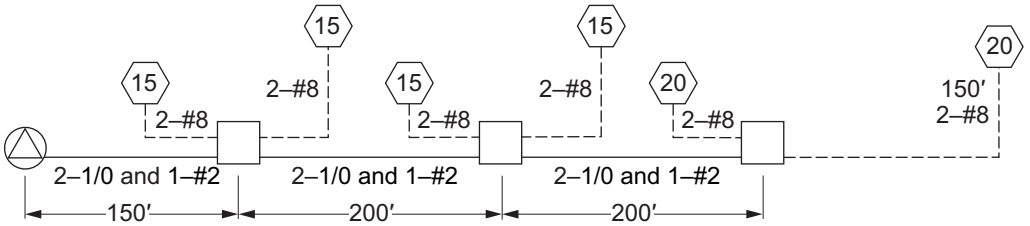
VD (C) = 1 - 150 W HPSV at 500 ft on #1/0 Aluminum = 500/100 × (0.050) = 0.25%

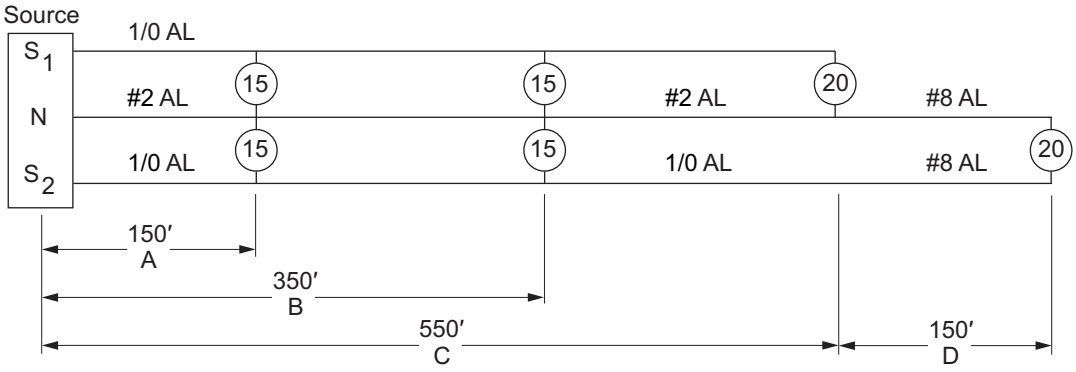
VD (D) = 1 - 150 W HPSV at 700 ft on #1/0 Aluminum = 700/100 × (0.050) = 0.35%

VD (E) = 1 - 150 W HPSV at 900 ft on #1/0 Aluminum = 900/100 × (0.050) = 0.45%

Total Voltage Drop at U9 = 1.25%

Example 3: 3-Wire, 120/240 V—Lights of Different Size





Problem:

Determine the total voltage drop at the last light.

Solution:

From Table 5–1 in this chapter, Voltage Drop Per Single Conductor, the voltage drops in phase wire S_2 contributed by the various lights are as follows:

$$VD(A) = \text{150 W HPSV @ 150' on 1/0 aluminum} = \frac{150}{100} \times (0.050) = 0.08\%$$

$$VD(B) = \text{150 W HPSV @ 350' on 1/0 aluminum} = \frac{350}{100} \times (0.050) = 0.18\%$$

$$VD(C) = \text{200 W HPSV @ 550' on 1/0 aluminum} = \frac{550}{100} \times (0.072) = 0.40\%$$

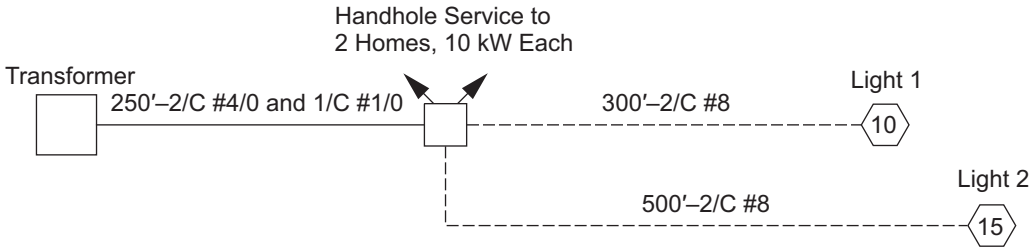
For 200 W HPSV on 2-#8 aluminum, the constant is 0.811.

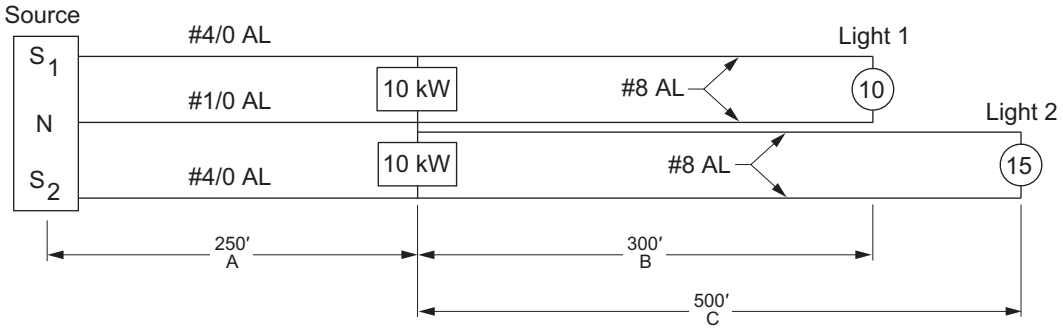
$$VD(D) = \text{200 W HPSV @ 150' ON 2-\#8 aluminum} = \frac{150}{100} \times (0.811) = 1.22\%$$

$$\text{Voltage drop in phase wire } S_2 = 0.08 + 0.18 + 0.40 + 1.22 = \underline{\underline{1.88}}\%$$

Appendix 5–2: Voltage Drop — Table of Constants and Examples *(Sheet 5 of 6)*

Example 4: Streetlights Served from Secondary Handhole





Problem:

I. Determine the voltage drop at light "1".

II. Determine the voltage drop at light "2".

Solution:

I. Using Table 5–1 in this chapter for #8 aluminum duplex, the voltage drop in the #8 duplex contributed by light I is as follows:

VD (B) = 100 W HPSV at 300′ on two #8 aluminum = $\frac{300}{100} \times (0.372) = 1.12\%$

The percent VD is within the allowable two-percent limit from a secondary low-voltage handhole. Therefore no further calculations are required.

II. The voltage drop in the #8 duplex contributed by light II is as follows:

VD (C) = 150 W HPSV at 500′ on two #8 aluminum $\frac{500}{100} \times (0.558) = 2.79\%$

The percent VD is larger than two percent; proceed to calculate the percent VD on the secondary subsystem per DDS–8, 3.3 "Voltage Drop Determination — Residential or Commercial/Industrial" and Table 8–1.

The secondary subsystem at (A) is made up of; the house loads (20 kW) plus the streetlight lamp loads (0.1 kW + 0.15 kW).

Thus, the percent VD on the secondary subsystem at (A) is:

$$\frac{VD(A) = 250 \text{ ft} \times (20 \text{ kW} + 0.1 \text{ kW} + 0.15 \text{ kW}) \times (0.0389\%/\text{kW})}{100 \text{ ft}}$$

$$VD(A) = 1.97\%$$

Therefore, the sum of the voltage drops on the secondary cable plus streetlight cable for light 2 is 2.79 percent plus 1.97% = 4.76%. Since this total is less than the allowable five percent-limit, the design is satisfactory.

Appendix 5–3: Percent Voltage Drop — HPSV Lights with #8 Al Duplex Cable *(Sheet 1 of 6)*

PERCENT VOLTAGE DROP HPSV LIGHTS WITH #8 AL CABLE

Table 5–2 through Table 5–5 provides a quick method to determine voltage drop for four common sizes of HPSV streetlights served with #8 Aluminum cable. Using the table for the appropriate lamp size, choose the row and column that corresponds to the number of lights and length of conductor to find the percent voltage drop for each run of cable. Add the voltage drop for each run of cable to determine the total voltage drop to the last light. See the examples following the tables.

Table 5–2: Percent Voltage Drop 5,800L HPSV, 70W with 2-#8 Al, 120 V

Conductor Feet	Number of Street Lights				
	1	2	3	4	5
10	0.03	0.05	0.08	0.11	0.14
20	0.05	0.11	0.16	0.22	0.27
30	0.08	0.16	0.24	0.32	0.41
40	0.11	0.22	0.32	0.43	0.54
50	0.14	0.27	0.41	0.54	0.68
60	0.16	0.32	0.49	0.65	0.81
70	0.19	0.38	0.57	0.76	0.95
80	0.22	0.43	0.65	0.86	1.08
90	0.24	0.49	0.73	0.97	1.22
100	0.27	0.54	0.81	1.08	1.35
120	0.32	0.65	0.97	1.30	1.62
140	0.38	0.76	1.13	1.51	1.89
160	0.43	0.86	1.30	1.73	2.16
180	0.49	0.97	1.46	1.94	2.43
200	0.54	1.08	1.62	2.16	2.70
220	0.59	1.19	1.78	2.38	2.97
240	0.65	1.30	1.94	2.59	3.24
260	0.70	1.40	2.11	2.81	3.51
280	0.76	1.51	2.27	3.02	3.78
300	0.81	1.62	2.43	3.24	4.05
320	0.86	1.73	2.59	3.46	4.32
340	0.92	1.84	2.75	3.67	4.59
360	0.97	1.94	2.92	3.89	4.86
380	1.03	2.05	3.08	4.10	
400	1.08	2.16	3.24	4.32	

Notes: Columns 2 through 5 not approved for use on new construction.

Appendix 5–3: Percent Voltage Drop — HPSV Lights with #8 Al Duplex Cable *(Sheet 2 of 6)*

Table 5–3: Percent Voltage Drop 9,500L HPSV, 100W with 2-#8 Al, 120 V

Conductor Feet	Number of Street Lights				
	1	2	3	4	5
10	0.04	0.07	0.11	0.15	0.19
20	0.07	0.15	0.22	0.30	0.37
30	0.11	0.22	0.33	0.45	0.56
40	0.15	0.30	0.45	0.60	0.74
50	0.19	0.37	0.56	0.74	0.93
60	0.22	0.45	0.67	0.89	1.12
70	0.26	0.52	0.78	1.04	1.30
80	0.30	0.60	0.89	1.19	1.49
90	0.33	0.67	1.00	1.34	1.67
100	0.37	0.74	1.12	1.49	1.86
120	0.45	0.89	1.34	1.79	2.23
140	0.52	1.04	1.56	2.08	2.60
160	0.60	1.19	1.79	2.38	2.98
180	0.67	1.34	2.01	2.68	3.35
200	0.74	1.49	2.23	2.98	3.72
220	0.82	1.64	2.46	3.27	4.09
240	0.89	1.79	2.68	3.57	4.46
260	0.97	1.93	2.90	3.87	4.84
280	1.04	2.08	3.12	4.17	
300	1.12	2.23	3.35	4.46	
320	1.19	2.38	3.57	4.76	
340	1.26	2.53	3.79		
360	1.34	2.68	4.02		
380	1.41	2.83	4.24		
400	1.49	2.98	4.46		

Notes: Columns 2 through 5 not approved for use on new construction.

Table 5–4: Percent Voltage Drop 16,000L HPSV, 150W with 2-#8 Al, 120 V

Conductor Feet	Number of Street Lights				
	1	2	3	4	5
10	0.06	0.11	0.17	0.22	0.28
20	0.11	0.22	0.33	0.45	0.56
30	0.17	0.33	0.50	0.67	0.84
40	0.22	0.45	0.67	0.89	1.12
50	0.28	0.56	0.84	1.12	1.40
60	0.33	0.67	1.00	1.34	1.67
70	0.39	0.78	1.17	1.56	1.95
80	0.45	0.89	1.34	1.79	2.23
90	0.50	1.00	1.51	2.01	2.51
100	0.56	1.12	1.67	2.23	2.79
120	0.67	1.34	2.01	2.68	3.35
140	0.78	1.56	2.34	3.12	3.91
160	0.89	1.79	2.68	3.57	4.46
180	1.00	2.01	3.01	4.02	
200	1.12	2.23	3.35	4.46	
220	1.23	2.46	3.68	4.91	
240	1.34	2.68	4.02		
260	1.45	2.90	4.35		
280	1.56	3.12	4.69		
300	1.67	3.35			
320	1.79	3.57			
340	1.90	3.79			
360	2.01	4.02			
380	2.12	4.24			
400	2.23	4.46			

Notes: Columns 2 through 5 not approved for use on new construction.

Appendix 5–3: Percent Voltage Drop — HPSV Lights with #8 Al Duplex Cable *(Sheet 4 of 6)*

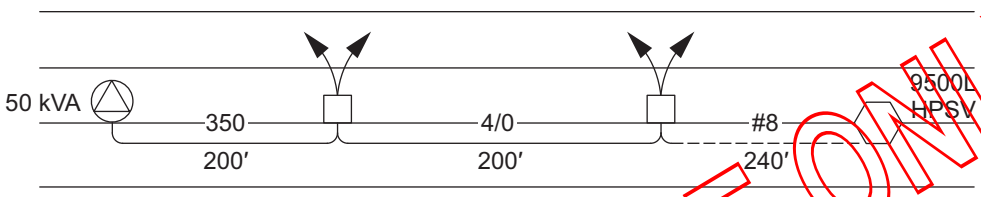
Table 5–5: Percent Voltage Drop 22,000L HPSV, 200W with 2-#8 Al, 120 V

Conductor Feet	Number of Street Lights				
	1	2	3	4	5
10	0.08	0.16	0.24	0.32	0.41
20	0.16	0.32	0.49	0.65	0.81
30	0.24	0.49	0.73	0.97	1.22
40	0.32	0.65	0.97	1.30	1.62
50	0.41	0.81	1.22	1.62	2.03
60	0.49	0.97	1.46	1.95	2.43
70	0.57	1.14	1.70	2.27	2.84
80	0.65	1.30	1.95	2.60	324
90	0.73	1.46	2.19	2.92	3:65
100	0.81	1.62	2.43	3.24	4.06
120	0.97	1.95	2.92	3.89	4.87
140	1.14	2.27	3.41	4.54	
160	1.30	2.60	3.89		
180	1.46	2.92	4.38		
200	1.62	3.24	4.87		
220	1.78	3.57			
240	1.95	3.89			
260	2.11	4.22			
280	2.27	4.54			
300	2.43	4.87			
320	2.60				
340	2.76				
360	2.92				
380	3.08				
400	3.24				

Notes: Columns 2 through 5 not approved for use on new construction.

Appendix 5–3: Percent Voltage Drop — HPSV Lights with #8 Al Duplex Cable *(Sheet 5 of 6)*

Example 1:

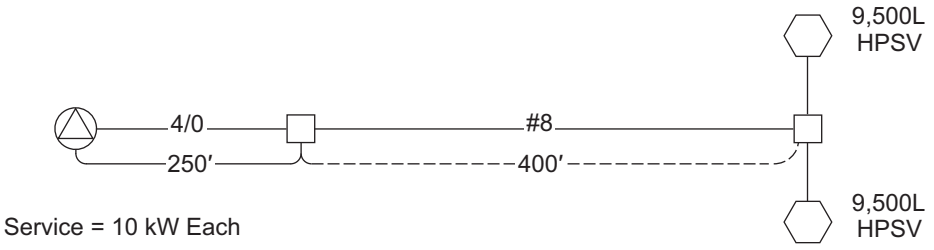


For the above system, determine if the voltage drop to the 9,500L HPSV streetlight meets the five percent voltage drop design criteria. Assume each service to be 5 kW demand. From Table 5–3, the voltage drop from the nearest handhole to the streetlight is 0.89 percent. The voltage drop at the last secondary handhole must always be three percent or less in order to meet design criteria of three percent VD to new residences. Therefore, the voltage drop to the streetlight cannot exceed 3% +.89% = 3.89%. Since this is less than five percent, the actual calculation of the voltage drop in the secondary system is not necessary.

FOR REFERENCE ONLY

Appendix 5–3: Percent Voltage Drop — HPSV Lights with #8 Al Duplex Cable *(Sheet 6 of 6)*

Example 2:



Determine if the above system meets allowable voltage drop design criteria for streetlights.

First, Table 5–3 gives a result of 2.98 percent for the #8 Al streetlight conductor. Since this exceeds two percent, the contribution of voltage drop for the secondary system must be calculated per Chapter DDS-8, Table 8–1.

The secondary subsystem is made up of the 10 kW load at 250 feet from the service, plus the two streetlight lamp loads (0.10 kW x 2 = 0.20 kW).

Thus, the percent VD sec is:

$$VD \text{ sec} = \frac{250 \text{ ft} \times (10\ kW + 0.20\ kW) \times \left(0.0389 \frac{\%}{kW}\right)}{100 \text{ ft}}$$

$$VD \text{ sec} = 0.99\%$$

Therefore, TOTAL percent VD = % VD_{sec} + % VDS.L.

TOTAL percent VD = 0.99% + 2.98% = 3.97%

Since the total voltage drop is less than the allowable 5.0 percent limit, the design is satisfactory.

Appendix 5–4: Allowable Cable Length — Table and Example *(Sheet 1 of 2)*

The Table 5–6 provides a quick method to check the voltage drop design criteria. Using the table, choose the row and column that corresponds to the HPSV lamp size, nominal spacing and conductor size to determine the maximum conductor length that will keep voltage drop below five percent. See the example following the table.

Table 5–6: Allowable Conductor Length from the Source to the Last Streetlight Three-Wire, 120/240 V, HPSV Lamps

Allowable Conductor Lengths (from the source to the last streetlight) for streetlight poles installed at a:										
Cable Size	**Nominal Spacing at 75′**	**% Voltage Drop**	**Nominal Spacing at 100′**	**% Voltage Drop**	**Nominal Spacing at 125′**	**% Voltage Drop**	**Nominal Spacing at 150′**	**% Voltage Drop**	**Nominal Spacing at 175′**	**% Voltage Drop**
22,000 lumens HPSV (200 Watts)										
1/0 Al	1,350′	4.86%	1,500′	4.61%	1,625′	4.41%	1,800′	4.54%	1,925′	4.54%
2 Al[a/]	1,050′	4.44%	1,200′	4.44%	1,375′	4.75%	1,500′	4.75%	1,575′	4.62%
16,000 lumens HPSV (150 Watts)										
1/0 Al	1,650′	4.90%	1,900′	4.95%	2,000′	4.46%	2,250′	4.75%	2,450′	4.85%
2 Al[a/]	1,350′	4.90%	1,500′	4.65%	1,625′	4.45%	1,800′	4.57%	1,925′	4.57%
9,500 lumens HPSV (100 Watts)										
1/0 Al	2,025′	4.85%	2,300′	4.75%	2,625′	4.99%	2,850′	4.95%	2,975′	4.68%
2 Al[a/]	1,650′	4.79%	1,900′	4.84%	2,125′	4.90%	2,250′	4.65%	2,450′	4.74%
5,800 lumens HPSV (70 Watts)										
1/0 Al	2,400′	4.90%	2,700′	4.70%	3,000′	4.68%	3,300′	4.75%	3,500′	4.62%
2 Al[a/]	1,950′	4.80%	2,200′	4.65%	2,500′	4.84%	2,700′	4.75%	2,975′	4.99%

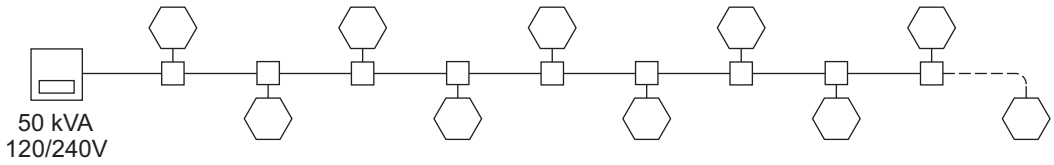
[a/] Not approved for use on new installations.

Appendix 5–4: Allowable Cable Length — Table and Example *(Sheet 2 of 2)*

Example 1:

A developer brings in a set of streetlight plans approved by the city. The plans call for 10 Edison-owned streetlights to be installed along a major street through the residential development. No new homes directly face onto the street, and the plan shows that the lights are 22,000 lumen HPSV, spaced 175 feet apart. The nearest sources is a pad-mounted transformer 150 feet from the first light. Determine the required service cable size.

Using the "100-foot rule," the most economical design calls for a handhole to be installed for each streetlight at the location where the conduit to the light breaks away from the main line trench. This design is shown below.



Notes:

1. All lights 22,000 L.N.D.S.
2. Streetlight spacing at 175 feet.
3. 2" duct between handholes, 10 feet of 1-1/2" duct between handhole to light.

Problem:

Determine the most economical conductor size for this installation.

Solution:

To determine the required conductor size to meet the five percent voltage-drop criteria, use Table 5–6 for 22,000 lumen HPSV. From the table, the allowed conductor length for 1/0 Al is 1,925 feet for 175 feet spacing at five percent voltage drop. Since the total conductor length (10 × 175 feet) or 1,750 feet is within the allowed length, 1/0 Al is the most economical conductor size.

Appendix 5–5: Series Streetlights — RO Transformer Loading Examples *(Sheet 1 of 4)*

Series StreetLights

RO transformers should be loaded to a minimum of 60 percent and a maximum of 100 percent of their nameplate rating. Table 5–7 contains series streetlight data for various lamp types to be used in determining starting and running loads. Five percent should be added to the total Volt-amps load to allow for line loss. See the examples following the table.

Table 5–7: Series Streetlight Data

Lamp Type	Lamp Watt Rating	Lamp Lumen Rating	Running Volts Per Unit	Volt-Amps Per Unit	
				Running*	Starting**
Incandescent	103 202 327 448 690	1,000 2,500 4,000 6,000 10,000	11.0 24.9 37.0 52.0 91.7	73 164 244 343 605	73 164 244 343 605
Mercury Vapor	100 175 250 400 700 1,000	4,000 7,900 12,000 21,000 41,000 55,000	22 38 49 72 128 189	145 251 323 475 845 1,247	300 400 470 650 1,200 1,550
High Pressure Sodium Vapor	50 70 100 150 200	4,000 5,800 9,500 16,000 22,000	13 17 23 32 47	93 118 170 235 360	200 280 400 570 750
Low-Pressure Sodium Vapor	35 55 90 135 180	4,800 8,000 13,500 22,500 33,000	8 11 20 28 40	53 73 132 185 264	250 260 440 600 600

* "Running" volt-amps per unit should be used to evaluate minimum RO load requirements

** "Starting" volt-amps per unit should be used to determine RO transformer size

Table 5–8: Performance Data for Constant-Current Regulators (RO Transformers)

kW Rating	Approx. kVA Input at All Loads	Secondary Open Circuit Voltage	Secondary Normal Load Voltage	Approx. MAX Output at Unity PF-kW	Efficiency [a/]				Primary Power Factor (%)			
					Full Load	3/4 Load	1/2 Load	1/4 Load	Full Load	3/4 Load	1/2 Load	1/4 Load
6.6 Amperes Secondary												
10	14.1	2,090	1,515	11.30	95.1	93.5	90.4	82.2	75	56	38	20
15	21.0	3,090	2,270	16.95	95.8	94.3	91.7	84.3	75	56	38	20
20	27.8	4,090	3,020	22.6	96.2	95.0	92.5	85.9	75	56	38	20
25	34.6	5,110	3,790	28.3	97.0	95.9	93.7	87.5	75	56	38	20
30	41.5	6,130	4,550	33.9	97.0	96.0	93.9	88.5	75	56	38	20

[a/] Conventional efficiency based on I^2R loss at 75 degrees C and measured core loss at normal primary voltage with secondary open.

Appendix 5–5: Series Streetlights — RO Transformer Loading Examples *(Sheet 3 of 4)*

Example 1:

Determine the RO transformer size required to serve a 6.6 A series circuit with the following mix of lamp sizes: 30 - 2,500 lumen incandescent, 10 - 10,000 lumen incandescent, and 8 - 22,000 lumen HPSV.

Calculate the starting load and determine the RO size required that will not exceed the maximum RO load requirement (100 percent):

Starting Load = # of Lamps × Starting Volt-Amps

30 - 2,500 lumen incandescent lamps	30 × 164 = 4,920 volt-amps
10 - 10,000 lumen incandescent lamps	10 × 605 = 6,050 volt-amps
8 - 22,000 lumen HPSV lamps	8 × 750 = 6,000 volt-amps
Subtotal	=16,970 volt-amps
5% Line Loss	= 849 volt-amps
Total Starting Load	= 17,819 volt-amps

This installation will require a 20 kW RO transformer to handle the lamp starting requirements.

Calculate the running load and check against the minimum load requirement for a 20 kW RO:

Running Load = # of Lamps × Running Volt-Amps

30 - 2,500 lumen incandescent lamps	30 × 164 = 4,920 volt-amps
10 - 10,000 lumen incandescent lamps	10 × 605 = 6,050 volt-amps
8 - 22,000 lumen HPSV lamps	8 × 360 = 2,880 volt-amps
Subtotal	= 13,850 volt-amps
5% Line Loss	= 693 volt-amps
Total Running Load	= 14,543 volt-amps

Minimum Load on a 20 kW RO is 60% or 20 x 0.6 = 12 kW or 12,000 volt-amps

A 20 kW RO is the proper size for this installation. It meets both the maximum load requirement (100 percent) for the starting load and the minimum load requirement (60 percent) for the running load.

Example 2:

In conjunction with a Rule 20 A conversion project 15 of 50 existing 6,000 Lumen 6.6 A Incandescent streetlights will be converted to multiple feed. Determine if, after the lights are removed, the 35 remaining streetlights will meet the minimum load requirement for the existing 25 kW RO transformer.

Running Load = # of Lamps × Running Volt-Amps

35 - 6,000 lumen incandescent lamps	35 × 343	= 12,005 volt-amps
	5% Line Loss	= 600 volt-amps
	Total Load	= 12,605 volt-amps

Minimum Load on a 25 kW RO is 60% or 25 × 0.6 = 15 kW or 15,000 Volt-amps

The remaining streetlight load is less than the minimum for a 25 kW RO, therefore the RO must be replaced with a smaller size so that the load falls between 60 percent and 100 percent of the RO nameplate rating. In this example a 15 kW should be installed.

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SOUTHERN CALIFORNIA EDISON
TRANSMISSION AND DISTRIBUTION

Section DDS–6: Underground Structure Applications

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1.0 Scope

This chapter provides criteria to be used in selecting the proper size structures that will accommodate equipment planned for new installations and also help determine equipment that may be installed in existing structures.

1.1 Above-Ground Equipment Policy

Effective August 2, 2010, SCE has implemented the Above-Ground Equipment (AGE) Policy as required by the California Public Utility Commission (CPUC). This policy will no longer accept requests for underground distribution systems that call for specified pieces of electrical equipment, for example, sub-surface equipment, to be installed in below-ground structures except in the following conditions:

A. In circumstances where it is technically not feasible to install equipment above ground. Technically Feasible is defined as:

> "The availability of the required physical space, either readily available or through architectural design, that can be set aside to accommodate the required electrical distribution equipment necessary for SCE to serve the customer. The required physical space includes the necessary room for structures, required perimeter walls or barriers and required operating clearances for equipment. The required space is defined by existing design standards within the operation and maintenance requirements that are incompliance with applicable safety codes and regulations such as CPUC General Order 128."

The required physical space includes the necessary room for structures, retaining walls or barriers and maintaining the required working clearances around pad-mounted equipment as shown in the *UGS Manual*.

B. Emergency situations or unplanned outages - Failed below-ground equipment in sub-surface operable enclosures will be replaced with similar below-ground equipment.

C. Installations in the public property and public rights-of-way where the local governments create insurmountable obstacles for pad-mounted equipment.

1.2 AGE Replacement Consideration

Consideration should be given to replacing existing below-ground equipment with aboveground equipment in the following situations.

A. On load additions projects if the load addition results from "customer-driven renovations of existing structures or other building activities resulting in a change of use or occupancy as defined by state or local law"; or,

B. Planned maintenance activities where obtaining appropriate easements for access and operations are possible.

Considerations should include minimizing additional SCE and customer costs, and whether the conversion is "technically" feasible as described in Sub-section 1.1.

1.3 Structure Application Table Discussion

Tables are provided that identify typical applications and the maximum equipment/cable recommended for each structure type and size. For those installations that would exceed these tables, contact Field Engineering for deviation approval. Each vault and associated equipment/cable has been sized to support worker and operation safety.

2.0 Design Criteria

Structures should be installed to accommodate anticipated growth and system needs for the next 10 years. For growth areas, a Master Duct Plan for feeder duct, circuitry, and cabling should be developed and reviewed periodically with Field Engineering.

2.1 Structure Type

Pad-mounted or surface-operable equipment and structures are the standard structure type to be used in the Edison Underground System.

When sub-surface structures are allowed per the AGE Initiative, tub-type structures are standard for vaults, manholes, Surface-Operable Enclosures (SOEs), and Pad-Mounted, Elbow-Connected (PME) structures used for feeder and Commercial/Industrial (C/I) systems. Tunnel or poured-in-place structures shall be installed on an exception basis only.

Bart Pads shall be used: (1) to retrofit situation where the existing fuse cabinet, and/or BURD or Subway transformers installed in a fenced enclosure or building vault need to be replaced with pad-mounted equipment, or (2) in new installations where a three-phase pad-mounted transformer is required for transformer room (walk-in vault) applications. See Table 6–8 for sizing and equipment.

For lot sales (five or more lots), if the development is determined to be a feeder system, and is a non-arterial roadway, 1/0 or 350 JCN may be adequate based on Planner load calculations and cable ratings. Design subsystems associated with arterial roadways to ultimately accommodate 1000 JCN cable.

2.2 Structure Spacing

Underground manholes and vaults for mainline installation shall be laid out based on the **pulling length** for the largest size cable identified in Table 9–1. For all other non-mainline structure installations, the structures shall be laid out to accommodate the maximum **pulling** length of the cable currently being installed.

EXAMPLE 1:

Scenario: Load justifies installing 350 kcmil mainline cable between two new vaults on a 12 kV circuit.

Question: What size cable should be used to determine the structure spacing?

Answer: Since the circuit voltage is 12 kV, the pulling length for 1,000 JCN (largest size) should be utilized when determining the spacing between the two structures.

Design structure installations for all other non-mainline structure to accommodate the maximum pulling length of the cable currently being installed. Lot sales (five or more) are an exception where structure spacing will be designed for the pull length for three-phase conductor.

2.3 Structure Location

Easements must take into consideration the clearances required to operate, maintain, and inspect these facilities. This is particularly important with pad-mounted equipment requiring operating clearances for hot-stick operation.

Locate the structures in the following areas:

1. Parkway or other non-traffic area maintaining the required access to replace the structure — preferred
2. Light-traffic area (parking lot or driveway not subject to truck traffic)—alternate
3. Full-traffic locations—least desirable

In all cases, consideration must be given to the following items when determining structure locations:

1. Clearance from other utilities' substructures in accordance with *G.O. 128*, Rule 31.4
2. Maintain a 36-inch minimum clearance, if space permits or can be provided at no additional cost or low cost minor work to accommodate the Americans with Disabilities Act of 1990 (ADA) and pedestrian right-of-way access requirements (Avoid structure placement in wheelchair ramp locations).
3. Traffic patterns
4. Traffic control requirements as established in the *California Joint Utilities Traffic Control Manual (CJUTCM)* and the *Pedestrian Traffic Control Manual (PTCM)*
5. Visibility for vehicles when using pad-mounted equipment
6. Aesthetics in relation to development plans
7. Governmental restrictions and regulations
8. Whenever possible, place pad-mounted structures and equipment away from areas with frequent irrigation to help prevent future corrosion.

   Install NEW stainless steel pad-mounted equipment only if every effort has been made to locate the pad-mount away from high-corrosion areas and the pad-mount is expected to be changed out within 15 years due to corrosion. Contact Field Engineering for approval.

   Existing mild steel pad-mounted equipment may be upgraded to stainless steel if the existing equipment has failed due to corrosion within 15 years of installation. Contact Field Engineering for approval.

   Note: All pad-mounted transformers purchased after 2004 are designed with stainless steel bottoms.

2.4 Special Conditions

A. SmartConnect Underground Communication Devices

SmartConnect communication devices provide solutions to capture and transfer meter data located in isolated locations. SmartConnect Operations Center (SOC) will determine the geographical placement of these devices to achieve the required extended coverage.

The following SmartConnect communication devices are available:

- RFLAN Range Extender (RRE)
- Socket Based Cell Relay (SBCR)

These SmartConnect communication devices require 120, 208 or 240 V service, and have the option to be served from either of the following underground structures:

1. SmartConnect Pad-Mount Post Assembly

   A SmartConnect Pad-Mount Post Assembly provides a solution to install the communication devices in a non-metallic enclosure attached to a steel post with a flange base suitable for mounting on concrete. The pad-mount post shall be located at the SCE pad-mounted single-phase or three-phase transformer that provides the optimal communication path as identified by the SOC. The communication post shall be installed and anchored only on concrete pads. If the transformer is on a polymer pad, contact Distribution Civil/Structural Engineering Group for guidance with the installation of the post. For minimum clearance, construction, and installation details refer to DUG AP 105.

2. SmartConnect Semi-Buried Pedestal Assembly

   The SmartConnect Semi-Buried Pedestal provides a solution to install the communication devices in a non-metallic pedestal casing where its base is buried 12 inches below grade or mounted above ground as applicable. The pedestal shall be located near a SCE pad-mounted or submersible transformer, or next to a splicing hand-hole or vent pipe, so as to gain the optimal communication path as identified by the SOC. For minimum clearance, construction, and installation details for the non-metallic pedestal refer to DUG AP 105.

3.0 Conduit Selection

The number of conduits and size of structures should be designed to serve all existing load, new load, and future load growth while still supporting all other system requirements.

3.1 Ten-Year Planning Horizon Guidelines

The following guidelines were developed to assist the planner how to determine the number of conduits needed to be installed today to accommodate existing load, new load, and future load growth for the next ten years. Note that these guidelines were purposely developed to be flexible in order to account for SCE's diverse territory. Each planner should use their district/area specific knowledge along with the information created from the list below to develop their final design. For primary conduit design, consult all interested parties, for example, Field Engineering, Telecom, and the appropriate Planning departments, before finalizing the design.

A. Design the Current Project

Determine the number of conduits and size of structures needed to serve your current project based on the criteria detailed in Section 3.2, Mainline Conduit Quantity Selection Guidelines.

B. Determine Requirements for Undeveloped Adjacent Land

Option 1:

If there is land beyond the initial project that is likely to be developed within ten years, include this available land when estimating potential future load for the project site. Assume that the land adjacent to your project will be developed using the same land profile that you are currently developing.

EXAMPLE: If a home builder is developing ten acres of land and there are an additional 20 acres of land beyond the initial project, calculate the load to be served for the entire 30 acres and install the required number of conduits.

Option 2:

If calculating future load requirements detailed in Option 1 are not possible or inaccurate, use the table below to estimate future load, conduit, and structure requirements for the undeveloped adjacent land.

Land Use Type	kW/Acre
Residential	12
Mixed Use	16
C/I	20

Note: Consider other sources/paths into the area when determining conduit requirements.

C. Determine Requirements for Rebuilding Existing Conduit Systems

If the current infrastructure is unable to serve existing/future load and civil work needs to be performed for a circuit upgrade or new installation, evaluate the following:

- Determine if additional conduits will need to be added to accommodate the potential load for adjacent/surrounding vacant land (if applicable).
- Determine if current system (conduits and structures) will support ten years of future load growth, for example, consumer and commercial technologies such as appliances, consumer electronics, and EVs.
- Determine if other SCE programs, for example, DSP, relocation, and telecom, will require more civil construction in the same area so that this work can be coordinated to be done at the same time to eliminate re-working the same area.

D. Determine Requirements for Possible Rule 20 Conversions

When converting overhead to underground, consider the number of conduits that will be needed to serve current and future load.

E. Consider Operational Flexibility

When designing the system, operational flexibility must be considered. When determining the electrical paths for your project design, consider the following items:

- Design the system and electrical paths to accommodate potential development in multiple directions.
- Design the system and electrical paths in a way that will minimize the customer impact to outages.
- Follow current SCE requirements for looped systems and circuit ties.

F. Consider Geographical Limitations

If there are natural or man-made barriers that restrict the placement of conduits, consider adding additional conduits and possibly an additional duct bank in this "bottleneck" path. For example;

- Mountains
- Waterways
- Freeways
- Storm Drains
- Bridge Crossing
- Bore Casings

G. Consider Existing and Future Substation Locations

Identify the distance from existing substations and planned future substations to the project, as this may increase the number of conduits needed. Contact Field Engineering for guidance.

3.2 Conduit Design Guidelines

Before finalizing the design, fill out and send the Conduit Allocation Resource Form (located in DDS-6, Section 3.1) to SCE's other groups that have a vested interest in conduit planning for feedback. Getting feedback from each group will ensure that work will not have to be duplicated a few years apart. For high growth areas, also consult your areas Master Duct Plan.

Use the following assumptions to develop your feeder conduit design:

A. Typically no more than four circuits should be in a single duct bank.

B. All circuits should be designed to serve a maximum of 400 A or less when initially constructed. 400 A primary current is approximately:
   - 4.1 kV ~ 2.8 MVA
   - 12 kV ~ 8.3 MVA
   - 16 kV ~ 11.3 MVA
   - 33 kV ~ 23.9 MVA

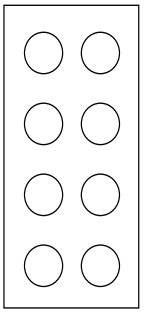
C. Future circuit requirements should consider load for the next 10 years.

D. 16 kV and below (and their spares) use five-inch conduit.

E. 25 kV and 33 kV (and their spares) use six-inch conduit.

F. When mixing five inch and six-inch conduits in the same duct bank, match conduit sizes horizontally (see example below):

Duct Bank Layout



- Telecom will **ALWAYS** be on top in five-inch conduit (if applicable)
- Five-inch conduits will **ALWAYS** be located above six-inch conduit (in mixed duct banks) and used for Telecom and circuits 16 kV and below
- Six-inch conduits will **ALWAYS** be located below five-inch and used for 25 kV and 33 kV circuits (in mixed duct banks)

Use the following tables to determine the proper diameter of mainline and secondary conduits required for the project, based on the ultimate size of conductor expected.

Table 6–1: Conduit Selection Criteria

Three-Phase Primary Cable (AWG or kcmil)		Conduit Size (in)
34.5 kV	Getaways Feeder	6
4—16 kV	Getaways Feeder (≥ 350 JCN) Radials or Services ≥ 350 JCN	5
	Radials or Services 1/0 JCN	5

Three-Phase Secondary and Service Cable (See Note 1)		Conduit Size (in)
600 V	Runs of 700 CLP > 100'	5
	Runs of 700 CLP < 100'	4 or 5
	1/0 AWG – 350 CLP	4

Commercial/Industrial Services		Single–Phase Size (in)	Three–Phase Size (in)
600 V	Traffic Signals, Streetlights, Secondary Systems, Wireless Technology Rate Services, and Billboards	3	3
	100–200 Amp Panels ≤ 350 CLP	3	3
	400 Amp Panels	4	4
	> 400 Amp Panels	See Table 6–3	

Single-Phase Primary Cable		Conduit Size (in)
12/16 kV	One or Two- 1/C 1/0	3 (See Note 6)

Single-Phase Secondary Cable		Conduit Size (in)
600 V	700 CLP	4 (5 for runs ≥ 100 ft)
	1/0 AWG– 350 CLP	3

Single-Phase Residential Services (Self-Contained Panels & CT Panels) (See Note 7)		Conduit Size (in)
600 V	100 — 125 Amp	3 (See Note 3)
	200 — 300 Amp	3
600 V	400 Amp (Class 320)	3
	400 Amp multi-family (w/o house panel) 400 Amp multi-family (w/house panel)	3 4
	600 Amp (CT Panel) (See Note 4) 600 Amp (multi-family w/o house panel) (see Note 4) 600 Amp (multi-family w/ house panel) (see Note 4)	4 (5 for runs ≥ 100 ft)
Three-Phase Residential Services		**Conduit Size (in)**
600 V	400 Amp (single-family or multi-family)	4
	600 Amp (single-family) Greater than or equal to 600 A (multi-family) **(See Note 1)**	4 See Table 6-3.
Streetlights		**Conduit Size (in)**
600 V	Streetlights (into streetlight bases) Streetlights only secondary	1-1/2 3 (See Note 5)

Notes:

1. Whenever possible, use 12'-6" radius sweeps on C/I (three-phase) secondary and service runs where 600 V, 700 CLP could be installed. Use bends when entering pull section of panels and pads, or when entering at the bases of riser poles. See Chapter DDS–9: Cable Pulling Section for definition of bends and sweeps.
2. See Chapter DDS–9: Cable Pulling Section for calculation of equivalent length.
3. A 2-1/2-inch reducer may be installed at the terminating pull section of the meter panel.
4. 600 A, single-phase residential panels require SCE approval. SCE Planner will consult with Field Engineering.
5. Consider the use of distribution-sized structures and conduit to allow for future growth and to avoid costly interceptions.
6. Lot sales and custom homes must use 5-inch conduit for primary structures designed for primary. Size easements for potential three-phase transformer structures. Determine structure spacing by the equivalent length for three-phase conductor. See Section 2.2 (Page 6–6).
7. Lot sales and custom homes will install a minimum 4-inch service conduit from transformer to each lot.

Table 6–2: Guide for Sizing Risers

Cable size (Al CLP)	≤ 600V		4/12/16 kV			34.5 kV
	3 Cond.	4 Cond.	1 Cond.	2 Cond.	3 Cond.	3 Cond.
–	–		–			–
#2 AWG	–	3" > 2"	–	–	–	–
	3" > 2"		3" > 2"	3"	4"	
1/0 AWG	–	3" > 2"	–	–	–	–
	3" > 2"		3" > 2"	3"	4"	
4/0 AWG	–	3"	–			5"
	3"					
350 kcmil	–	3"	4" (See Note 5)			–
	3"					
700 kcmil	3"	4"	–			–
750 kcmil (See Note 7)	–	–	5"			6"
1,000 kcmil	–	–	5"			–
1,500 kcmil	–	–	–			6"

Notes:

1. All risers shall be based upon Schedule 80 PVC conduit below the 8-foot level, and based on Schedule 40 PVC conduit above the eight-foot level. Refer to the *Distribution Underground Construction Standards (DUG) Manual*, Section CR 110.2 for riser material.
2. Generally, only one reduction in size is recommended.
3. 2-1/2-inch Schedule 80 is the minimum size PVC that may be used below the eight-foot level.
4. 3" > 2" means: "reduce to smaller" size above the eight-foot level.
5. Install five-inch to four-inch reducer at grade.
6. May be reduced in size one foot above ground level. Refer to *DUG Manual*, Section CR 110.
7. 750 JCN cable will only be utilized as specified in DDS-9, Table 9–1.

Table 6–3: Number of Conduits for Commercial/Industrial Services

Main Switch Ultimate Capacity (A)	Number of Conduits
400 A	One 4-inch
600 A /800 A	Two 4-inch
1,000 A	Four 4-inch (See Note 7)
1,200 A	Four 4-inch
1,600 A	Six 4-inch
2,000 A /2,500 A	Two banks of Four 4-inch (See Note 6)
3,000 A	Two banks of Six 4-inch (See Note 6)
4,000 A	Cable Trench (See Note 9)

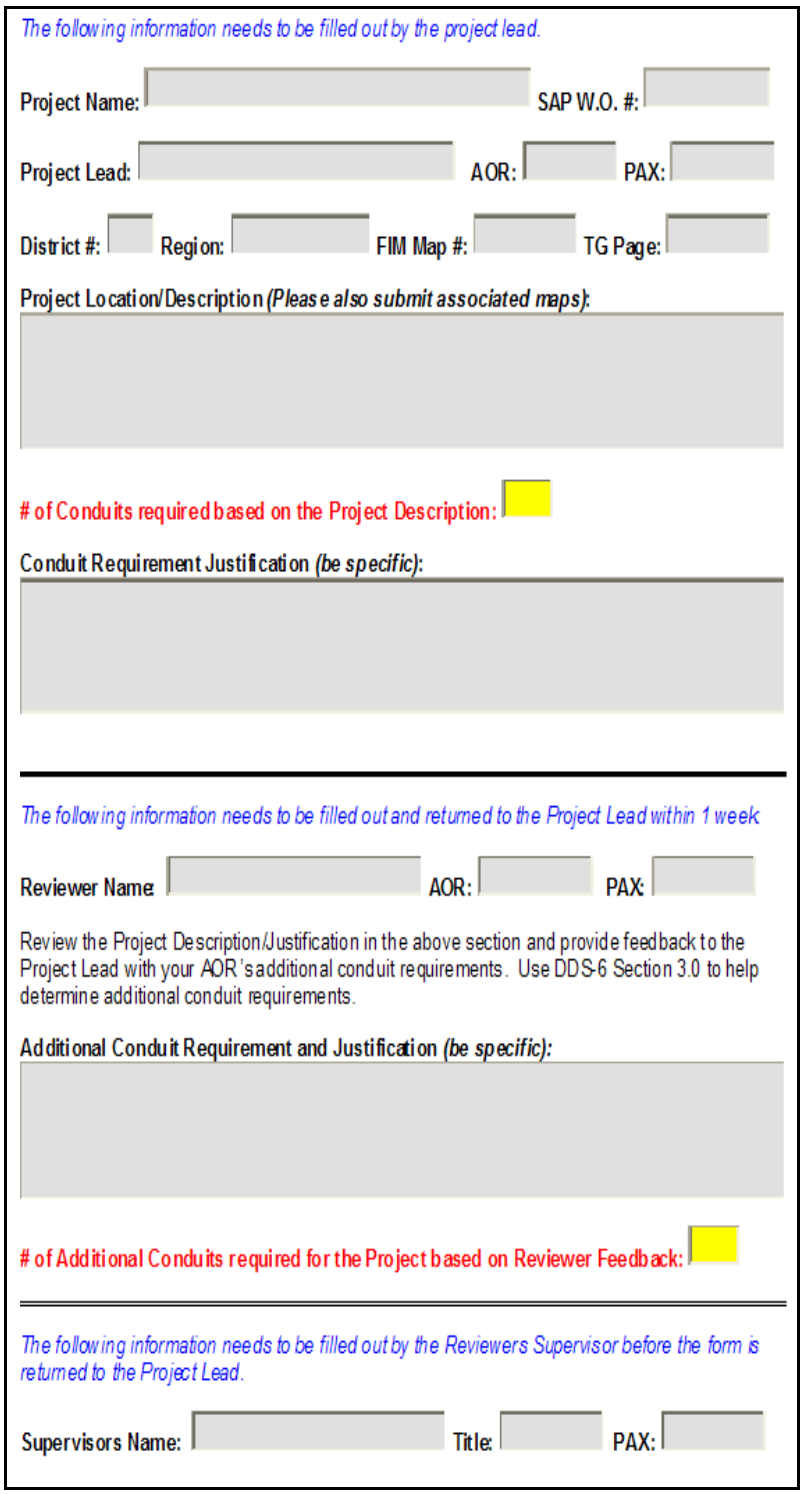
Notes:

1. The recommended number of conduits is based on ultimate ampacities of cable (700 kcmil) at 75 percent load factor.
2. For alternate designs, contact Field Engineering.
3. For ampacities of cable in trench or conduit, refer to Chapter DDS-9, Table 9–4 and Table 9–5.
4. Ultimate ampacity is based on use of 700 kcmil Al cable in each conduit.
5. When 700 kcmil Al cable will be pulled beyond 100' equivalent straight length, use five-inch conduit.
6. Cable trench is preferred. When two conduit banks are used, they shall be spaced a minimum of six feet apart, until conduit is configured to pull section.
7. Three four-inch conduits may be used, but four, four-inch conduits create a block for semi-encasement.
8. For commercial and industrial installations (including specification buildings), size all conduits and structures to the main switch or pull section capacity. However, if the main switch or pull section capacity used for strip or retail commercial building(s) exceeds the normally expected ultimate peak demand by 200 percent, the number of ducts from the transformer and the structure size may be reduced. The main switch or pull section capacity will be considered excessive when it is equal to or greater than 200 percent of the calculated demand using one of the three methods for determining demand as shown in the 5.0 Design Criteria in DDS–3.
9. Cable trench is preferred. When it is not practical to install cable trench, two banks of seven four-inch conduits may be used, and they shall be placed a minimum of six feet apart.
10. Table 6–1 should be used to size conduits for three-phase service to multi-family buildings.

3.3 Conduit Allocation Resources Form

The Conduit Allocation Resource (CAR) Form, shown in Figure 6–1, needs to be completed anytime civil work will be performed to upgrade and/or install new mainline conduits and structures. The top section of this form should be completed by the project owner, then distributed to all other interested groups that might have additional conduit needs. Each group (Field Engineering, New Development Planning, Local Planning, Technical Planning and Carrier Solutions-Telecom) shall complete the bottom section of this form and return it back to the project owner within one week from the date of receipt.

Figure 6–1: Conduit Allocation Resource (CAR) Form



The following information needs to be filled out by the project lead.

Project Name: SAP W.O. #:

Project Lead: AOR: PAX:

District #: Region: FIM Map #: TG Page:

Project Location/Description *(Please also submit associated maps)*:

# of Conduits required based on the Project Description:

Conduit Requirement Justification *(be specific)*:

The following information needs to be filled out and returned to the Project Lead within 1 week

Reviewer Name: AOR: PAX:

Review the Project Description/Justification in the above section and provide feedback to the Project Lead with your AOR's additional conduit requirements. Use DDS-6 Section 3.0 to help determine additional conduit requirements.

Additional Conduit Requirement and Justification *(be specific)*:

# of Additional Conduits required for the Project based on Reviewer Feedback:

The following information needs to be filled out by the Reviewers Supervisor before the form is returned to the Project Lead.

Supervisors Name: Title: PAX:

Figure 6–2: Completed Sample Form

The following information needs to be filled out by the project lead.

Project Name: Rule 20 on Broadway **SAP W.O. #:** 12345678

Project Lead: Pete Planner **AOR:** Local Planning **PAX:** 12345

District #: 46 **Region:** South **FIM Map #:** 123-4567-8 **TG Page:** 929

Project Location/Description *(Please also submit associated maps)*:

The overhead line on Broadway, from 1st St to 7th St will be undergrounded. The existing circuit is the Fred 12kV.

# of Conduits required based on the Project Description: 2-5'

Conduit Requirement Justification *(be specific)*:

One conduit will be required to accommodate the existing Fred 12kV circuit and the second will be utilized as a spare for emergency use.

SAMPLE

The following information needs to be filled out and returned to the Project Lead within 1 week.

Reviewer Name: Edith Engineer **AOR:** F.E. **PAX:** 54321

Review the Project Description/Justification in the above section and provide feedback to the Project Lead with your AOR's additional conduit requirements. Use DDS-6 Section 3.0 to help determine additional conduit requirements.

Additional Conduit Requirement and Justification *(be specific)*:

In addition to the two conduits needed for the existing O/H circuit, two additional circuits will be required: One for a future circuit identified in the Distribution Substation Plan (DSP) and one to serve the project load of 9 MVA for the "Happy Acres" development.

# of Additional Conduits required for the Project based on Reviewer Feedback: 2-5'

The following information needs to be filled out by the Reviewers Supervisor before the form is returned to the Project Lead.

Supervisors Name: Susan Supervisor **Title:** FE Mgr **PAX:** 33333

4.0 Structure Application Tables

Structures selected shall be installed based on the forecasted system needs for the next 10 years. Table 6–4 through Table 6–13 may be used to determine the maximum cable/equipment that may be installed in various structure types and sizes.

These tables are based on requirements for working space, cable shaping, and equipment mounting. The tables must be followed when planning new structure installations or adding cable/equipment to existing structures. Unusual circumstances may warrant deviating from the tables. Deviations must be processed based on the requirements defined in the *TDBU Standards Process Manual*, which is available in the Standards & Publications Portal Site.

Table 6–6 provides application criteria for pull boxes. It gives the maximum number and size cable runs and type primary termination recommended for each pull box size. When using this table, only one voltage classification should be used at a time. For example, a 2' × 3' × 3' pull box may contain runs of 3Ø, 700 kcmil secondaries **OR** three runs of 1Ø (6.9 kV or 9.5 kV) primary with three straight splices, but **NOT** both. The 2'-6" × 4' or 3' × 5' pull boxes allow for a combination of primary and secondary cables.

Existing structures with more cable/equipment than allowed by the tables should not be rebuilt merely because they do not meet the new standard. Good engineering and operating judgment must be exercised when work is required in such a structure. Specific circumstances may justify deviating from the tables. Deviations must be processed based on the requirements defined in the *TDBU Standards Process Manual*, which is available in the Standards & Publications Portal Site.

For this chapter only, the following definitions apply:

Run	A run refers to any set of primary or secondary cables that enters the structure from any direction. A run may be one to four conductors, for example: 1-1/0 AWG 6.9 kV or 3-700 kcmil and 1-350 kcmil Al CLP 120/208 V. The tables in this chapter refer to primary runs only, unless the run is separately identified as secondary in the tables.

Table 6–4: New Secondary Handholes for Single-Phase and Three-Phase Cables

Structure (W × L × D)	Material	Location	Application	MAX Number of Cable Runs	Phase		MAX Cable Size
					Single	Three	
13" × 24" × 15"	Plastic	Parkways and Soil	Streetlights	4	Yes	No	350 kcmil
13" × 24" × 24"	Concrete	Sidewalks and Concrete		4	Yes	No	350 kcmil
17" × 30" × 15"	Plastic	Parkways and Soil	Residential	6	Yes	No	350 kcmil (See Note 2)
17" × 30" × 18"	Plastic Fiberglass Reinforced Plastic	Light Traffic	Residential/ Commercial	6	Yes	No	350 kcmil (See Note 2)
17" × 30" × 24"	Concrete	Sidewalks and Concrete	Residential/ Commercial	6	Yes	No	350 kcmil (See Note 2)
			Commercial	4	No	Yes	350 kcmil

Notes:

1. Fiberglass Reinforced Plastic (FRP) handholes may be used in driveways or parking lots on private property that are not subject to truck traffic.
2. For 17" × 30" handholes, three runs of 350 kcmil cable may be used. All other cable runs shall be 4/0 AWG or smaller. When all conduits are occupied with cable runs, no additional temporary or permanent services will be allowed in the 17" x 30" handhole.
3. Minimum of three inches crushed rock to be installed under structure.
4. For handhole installations, refer to UGS, Section HP 205.

Table 6–5: Existing Secondary Handholes for Single-Phase and Three-Phase Cables

Structure (W × L × D)	Material	Location	Application	MAX Number of Cable Runs	Phase		MAX Cable Size
					Single	Three	
10-1/2" × 17" × 12" (See Note 1)	Concrete	Sidewalks and Concrete	Streetlights Only	3	Yes	No	1/0 AWG
13" × 24" × 15" (See Note 1)	Plastic	Parkways and Soil	Residential	4	Yes	No	350 kcmil
13" × 24" × 18" (See Note 1)	Plastic Fiberglass Reinforced Plastic	Light Traffic	Residential/ Commercial (See Note 1)	4	Yes	No	350 kcmil
13" × 24" × 24" (See Note 1)	Concrete	Sidewalks and Concrete	Residential/ Commercial	6	Yes	No	350 kcmil

Notes:

1. Not approved for use on new installations.
2. Fiberglass Reinforced Plastic (FRP) handholes may be used in driveways or parking lots on private property that are not subject to truck traffic.
3. Minimum of three inches crushed rock to be installed under structure.
4. For handhole installations, refer to UGS, Section HP 205.

Table 6–6: New and Existing Pull Boxes for Primary and Secondary Cable

Structure Size	4-16 kV 3-Phase 600A Runs	4-16 kV 3-Phase 200A Runs, MAX Cable Size	4-16 kV 1-Phase Runs, MAX Cable Size	6.9/ 9.4 kV Runs, MAX Cable Size	Secondaries Runs, MAX Cable Size	Splices or Junction Bars			
						Straight	200 A T-Taps or 600 A Separable Connectors (See Note 8)	3W	4W
2′ x 3′ x 3′ (See Note 1)	—	2, 1/0 AWG	—	—	—	3	—	—	—
	—	—	3, 1/0 AWG	—	—	—	2	—	—
	—	—	—	6, 1/0 AWG	—	3	—	—	—
	—	—	—	3, 1/0 AWG	—	—	1	1	—
	—	—	—	—	4, 700 kcmil	—	—	—	—
2′-6" x4′ x 3′-6" (See Note 5)	—	4, 1/0 AWG	—	—	—	6	—	—	—
	—	3, 1/0 AWG	—	—	—	—	3	3	—
	—	2, 1/0 AWG	1, 1/0 AWG	—	—	—	3	3	—
	—	2, 1/0 AWG	—	3, 1/0 AWG	—	—	3	3	—
	—	2, 1/0 AWG	—	—	4, 700 kcmil	3	—	—	—
	—	1, 1/0 AWG	2, 1/0 AWG	—	—	—	3	3	—
	—	1, 1/0 AWG	—	6, 1/0 AWG	—	—	3	3	—
	—	—	3, 1/0 AWG	—	—	—	2	2	—
	—	—	—	4, 1/0 AWG	—	—	—	—	1
	—	—	—	9, 1/0 AWG	—	—	3	3	—
	—	—	—	—	6, 700 kcmil	—	—	—	—
3′ x 5′ x 4′ (See Note 5)	4, 350 kcmil	—	—	—	—	6	—	—	—
	2, 350 kcmil	1, 1/0 AWG	—	—	—	—	3	—	—
	2, 350 kcmil	—	1, 1/0 AWG	—	—	—	3	—	—
	2, 350 kcmil	—	—	3, 1/0 AWG	—	—	3	—	—
	2, 350 kcmil	—	—	—	6, 700 kcmil	3	—	—	—
	1, 350 kcmil	2, 1/0 AWG	—	—	—	—	3	—	—
	1, 350 kcmil	—	—	6, 1/0 AWG	—	—	3	—	—
	—	4, 1/0 AWG	—	—	—	—	—	—	3
	—	3, 1/0 AWG	1, 1/0 AWG	—	—	—	—	—	3
	—	3, 1/0 AWG	—	3, 1/0 AWG	—	—	—	—	3
	—	2, 1/0 AWG	2, 1/0 AWG	—	—	—	—	—	3
	—	2, 1/0 AWG	—	3, 1/0 AWG	—	—	—	—	3
	—	2, 1/0 AWG	—	—	6, 700 kcmil	3	—	—	—
	—	—	4, 1/0 AWG	—	—	—	—	—	2
	—	—	—	9, 1/0 AWG	—	—	3	3	—
	—	—	—	—	10, 700 kcmil	—	—	—	—

Notes:

1. May need to add 12"-grade ring to maintain required 30" cover.
2. For this table only, a **Run** refers to any set of primary and secondary cables that enters the structure from any direction. A run may be one to four conductors (for example: 1-1/0 AWG 6.9 kV or 3-700 kcmil and 1-350 kcmil Al CLP 120/208 V).
3. Parkway (use RPM) and light-traffic (use concrete) pull boxes are available in all sizes.
4. Intercept pull boxes are available in all sizes.
5. Load-break junctions have limited applications in 3Ø systems; Refer to DDS for design criteria. Load-break junction installations should consider the following:
   a. Junctions should be mounted with a 45 degrees upwards angle for surface operability.
   b. Rack cables to ensure operability of the junctions and the ability to park elbows.
   c. In pull boxes, maintain a clear space in the center to allow for cable pulling inside the box. This can be done by:

- Noting that three, 3-way or 4-way junctions will not fit side-by-side in a 3' x 5' x 4' pull box. One junction should be mounted on the narrow end. Avoid mounting on opposite five-foot sides.
- Proper racking cables.

6. Pull boxes are intended to be used for primary cable only. For secondary cable only, handholes are preferred; and for combinations of primary and secondary cables, pull boxes should be used.
7. For existing installations, only two runs with straight splice are allowed when replacement of 500 kcmil PILC in 3' x 5' pull boxes.
8. A single 600 A T-Body Splice is designed to perform the task of two in-line stacked 600 A Separable Connectors (T-Bodies). Refer to DUG, JJ 657 for a detail application guide for the 15/25 kV 600 A T-Body Splice, and DUG JJ 667 for the 35 kV 600 A T-Body Splice.

Table 6–7: New and Existing Manholes

Structure Size	34.5 kV, 3-Phase 600 A Runs, MAX Cable Size	4-16 kV, 3-Phase, 600 A Runs, MAX Cable Size	3-Phase, 200 A Runs, MAX Cable Size	3-W or 4-W MAX Junction Bar
4' x 4' x 5' (See Note 1)	—	—	3 Runs 1/0 AWG	3
4' x 6'-6" x 7' (See Note 1)	—	2 Runs 1,000 kcmil	3 Runs 1/0 AWG	3
	—	4 Runs 350 kcmil	3 Runs 1/0 AWG	3
4'-6" x 8'-6" x 7' (See Note 1)	—	2 Runs 1,000 kcmil	3 Runs 1/0 AWG	3
	—	4 Runs 350 kcmil	4 Runs 1/0 AWG	3
5' x 10'-6" x 7'	4 Runs, 750 kcmil	—	3 Runs, 1/0 AWG	3
	2 Runs, 750 kcmil	2 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	3
	—	4 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	3
	—	3 Runs, 1,000 kcmil	5 Runs, 1/0 AWG	3
	—	8 Runs 1,000 kcmil	—	—
6' x 8' x 7' (See Note 1)	—	6 Runs, 1,000 kcmil	—	3
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	3

Table 6–7: New and Existing Manholes

Structure Size	34.5 kV, 3-Phase 600 A Runs, MAX Cable Size	4-16 kV, 3-Phase, 600 A Runs, MAX Cable Size	3-Phase, 200 A Runs, MAX Cable Size	3-W or 4-W MAX Junction Bar
6' x 12' x 7'	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	—	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	—	—
	2 Runs, 1,500 kcmil	—	6 Runs, 4/0 AWG	3
	—	8 Runs, 1,000 kcmil	—	—
	—	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	3
	—	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	6
	—	2 Runs, 1,000 kcmil	8 Runs, 1/0 AWG	6
	—	—	10 Runs, 1/0 AWG	6
	2 Runs, 1,500 kcmil	3 Runs, 1,000 kcmil	1 Run 1/0 AWG	3
7' x 7' x 7' (See Note 1)	—	6 Runs, 1,000 kcmil	—	—
	—	4 Runs, 1,000 kcmil	4 Runs 1/0 AWG	—

Notes:

1. Structures are obsolete and no longer approved for new construction.
2. Wrap or offset cables in manholes where possible. Refer to *DUG*, RS 200 for details.

Table 6–8: New and Existing Pad-Mounted Transformer Structures

Structure (W x L x D)	MAX Size (kVA)	MAX Cable Runs	Phase		MAX Cable Size	Splice	MAX Junction Bar		Comments
			Single	Three		"T"	3W	4W	
4'-6" x 7' Pad with 3' x 5' Pull Box	25 (for 33 kV CPT Only)	2	Yes	No	4/0 CLP (primary), #8 AWG (service / secondary)	No	No	No	Refer to *DUG*, TX 300.4. (See Note 6)
48" x 54" Pad (Concrete or RPM)	100	3—Primary, 4—Secondary	Yes	No	1/0 CLP (primary), 350 kcmil (service / secondary)	No	No	No	See Notes 1 and 4
94" x 72" Pad (Concrete)	500	2—Primary, 4—Secondary	No	Yes	1/0 CLP (primary), 700 kcmil (service / secondary)	No	No	No	(See Note 1)
6' x 8'-6" Slab Box	500	3—Primary	No	Yes	1/0 CLP (primary), 700 kcmil (service / secondary)	Yes	Yes	No	See Notes 2 and 3
8' x 10' x 6' Slab Box	1,000	3—Primary	No	Yes	1/0 CLP (primary) 700 kcmil (service / secondary)	Yes	Yes	No	See Note 3
10' x 12 ' Pad with 5' x 8'-6" x 5' Box (Slab Box)	3,750	3—Primary	No	Yes	350 kcmil (primary), 700 kcmil service	Yes	Yes	No	See Note 5
Poured-in-Place Pad	3,750	3—Primary	Yes	Yes	350 kcmil (primary), 700 kcmil service	No	No	No	Refer to UGS, Section 510, Pre-cast Preferred
60" x 72" x 22" Bart Pad w/Box	500	2—Primary	Yes	Yes	1/0 CLP (primary), 350 kcmil (service / secondary)	No	No	No	Refer to UGS, SS 508
72" x 114" x 22" Bart Pad w/Box	1,500	2—Primary	Yes	Yes	1/0 CLP (primary), 700 kcmil (service / secondary)	No	No	No	Refer to UGS, SS 508
72" x 114" x 30" Bart Pad w/Box	2,500	2—Primary	Yes	Yes	1/0 CLP (primary), 700 kcmil (service / secondary)	No	No	No	Refer to UGS, SS 508

Table 6–8: New and Existing Pad-Mounted Transformer Structures — *Continued*

Notes:

1. A pad should be used with four or less secondary/service conduits. Six conduits may be installed to a pad if the cable is 350 kcmil or smaller, or if it is unlikely that all six conduits will ever be used, and up to two additional #8 streetlight runs may be added. Refer to the *DUG Manual*, Section TX 190.
2. A slab box is normally required for more than four secondary/service conduits except as noted in Note 1.
3. When using a slab box with 3Ø transformers up to 1,000 kVA where 6–4" conduits will leave the structure through a single corner, specify a 12" grade ring to ensure 30" of cover over the conduits. For conduit placement, refer to the *UGS Manual*, Section SS 530.
4. When replacing a standard pad-mounted with a minipad-mounted transformer, a 17" x 30" x 15" inverted handhole (SAP 10117726) shall be installed under the cable opening in the pad. Refer to *DUG Manual*, Section TX 190 for additional information.
5. Applications requiring a cable trench will require a special order 10' x 12' slab box w/24" x 30" window. Specify which corner is to receive the window at the time of ordering.
6. The single phase, 25 kVA (33 kV) control power transformer shall not be used for residential, commercial, or street lighting loads, and is dedicated or limited only to provide control power for underground automated equipment. Refer to the *Distribution Underground Construction (DUG) Manual*, Section TX 300.4 for additional information.
7. A single 600 A T-Body Splice is designed to perform the task of two in-line stacked 600 A Separable Connectors (T-Bodies). Refer to DUG, JJ 657 for a detail application guide for the 15/25 kV 600 A T-Body Splice, and DUG JJ 667 for the 35 kV 600 A T-Body Splice.

Table 6–9: New and Existing Pad-Mounted Switch Structures

Structure (W x L x D)	Type	MAX Cable Runs	Phase		MAX Cable Size	Splice		MAX Junction Bar		Comments
			Single	Three		Straight	"T"	3W	4W	
48" x 54" Pad (Concrete or RPM)	2-Way, 1-Pole (PME-1), 2-Way, 2-Pole (PME-2), or LBFC	2	Yes	No	1/0 CLP	No	No	No	No	See Note 5
4' x 6' Pad with 17' x 30" x 15" Plastic Handhole	PME-3 through PME-5 Switchgear	2	Yes	Yes	1/0 CLP	No	No	No	No	See Notes 2 and 3
4' x 6' Pad with 2'-6" x 4' Box	PME-4 and PME-5 Switchgear	3 Primary 1 Secondary	Yes	Yes	1/0 CLP	No	No	No	No	See Note 4
5' x 10'-6" x 7' Tub-Type PME Structure	PME-6 through PME-12, S&C PE Gear, Primary Metering Cabinet	4-600 A, 4-200 A	Yes	Yes	1,000 kcmil	Yes	No	Yes	No	See Notes 6 and 7
7' x 14' x 11' Tub-Style Structure with Modular Top Type II	PME-6 through PME-12 Switchgear	8-600 A, 3-200 A	Yes	Yes	1,000 kcmil	Yes	No	Yes	Yes	See Note 7
4'-6" x 7' Pad with 3' x 5' Pull Box	2-Way Pad-Mounted Gas Switch	2	Yes	Yes	1,000 kcmil	No	No	No	No	See Note 1
7' x 8' Pad with 4' x 7' x 5' Pull Box	2-, 3-, and 4-Way Pad-Mounted Gas Switch	4-600 A, 4-200 A	Yes	Yes	1,000 kcmil	No	No	Yes	Yes	See Notes 1, 6, and 7
6' x 8'-6" Slab Box	RAR or VFI-4	3	No	Yes	1,500 kcmil	No	No	Yes	No	Refer to UG, SS 530. See Notes 6 and 7
7' x 14' x 11' Tub-Style Structure with Modular Top Type I	4-, 5-, and 6-Way Pad-Mounted Gas Switch	8-600 A, 3-200 A	Yes	Yes	1,000 kcmil	Yes	No	Yes	Yes	See Note 7
10' x 12' Pad with 8' x 10' x 7' Box (Slab Box)	6-Way Pad-Mounted Gas Switch	6-200 A, 6-600 A	Yes	Yes	1,000 kcmil	No	No	No	Yes	See Notes 6 and 7

Table 6–9: New and Existing Pad-Mounted Switch Structures — *Continued*

8' x 10' x 8" Pad with 4' x 7' x 3'-6" Box	5-Way Pad-Mounted Gas Switch, VFI-9, VFI-12 Bypass Switch, or 33 kV Primary Metering Cabinet	6	No	Yes	1,500 kcmil	No	No	No	No	See Notes 6 and 7

Notes:

1. The 2-way switch may be installed on either a 4'-6" × 7' pad with a 3' × 5' pull box (Refer to the *Underground Structures* (*UGS) Manual*, 536) or the 7' × 8' pad with 4' ×7' × 5' pull box (Refer to the *UGS Manual*, 537).
2. Not to be used as cable pulling structures; cable feeding only.
3. For the installation of PME-3, PME-4, and PME-5, the following criteria shall be met:
   a. The unidirectional pulling limitation of the installation shall meet the equivalent pulling length in Chapter DDS-9, Table 9–12.
   b. The unidirectional pulling limitation of the installation shall satisfy the equivalent pulling length in Chapter DDS-9, Table 9–12 in the case of upgrading the existing cable to a larger size in the anticipated future.
4. When replacing PMH-4 with PME-4, use larger pad SAP 10117287 with existing box.
5. When installing a PME-1 or PME-2 or load-break fuse cabinets on a 48" x 54" pad, a 17" x 30" x 15" plastic inverted handhole (SAP 10117726) is required. The inverted handhole will be installed under the cable opening in the pad. Refer to the *Underground Structures Standards (UGS) Manual*, Section SS 506, for additional information.
6. BURD transformers can be installed in a PME structure when allowed per the AGE Policy. See Section 1.0 for details. If a BURD transformer is located in a PME structure and work is being done to the PME switch or structure, the existing BURD transformer should be considered as being "grandfathered" in place and does not need to be removed from the structure and replaced with a pad-mounted transformer.
7. For automating a Pad-Mounted Gas Switch, PME switchgear, or AR only one PT for automation control power is allowed inside the structure.
8. A single 600 A T-Body Splice is designed to perform the task of two in-line stacked 600 A Separable Connectors (T-Bodies). Refer to DUG, JJ 657 for a detail application guide for the 15/25 kV 600 A T-Body Splice, and DUG JJ 667 for the 35 kV 600 A T-Body Splice.

Table 6–10: Pad-Mounted Capacitor Structures

Structure (W x L x D)	Type	MAX Cable Runs	Phase		MAX Cable Size	Splice		MAX Junction Bar		Comments
			Single	Three		Straight	"T"	3W	4W	
66" x 72"	Pad-Mounted Capacitor Cabinet	1	No	Yes	1/0 CLP	No	No	No	No	Refer to UGS, Section SS 520

Notes:

1. Pad-mounted capacitor banks can be installed on existing 72" x 94" pad.

Table 6–11: BURD Equipment Structures

Equipment	Structure (W x L x D)	Equipment Type/Size	MAX Cable Run	Phase		MAX Cable Size	Splice		MAX Junction Bar		Comments
				Single	Three		Straight	"T"	3W	4W	
BURD Transformers	36" (ID) x 6' Concrete	25-100 kVA	2	Yes	No	1/0 CLP (Primary), 350 kcmil (Secondary /Service)	No	No	No	No	See Notes 2 and 4
	44" (ID) x 72" Plastic or Concrete	25-100 kVA	2	Yes	No	1/0 CLP (Primary), 350 kcmil (Secondary /Service)	No	No	No	No	(See Note 2)
BURD Switches	36" (ID) x 3' Plastic or Concrete	2W, 1-Pole Fused or 2W, 1- or 2-Pole Nonfused or 3W, 2-Pole Nonfused	2	Yes	No	1/0 CLP	No	No	No	No	See Notes 2 and 4
	4' x 4' x 4' Concrete	2W, 2-Pole Fused BURD, or any 3-Pole BURD Switch (fused or nonfused), or three, 3W Junction Bars	3	No	Yes	1/0 CLP	No	No	1-Set	No	(See Note 3)

Notes:

1. Pad-mounted equipment is the standard design for serving new residential, commercial or industrial loads. BURD equipment should not be used except where allowed in Section 1.0 and DDS-4, Section 5.0.
2. The concrete transformer enclosures and 36-inch diameter concrete switch enclosures shall be used in rocky areas only.
3. The $4' \times 4'$ concrete switch enclosures are available for parkway or full-traffic applications.
4. Not approved for new installations, use 4' x 4' x 4' for BURD switches and 44" x 72" for BURD transformers.

Table 6–12: New Vaults and SOE Cable and Equipment Standards

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 11)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
5' x 8'-6" x 5' (See Note 13)	—	4 Runs, 1,000 kcmil	—	—	—	—	—	—	—
	—	2 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	—	—	1	50	—	—
	—	4 Runs, 350 kcmil	4 Runs, 1/0 AWG	—	—	—	—	3	See Appendix 6-2, Figure 6-3
	—	3 Runs, 350 kcmil	5 Runs, 1/0 AWG	—	—	—	—	3	See Appendix 6-2, Figure 6-3
	4 Runs, 4/0 AWG	—	—	—	—	—	—	—	—
	—	2 Runs, 350 kcmil	3 Runs, 1/0 AWG	—	—	2	50	3	—
6' x12' x7' (See Note 14)	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	—	—	—	—	—	—	—
	2 Runs, 1,500 kcmil	3 Runs, 1,000 kcmil	1 Run, 1/0 AWG	1-4 Way RAM only	No	—	—	—	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	—	—	—	—	—	—	—
	2 Runs, 1,500 kcmil	—	6 Runs, 1/0 AWG	—	—	—	—	3	—
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	1-4 Way RAM only	No	1	100	3	See Appendix 6-2, Figure 6-5
	—	9 Runs, 1,000 kcmil	—	1-4 Way RAM only	No	—	—	—	—
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	—	—	3	167	3	See Appendix 6-2, Figure 6-6
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	—	—	4	3-100	3	With 1 Fused BURD Switch

Table 6–12: New Vaults and SOE Cable and Equipment Standards — *Continued*

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 11)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
7' x14' x 8'	4 Runs, 1,500 kcmil	—	—	1-4 Way	—	—	—	—	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-6 Way	Yes	—	—	3	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	1	100	3	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	4	3-100	3	With 1 Fused BURD Switch
	—	8 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way, 1-5 Way, or 1-6 Way	Yes	1	100	3	See Appendix 6-2, Figure 6-7
	—	8 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	2	100	3	See Appendix 6-2, Figure 6-8
	—	9 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	1	100	—	—
	—	9 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	4	3-100	3	With 1 Fused BURD Switch; See Appendix 6-2, Figure 6-9
	—	9 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-6 Way	Yes	—	—	3	—
	2 Runs, 1,500kcmil	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	3	167	3	—
	—	9 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	3	167	—	—

Table 6–12: New Vaults and SOE Cable and Equipment Standards — *Continued*

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 11)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
7' x18' x8'	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	1	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	2	100	6	See Appendix 6-2, Figure 6-11
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	3	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	4	3-333	6	See Appendix 6-2, Figure 6-12
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	1	100	6	See Appendix 6-2, Figure 6-10
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	2	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	3	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	4	3-333	6	See Appendix 6-2, Figure 6-12
	—	10 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	1	100	3	—
	—	10 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	2	100	3	—
	—	10 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	3	100	3	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	4	3-333	6	See Appendix 6-2, Figure 6-12

Notes:

1. For this table only, a **Run** refers to any set of primary cables that enters the structure from any direction. A run may be one to four conductors. Where two or three single conductor 1/0 AWG runs enter a structure, they maybe "grouped" and considered a run.
2. For examples showing how to use this table, See Appendix 6-1.
3. Pad-mounted equipment is the standard design for serving new residential, commercial or industrial loads. BURD equipment should not be used except where allowed in Section 1.0 and DDS-4, Section 5.0
4. Vents are required when installed transformation is $\leq$ 225 kVA. Blowers are required when installed transformation is greater than 225 kVA. Refer to the *DUG* Manual, Section VE110.
5. Single-phase fused BURD transformers shall not be used for closed delta service. When it is necessary to build a closed delta bank in a submersible structure, nonfused transformers must be used with a separate fuse device. Fused BURD transformers may be used in open delta banks for serving 120/240 V, three-phase, four-wire loads.
6. Pertains only to primary cable. When using this table, do not consider secondary runs.
7. One-set of 600 A/200 A to be used to connect PT for automation purposes.
8. No more than four circuits by name are allowed in any structure.
9. Any 600 A run could be replaced with a 200 A run.

10. Any BURD transformer (167 kVA MAX) can be replaced by a BURD switch and vice versa.
11. Only RAM switches can be automated.
12. Wrap or offset cables in SOE and vaults where possible. Refer to *DUG*, RS 200 for details.
13. Existing non-staggered bushing RAM switches installed in SOEs are grandfathered. Replacement of non-staggered bushing with staggered bushing RAM switches is NOT allowed. An existing SOE with a grandfathered non-staggered RAM switch is considered full, and no additional equipment shall be added.
14. Existing automated RAM switches are grandfathered.

Table 6–13: MAX Cable and Equipment for Existing SOE and Vaults (See Note 2)

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 10)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
4' x 7' x 4'	—	2 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	—	—	3	—
	—	—	6 Runs, 1/0 AWG	—	—	1	—	3	BURD Switch Only
4' x 7' x 7'	—	4 Runs, 350 AWG	3 Runs, 1/0 AWG	—	—	—	—	3	—
	—	2 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	—	—	3	
	—	—	6 Runs, 1/0 AWG	—	—	2	50	—	—
5' x 8'-6" x 7' (See Note 12)	4 Runs, 750 kcmil	2 Runs, 750 AWG	—	—	—	—	—	—	—
	4 Runs, 750 kcmil	—	2 Runs, 1/0 AWG	—	—	—	—	—	—
	2 Runs, 750 kcmil	2 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	—	—	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	—	—	2	50	3	—
	—	3 Runs, 1,000 kcmil	5 Runs, 1/0 AWG	—	—	2	50	3	—
	—	2 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	50	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 350 AWG	—	—	3	—	3	Allow for 2-Way, 1 Pole BURD Switch
5' x 10'-6" x 7'	4 Runs, 750 kcmil	0 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	100	3	—
	2 Runs, 750 kcmil	2 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	100	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	—	—	2	100	3	—
	—	3 Runs, 1,000 kcmil	5 Runs, 1/0 AWG	—	—	2	100	3	—
	—	2 Runs, 1,000 kcmil	3 Runs 1/0 AWG	—	—	3	100	3	—
	—	8 Runs, 1,000 kcmil	—	—	—	—	—	—	—

Table 6–13: MAX Cable and Equipment for Existing SOE and Vaults (See Note 2) *– Continued*

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 10)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
6' x 10' x 7' (See Note 13)	4 Runs, 750 kcmil	2 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	100	3	—
	2 Runs, 750 kcmil	4 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	100	3	—
	2 Runs, 750 kcmil	3 Runs. 1,000 kcmil	1 Run, 1/0 AWG	1-4 Way RAM only	No	—	—	—	—
	—	8 Runs, 1,000 kcmil	—	1-4 Way RAM only	No	—	—	—	—
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	—	—	2	100	3	—
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	1-3 Way RAM only	No	1	100	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	—	—	2	100	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	1-4 Way RAM only	No	—	—	3	—
	—	3 Runs, 1,000 kcmil	5 Runs, 1/0 AWG	—	—	2	100	3	—
	—	4 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	3	100	3	—
6' x 10' x 9'-4" (See Note 13)	4 Runs, 750 kcmil	2 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	100	3	—
	2 Runs, 750 kcmil	4 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	100	3	—
	2 Runs, 750 kcmil	3 Runs, 1,000 kcmil	1 Runs, 1/0 AWG	1-4 Way RAM only	No	—	—	—	—
	—	8 Runs, 1,000 kcmil	—	1-4 Way RAM only	No	—	—	—	—
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	—	—	2	100	3	—
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	1-3 Way RAM only	No	1	100	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	—	—	2	100	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	1-4 Way RAM only	No	—	—	3	—
	—	3 Runs, 1,000 kcmil	5 Runs, 1/0 AWG	—	—	2	100	3	—
	—	4 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	3	100	3	—

Table 6–13: MAX Cable and Equipment for Existing SOE and Vaults (See Note 2) *– Continued*

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 10)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
7' x 10' x 8'	4 Runs, 1,500 kcmil	2 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	100	3	—
	2 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	100	3	—
	2 Runs, 1,500 kcmil	3 Runs, 1,000 kcmil	1 Runs, 1/0 AWG	1-4 Way	Yes	—	—	—	—
	—	8 Runs, 1,000 kcmil	—	1-4 Way	Yes	—	—	—	—
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	—	—	2	100	3	—
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	1-3 Way	Yes	1	100	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	—	—	2	100	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	1-4 Way	Yes	—	—	3	—
	—	3 Runs, 100 AWG	5 Runs 1/0 AWG	—	—	2	100	3	—
	—	4 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	3	100	3	—
7' x 16' x 8'	4 Runs, 1,500 kcmil	—	—	1-4 Way	Yes	—	—	—	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-6 Way	Yes	—	—	3	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	1	—	3	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	4	3-167	3	With 1 Fused BURD Switch
	—	8 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	1	100	3	—
	—	8 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	4	3-167	3	With 1 Fused BURD Switch
	—	8 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-6 Way	Yes	—	—	3	—
	—	7 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-5 Way	Yes	1	100	3	—
	—	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-6 Way	Yes	1	100	3	—
	—	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	1	100	3	—
	—	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	2	100	3	—

Table 6–13: MAX Cable and Equipment for Existing SOE and Vaults (See Note 2) *– Continued*

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 10)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
7' x 20' x 9'-4"	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	1	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	2	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	3	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	4	3-333	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	1	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	2	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	3	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	4	3-333	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	1	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	2	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	3	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	4	3-333	6	—

Table 6–13: MAX Cable and Equipment for Existing SOE and Vaults (See Note 2) *— Continued*

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 10)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
7' x 22' x 8'	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	2	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	2	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	3	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	4	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	6	(2) 3-333	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	3	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	4	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	6	(2) 3-333	6	With 1 Fused BURD Switch
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	2	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	3	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	4	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	6	(2) 3-333		—

Table 6–13: MAX Cable and Equipment for Existing SOE and Vaults (See Note 2) *– Continued*

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 10)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
7' x 24' x 8'	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	2	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	3	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	4	100	6	With 1 Fused BURD Switch
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	6	(2) 3-333	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	2	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	3	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	4	100	6	With 1 Fused BURD Switch
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	6	(2) 3-333	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	2	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	3	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	4	100	6	With 1 Fused BURD Switch
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	—	—	—	—
8' x 10' x 9'-4"	4 Runs, 1,500 kcmil	2 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	100	3	—
	2 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	2	100	3	—
	2 Runs, 1,500 kcmil	3 Runs, 1,000 kcmil	1 Runs, 1/0 AWG	1-4 Way	Yes	—	—	—	—
	—	8 Runs, 1,000 kcmil	—	1-4 Way	Yes	—	—	3	—
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	—	—	2	100	3	—
	—	6 Runs, 1,000 kcmil	2 Runs, 1/0 AWG	1-3 Way	Yes	1	100	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	—	—	2	100	3	—
	—	4 Runs, 1,000 kcmil	4 Runs, 1/0 AWG	1-4 Way	Yes	—	—	3	—
	—	3 Runs, 1,000 kcmil	5 Runs, 1/0 AWG	—	—	2	100	3	—
	—	4 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	3	100	3	—

Table 6–13: MAX Cable and Equipment for Existing SOE and Vaults (See Note 2) *– Continued*

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 10)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
8' x 14' x 9'-4"	4 Runs, 1,500 kcmil	—	—	1-4 Way	Yes	—	—	—	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-6 Way	Yes	—	—	3	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	1	100	3	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	4	3-167	3	With 1 Fused BURD Switch
	—	8 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	1	100	3	—
	—	8 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	—	—	4	3-167	3	With 1 Fused BURD Switch
	—	8 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-6 Way	Yes	—	—	3	—
	—	7 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-5 Way	Yes	1	100	3	—
	—	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-6 Way	Yes	1	100	3	—
	—	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	1	100	3	—
	—	6 Runs, 1,000 kcmil	3 Runs, 1/0 AWG	1-4 Way	Yes	2	100	3	—

Table 6–13: MAX Cable and Equipment for Existing SOE and Vaults (See Note 2) *– Continued*

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 10)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
8' x 18' x 9'-4"	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	1	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	2	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	3	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	4	3-333	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	1	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	2	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	3	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	4	3-333	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	1	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	2	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	3	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	4	3-333	6	—

Table 6–13: MAX Cable and Equipment for Existing SOE and Vaults (See Note 2) — *Continued*

Structure Size	34.5 kV, 3-Phase, 600 A Runs, MAX Cable Sizes	4-16 kV, 3-Phase, 600 A, MAX Cable Sizes	4-16 kV, 3-Phase, 200 A Runs, MAX Cable Sizes	Switches (RAM or RAG) (See Note 10)	Automation	MAX BURD Count (XFMR /Switch)	Transformer Size (kVA MAX)	MAX 600 A/200 A, 3-W or 4-W Junction Bar	Comments
8' x 22' x 9'-4"	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	2	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	3	100	6	—
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	4	100	6	With 1 Fused BURD Switch
	4 Runs, 1,500 kcmil	4 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	6	(2) 3-333	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	2	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	3	100	6	—
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	4	100	6	With 1 Fused BURD Switch
	2 Runs, 1,500 kcmil	6 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	6	(2) 3-333	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	2-4 Way	Yes	2	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-5 or 6 Way	Yes	3	100	6	—
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	1-4 Way	Yes	4	100	6	With 1 Fused BURD Switch
	—	8 Runs, 1,000 kcmil	6 Runs, 1/0 AWG	—	—	6	(2) 3-333	6	—

Notes:

1. For this table only, a **Run** refers to any set of primary cables that enters the structure from any direction. A run may be one to four conductors. Where two or three single conductor 1/0 AWG runs enter a structure, they maybe "grouped" and considered a run.
2. Structures listed on this table are obsolete and no longer approved for new construction.
3. Pad-mounted equipment is the standard design for serving new residential, commercial or industrial loads. BURD equipment should not be used except where allowed in Section 1.0 and DDS-4, Section 5.0
4. Vents are required when installed transformation is ≤225 kVA. Blowers are required when installed transformation is greater than 225 kVA. Refer to the *DUG Manual*, Section VE110.
5. Single-phase fused BURD transformers shall not be used for closed delta service. When it is necessary to build a closed delta bank in a submersible structure, nonfused transformers must be used with a separate fuse device. Fused BURD transformers may be used in open delta banks for serving 120/240 V, three-phase, four-wire loads.
6. Pertains only to primary cable. When using this table, do not consider secondary runs.
7. One-set of 600 A/200 A to be used to connect PT for automation purposes.
8. Any 600 A run could be replaced with a 200 A run.
9. Any BURD transformer (167 kVA MAX) can be replaced by a BURD switch and vice versa.
10. Only RAM switches can be automated.
11. Wrap or offset cables in SOE and vaults where possible. Refer to *DUG*, RS 200 for details.

12. Existing non-staggered bushing RAM switches installed in SOEs are grandfathered. Replacement of non-staggered bushing with staggered bushing RAM switches is NOT allowed. An existing SOE with a grandfathered non-staggered RAM switch is considered full, and no additional equipment shall be added.
13. Existing automated RAM switches are grandfathered.

Appendix 6–1: Examples Showing How to Use Table 6-12

Vaults and SOE Cable and Equipment Configurations
Refer to Note 3 of Table 6–12 for Application of Sub-Surface Equipment in Below-Ground Structures

EXAMPLE 1:

Determine type and structure size for the following cables and equipment:
One, 4-Way SF_6 Switch
One, 100 kVA BURD Transformer
One, 75 kVA BURD Transformer

Answer 1: 7' × 14' × 8' Tub-Type Vault.
A 7' × 14' × 8' vault can hold one, 4-Way switch, a maximum of two BURD transformers and/or BURD switches, the maximum transformer size allowed is 100 kVA.

EXAMPLE 2:
Determine type and structure size for the following cables and equipment:
Three, 333 kVA BURD Transformers

Answer 2: 7' × 18' × 8' Tub-Type Vault.
Fuse Cabinet and external switch is required.
A 7' × 18'× 8' vault can hold a maximum number of three BURD transformers and/or BURD switches, and the maximum transformer size allowed is 333 kVA.

EXAMPLE 3:
Can you install one 4-way RAM switch and one, 75 kVA, 120/240 V BURD transformer in a 5' × 10'-6" × 7' tub-type vault?

Answer 3: No. A 7' × 14' × 7' tub-type vault should be used.
Table 6–12 shows that one, 4-way switch and up to two, 100 kVA BURD transformers can be installed in a 7' × 14' × 8' tub-type vault.
If a 4-way RAM switch is not absolutely needed, a 3-way, BURD switch and up to two BURD transformers (maximum 100 kVA each) may be used in a 6' × 12' × 7' tub- type vault.

EXAMPLE 4:
Determine type and structure size for the following cables and equipment: A bank of 3-75 kVA 277/480 V transformers.

Answer 4A: 6' × 12' × 7' tub-type vault, or

Answer 4B: 7' × 14' × 8' with external fuse, or

Answer 4C: 7' × 18' × 8' with one fused BURD switch.

Appendix 6–2: Structures with Cable and Equipment (Sheet 1 of 5) **Refer to Note 3 of Table 6-12 for Application of Sub-Surface Equipment in Below-Ground Structures**

Figure 6–3: 5' x 8'-6" x 5' SOE — Using Cable Only, No Equipment

(The illustration shows the maximum allowable pieces of equipment for a vault of this size.)

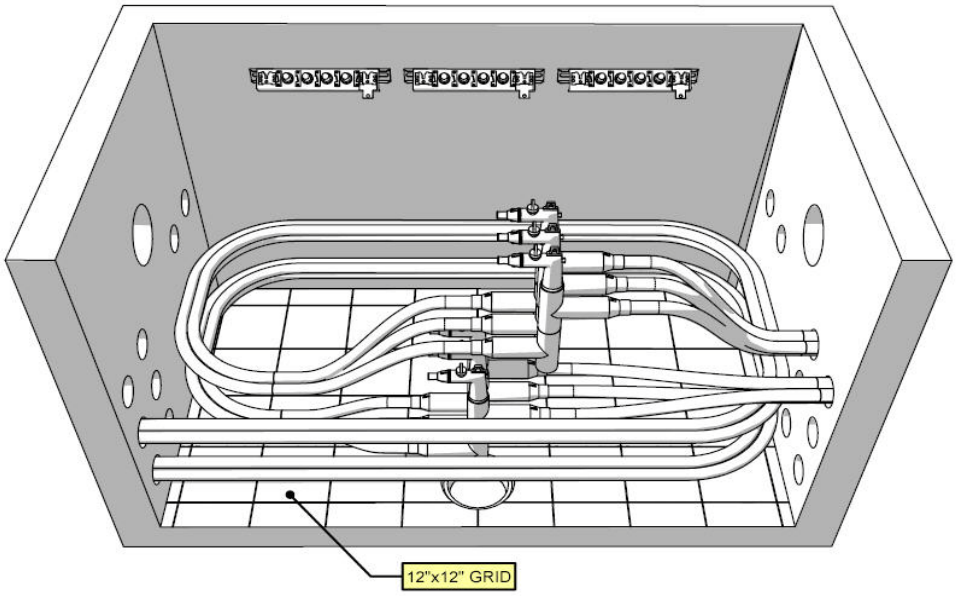
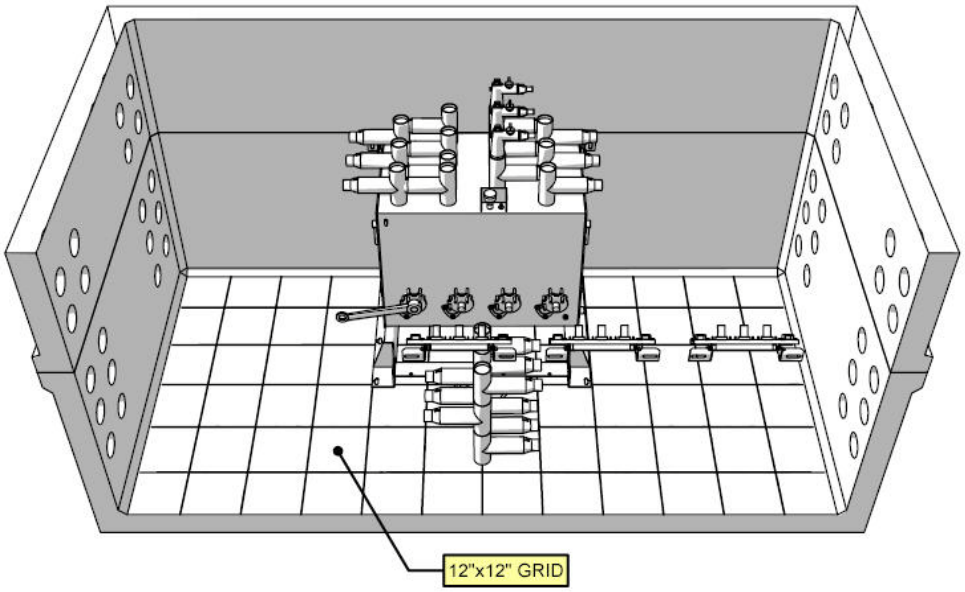


Figure 6–4: 6' x 12' x 7' Vault — Using 4-Way RAM Switch and 3-Way Junction Bars (J-Bars)

(The illustration shows the maximum allowable pieces of equipment for a vault of this size.)



Appendix 6-2: Structures with Cable and Equipment (Sheet 2 of 5)
****Refer to Note 3 of Table 6-12 for Application of Sub-Surface Equipment in Below-Ground Structures****

Figure 6–5: 6' x 12' x 7' Vault — Using 3-Way RAM Switch, BURD Transformer/Switch & 4-Way J-Bar

(The illustration shows the maximum allowable pieces of equipment for a vault of this size.)

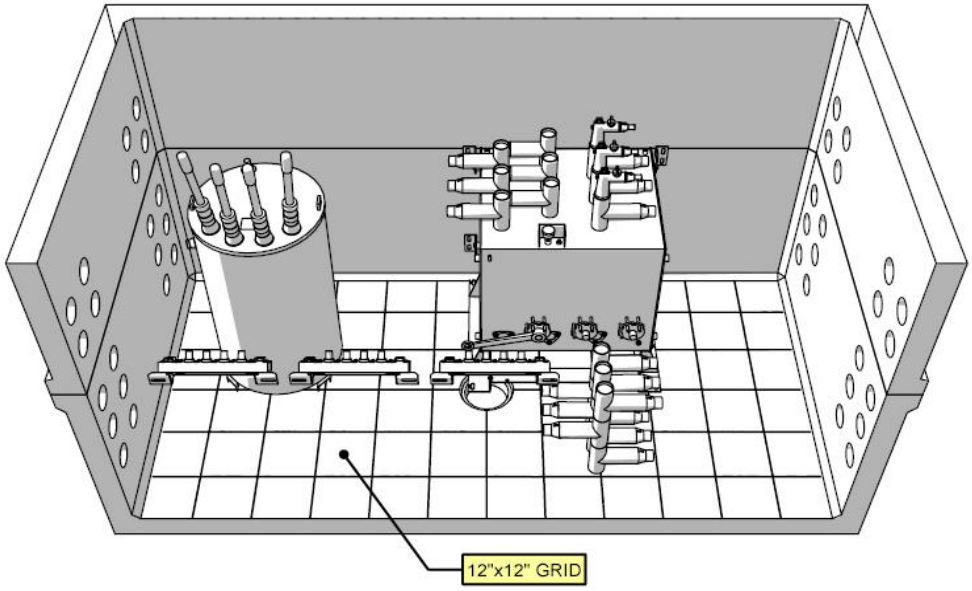
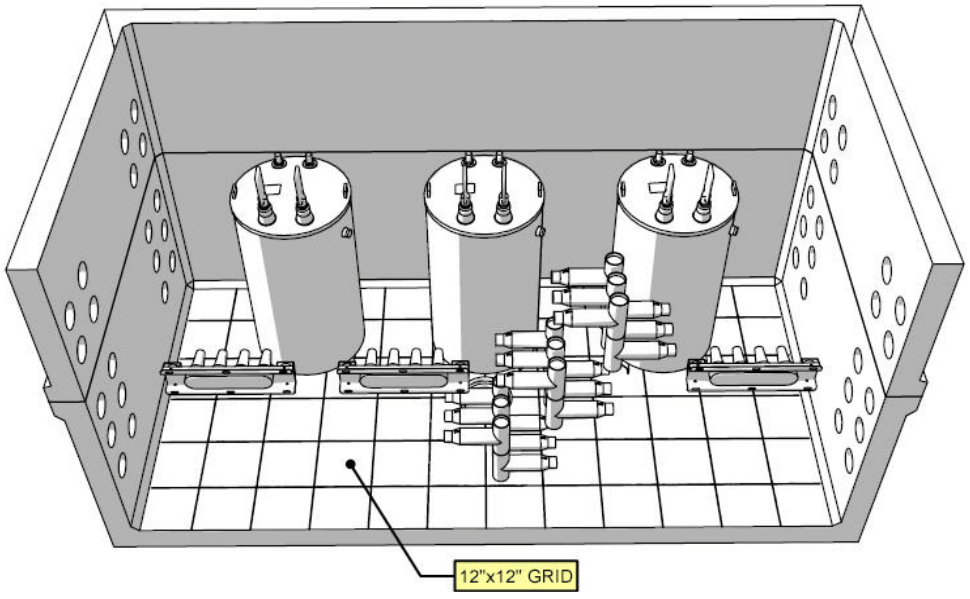


Figure 6–6: 6' x 12' x 7' Vault — Using BURD Transformer/Switches & 4-Way J-Bars

(The illustration shows the maximum allowable pieces of equipment for a vault of this size.)



Appendix 6-2: Structures with Cable and Equipment (Sheet 3 of 5)
****Refer to Note 3 of Table 6-12 for Application of Sub-Surface Equipment in Below-Ground Structures****

Figure 6–7: 7' x 14' x 8' Vault — Using 6-Way RAM Switch, Potential Transformer (PT) for Automation, BURD Transformer/Switch & 4-Way J-Bars

(The illustration shows the maximum allowable pieces of equipment for a vault of this size.)

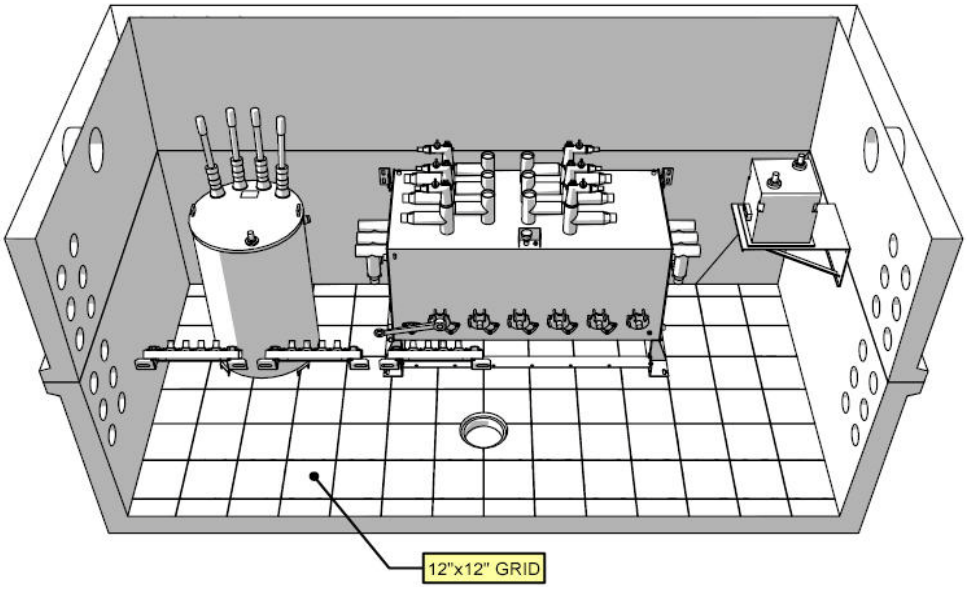
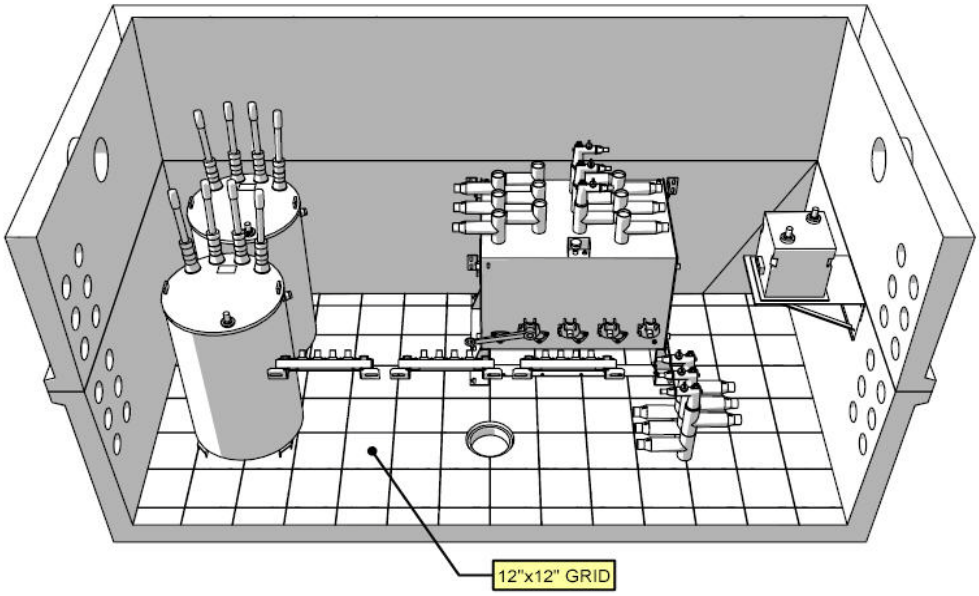


Figure 6–8: 7' x 14' x 8' Vault — Using 4-Way RAM/RAG Switch, PT for Automation, BURD Transformers/Switches & 4-Way J-Bars

(The illustration shows the maximum allowable pieces of equipment for a vault of this size.)



Appendix 6-2: Structures with Cable and Equipment (Sheet 4 of 5)
Refer to Note 3 of Table 6-12 for Application of Sub-Surface Equipment in Below-Ground Structures

Figure 6–9: 7' x 14' x 8' Vault — Using BURD Transformers/Switches and 4-Way J-Bars

(The illustration shows the maximum allowable pieces of equipment for a vault of this size.)

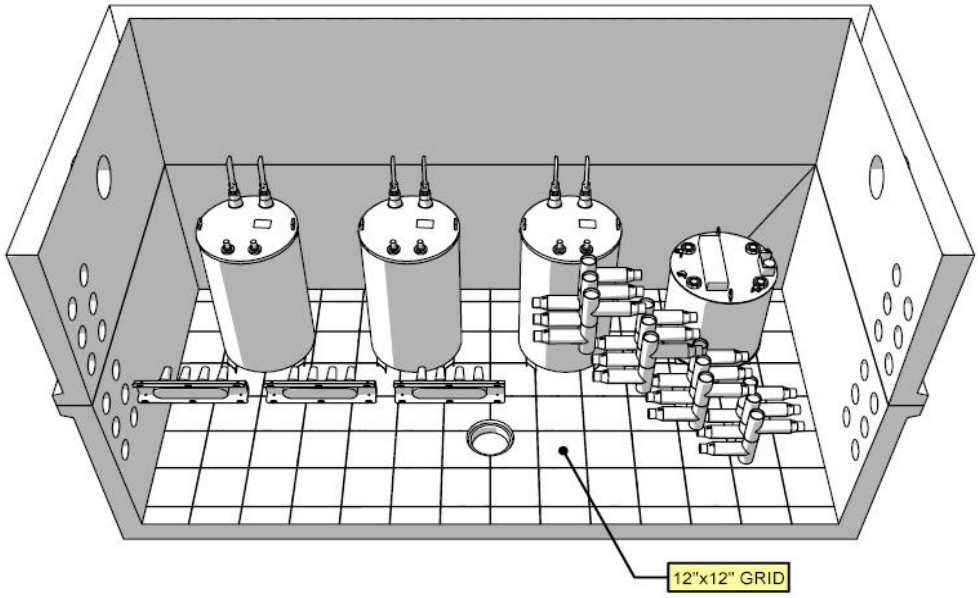
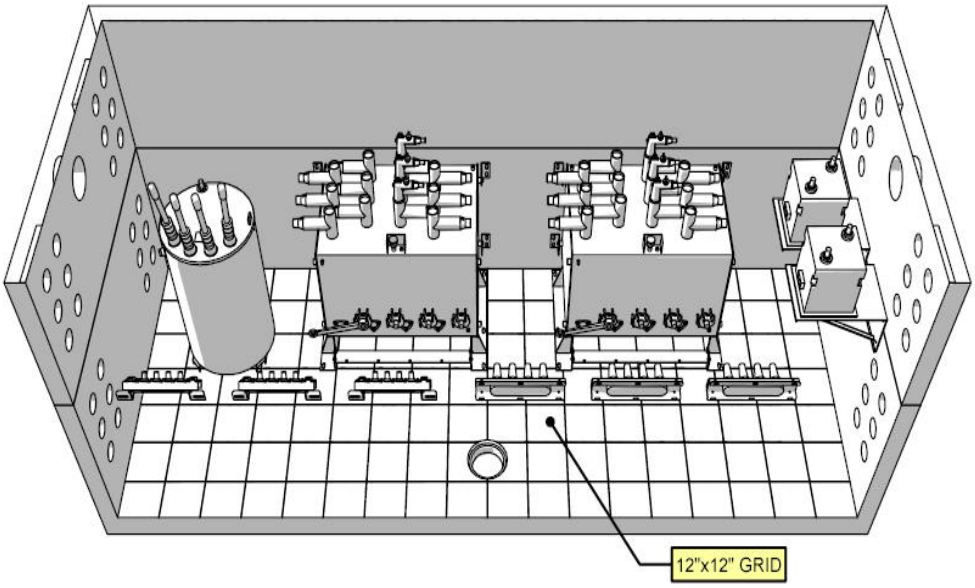


Figure 6–10: 7' x 18' x 8' Vault — Using RAM Switches, PTs for Automation, BURD Transformer/Switch & 4-Way J-Bars

(The illustration shows the maximum allowable pieces of equipment for a vault of this size.)



Appendix 6-2: Structures with Cable and Equipment (Sheet 5 of 5)
****Refer to Note 3 of Table 6-12 for Application of Sub-Surface Equipment in Below-Ground Structures****

Figure 6–11: 7' x 18' x 8' Vault — Using 6-Way RAM Switch, PT for Automation, BURD Transformers/Switches & 4-Way J-Bars

(The illustration shows the maximum allowable pieces of equipment for a vault of this size.)

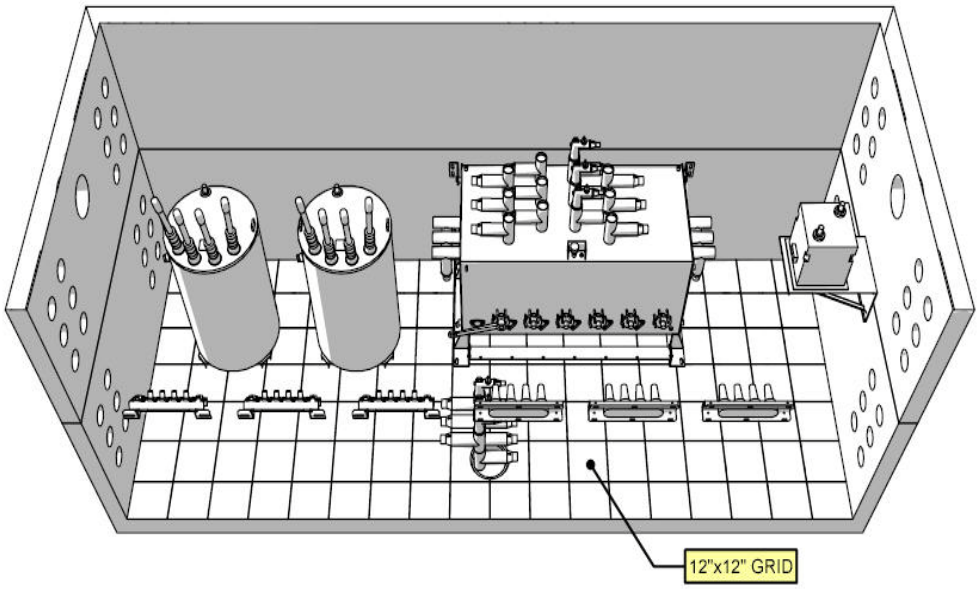
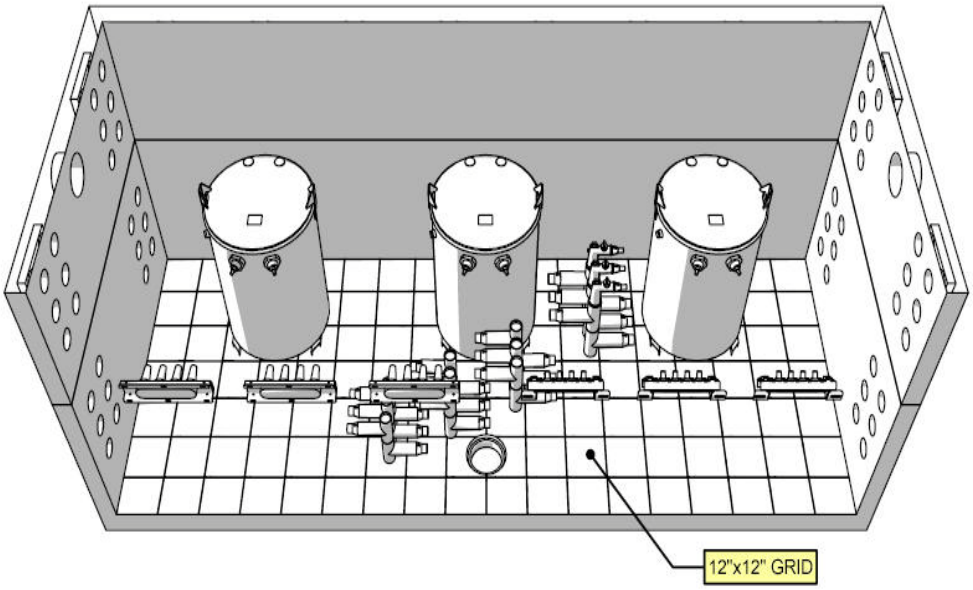


Figure 6–12: 7' x 18' x 8' Vault — Using BURD Transformers/Switches and 4-Way J-Bars

(The illustration shows the maximum allowable pieces of equipment for a vault of this size.)



Southern California Edison
Transmission and Distribution Business Unit

Chapter DDS–7: Transformer Loading

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DDS—7
Transformer Loading

1.0 Scope

This chapter provides loading criteria for transformers serving residential and commercial/industrial loads.

2.0 Residential Transformer Loading

2.1 Residential Transformer Loading Tables

Residential Transformer Loading Chapter DDS-7, Table 7–1 through Table 7–5 shall be used to determine the maximum number of dwellings of a given square footage that can be served by a transformer. The tables apply to single-family and multi-family residential developments up to 5,000 square feet per unit and cover the five climate zones. Within each climate zone (except Zone 9), separate tables are provided for homes with and without central air conditioning.

The tables also apply to single-family residential lot sales developments based on the average square footage of homes determined by the development lot size and restrictions.

Multi-family dwellings are often smaller units having lower diversified demands at the serving transformer. Therefore, the number of units served per transformer is to be increased by 20 percent above the numbers in the standards.

The number of transformer locations should be kept to a minimum by maximizing the number of residential customers per transformer. Generally, it is more economical to install 50 kVA or 75 kVA transformers depending on lot sizes and size of homes. Site-specific analysis must be performed to arrive at the most economical design.

In single-family developments, 100 kVA transformers shall not normally be used for new installations. In multi-family developments, 100 kVA pad-mounted transformers may be used for new installations.

Directions for using these tables and determining Design Square Feet for use with Chapter DDS–4, Table 4–5:

1. Calculate the average square-feet size of the residential dwellings under consideration (rounded up to the nearest 200 square feet) and their average air conditioning size (rounded up to the nearest 1/2 ton).
2. Find the Average Square Feet size in the Residential Transformer Loading table for the appropriate climate zone, Chapter DDS-7, Table 7–1 through Table 7–6. Compare the Assumed Average A/C Ton from that column to the Actual Average A/C Tons of the residences. If the Assumed Average A/C Ton value and the Actual Average A/C Tons match, the Average Square Feet size is also the Design Square Feet. Use the transformer loading information from this line on the table to design the transformer system. Also use this Design Square Feet to determine the kW Demand for secondary system design in Chapter DDS-4, Table 4–5.

If the dwellings have a larger average A/C Tons than the Assumed Value in the table,

- Go down the column until you find the smallest-sized home where the Assumed A/C Tons and the Average Tons match.
- The Square Feet shown on the line where this match is achieved is the Design Square Feet.
- Use the transformer loading information from this line on the table to design the transformer system. Also use this Design Square Feet to determine the kW Demand for secondary system design in Chapter DDS-4, Table 4–5.

If the homes have smaller Average A/C Tons, than the Assumed Value in the table,

- Record the Minimum Square Feet size next to the Assumed Average A/C Ton value.
- Now go up the Assumed Average A/C Ton column until you find the largest-sized home where the Assumed A/C Tons and the Average Tons match.
- Compare the Square Feet shown on the line where this match is achieved to the Minimum Square Feet size just recorded. The Design Square Feet will be the larger of these two numbers.
- Use the transformer loading information from the line corresponding to the Design Square Feet to design the transformer system. Also use the Design Square Feet to determine the kW Demand for secondary system design in Chapter DDS-4, Table 4–5.

The Minimum Square Feet values in the right-hand column assure that homes with unusually small air conditioners are still provided with adequately sized service equipment. The Minimum Square Feet values for Climate Zone 9 are the same as the Square Feet values in the left most column of the table to assure homes built in this climate zone are built with service equipment sized for no less than average sized air conditioners.

Examples that demonstrate the use of these tables are included in Appendix 7–1.

Table 7–1: Residential Transformer Loading — Climate Zone 1

Catalina, Inglewood, Long Beach (Part), Huntington Beach, Saddleback (Part), Santa Barbara (Part), Santa Monica (Part), South Bay, Thousand Oaks (Part), Ventura (Part)

Design Square Feet	Pad-Mounted Transformers				BURD Transformers [d/]				Assumed Average A/C Ton / MIN Sq Ft[a/]
	MAX Number of Customers/ Transformer Size[b/]				MAX Number of Customers/ Transformer Size[b/]				
	25 kVA	50 kVA	75 kVA	100 kVA[c/]	25 kVA	50 kVA	75 kVA	100 kVA[c/]	
Units with Central Air Conditioning									
800	8	15	22		6	15	21		2.0/800
1,000	7	14	21		6	14	20		2.0/800
1,200	6	14	20		5	13	19		2.0/800
1,400	6	13	19		5	12	18		2.5/800
1,600	5	13	18	24	5	12	17	24	3.0/800
1,800	5	12	18	23	4	11	16	23	3.5/800
2,000	5	12	17	22	4	11	15	22	3.5/800
2,200	4	11	16	21	4	10	15	21	4.0/800
2,400	4	10	16	20	4	9	15	20	4.5/800
2,600	4	10	15	19	4	8	14	20	5.0/800
2,800	4	8	15	19	3	8	14	19	5.0/800
3,000	4	8	14	18	3	7	13	18	5.0/800
3,200	4	7	13	18	3	7	13	18	5.5/800
3,400	3	7	13	17	3	7	12	17	6.0/1,000
3,600	3	7	12	17	2	6	12	17	6.5/1,000
3,800	3	7	12	16	2	6	11	16	7.0/1,200
4,000	3	6	11	15	2	5	11	15	7.0/1,200
4,200	3	6	10	15	2	5	10	15	7.5/1,600
4,400	2	5	10	14	2	5	9	14	8.0/1,600
4,600	2	5	9	14	2	5	9	14	8.0/1,600
4,800	2	5	8	14	2	5	8	14	8.5/2,000
5,000	2	5	8	13	2	5	8	14	9.0/2,000

kVA	Pad-Mounted		BURD [d/]	
	Install. Range	Removal Point	Install. Range	Removal Point
25	0-38	60	0-34	46
50	39-69	97	35-66	87
75	70-100	135	67-93	124
100	101-130	155	94-131	156

a/ If the homes have air conditioners sized differently than the "Assumed A/C Ton" shown, use the adjustment procedure described in Section 2.1 to determine transformer loading.

b/ Increase the number of units served per transformer by 20 percent for multi-family dwellings.

c/ Not generally recommended for initial installation.

d/ Pad-mounted transformers are the standard design for serving new residential loads. BURD transformers should not be used except where allowed in DDS-4, Section 5.0 and DDS-6, Section 1.0.

Notes: *The recommended units-per-transformer values in this table incorporate average residential power factor and residential coincidence factors.*

Table 7–2: Residential Transformer Loading — Climate Zone 3

Santa Ana, Compton, Long Beach (Part), Fullerton, Santa Barbara (Part), Saddleback (Part), Santa Monica (Part), Thousand Oaks (Part), Ventura (Part), Whittier

Design Square Feet	Pad-Mounted Transformers				BURD Transformers [d/]				Assumed Average A/C Ton / MIN Sq Ft[a/]
	MAX Number of Customers/ Transformer Size[b/]				MAX Number of Customers/ Transformer Size[b/]				
	25 kVA	50 kVA	75 kVA	100 kVA[c/]	25 kVA	50 kVA	75 kVA	100 kVA[c/]	
Units with Central Air Conditioning									
800	7	14	21		6	14	21		2.0/800
1,000	6	14	20		5	13	20		2.0/800
1,200	6	13	19		5	12	19		2.0/800
1,400	6	13	18	23	4	12	18	24	2.5/800
1,600	5	12	18	22	4	11	18	22	3.0/800
1,800	5	11	17	21	4	11	17	21	3.5/800
2,000	4	11	16	20	3	9	16	20	3.5/800
2,200	4	10	15	19	3	8	15	20	4.0/800
2,400	4	9	15	19	3	8	15	19	4.5/800
2,600	4	8	14	18	3	8	14	18	5.0/800
2,800	4	8	14	17	3	7	14	18	5.0/800
3,000	4	8	13	17	3	7	13	17	5.5/800
3,200	4	7	12	16	2	6	13	16	6.0/800
3,400	3	6	12	16	2	6	12	16	6.0/1,000
3,600	3	6	12	15	2	5	12	15	6.5/1,000
3,800	3	6	11	15	2	5	12	15	7.0/1,200
4,000	3	6	10	15	2	5	11	15	7.0/1,200
4,200	2	5	9	14	2	5	10	14	7.5/1,600
4,400	2	5	9	13	2	5	10	13	8.0/1,600
4,600	2	5	9	13	2	5	9	13	8.0/2,000
4,800	2	5	8	13	1	5	9	13	8.5/2,000
5,000	2	5	8	12	1	4	8	12	9.0/2,000

kVA	Pad-Mounted		BURD [d/]	
	Install. Range	Removal Point	Install. Range	Removal Point
25	0-38	56	0-32	43
50	39-66	92	33-62	82
75	67-95	127	63-86	116
100	96-122	146	87-122	147

[a/] If the homes have air conditioners sized differently than the "Assumed A/C Ton" shown, use the adjustment procedure described in Section 2.1 to determine transformer loading.

[b/] Increase the number of units served per transformer by 20 percent for multi-family dwellings.

[c/] Not generally recommended for initial installation.

d/Pad-mounted transformers are the standard design for serving new residential loads. BURD transformers should not be used except where allowed in DDS-4, Section 5.0 and DDS-6, Section 1.0.

Notes: *The recommended units-per-transformer values in this table incorporate average residential power factor and residential coincidence factors.*

Table 7–3: Residential Transformer Loading — Climate Zone 5

Covina, Monrovia, Montebello, Ontario, Thousand Oaks (Part), Valencia (Part), Ventura (Part)

Design Square Feet	Pad-Mounted Transformers				BURD Transformers [d/]				Assumed Average A/C Ton / MIN Sq Ft[a/]
	MAX Number of Customers/ Transformer Size[b/]				MAX Number of Customers/ Transformer Size[b/]				
	25 kVA	50 kVA	75 kVA	100 kVA[c/]	25 kVA	50 kVA	75 kVA	100 kVA[c/]	
Units with Central Air Conditioning									
800	7	14	20		5	13	18		2.0/800
1,000	6	14	19		5	12	18		2.0/800
1,200	6	13	18	23	4	12	17	24	2.5/800
1,400	5	12	17	22	4	11	16	22	3.0/800
1,600	4	12	17	21	4	10	15	22	3.0/800
1,800	4	11	16	20	4	9	15	21	3.5/800
2,000	4	10	15	20	3	8	14	20	4.0/800
2,200	4	9	15	19	3	8	13	19	4.5/800
2,400	4	8	14	18	3	8	13	18	5.0/800
2,600	4	8	14	17	3	7	12	18	5.0/800
2,800	3	7	13	17	2	6	12	17	5.5/800
3,000	3	7	13	16	2	6	11	17	6.0/800
3,200	3	6	12	15	2	6	11	16	6.5/1,000
3,400	2	6	12	15	2	6	11	15	7.0/1,000
3,600	2	6	11	14	2	6	10	15	7.0/1,400
3,800	2	6	10	14	2	5	10	14	7.5/1,400
4,000	2	5	9	14	2	5	9	14	8.0/1,800
4,200	2	5	9	13	2	4	8	13	8.0/1,800
4,400	2	5	8	13	2	4	8	13	8.5/1,800
4,600	2	5	8	13	2	4	8	13	9.0/1,800
4,800	2	4	8	12	2	4	7	12	9.5/2,600
5,000	2	4	7	11	2	4	7	12	9.5/2,600

kVA	Pad-Mounted		BURD [d/]	
	Install. Range	Removal Point	Install. Range	Removal Point
25	0-36	55	0-31	42
50	37-65	88	32-59	79
75	66-91	122	60-83	112
100	92-115	139	84-117	141

[a/] If the homes have air conditioners sized differently than the "Assumed A/C Ton" shown, use the adjustment procedure described in Section 2.1 to determine transformer loading.

[b/] Increase the number of units served per transformer by 20 percent for multi-family dwellings.

[c/] Not generally recommended for initial installation.

d/Pad-mounted transformers are the standard design for serving new residential loads. BURD transformers should not be used except where allowed in DDS-4, Section 5.0 and DDS-6, Section 1.0.

Notes: *The recommended units-per-transformer values in this table incorporate average residential power factor and residential coincidence factors.*

Table 7–4: Residential Transformer Loading — Climate Zone 7

Antelope Valley, Arrowhead, Foothill, Menifee, Victorville, Redlands, San Joaquin Valley, Valencia (Part), Wildomar

Design Square Feet	Pad-Mounted Transformers				BURD Transformers [d/]				Assumed Average A/C Ton / MIN Sq Ft[b/]
	MAX Number of Customers/ Transformer Size[a/]				MAX Number of Customers/ Transformer Size[a/]				
	25 kVA	50 kVA	75 kVA	100 kVA[c/]	25 kVA	50 kVA	75 kVA	100 kVA[c/]	
Units with Central Air Conditioning									
800	6	13	18		5	12	17		2.0/800
1,000	6	13	18	22	4	11	16	23	2.0/800
1,200	5	12	17	21	4	11	15	21	2.5/800
1,400	5	12	16	20	4	10	14	20	3.0/800
1,600	5	11	15	19	4	9	14	20	3.0/800
1,800	4	10	15	19	3	8	13	19	3.5/800
2,000	4	9	14	18	3	7	12	18	4.0/800
2,200	4	8	13	17	3	7	12	17	4.5/800
2,400	3	8	13	16	2	7	12	17	5.0/800
2,600	3	7	12	16	2	6	11	16	5.0/800
2,800	3	7	12	15	2	6	11	15	5.5/800
3,000	3	7	12	15	2	6	10	15	6.0/800
3,200	3	6	11	14	2	5	10	14	6.5/1,200
3,400	3	6	10	13	2	5	9	13	7.0/1,200
3,600	3	5	9	13	2	4	8	13	7.0/1,200
3,800	3	5	9	13	2	4	8	13	7.5/1,600
4,000	3	5	8	12	2	4	8	12	8.0/1,600
4,200	3	5	8	12	2	4	7	12	8.0/1,600
4,400	2	5	8	12	2	4	6	12	8.5/2,200
4,600	2	5	7	11	2	4	6	11	9.0/2,200
4,800	2	4	7	10	2	4	6	11	9.5/2,200
5,000	2	4	6	10	2	4	6	10	9.5/2,200

kVA	Pad-Mounted		BURD[d/]	
	Install. Range	Removal Point	Install. Range	Removal Point
25	0-36	51	0-28	38
50	37-61	81	29-54	72
75	62-83	112	55-75	102
100	84-105	128	76-106	129

a/ Increase the number of units served per transformer by 20 percent for multi-family dwellings.

b/ If the homes have air conditioners sized differently than the "Assumed A/C Ton" shown, use the adjustment procedure described in Section 2.1 to determine transformer loading.

c/ Not generally recommended for initial installation.

d/Pad-mounted transformers are the standard design for serving new residential loads. BURD transformers should not be used except where allowed in DDS-4, Section 5.0 and DDS-6, Section 1.0.

Notes: *The recommended units-per-transformer values in this table incorporate average residential power factor and residential coincidence factors.*

Table 7–5: Residential Transformer Loading — Climate Zone 9

Bishop, Blythe, Barstow, Palm Springs, Ridgecrest, Yucca Valley

Square Feet	Pad-Mounted Transformers				BURD Transformers[d/]				Assumed Average A/C Ton / MIN Sq Ft[a/]
	MAX Number of Customers/ Transformer Size[b/]				MAX Number of Customers/ Transformer Size[b/]				
	25 kVA	50 kVA	75 kVA	100 kVA[c/]	25 kVA	50 kVA	75 kVA	100 kVA[c/]	
Units with Central Air Conditioning									
800	5	12	16	21	4	11	15	21	2.0/800
1,000	5	11	15	19	4	9	14	20	2.5/1,000
1,200	4	9	14	18	3	8	13	18	3.0/1,200
1,400	3	8	14	17	3	7	12	17	3.5/1,400
1,600	3	8	12	16	2	6	12	16	4.0/1,600
1,800	3	7	12	15	2	6	11	15	4.5/1,800
2,000	3	6	11	15	2	5	10	14	5.0/2,000
2,200	3	6	10	14	2	5	9	13	5.5/2,200
2,400	3	5	9	13	2	5	8	13	6.0/2,400
2,600	3	5	8	12	2	4	7	12	6.5/2,600
2,800	2	4	7	12	2	4	7	12	7.0/2,800
3,000	2	4	7	11	2	4	6	11	7.5/3,000
3,200	2	4	7	9	2	4	6	10	8.0/3,200
3,400	2	4	6	9	2	3	5	9	8.5/3,400
3,600	2	3	5	8	1	3	5	8	9.0/3,600
3,800	2	3	5	8	1	3	5	8	9.5/3,800
4,000	2	3	5	7	1	2	5	7	10.0/4,000
4,200	2	3	5	7	1	2	5	7	10.5/4,200
4,400	1	3	5	7	1	2	4	7	11.0/4,400
4,600	1	3	5	7	1	2	4	7	11.5/4,600
4,800	1	3	5	6	1	2	4	6	12.0/4,800
5,000	1	3	4	6	1	2	3	6	12.5/5,000

kVA	Pad-Mounted		BURD[d/]	
	Install. Range	Removal Point	Install. Range	Removal Point
25	0-35	50	0-28	38
50	36-60	80	29-53	71
75	61-82	110	54-74	100
100	83-104	126	75-104	127

a/ If the homes have air conditioners sized differently than the "Assumed A/C Ton" shown, use the adjustment procedure described in Section 2.1 to determine transformer loading.

b/ Increase the number of units served per transformer by 20 percent for multi-family dwellings.

c/ Not generally recommended for initial installation.

d/Pad-mounted transformers are the standard design for serving new residential loads. BURD transformers should not be used except where allowed in DDS-4, Section 5.0 and DDS-6, Section 1.0.

Notes: *The recommended units-per-transformer values in this table incorporate average residential power factor and residential coincidence factors.*

Table 7–6: Overhead Transformer Loading

Overhead — Zone 1			
(kVA)	Install Range		Removal Point
	(1)	(2)	
10			16
15			31
25	0-22	0-22	44
37.5	23-31	23-47	69
50	32-51	48-64	85
75	52-63	65-84	116
100	64-119	85-119	143

Climate Zone 1
Catalina, Huntington Beach, Long Beach (Part), Saddleback (Part), Santa Barbara (Part), Santa Monica (Part), South Bay, Thousand Oaks (Part), Ventura (Part)

Overhead — Zone 3			
(kVA)	Install Range		Removal Point
	(1)	(2)	
10			15
15			29
25	0-21	0-21	41
37.5	22-32	22-46	65
50	33-48	47-60	80
75	49-63	61-79	107
100	64-111	80-111	134

Climate Zone 3
Compton, Fullerton, Long Beach (Part), Saddleback (Part), Santa Ana, Santa Barbara (Part), Santa Monica (Part), Thousand Oaks (Part), Ventura (Part), Whittier

Overhead — Zone 5			
(kVA)	Install Range		Removal Point
	(1)	(2)	
10			14
15			27
25	0-22	0-22	39
37.5	23-31	22-45	61
50	32-49	46-57	76
75	50-60	58-75	104
100	61-104	76-104	127

Climate Zone 5
Covina, Monrovia, Montebello, Ontario, Thousand Oaks (Part), Valencia (Part), Ventura (Part)

Overhead — Zone 7			
(kVA)	Install Range		Removal Point
	(1)	(2)	
10			13
15			25
25	0-21	0-21	36
37.5	22-28	21-41	56
50	29-45	42-51	69
75	46-59	52-68	95
100	60-95	69-95	117

Climate Zone 7
Antelope Valley, Arrowhead, Foothill, Menifee, Victorville (Part), Redlands, San Joaquin Valley, Valencia (Part), Wildomar

Overhead — Zone 9			
(kVA)	Install Range		Removal Point
	(1)	(2)	
10			13
15			25
25	0-20	0-20	35
37.5	21-28	21-40	55
50	29-45	41-50	68
75	46-59	51-67	93
100	60-94	68-94	115

Climate Zone 9
Bishop, Blythe, Victorville (Part), Palm Springs, Ridgecrest, Yucca Valley

Note(s):
1. 10 and 15 kVA overhead transformers are not approved for use on new installations.

Transformer Selection Steps:

The above tables are based on economic loading ranges of transformers which are impacted by cost of pole replacement. To account for the economic impact of pole replacement, the overhead transformer tables above provide two installation ranges (Column 1 and Column 2). Please follow the steps below to determine when to use each column.

Step 1: Size transformer using Column 1 for all transformer installations.

Step 2: Determine if transformer selected (from Column 1) will trigger an automatic pole replacement.

a. If **YES**, proceed to Step 3.

b. If **NO**, proceed to Step 6.

Step 3: Disregard transformer sizing from Column 1 and size transformer using Column 2.

Step 4: Determine if transformer selected (from Column 2) will trigger an automatic pole replacement.

a. If **YES**, proceed to Step 5.

b. If **NO**, proceed to Step 7.

Step 5: Consider installing a second transformer on an adjacent pole to eliminate the need to perform a pole replacement. If this is not possible, proceed to Step 6.

Step 6: Disregard transformer sizing from Column 2, create work order to replace the pole and size transformer using Column 1.

Step 7: Replace transformer.

Table 7–7: Residential Transformer Loading — 120/208 Service to Multi-Family[d/e/]

Design Square Feet	Climate Zone 1-7 — All areas not included in Climate Zone 9			Climate Zone 9 — Bishop, Blythe, Barstow, Palm Springs, Ridgecrest and Yucca Valley		
	MAX Number of Customers/ Transformer Size[a/]		Assumed Average A/C Ton / MIN Sq Ft[b/ c/]	MAX Number of Customers/ Transformer Size[a/]		Assumed Average A/C Ton / MIN Sq Ft[b/ c/]
	75 kVA	150 kVA		75 kVA	150 kVA	
Units with Central Air Conditioning						
600	39	-	1.5/600	33	-	2.0/600
800	36	-	1.5/600	30	-	2.0/800
1,000	33	-	1.5/600	27	-	2.0/1,000
1,200	31	-	2.0/600	25	48	2.5/1,200
1,400	29	-	2.5/600	23	47	3.0/1,400
1,600	27	-	2.5/600	21	43	3.5/1,600
1,800	26	-	3.0/600	20	41	3.5/1,800
2,000	24	48	3.5/600	19	38	4.0/2,000
2,200	23	47	3.5/600	18	36	4.5/2,200
2,400	22	44	4.0/600	17	34	5.0/2,400
2,600	21	42	4.0/600	15	32	5.5/2,600
Units without Central Air Conditioning						
1,800	48	-	-	-	-	-
2,000	47	-	-	-	-	-
2,200	45	-	-	-	-	-
2,400	43	-	-	-	-	-
2,600	41	48	-	-	-	-
Three-Phase Pad-Mount						
kVA		**Install Range**			**Removal Point**	
75		0-98			98	
150		99-195			195	

[a/] These tables are designed for multi-family units. **DO NOT** increase by 20 percent.

[b/] If the homes have air conditioners sized differently than the "Assumed A/C Ton" shown, use the adjustment procedure described in Section 2.1 to determine transformer loading.

[c/] Use a minimum 2 A/C Ton to perform flicker calculations. The Assumed A/C Ton values in this Table are provided for proper selection of transformers only.

[d/] The recommended units-per-transformer values in this table incorporate appropriate loading for multi-family homes (20 percent more units per transformer than single-family units), average residential power factor (90 percent) and residential coincidence factors (Table 4–2).

[e/] Buildings with more than 48 units should be referred to Field Engineering to ensure elevator or other high-rise building loads are properly included in the service design.

2.2 Transformers Serving Custom Homes

When serving custom homes or homes above 5,000 square feet, use the procedures in Chapter DDS–4, 5.3.G to determine transformer loading. See Chapter DDS–4, Example 1—3, for sample calculations.

3.0 Commercial/Industrial Transformer Loading

Transformer capacity shall be installed to supply the sum of all loads to be served. Generally, no diversity should be expected among individual customers in commercial and industrial areas.

The transformer selected shall be the smallest that will handle the expected load within the allowable load limits. Transformers may be operated at loads above their nameplate rating as shown in Chapter DDS 7, Table 7–8. This table is the same as Chapter DDS-3, Table 3–3.

Table 7–8: Load Limits of Transformers Serving C/I Customers

Customer Monthly Load Factor (%)	Transformer Load Limit (% of Transformer Rating)
0-64	130%
65-74	125%
75-100	120%

Note: A customer's monthly load factor can be determined using Chapter DDS-3, Table 3–1 or by calculation as follows:

$$\text{Monthly Load Factor} = \frac{\text{Monthly kWh Usage x 100}}{\text{kW Demand x No. of Days/Months x 24 Hours}}$$

The above formula only relates to existing customers.

3.1 Instruction for Use of Transformer Sizing Chart

Figure 7–1 is a guide for selecting the proper size of transformer to be used for three-phase or combination single and three-phase loads. The chart is designed to supply the load through the most economical transformer bank utilizing size and type of connection. While the chart is based on 95 percent power factor for the single-phase load and 80 percent power factor for the three-phase load, the results will be sufficiently accurate for all usual loads. When using the chart, strict adherence to the transformer bank sizes is required.

3.2 120/240 Volt, Three-Phase Pad-Mounted Transformer Loading

When installing a three-phase pad-mounted transformer to serve three-phase, four-wire load (three-phase 240 V, three-wire service with a 120 V, single-phase mid-tap), perform the following steps:

Note: 120/208 V is our current voltage used to serve residential and small commercial three-phase load. A 120/240 V three-phase, four-wire pad mount would only be used to retrofit an existing situation. 120/208 V would be used for all new installations.

Step 1: Verify that the customer requires 240 V three-phase, four-wire service.

Step 2: Calculate/verify the customer's Historical Demand (three phase and single phase).

Step 3: Calculate the Customer Load Factor. See DDS-7, Section 3.0, Table 7–8.

Step 4: Use Historical demands (from Step 2) and Customer Load Factor (from Step 3) and apply them to the Table 7-9 below. To use the table below:

a. Evaluate only the three rows associated with the Customer Load Factor.

b. Evaluate only the column associated with the single-phase demand.

c. Choose the smallest transformer that will accommodate both the three phase and single-phase demands at the calculated Customer Load Factor.

Table 7–9: 240 V, Three-Phase, Four-Wire Transformer Loading Table

Customer Load Factor (%)	Transformer Nameplate kVA Rating	MAX Three-Phase kVA Ratings based on Connected Single-Phase Load							
		0	1-10	11-15	16-25	26-37	38-50	51-75	76-100
0-64% (130% OL)	75	95	75	70	50				
	300	390	370	360	345	320	300	250	200
	500	650	630	620	605	580	560	515	465
65-74% (125% OL)	75	90	75	65	45				
	300	375	355	345	330	305	280	235	185
	500	625	605	595	580	555	535	485	440
75-100% (120% OL)	75	90	70	60	40				
	300	360	340	330	315	290	265	220	170
	500	600	580	570	555	530	510	460	415

Note(s):

Refer to Appendix 7–2: 120/240 Volt Commercial Pad-mounted Transformer Loading example.

A. Temperature Zones 1 through 7, 1Ø and 3Ø Loads

Examples:

1Ø Load (kW)	3Ø Load (kW)	Transformer Bank (kVA)
9	15	15–10
76	40	75–37 1/2–37 1/2

B. Temperature Zone 9, 1Ø and 3Ø Loads

Increase both the 1Ø and 3Ø loads by 10 percent before selecting transformer from the chart.

Examples:

		Add 10% to Loads		
1Ø Load (kW)	3Ø Load (kW)	1Ø Load (kW)	3Ø Load (kW)	Transformer Bank (kVA)
6	4	6.6	4.4	10–5
30	30	33.0	33.0	37 1/2–15
90	50	99.0	55.0	75–50–50

C. For Temperature Zones 1 through 7, 3Ø Loads Only

For loads that are only 3Ø, the chart can be used by assuming a combination of the 3Ø load with 1 kVA 1Ø load.

Examples:

1Ø Load (kW)	3Ø Load (kW)	Transformer Bank (kVA)
0	15	10–10
0	45	25–25

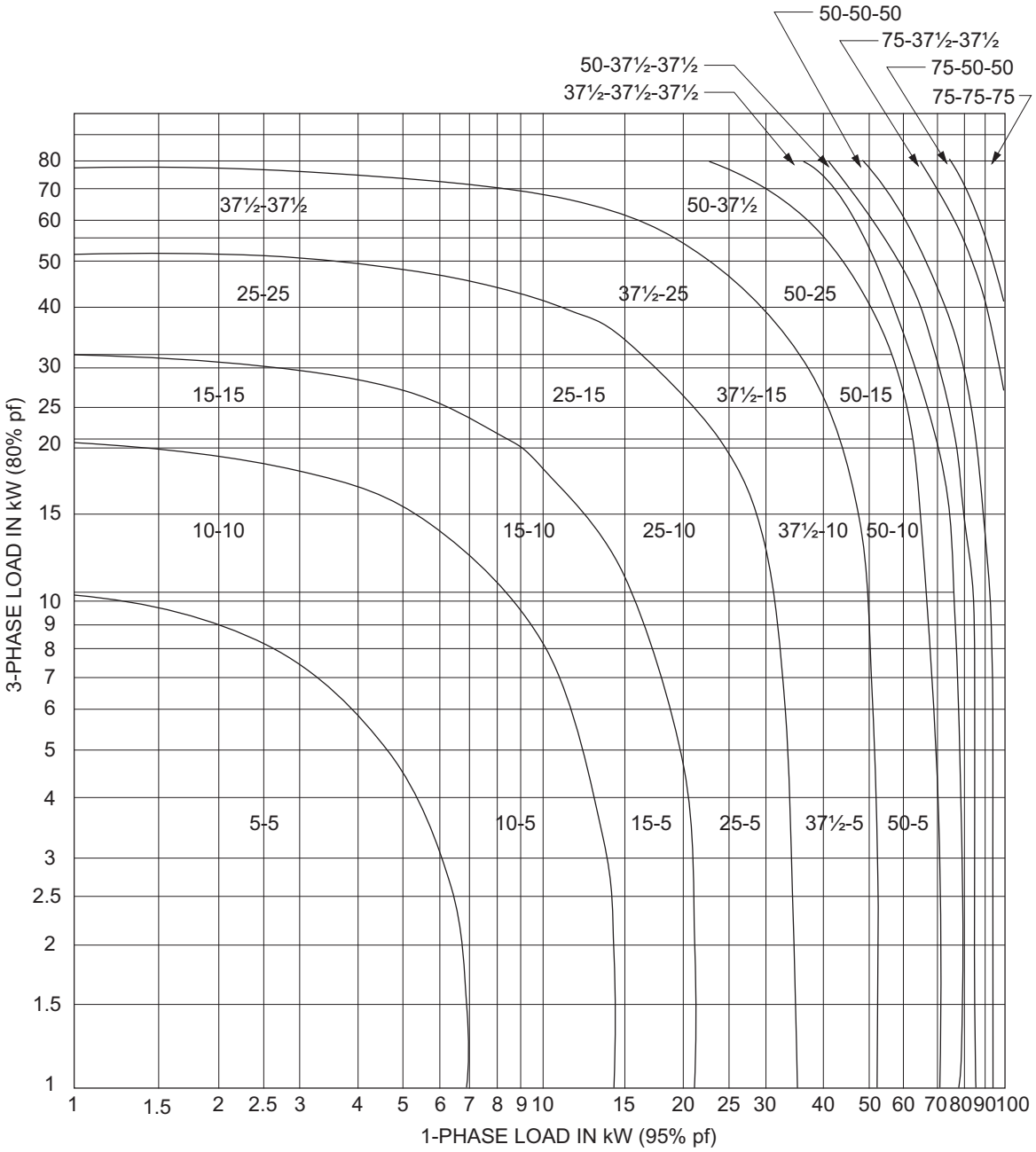
D. Temperature Zone 9, 3Ø Loads

Examples:

		Add 10% to Loads		
1Ø Load (kW)	3Ø Load (kW)	1Ø Load (kW)	3Ø Load (kW)	Transformer Bank (kVA)
6	60	0	66	37 1/2–25
0	10	0	11	5–5

If the combination of 1Ø and 3Ø loads exceeds the limits of the chart, use closed-delta connections.

Figure 7–1: Transformer Sizing Chart for Commercial Loading



Appendix 7–1: Residential Transformer Loading *(Sheet 1 of 8)*

EXAMPLE 1:

A residential development consists of 55 homes located in Climate Zone 7. The homes have air conditioning and the square footage of the four models is 2,000, 2,200, 2,400, and 2,800 square feet with a four-ton air conditioner in all the models except the 2,800- square-foot model which uses a five-ton unit. Determine the number and size of pad-mounted transformers.

Given Data:

55 single-family homes

Climate Zone 7

2,000, 2,200, 2,400 square feet with four-ton air conditioners

2,800 square feet with five-ton air conditioners

1. Determine the average size of the homes.

   If the number of homes and size distribution is known, then using the assumed distribution below for this example,

Square Feet/House		No. of Houses		Square Feet
2,000	×	10	=	20,000
2,200	×	15	=	33,000
2,400	×	17	=	40,800
2,800	×	13	=	36,400
			Total	130,200 Sq Ft

   130,200 square feet ÷ 55 homes = 2,367.2 average square feet per house.

2. If number of homes of each model is not known, then,

Square Feet/House	
2,000	
2,200	
2,400	
+ 2,800	
Total	9,400 ÷ 4 = 2,350 average square feet per house

   In either case, round up to 2,400 average square feet.

3. Determine the average A/C Ton of the homes.

   If the number of homes and A/C Ton size distribution are known, then using the assumed distribution below for this example,

A/C Ton/House		No. of Houses		A/C Ton
4	×	42	=	168
5	×	13	=	65
			Total	233 Ton

233 Ton ÷ 55 Homes = 4.2 Average A/C Ton per House

or, if number of homes of each model is not known, then,

A/C Ton

4 + 4 + 4 + 5 = 17

Total 17 ÷ 4 = 4.25 Average A/C Ton per House

In either case, round up to the nearest 1/2 Ton, or 4.5 A/C Ton average.

Determine the Design Square Feet Size of the Homes.

The following is extracted from Chapter DDS-7, Table 7–4, Residential Transformer Loading—Climate Zone 7, with air conditioning and pad-mounted transformers (pad-mounted transformers are to be utilized in this design).

Design Square Feet	Pad-Mounted Transformer Size			Assumed A/C Ton/MIN Square Feet
	MAX No. of Customers			
	25 kVA	50 kVA	75 kVA	
2,000	4	9	14	4.0/800
2,200	4	8	13	4.5/800
2,400	3	8	13	5.0/800
2,600	3	7	12	5.0/800
2,800	3	7	12	5.5/800

The table has values for 2,400 square-feet units, but the assumed A/C size is five ton for a 2,400 square-foot house. Since the actual A/C size is 4.5 Ton, record the Minimum Square Feet from this line (800 square-feet minimum) and then go up the Assumed A/C Ton column until a match is found for the largest unit size with a 4.5 Ton A/C. This match occurs on the line for 2,200 square-foot homes. The Design Square Feet size of these homes will be the larger of 2,200 square feet, or the minimum size of 800 square feet. In this example, the Design Square Feet size of these houses is 2,200 square feet.

Up to eight customers can be served from a 50 kVA pad-mounted transformer or up to 13 customers from a 75 kVA pad-mounted transformer with a Design Square Feet Size of 2,200 square feet. The final design could consist of six, 50 kVA transformers; four, 75 kVA transformers; or some combination of the two.

The preliminary design for the project should be for six, 50 kVA transformers, but the final design should be the least-cost combination of transformers and secondary components that meet voltage drop and flicker design criteria. Specific lot sizes and lot arrangement may require the use of some 25 kVA and 75 kVA transformers. Use the Design Square Feet size of 2,200 square feet for these houses in Chapter DDS-4, Table 4–5 to find the Diversified Residential kW Demand used to perform voltage-drop calculations.

EXAMPLE 2:

A residential development consists of 16, single-family dwellings located in Climate Zone 7. The homes have a square footage of 3,200 square feet each with a six-ton air conditioner. Determine the number and size of the pad-mounted transformers.

Given Data:

16, Single-Family Homes

Climate Zone 7

Each home is 3,200 square feet for each is equipped with a six-ton air conditioner.

The following is extracted from Chapter DDS-7, Table 7–4, residential Transformer Loading - Climate Zone 7, with air conditioning and pad-mount transformers (pad-mount transformers are to utilized in this design).

Design Square Feet	Pad-Mounted Transformer Size			Assumed A/C Ton/MIN Square Feet
	MAX No. of Customers			
	25 kVA	50 kVA	75 kVA	
2,800	3	7	12	5.5/800
3,000	3	7	12	6.0/800
3,200	3	6	11	6.5/1,200
3,400	3	6	10	7.0/1,200

The table has values for 3,200 square-feet units, but the Assumed A/C size is 6.5 tons for a 3,200 square-foot house. Since the actual A/C size is six tons, record the minimum square feet from this line (1,200 square-foot minimum) and then go up the Assumed A/C Ton column until a match is found for the largest unit size with a six-ton A/C. This match occurs on the line for 3,000 square-foot homes. The Design Square Feet size of these homes will be the larger of 3,000 square feet or the minimum size of 1,200 square feet. In this example, the Design Square Feet size of these houses is 3,000 square feet.

Up to 12 customers can be served from a 75 kVA transformer. The final design could consist of 2, 75 kVA transformer or 3, 50 kVA transformers, or some other combination. The preliminary design for the project should be for 2, 75 kVA transformer. The final design should be the least-cost combination of transformers and secondary components that meet voltage drop and flicker design criteria. Use the Design Square Feet size of 3,000 square feet for these houses when using Chapter DDS-4, Table 4–5 to find the Diversified Residential kW Demand used to perform voltage drop calculations.

EXAMPLE 3:

A residential development in Climate Zone 5 consists of 160 apartment units of eight buildings, each containing 20 units. The average size of the apartments is 1,200 square feet. Each unit has one, 2-1/2 ton air conditioner. Determine the number and size of pad-mounted transformers.

Given Data:

160 units
Eight buildings (with 20 customers each)
Climate Zone 5
1,200 square feet per unit
One, 2-1/2 ton air conditioner

The following has been extracted from Chapter DDS-7, Table 7–3, Residential Transformer Loading Table—Climate Zone 5, with pad-mounted transformers (pad-mounted transformers are the standard for design in residential multi-family developments).

Square Feet	Pad-Mounted Transformer Size				Assumed A/C Ton/MIN Sq Ft
	MAX No. of Customers				
	25 kVA	50 kVA	75 kVA	100 kVA	
1,200	6	13	18	23	2.5/800

Determine the Design Square Feet Size of the Homes.

Compare the Actual A/C size with the Assumed A/C Ton. In this example they agree, so no adjustment is required for unusually large or small air conditioners. The Design Square Feet size is also the average size of 1,200 square feet.

First consider the use of 100 kVA pad-mounted transformers in the design of a multi-family residential development due to a low probability of future unidentified load growth. The data above, taken from the Climate Zone 5 table (Table 7–3) indicates that 23 customers could be served. However, for multi-family dwellings the number of units that can be served by a transformer is increased by 20 percent because they have lower-diversified demands.

The 23 customers from the table above increased by 20 percent equals 28 customers that can be served from one, 100 kVA transformer.

The minimum number of 100 kVA transformers is determined by dividing the 160 units by 28 customers.

$$\text{No. of 100 kVA transformers} = \frac{160}{47} = 5.7$$

Therefore, six 100 kVA transformers (each serving two buildings) are to be used in the preliminary design provided that the service plan meets voltage drop and flicker criteria. Transformer placement requirements may preclude the use of all 100 kVA transformers such that more than four transformers and the use of some 50 kVA transformers may be appropriate.

Appendix 7–1: Residential Transformer Loading *(Sheet 6 of 8)*

Use the Design Square Feet size of 1,200 square feet in Chapter DDS-4, Table 4–5 for these houses to find the Diversified Residential kW Demand used to perform voltage drop calculations.

EXAMPLE 4:

A residential development in Climate Zone 9 consists of 120 apartment units in three buildings, each containing 40 units. The average size of the apartments is 1,400 square feet. Each unit has a three and a half-ton air conditioner. Determine the number and size of transformers.

Given Data:

120 units

Three buildings (with 40 customers each)

Climate Zone 9

1,400 square feet per unit

3-1/2-ton air conditioner per unit

The developer's building and meter location arrangement favors three transformer locations, each transformer location serving one of the three buildings. In this case, the designer chooses to consider 120/208 V three-phase service.

The following has been extracted from Chapter DDS-7, Table 7–7 "Residential Transformer Loading — 120/208 Service to Multi-Familyd/e/" (Page 7–12), Climate Zone 9, with pad-mount transformers (pad-mount transformers are the standard for design in residential multi-family developments).

Design Square Feet	Pad-Mounted Transformer Size		Assumed A/C Ton/MIN Square Feet
	MAX Number of Customers/Transformer Size		
	75 kVA	150 kVA	
1,400	23	47	3.0/1,400
1,600	21	43	3.5/1,600
1,800	20	41	3.5/1,800

The table has values for a 1,400 square-foot apartment, but the assumed A/C size is three Ton for a 1,400 square-foot apartment. Since the actual A/C size is planned to be 3.5 Ton, use the Maximum Number of Customer/Transformer Size values for the smallest unit size with 3.5-Ton A/C or 1,600 square feet. The Design Square Feet size for these apartments is 1,600 square feet.

The maximum number of 1,600 square-foot apartments that can be served from a 150 kVA transformer is 43. The minimum number of 150 kVA transformers is determined by dividing the 120 units by 43 customers. Therefore, three, 150 kVA transformers (each serving a building of 40 units) are to be used in the preliminary design provided that the service plan meets voltage drop and flicker criteria.

To determine voltage drop refer to Chapter DDS-4, Table 4–5 to find the appropriate kW demand value. The following has been extracted from Table 4–5.

Appendix 7–1: Residential Transformer Loading *(Sheet 8 of 8)*

Dwelling Type	Square Feet	Climate Zone 9 kW Demand
Multi-Family	1,400	5.5
	1,600	6
	1,800	6

The Design Square Feet size for these apartments is 1,600 square feet. The kW Demand for a 1,600 square-foot apartment is 6 kW.

Use this 6 kW Demand value to calculate the voltage drop as described in Chapter DDS–8, Section 3.0 (Page 8–4).

When applying voltage drop factors from Table 8–1, use the three-phase column for this example labeled: Commercial/Industrial or Residential (Apartment) Three-Phase, 208 V.

Flicker from single-phase air conditioners served from three-phase transformers or banks serving multi-family buildings need not be calculated.

Appendix 7–2: 120/240 Volt Commercial Pad-mounted Transformer Loading

Example 1:

Customer A needs to perform a Rule 20 transformer change out. Customer A's historical demand is 66 kVA, three-phase, and 12 kVA, single-phase and his Customer Load Factor is 67 percent. What transformer should be applied?

Answer: 75 kVA

Step 1: 240 kVA, three-phase, four-wire service is required for customer.

Step 2: Historical Demand is:

- Three Phase, 66 kVA
- Single Phase, 12 kVA

Step 3: Customer's Load Factor was calculated to be 67 percent.

Step 4: Use the table:

a. 67 percent Customer Load Factor means that only the following rows apply:

Customer Load Factor (%)	Transformer Nameplate kVA Rating	MAX Three-Phase kVA Ratings Based on Connected Single-Phase Demand							
		0	1-10	11-15	16-25	26-37	38-50	51-75	76-100
65-74% (125% OL)	75	90	75	65	45				
	300	375	355	345	330	305	280	235	185
	500	625	605	595	580	555	535	485	440

b. 12 kVA of single-phase load means only the following column applies:

Customer Load Factor (%)	Transformer Nameplate kVA Rating	MAX Three-Phase kVA Ratings Based on Connected Single-Phase Demand
		5-12
65-74% (125% OL)	75	75
	300	355
	500	605

c. Because the historical three-phase demand is 66 kVA, a 75 kVA transformer should be installed.

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Southern California Edison
Transmission and Distribution Business Unit

Chapter DDS–8: Voltage Drop/Flicker

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DDS—8
Voltage Drop/Flicker

1.0 Scope

This chapter provides criteria and methods to be used to evaluate allowable voltage drop and flicker. Addressed are criteria and methods for both overhead and underground systems. Also provided are criteria for responding to customer requests for short-circuit duty calculations.

2.0 Design Criteria

Secondary and service cables shall be selected to meet the expected demand without exceeding the voltage drop and flicker criteria described below.

2.1 Voltage Drop — Residential and Commercial

Voltage drop criteria is based on the calculated percent voltage drop for the secondary and service cable/conductors from the transformer to the customer's meter. The calculated voltage drop shall be made using the total expected demand for all customers served by each line segment.

The total voltage drop shall not exceed the following:

A. Three percent on new installations

B. Five percent on existing installations — When upgrading existing facilities due to New Business work, the five percent requirement applies to the end-of-line customer (the customer served electrically furthest from the transformer).

C. Low-voltage complaints requiring a work order will be designed to meet the minimum requirements for Rule 2.

Note: Panel upgrade and/or new service/secondary changes would be considered as existing installations.

2.2 Flicker — Residential

Flicker criteria are based on the calculated voltage fluctuation caused by the high starting current of air-conditioning equipment. Flicker is the total voltage fluctuation calculated through the transformer, secondary, and service.

Where multiple units are served from a single transformer or secondary, calculate the flicker for the worst case, *for example,* the largest unit with the longest service). Since flicker caused by starting an air conditioner is of short duration, it is assumed that only one unit will start at a time.

Total residential flicker shall not exceed:

- Five percent on underground and overhead installations for end-of-line customers.

2.3 Flicker — Commercial

Flicker may be a concern when customers have large air-conditioning equipment, motors (over 100 hp), arc welders, arc furnaces, or other types of equipment with high starting currents. Consult Field Engineering to evaluate service to these customers.

All motor installations of 100 horsepower or greater must be reviewed by Field Engineering to determine the ability of the circuit to handle the large motor load. To complete this determination, Field Engineering requires the following information:

- Size of motor (HP)
- Locked rotor current of motor or NEMA code letter of motor
- Size, length, and number of service cables/conductors
- Size and length of secondary cables/conductors
- Size and secondary voltage of serving transformer
- Primary wire/cable sizes and lengths from substation to transformer
- Substation and circuit name and voltage

Additionally, if customer is using a 'soft-start' system, Field Engineering will need to know what type of system is being considered, for example, autotransformer, primary resistor, partial winding, and so on).

3.0 Voltage Drop Determination

3.1 Residential Demand

To estimate the kW demand needed for determining residential voltage drop, use Chapter DDS-4, Table 4–5 for dwelling units up to 5,000 square feet. For larger custom homes above 5,000 square feet, the demand can be determined using the connected load provided in the developer's plans. This method is described in Chapter DDS–4, Section 5.3, H.

3.2 Commercial/Industrial Demand

Voltage drop for commercial/industrial customers should be calculated using demands estimated in accordance with the methods described in Chapter DDS–3, Section 5.0, (Page 3–5).

3.3 Voltage Drop Determination — Residential or Commercial/Industrial

Percent voltage drop for either single-phase or three-phase, residential or C/I may be calculated using per amp and per kW voltage drop constants. Voltage drop constants for underground cables are provided in Table 8–1 and Table 8–2, and constants for overhead conductors are provided in Table 8–3 and Table 8–4. These constants may be used with the following formulas:

(1) $$\%VD = \frac{\text{Feet} \times \text{kW} \times (\text{per kW Constant})}{100 \times N}$$

or

(2) $$\%VD = \frac{\text{Feet} \times \text{Line Amp (See Note)} \times (\text{per Amp Constant})}{100 \times N}$$

N = number of parallel cable runs

Note: Formula (2 above) accounts, for the affect of power factor (PF) on line amp. The Amp Constant was calculated based on 0.9 PF for residential and.85 PF for C/I. If total load kW is known use formula (1 above). If using formula (2), convert the total kW to kVA (using the equation kVA=kW/PF) and then to line amp.

EXAMPLE 1:

Calculate Voltage Drop for Residential Load - 120/240 V.L

Given: 10 kW load on 100 feet of 1/0 CLP

Percent Voltage Drop*

Conductor Size (AWG or kcmil)	Current Capacity (Amps)	kW Capacity at 240 V	Residential Single-Phase 120/240 V	
			Per Amp	Per kW
1/0	190	41	0.0158	0.0731

* Partial table extracted from Table 8–3.

USING FORMULA (1)

$$\% \text{ Voltage Drop} = \frac{\text{Feet} \times \text{kW} \times (\text{per kW Constant})}{100 \times \text{N}}$$

$$\% \text{ Voltage Drop} = \frac{100 \times 10 \times 0.0731}{100} = 0.73\%$$

USING FORMULA (2)

First, convert 10 kW to Line Amp

Using 0.9 PF for residential, 10 kW, $\left(\frac{10\text{kW}}{0.9} = 11.11\text{kVA}\right)$ or 46.3 Line Amps

$$\% \text{ Voltage Drop} = \frac{\text{Feet} \times \text{LineAmp} \times (\text{per Amp Constant})}{100 \times \text{N}}$$

$$\% \text{ Voltage Drop} = \frac{100 \times 46.31 \times 0.0158}{100} = 0.73\%$$

Table 8–1: Voltage Drop Constants — Aluminum CLP DUG Cable

Aluminum CLP Cable										
Conductor Size (AWG or kcmil)	**Residential Single-Phase 120/240 Volt**		**C/I Single-Phase 120/240 Volt**		**C/I Three-Phase 240 Volt**		**C/I or Res. (Apartment) Three-Phase 208 Volt**		**C/I Three-Phase 480 Volt**	
	Per Amp	**Per kW**	**Per Amp**	**Per kW**	**Per Amp**	**Per kW**	**Per Amp**	**Per kW**	**Per Amp**	**Per kW**
No. 2	0.0243	0.1125	0.0233	0.1141	0.0202	0.0571	0.0233	0.0760	0.0100	0.0143
1/0	0.0158	0.0731	0.0152	0.0746	0.0132	0.0373	0.0152	0.0497	0.0066	0.0094
4/0	0.0084	0.0389	0.0082	0.0404	0.0071	0.0202	0.0082	0.0269	0.0036	0.0050
350	0.0055	0.0256	0.0055	0.0270	0.0048	0.0135	0.0055	0.0180	0.0024	0.0034
700	0.0033	0.0152	0.0034	0.0165	0.0029	0.0082	0.0034	0.0110	0.0015	0.0021

Notes:

1. Based on 65 degrees C conductor temperature.
2. Based on residential load power factor PF = 0.9 and C/I load power factor PF = 0.85.

Table 8–2: Voltage Drop Constants — Copper CLP DUG Cable

Copper CLP Cable								
Conductor Size (AWG or kcmil)	C/I Single-Phase 120/240 Volt		C/I Three-Phase 240 Volt		C/I Three-Phase 208 Volt		C/I Three-Phase 480 Volt	
	Per Amp	Per kW	Per Amp	Per kW	Per Amp	Per kW	Per Amp	Per kW
No. 4	0.0227	0.1114	0.0197	0.058	0.0227	0.0742	0.0099	0.0139
No. 2	0.0147	0.0720	0.0127	0.0361	0.0147	0.0481	0.0064	0.0090
2/0	0.0080	0.0391	0.0069	0.0196	0.0080	0.0261	0.0035	0.0049
250	0.0049	0.0238	0.0042	0.0120	0.0048	0.0159	0.0024	0.0029
500	0.0030	0.0145	0.0026	0.0073	0.0029	0.0097	0.0013	0.0018
750	0.0026	0.0128	0.0023	0.0064	0.0026	0.0085	0.0011	0.0016

Notes:

1. Based on 65 degrees C conductor temperature.
2. Based on residential load power factor PF = 0.9 and C/I load power factor PF = 0.85.

Table 8–3: Voltage Drop Constants — Overhead Conductor

Aluminum Cable												
Conductor Size (AWG or kcmil)	**Current Capacity (Amps)**	**kW Capacity at 240V**	**Residential Single-Phase 120/240 Volt**		**C/I Single-Phase 120/240 Volt**		**C/I Three-Phase 240 Volt**		**C/I or Res. (Apartment) Three-Phase 208 Volt**		**C/I Three-Phase 480 Volt**	
			Per Amp	**Per kW**	**Per Amp**	**Per kW**	**Per Amp**	**Per kW**	**Per Amp**	**Per kW**	**Per Amp**	**Per kW**
Aluminum			Triplex	Triplex	Triplex	Triplex	Quad	Quad	Quad	Quad	Quad	Quad
#4	110	24	0.0380	0.1761	0.0363	0.1777	0.0314	0.0889	0.0362	0.1185	0.0157	0.0223
#2	145	31	0.0243	0.1125	0.0233	0.1141	0.0202	0.0571	0.0233	0.0760	0.0100	0.0143
1/0	190	41	0.0158	0.0731	0.0152	0.0746	0.0132	0.0373	0.0152	0.0497	0.0066	0.0094
4/0	275	65	0.0084	0.0389	0.0082	0.0404	0.0071	0.0202	0.0082	0.0269	0.0036	0.0050
WAL Open Wire												
#2	140	30	0.0280	0.1295	0.0277	0.1358	0.0240	0.0680	0.0277	0.0905	0.0120	0.0170
1/0	190	41	0.0191	0.0884	0.0193	0.0945	0.0167	0.0473	0.0192	0.0630	0.0083	0.0119
4/0	280	60	0.0114	0.0526	0.0119	0.0582	0.0103	0.0291	0.0119	0.0388	0.0051	0.0073

Conductor Size (AWG or kcmil)	**Current Capacity (Amps)**	**kW Capacity at 120V**	**Residential Single-Phase 120/240 Volt**	
			Per Amp	**Per kW**
Al Duplex				
#6	80	9	0.1200	1.1100
#4	110	12	0.0760	0.7040

Notes:

1. Based on 65 degrees C conductor temperature (Engineering Information).
2. Based on residential load power factor PF = 0.9 and C/I load power factor PF = 0.85.

Table 8–4: Voltage Drop Constants — Overhead Copper Conductor

Copper												
Conductor Size (AWG or kcmil)	**Current Capacity (Amps)**	**kW Capacity at 240V**	**Residential Single-Phase 120/240 Volt**		**C/I Single-Phase 120/240 Volt**		**C/I Three-Phase 240 Volt**		**C/I or Res. (Apartment) Three-Phase 208 Volt**		**C/I Three-Phase 480 Volt**	
			Per Amp	**Per kW**	**Per Amp**	**Per kW**	**Per Amp**	**Per kW**	**Per Amp**	**Per kW**	**Per Amp**	**Per kW**
Copper			Triplex	Triplex	Triplex	Triplex	Quad	Quad	Quad	Quad	Quad	Quad
#6	95	21	0.0369	0.1709	0.0352	0.1726	0.0305	0.0864	0.0352	0.1151	0.0152	0.0216
#4	125	27	0.0237	0.1098	0.0227	0.1140	0.0197	0.0558	0.0227	0.0742	0.0099	0.0139
#2	170	37	0.0152	0.0705	0.0147	0.0721	0.0127	0.0361	0.0147	0.0481	0.0064	0.0090
Copper Open Wire												
#4	170	27	0.0281	0.1300	0.0279	0.1365	0.0242	0.0683	0.0278	0.0910	0.0120	0.0171
#2	230	37	0.0192	0.0891	0.0195	0.0954	0.0169	0.0477	0.0194	0.0636	0.0084	0.0120
2/0	355	57	0.0115	0.0533	0.0121	0.0591	0.0105	0.0296	0.0120	0.0394	0.0052	0.0074
4/0	480	78	0.0087	0.0404	0.0094	0.0460	0.0081	0.0230	0.0094	0.0307	0.0041	0.0058

Conductor Size (AWG or kcmil)	**Current Capacity (Amps)**	**kW Capacity at 120V**	**Residential Single-Phase 120/240 Volt**	
			Per Amp	**Per kW**
Cu Duplex				
#6	80	9	0.0738	0.6834

Table 8–5: Conductor Impedance (R and X Values)

Conductor Impedance per 100 Ft[a/]					
Underground Aluminum CLP	**#2**	**1/0**	**4/0**	**350**	**700**
R	0.0616	0.0390	0.0194	0.0118	.006
X	0.0066	0.0064	0.0062	0.0060	.0056
Z	0.0620	0.0395	0.0204	0.0132	.0082
Overhead Aluminum Triplex	**#4**	**#2**	**1/0**	**4/0**	—
R	0.09800	0.06160	0.03900	0.01940	—
X	0.00700	0.00660	0.00640	0.00620	—
Z	0.09825	0.06195	0.03952	0.02037	—
Overhead WAL Open Wire	**#2**	**1/0**	**4/0**	—	—
R	0.0614	0.0382	0.0185	—	—
X	0.0270	0.0260	0.0240	—	—
Z	0.0671	0.0462	0.0303	—	—
Overhead Aluminum Duplex	**#6**	**#4**	—	—	—
R	0.15500	0.09800	—	—	—
X	0.01060	0.00700	—	—	—
Z	0.15536	0.09825	—	—	—
Overhead Copper Triplex	**#6**	**#4**	**#2**	—	—
R	0.0947	0.0598	0.0374	—	—
X	0.0076	0.0070	0.0066	—	—
Z	0.0950	0.0602	0.0380	—	—
Overhead Copper Wire	**#4**	**#2**	**2/0**	**4/0**	—
R	0.0612	0.0381	0.0185	0.0116	—
X	0.0280	0.0270	0.0250	0.0240	—
Z	0.0673	0.0467	0.0311	0.0266	—
Overhead Copper Duplex	**#6**	—	—	—	—
R	0.09470	—	—	—	—
X	0.00760	—	—	—	—
Z	0.09500	—	—	—	—

a. For Reference Only

4.0 Flicker Determinations

4.1 Residential Flicker — Underground

On underground residential systems the total flicker through the transformer, secondary, and service cable shall be limited to a maximum of **five percent**. Table 8–6 provides the percent flicker through the transformer as a function of air conditioner (A/C) size and transformer size. Flicker through the secondary and service cable is provided in Table 8–7 as a function of A/C size and cable size and length.

Homes without air conditioning should conform to flicker criteria for a two-ton air conditioner. This will allow for pool equipment, window air conditioners, and miscellaneous other single-phase motor starting.

An example demonstrating the use of Table 8–6 and Table 8–7 is included in Appendix 8–1 (Page 8–36).

Table 8–6: Percent Flicker through Underground Transformer

Transformer kVA	A/C Tons (Locked Rotor Current, Amps)							
	2 (61)	**2-1/2 (81)**	**3 (97)**	**3-1/2 (111)**	**4 (122)**	**5 (142)**	**6 (158)**	**7 (172)**
25	1.4	1.8	2.2	2.5	2.8	3.2	3.6	3.9
50	0.7	0.9	1.1	1.3	1.4	1.6	1.8	1.9
75	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.3
100	0.3	0.5	0.5	0.6	0.7	0.8	.9	1.0

Parameters Used for Table

1. Transformer regulation at rated load and 0.9 power factor = 2.0 percent
2. Transformer impedance not to exceed 2.5 percent
3. Motor starting power factor = 0.75

Table 8–7: Percent Flicker through Underground Secondary and Service Cable *(Sheet 1 of 3)*

2-Ton A/C 61 Amps Starting Current					2-1/2-Ton A/C 81 Amps Starting Current					3-Ton A/C 97 Amps Starting Current				
Feet	**No. 2**	**1/0**	**4/0**	**350**	**Feet**	**No. 2**	**1/0**	**4/0**	**350**	**Feet**	**No. 2**	**1/0**	**4/0**	**350**
10	0.1	0.1	0.0	0.0	10	0.2	0.1	0.1	0.0	10	0.2	0.1	0.1	0.1
20	0.3	0.2	0.1	0.1	20	0.3	0.2	0.1	0.1	20	0.4	0.3	0.2	0.1
30	0.4	0.3	0.1	0.1	30	0.5	0.3	0.2	0.1	30	0.6	0.4	0.2	0.2
40	0.5	0.3	0.2	0.1	40	0.7	0.5	0.3	0.2	40	0.8	0.5	0.3	0.2
50	0.6	0.4	0.2	0.2	50	0.9	0.6	0.3	0.2	50	1.0	0.7	0.4	0.3
60	0.8	0.5	0.3	0.2	60	1	0.7	0.4	0.3	60	1.2	0.8	0.5	0.3
70	0.9	0.6	0.3	0.2	70	1.2	0.8	0.4	0.3	70	1.4	0.9	0.5	0.4
80	1.0	0.7	0.4	0.3	80	1.4	0.9	0.5	0.3	80	1.6	1.1	0.6	0.4
90	1.2	0.8	0.4	0.3	90	1.5	1	0.6	0.4	90	1.8	1.2	0.7	0.5
100	1.3	0.9	0.5	0.3	100	1.7	1.1	0.6	0.4	100	2.0	1.4	0.8	0.5
110	1.4	0.9	0.5	0.4	110	1.9	1.2	0.7	0.5	110	2.2	1.5	0.8	0.6
120	1.5	1.0	0.6	0.4	120	2	1.4	0.8	0.5	120	2.5	1.6	0.9	0.6
130	1.7	1.1	0.6	0.4	130	2.2	1.5	0.8	0.6	130	2.7	1.8	1	0.7
140	1.8	1.2	0.7	0.5	140	2.4	1.6	0.9	0.6	140	2.9	1.9	1.1	0.7
150	1.9	1.3	0.7	0.5	150	2.6	1.7	0.9	0.6	150	3.1	2	1.1	0.8
160	2.1	1.4	0.8	0.5	160	2.7	1.8	1	0.7	160	3.3	2.2	1.2	0.8
170	2.2	1.4	0.8	0.6	170	2.9	1.9	1.1	0.7	170	3.5	2.3	1.3	0.9
180	2.3	1.5	0.9	0.6	180	3.1	2	1.1	0.8	180	3.7	2.4	1.4	0.9
190	2.4	1.6	0.9	0.6	190	3.2	2.1	1.2	0.8	190	3.9	2.6	1.4	1
200	2.6	1.7	0.9	0.7	200	3.4	2.3	1.3	0.9	200	4.1	2.7	1.5	1
210	2.7	1.8	1.0	0.7	210	3.6	2.4	1.3	0.9	210	4.3	2.8	1.6	1.1
220	2.8	1.9	1.0	0.7	220	3.8	2.5	1.4	1	220	4.5	3	1.7	1.1
230	3.0	2.0	1.1	0.7	230	3.9	2.6	1.4	1	230	4.7	3.1	1.8	1.2
240	3.1	2.0	1.1	0.8	240	4.1	2.7	1.5	1	240	4.9	3.2	1.8	1.2
250	3.2	2.1	1.2	0.8	250	4.3	2.8	1.6	1.1	250	5.1	3.4	1.9	1.3
260	3.3	2.2	1.2	0.8	260	4.4	2.9	1.6	1.1	260	5.3	3.5	2	1.3
270	3.5	2.3	1.3	0.9	270	4.6	3.1	1.7	1.2	270		3.7	2	1.4
280	3.6	2.4	1.3	0.9	280	4.8	3.2	1.8	1.2	280		3.8	2.1	1.5
290	3.7	2.5	1.4	0.9	290		3.3	1.8	1.3	290		3.9	2.2	1.5
300	3.9	2.6	1.4	1.0	300		3.4	1.9	1.3	300		4.1	2.3	1.6
350	4.5	3.0	1.7	1.1	350		4	2.2	1.5	350		4.7	2.6	1.8
400	5.1	3.4	1.9	1.3	400		4.5	2.5	1.7	400		5.4	3	2.1
450		3.8	2.1	1.5	450		5.1	2.8	1.9	450			3.4	2.3
500		4.3	2.4	1.6	500			3.1	2.2	500			3.8	2.6
550		4.7	2.6	1.8	550			3.5	2.4	550			4.1	2.8
600		5.1	2.8	2.0	600			3.8	2.8	600			4.5	3.1
650			3.1	2.1	650			4.1	3.0	650			4.9	3.4
700			3.3	2.3	700			4.4	3.2	700			5.3	3.6
750			3.6	2.4	750			4.7	3.4	750				3.9
800			3.8	2.6	800				3.7	800				4.1
850			4.0	2.8	850				3.9	850				4.4
900			4.3	2.9	900				4.1	900				4.7
950			4.5	3.1	950				4.4	950				4.9
1,000			4.7	3.3	1,000				4.6	1,000				5.2

Parameters Used for Flicker Tables:

1. Motor starting power factor = 0.75
2. Cable constants (ohms/100'):

	No. 2	1/0	4/0	350
R	.0616	.0390	.0194	.0118
X	.0066	.0064	.0062	.0060

Table 8–7: Percent Flicker through Underground Secondary and Service Cable *(Sheet 2 of 3)*

3-1/2-Ton A/C 111 Amps Starting Current					4 -Ton A/C 122 Amps Starting Current					5-Ton A/C 142 Amps Starting Current				
Feet	**No. 2**	**1/0**	**4/0**	**350**	**Feet**	**No. 2**	**1/0**	**4/0**	**350**	**Feet**	**No. 2**	**1/0**	**4/0**	**350**
10	0.2	0.2	0.1	0.1	10	0.3	0.2	0.1	0.1	10	0.3	0.2	0.1	0.1
20	0.5	0.3	0.2	0.1	20	0.5	0.3	0.2	0.1	20	0.6	0.4	0.2	0.2
30	0.7	0.5	0.3	0.2	30	0.8	0.5	0.3	0.2	30	0.9	0.6	0.3	0.2
40	0.9	0.6	0.3	0.2	40	1	0.7	0.4	0.3	40	1.2	0.8	0.4	0.3
50	1.2	0.8	0.4	0.3	50	1.3	0.9	0.5	0.3	50	1.5	1.0	0.6	0.4
60	1.4	0.9	0.5	0.4	60	1.5	1	0.6	0.4	60	1.8	1.2	0.7	0.5
70	1.6	1.1	0.6	0.4	70	1.8	1.2	0.7	0.5	70	2.1	1.4	0.8	0.5
80	1.9	1.2	0.7	0.5	80	2.1	1.4	0.8	0.5	80	2.4	1.6	0.9	0.6
90	2.1	1.4	0.8	0.5	90	2.3	1.5	0.9	0.6	90	2.7	1.8	1.0	0.7
100	2.3	1.5	0.9	0.6	100	2.6	1.7	0.9	0.7	100	3.0	2.0	1.1	0.8
110	2.6	1.7	0.9	0.7	110	2.8	1.9	1	0.7	110	3.3	2.2	1.2	0.8
120	2.8	1.9	1	0.7	120	3.1	2	1.1	0.8	120	3.6	2.4	1.3	0.9
130	3	2	1.1	0.8	130	3.3	2.2	1.2	0.8	130	3.9	2.6	1.4	1.0
140	3.3	2.2	1.2	0.8	140	3.6	2.4	1.3	0.9	140	4.2	2.8	1.5	1.1
150	3.5	2.3	1.3	0.9	150	3.9	2.6	1.4	1	150	4.5	3.0	1.7	1.1
160	3.7	2.5	1.4	0.9	160	4.1	2.7	1.5	1	160	4.8	3.2	1.8	1.2
170	4	2.6	1.5	1	170	4.4	2.9	1.6	1.1	170	5.1	3.4	1.9	1.3
180	4.2	2.8	1.6	1.1	180	4.6	3.1	1.7	1.2	180		3.6	2.0	1.4
190	4.4	2.9	1.6	1.1	190	4.9	3.2	1.8	1.2	190		3.8	2.1	1.4
200	4.7	3.1	1.7	1.2	200		3.4	1.9	1.3	200		4.0	2.2	1.5
210	4.9	3.3	1.8	1.2	210		3.6	2	1.4	210		4.2	2.3	1.6
220	5.1	3.4	1.9	1.3	220		3.7	2.1	1.4	220		4.4	2.4	1.7
230		3.6	2	1.4	230		3.9	2.2	1.5	230		4.6	2.5	1.7
240		3.7	2.1	1.4	240		4.1	2.3	1.6	240		4.8	2.6	1.8
250		3.9	2.2	1.5	250		4.3	2.4	1.6	250		5.0	2.8	1.9
260		4	2.2	1.5	260		4.4	2.5	1.7	260			2.9	2.0
270		4.2	2.3	1.6	270		4.6	2.6	1.8	270			3.0	2.0
280		4.3	2.4	1.7	280		4.8	2.7	1.8	280			3.1	2.1
290		4.5	2.5	1.7	290			2.7	1.9	290			3.2	2.2
300		4.6	2.6	1.8	300			2.8	2	300			3.3	2.3
350		5.4	3	2.1	350			3.3	2.3	350			3.9	2.7
400			3.5	2.4	400			3.8	2.6	400			4.4	3.0
450			3.9	2.7	450			4.3	2.9	450			5.0	3.4
500			4.3	3	500			4.7	3.3	500				3.8
550			4.7	3.3	550			5.2	3.6	550				4.2
600			5.2	3.6	600				3.9	600				4.6
650				3.9	650				4.2	650				4.9
700				4.2	700				4.6	700				5.3
750				4.4	750				4.9					
800				4.7										
850				5										

Parameters Used for Flicker Tables:

1. Motor starting power factor = 0.75
2. Cable constants (ohms/100'):

	No. 2	1/0	4/0	350
R	.0616	.0390	.0194	.0118
X	.0066	.0064	.0062	.0060

Table 8–7: Percent Flicker through Underground Secondary and Service Cable *(Sheet 3 of 3)*

6-Ton A/C 158 Amps Starting Current					7 -Ton A/C 172 Amps Starting Current				
Feet	No. 2	1/0	4/0	350	Feet	No. 2	1/0	4/0	350
10	0.3	0.2	0.1	0.1	10	0.4	0.2	0.1	0.1
20	0.7	0.4	0.2	0.2	20	0.7	0.5	0.3	0.2
30	1	0.7	0.4	0.3	30	1.1	0.7	0.4	0.3
40	1.3	0.9	0.5	0.3	40	1.4	1	0.5	0.4
50	1.7	1.1	0.6	0.4	50	1.8	1.2	0.7	0.5
60	2	1.3	0.7	0.5	60	2.2	1.4	0.8	0.6
70	2.3	1.5	0.9	0.6	70	2.5	1.7	0.9	0.6
80	2.7	1.8	1	0.7	80	2.9	1.9	1.1	0.7
90	3	2	1.1	0.8	90	3.3	2.2	1.2	0.8
100	3.3	2.2	1.2	0.8	100	3.6	2.4	1.3	0.9
110	3.7	2.4	1.4	0.9	110	4	2.6	1.5	1
120	4	2.6	1.5	1	120	4.3	2.9	1.6	1.1
130	4.3	2.9	1.6	1.1	130	4.7	3.1	1.7	1.2
140	4.7	3.1	1.7	1.2	140	5.1	3.4	1.9	1.3
150	5	3.3	1.8	1.3	150		3.6	2	1.4
160		3.5	2	1.4	160		3.8	2.1	1.5
170		3.7	2.1	1.4	170		4.1	2.3	1.6
180		4	2.2	1.5	180		4.3	2.4	1.7
190		4.2	2.3	1.6	190		4.6	2.5	1.7
200		4.4	2.5	1.7	200		4.8	2.7	1.8
210		4.6	2.6	1.8	210		5	2.8	1.9
220		4.8	2.7	1.9	220			2.9	2
230		5.1	2.8	1.9	230			3.1	2.1
240			2.9	2	240			3.2	2.2
250			3.1	2.1	250			3.3	2.3
260			3.2	2.2	260			3.5	2.4
270			3.3	2.3	270			3.6	2.5
280			3.4	2.4	280			3.7	2.6
290			3.6	2.4	290			3.9	2.7
300			3.7	2.5	300			4	2.8
350			4.3	3	350			4.7	3.2
400			4.9	3.4	400			5.3	3.7
450				3.8	450				4.1
500				4.2	500				4.6
550				4.6	550				5.1
600				5.1	600				

Parameters Used for Flicker Tables:

1. Motor starting power factor = 0.75
2. Cable constants (ohms/100'):

	No. 2	1/0	4/0	350
R	.0616	.0390	.0194	.0118
X	.0066	.0064	.0062	.0060

4.2 Residential Flicker — Overhead

On overhead residential systems the total flicker through the transformer, secondary, and service conductor shall be limited to a maximum of **five percent**. Table 8–8 provides the percent flicker through the transformer as a function of air conditioner (A/C) size and transformer size. Flicker through triplex and open-wire secondary and service conductors is provided in Table 8–9 as a function of A/C size and conductor size and length.

Homes without air conditioning should conform to flicker criteria for a two-ton air conditioner. This will allow for pool equipment, window air conditioners, and miscellaneous other single-phase motor starting.

An example demonstrating the use of Table 8–8 and Table 8–9 is included in Appendix 8–2 (Page 8–40).

Table 8–8: Percent Flicker through Overhead Transformer

Transformer kVA	A/C Tons (Locked Rotor Current)							
	2 (61)	2-1/2 (81)	3 (97)	3-1/2 (111)	4 (122)	**5 (142)**	6 (158)	7 (172)
10	3.4	4.6	5.5	6.3	6.9	8.0	8.9	9.7
15	2.3	3.1	3.7	4.2	4.6	5.4	6.0	6.5
25	1.4	1.8	2.2	2.5	2.8	3.2	3.6	3.9
37.5	0.9	1.2	1.5	1.7	1.8	2.1	2.4	2.6
50	0.7	0.9	1.1	1.3	1.4	1.6	1.8	1.9
75	0.5	0.6	0.7	0.6	0.9	1.1	1.2	1.3
100	0.3	0.5	0.5	0.6	0.7	0.8	0.9	1.0
167	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6

Notes:

1. Transformer regulation at rated load and 0.9 power factor = 2.0percent
2. Transformer impedance not to exceed 2.5 percent
   Transformer resistance used = 1.2 percent
   Transformer reactance used = 2.2 percent
3. Motor starting power factor = 0.75

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 1 of 12)*

Percent Flicker — Aluminum Triplex														
2 - Ton A/C* 61 Amps Starting current					2-1/2 - Ton A/C 81 Amps Starting Current					3 - Ton A/C 97 Amps Starting Current				
Feet	**No. 4**	**No. 2**	**1/0**	**4/0**	**Feet**	**No. 4**	**No. 2**	**1/0**	**4/0**	**Feet**	**No. 4**	**No. 2**	**1/0**	**4/0**
10	0.2	0.1	0.1	0.0	10	0.3	0.2	0.1	0.1	10	0.3	0.2	0.1	0.1
20	0.4	0.3	0.2	0.1	20	0.5	0.3	0.2	0.1	20	0.6	0.4	0.3	0.2
30	0.6	0.4	0.3	0.1	30	0.8	0.5	0.3	0.2	30	0.9	0.6	0.4	0.2
40	0.8	0.5	0.3	0.2	40	1.1	0.7	0.5	0.3	40	1.3	0.8	0.5	0.3
50	1.0	0.6	0.4	0.2	50	1.3	0.9	0.6	0.3	50	1.6	1	0.7	0.4
60	1.2	0.8	0.5	0.3	60	1.6	1	0.7	0.4	60	1.9	1.2	0.8	0.5
70	1.4	0.9	0.6	0.3	70	1.8	1.2	0.8	0.4	70	2.2	1.4	0.9	0.5
80	1.6	1.0	0.7	0.4	80	2.1	1.4	0.9	0.5	80	2.5	1.6	1.1	0.6
90	1.8	1.2	0.8	0.4	90	2.4	1.5	1	0.6	90	2.8	1.8	1.2	0.7
100	2.0	1.3	0.9	0.5	100	2.6	1.7	1.1	0.6	100	3.2	2	1.4	0.8
110	2.2	1.4	0.9	0.5	110	2.9	1.9	1.2	0.7	110	3.5	2.2	1.5	0.8
120	2.4	1.5	1.0	0.6	120	3.2	2	1.4	0.8	120	3.8	2.5	1.6	0.9
130	2.6	1.7	1.1	0.6	130	3.4	2.2	1.5	0.8	130	4.1	2.7	1.8	1
140	2.8	1.8	1.2	0.7	140	3.7	2.4	1.6	0.9	140	4.4	2.9	1.9	1.1
150	3.0	1.9	1.3	0.7	150	4	2.6	1.7	0.9	150	4.7	3.1	2	1.1
160	3.2	2.1	1.4	0.8	160	4.2	2.7	1.8	1	160	5.1	3.3	2.2	1.2
170	3.4	2.2	1.4	0.8	170	4.5	2.9	1.9	1.1	170		3.5	2.3	1.3
180	3.6	2.3	1.5	0.9	180	4.7	3.1	2	1.1	180		3.7	2.4	1.4
190	3.8	2.4	1.6	0.9	190	5	3.2	2.1	1.2	190		3.9	2.6	1.4
200	4.0	2.6	1.7	0.9	200		3.4	2.3	1.3	200		4.1	2.7	1.5
210	4.2	2.7	1.8	1.0	210		3.6	2.4	1.3	210		4.3	2.8	1.6
220	4.4	2.8	1.9	1.0	220		3.8	2.5	1.4	220		4.5	3	1.7
230	4.6	3.0	2.0	1.1	230		3.9	2.6	1.4	230		4.7	3.1	1.7
240	4.8	3.1	2.0	1.1	240		4.1	2.7	1.5	240		4.9	3.2	1.8
250	5.0	3.2	2.1	1.2	250		4.3	2.8	1.6	250		5.1	3.4	1.9
260		3.3	2.2	1.2	260		4.4	2.9	1.6	260			3.5	2
270		3.5	2.3	1.3	270		4.6	3.1	1.7	270			3.7	2
280		3.6	2.4	1.3	280		4.8	3.2	1.8	280			3.8	2.1
290		3.7	2.5	1.4	290		4.9	3.3	1.8	290			3.9	2.2
300		3.9	2.6	1.4	300		5.1	3.4	1.9	300			4.1	2.3
350		4.5	3.0	1.7	350			4	2.2	350			4.7	2.6
400		5.1	3.4	1.9	400			4.5	2.5	400			5.4	3
450			3.8	2.1	450			5.1	2.8	450				3.4
500			4.3	2.4	500				3.1	500				3.8
550			4.7	2.6	550				3.5	550				4.1
600			5.1	2.8	600				3.8	600				4.5
650				3.1	650				4.1	650				4.9
700				3.3	700				4.4	700				5.3
750				3.6	750				4.7	750				
800				3.8	800				5	800				
850				4.0	850					850				
900				4.3	900					900				
950				4.5	950					950				
1,000				4.7	1,000					1,000				

Parameters Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No. 4	No. 2	1/0	4/0
R	0.9800	0.6160	0.3900	0.1940
X	0.0700	0.0660	0.0640	0.0620

*Non-A/C home will have their flicker based on a 2-ton A/C flicker.

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 2 of 12)*

Percent Flicker — Aluminum Triplex														
3-1/2 - Ton A/C 111 Amps Starting Current					4 - Ton A/C 122 Amps Starting Current					5 - Ton A/C 142 Amps Starting Current				
Feet	**No. 4**	**No. 2**	**1/0**	**4/0**	**Feet**	**No. 4**	**No. 2**	**1/0**	**4/0**	**Feet**	**No. 4**	**No. 2**	**1/0**	**4/0**
10	0.4	0.2	0.2	0.1	10	0.4	0.3	0.2	0.1	10	0.5	0.3	0.2	0.1
20	0.7	0.5	0.3	0.2	20	0.8	0.5	0.3	0.2	20	0.9	0.6	0.4	0.2
30	1.1	0.7	0.5	0.3	30	1.2	0.8	0.5	0.3	30	1.4	0.9	0.6	0.3
40	1.4	0.9	0.6	0.3	40	1.6	1	0.7	0.4	40	1.8	1.2	0.8	0.4
50	1.8	1.2	0.8	0.4	50	2	1.3	0.9	0.5	50	2.3	1.5	1.0	0.6
60	2.2	1.4	0.9	0.5	60	2.4	1.5	1	0.6	60	2.8	1.8	1.2	0.7
70	2.5	1.6	1.1	0.6	70	2.8	1.8	1.2	0.7	70	3.2	2.1	1.4	0.8
80	2.9	1.9	1.2	0.7	80	3.2	2.1	1.4	0.8	80	3.7	2.4	1.6	0.9
90	3.3	2.1	1.4	0.8	90	3.6	2.3	1.5	0.9	90	4.2	2.7	1.8	1.0
100	3.6	2.3	1.5	0.9	100	4	2.6	1.7	0.9	100	4.6	3.0	2.0	1.1
110	4	2.6	1.7	0.9	110	4.4	2.8	1.9	1	110	5.1	3.3	2.2	1.2
120	4.3	2.8	1.9	1	120	4.8	3.1	2	1.1	120		3.6	2.4	1.3
130	4.7	3	2	1.1	130	5.2	3.3	2.2	1.2	130		3.9	2.6	1.4
140	5.1	3.3	2.2	1.2	140		3.6	2.4	1.3	140		4.2	2.8	1.5
150		3.5	2.3	1.3	150		3.9	2.6	1.4	150		4.5	3.0	1.7
160		3.7	2.5	1.4	160		4.1	2.7	1.5	160		4.8	3.2	1.8
170		4	2.6	1.5	170		4.4	2.9	1.6	170		5.1	3.4	1.9
180		4.2	2.8	1.6	180		4.6	3.1	1.7	180			3.6	2.0
190		4.4	2.9	1.6	190		4.9	3.2	1.8	190			3.8	2.1
200		4.7	3.1	1.7	200		5.1	3.4	1.9	200			4.0	2.2
210		4.9	3.3	1.8	210			3.6	2	210			4.2	2.3
220		5.1	3.4	1.9	220			3.7	2.1	220			4.4	2.4
230			3.6	2	230			3.9	2.2	230			4.6	2.5
240			3.7	2.1	240			4.1	2.3	240			4.8	2.6
250			3.9	2.2	250			4.3	2.4	250			5.0	2.8
260			4	2.2	260			4.4	2.5	260				2.9
270			4.2	2.3	270			4.6	2.6	270				3.0
280			4.3	2.4	280			4.8	2.7	280				3.1
290			4.5	2.5	290			4.9	2.7	290				3.2
300			4.6	2.6	300			5.1	2.8	300				3.3
350			5.4	3	350				3.3	350				3.9
400				3.5	400				3.8	400				4.4
450				3.9	450				4.3	450				5.0
500				4.3	500				4.7	500				
550				4.7	550				5.2	550				
600				5.2	600					600				
650					650					650				
700					700					700				

Parameters Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No. 4	No. 2	1/0	4/0
R	0.9800	0.6160	0.3900	0.1940
X	0.0700	0.0660	0.0640	0.0620

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 3 of 12)*

Percent Flicker — Aluminum Triplex									
6-Ton A/C 158 Amps Starting Current					7 -Ton A/C 172 Amps Starting Current				
Feet	No. 4	No. 2	1/0	4/0	Feet	No. 4	No. 2	1/0	4/0
10	0.5	0.3	0.2	0.1	10	0.6	0.4	0.2	0.1
20	1	0.7	0.4	0.2	20	1.1	0.7	0.5	0.3
30	1.5	1	0.7	0.4	30	1.7	1.1	0.7	0.4
40	2.1	1.3	0.9	0.5	40	2.2	1.4	1	0.5
50	2.6	1.7	1.1	0.6	50	2.8	1.8	1.2	0.7
60	3.1	2	1.3	0.7	60	3.4	2.2	1.4	0.8
70	3.6	2.3	1.5	0.9	70	3.9	2.5	1.7	0.9
80	4.1	2.7	1.8	1	80	4.5	2.9	1.9	1.1
90	4.6	3	2	1.1	90	5	3.3	2.2	1.2
100	5.1	3.3	2.2	1.2	100		3.6	2.4	1.3
110		3.7	2.4	1.4	110		4	2.6	1.5
120		4	2.6	1.5	120		4.3	2.9	1.6
130		4.3	2.9	1.6	130		4.7	3.1	1.7
140		4.7	3.1	1.7	140		5.1	3.4	1.9
150		5	3.3	1.8	150			3.6	2
160			3.5	2	160			3.8	2.1
170			3.7	2.1	170			4.1	2.3
180			4	2.2	180			4.3	2.4
190			4.2	2.3	190			4.6	2.5
200			4.4	2.5	200			4.8	2.7
210			4.6	2.6	210			5	2.8
220			4.8	2.7	220				2.9
230			5.1	2.8	230				3.1
240				2.9	240				3.2
250				3.1	250				3.3
260				3.2	260				3.5
270				3.3	270				3.6
280				3.4	280				3.7
290				3.6	290				3.9
300				3.7	300				4
350				4.3	350				4.7
400				4.9	400				5.3
450					450				
500					500				

Parameters Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No. 4	No. 2	1/0	4/0
R	0.9800	0.6160	0.3900	0.1940
X	0.0700	0.0660	0.0640	0.0620

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 4 of 12)*

Percent Flicker WAL Open Wire												
2 - Ton A/C* 61 Amps Starting Current				2-1/2 - Ton A/C 81 Amps Starting Current				3 - Ton A/C 97 Amps Starting Current			
Feet	No. 2	1/0	4/0	Feet	No. 2	1/0	4/0	Feet	No. 2	1/0	4/0
10	0.2	0.1	0.1	10	0.2	0.2	0.1	10	0.3	0.2	0.1
20	0.3	0.2	0.2	20	0.4	0.3	0.2	20	0.5	0.4	0.2
30	0.5	0.3	0.2	30	0.6	0.5	0.3	30	0.8	0.6	0.4
40	0.6	0.5	0.3	40	0.9	0.6	0.4	40	1	0.7	0.5
50	0.8	0.6	0.4	50	1.1	0.8	0.5	50	1.3	0.9	0.6
60	1.0	0.7	0.5	60	1.3	0.9	0.6	60	1.5	1.1	0.7
70	1.1	0.8	0.5	70	1.5	1.1	0.7	70	1.8	1.3	0.8
80	1.3	0.9	0.6	80	1.7	1.2	0.8	80	2.1	1.5	1
90	1.5	1.0	0.7	90	1.9	1.4	0.9	90	2.3	1.7	1.1
100	1.6	1.2	0.8	100	2.2	1.5	1	100	2.6	1.9	1.2
110	1.8	1.3	0.8	110	2.4	1.7	1.1	110	2.8	2	1.3
120	1.9	1.4	0.9	120	2.6	1.9	1.2	120	3.1	2.2	1.4
130	2.1	1.5	1.0	130	2.8	2	1.3	130	3.4	2.4	1.6
140	2.3	1.6	1.1	140	3	2.2	1.4	140	3.6	2.6	1.7
150	2.4	1.7	1.1	150	3.2	2.3	1.5	150	3.9	2.8	1.8
160	2.6	1.9	1.2	160	3.5	2.5	1.6	160	4.1	3	1.9
170	2.8	2.0	1.3	170	3.7	2.6	1.7	170	4.4	3.2	2
180	2.9	2.1	1.4	180	3.9	2.8	1.8	180	4.6	3.3	2.2
190	3.1	2.2	1.4	190	4.1	2.9	1.9	190	4.9	3.5	2.3
200	3.2	2.3	1.5	200	4.3	3.1	2	200	5.2	3.7	2.4
210	3.4	2.4	1.6	210	4.5	3.2	2.1	210		3.9	2.5
220	3.6	2.6	1.7	220	4.7	3.4	2.2	220		4.1	2.6
230	3.7	2.7	1.7	230	5	3.6	2.3	230		4.3	2.8
240	3.9	2.8	1.8	240		3.7	2.4	240		4.4	2.9
250	4.1	2.9	1.9	250		3.9	2.5	250		4.6	3
260	4.2	3.0	2.0	260		4	2.6	260		4.8	3.1
270	4.4	3.1	2.0	270		4.2	2.7	270		5	3.2
280	4.5	3.3	2.1	280		4.3	2.8	280			3.4
290	4.7	3.4	2.2	290		4.5	2.9	290			3.5
300	4.9	3.5	2.3	300		4.6	3	300			3.6
350		4.1	2.6	350		5.4	3.5	350			4.2
400		4.7	3.0	400			4	400			4.8
450		5.2	3.4	450			4.5	450			5.4
500			3.8	500			5	500			
550			4.2	550				550			
600			4.5	600				600			
650			4.9	650				650			
700			5.3	700				700			
750				750				750			
800				800				800			

Parameters Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No. 2	1/0	4/0
R	0.6140	0.3823	0.1854
X	0.2700	0.2600	0.2400

*Non-A/C home will have their flicker based on a 2-ton A/C flicker.

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 5 of 12)*

Percent Flicker WAL Open Wire												
3-1/2 - Ton A/C 111 Amps Starting Current				4 - Ton A/C 122 Amps Starting Current				5 - Ton A/C 142 Amps Starting Current			
Feet	No. 2	1/0	4/0	Feet	No. 2	1/0	4/0	Feet	No. 2	1/0	4/0
10	0.3	0.2	0.1	10	0.3	0.2	0.2	10	0.4	0.3	0.2
20	0.6	0.4	0.3	20	0.6	0.5	0.3	20	0.8	0.5	0.4
30	0.9	0.6	0.4	30	1	0.7	0.5	30	1.1	0.8	0.5
40	1.2	0.8	0.6	40	1.3	0.9	0.6	40	1.5	1.1	0.7
50	1.5	1.1	0.7	50	1.6	1.2	0.8	50	1.9	1.4	0.9
60	1.8	1.3	0.8	60	1.9	1.4	0.9	60	2.3	1.6	1.1
70	2.1	1.5	1	70	2.3	1.6	1.1	70	2.6	1.9	1.2
80	2.4	1.7	1.1	80	2.6	1.9	1.2	80	3.0	2.2	1.4
90	2.7	1.9	1.2	90	2.9	2.1	1.4	90	3.4	2.4	1.6
100	3	2.1	1.4	100	3.2	2.3	1.5	100	3.8	2.7	1.8
110	3.3	2.3	1.5	110	3.6	2.6	1.7	110	4.2	3.0	1.9
120	3.5	2.5	1.7	120	3.9	2.8	1.8	120	4.5	3.3	2.1
130	3.8	2.8	1.8	130	4.2	3	2	130	4.9	3.5	2.3
140	4.1	3	1.9	140	4.5	3.3	2.1	140	5.3	3.8	2.5
150	4.4	3.2	2.1	150	4.9	3.5	2.3	150		4.1	2.6
160	4.7	3.4	2.2	160	5.2	3.7	2.4	160		4.3	2.8
170	5	3.6	2.3	170		4	2.6	170		4.6	3.0
180		3.8	2.5	180		4.2	2.7	180		4.9	3.2
190		4	2.6	190		4.4	2.9	190		5.2	3.3
200		4.2	2.8	200		4.7	3	200		5.4	3.5
210		4.5	2.9	210		4.9	3.2	210		5.7	3.7
220		4.7	3	220		5.1	3.3	220		6.0	3.9
230		4.9	3.2	230			3.5	230		6.2	4.1
240		5.1	3.3	240			3.6	240		6.5	4.2
250			3.4	250			3.8	250		6.8	4.4
260			3.6	260			3.9	260			4.6
270			3.7	270			4.1	270			4.8
280			3.9	280			4.2	280			4.9
290			4	290			4.4	290			5.1
300			4.1	300			4.5	300			5.3
350			4.8	350			5.3	350			6.2
400			5.5	400			6	400			7.0
450			6.2	450				450			
500			6.9	500				500			
550				550				550			
600				600				600			

Parameter Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No. 2	1/0	4/0
R	0.6140	0.3823	0.1854
X	0.2700	0.2600	0.2400

*Non-A/C home will have their flicker based on a 2-ton A/C flicker.

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 6 of 12)*

Percent Flicker WAL Open Wire							
6 - Ton A/C 158 Amps Starting Current				7 - Ton A/C 172 Amps Starting Current			
Feet	**No. 2**	**1/0**	**4/0**	**Feet**	**No. 2**	**1/0**	**4/0**
10	0.4	0.3	0.2	10	0.5	0.3	0.2
20	0.8	0.6	0.4	20	0.9	0.7	0.4
30	1.3	0.9	0.6	30	1.4	1	0.6
40	1.7	1.2	0.8	40	1.8	1.3	0.9
50	2.1	1.5	1	50	2.3	1.6	1.1
60	2.5	1.8	1.2	60	2.7	2	1.3
70	2.9	2.1	1.4	70	3.2	2.3	1.5
80	3.4	2.4	1.6	80	3.7	2.6	1.7
90	3.8	2.7	1.8	90	4.1	3	1.9
100	4.2	3	2	100	4.6	3.3	2.1
110	4.6	3.3	2.2	110	5	3.6	2.3
120	5	3.6	2.4	120		3.9	2.6
130		3.9	2.5	130		4.3	2.8
140		4.2	2.7	140		4.6	3
150		4.5	2.9	150		4.9	3.2
160		4.8	3.1	160		5.3	3.4
170		5.1	3.3	170			3.6
180			3.5	180			3.8
190			3.7	190			4.1
200			3.9	200			4.3
210			4.1	210			4.5
220			4.3	220			4.7
230			4.5	230			4.9
240			4.7	240			5.1
250			4.9	250			
260			5.1	260			
270				270			
280				280			
290				290			
300				300			

Parameter Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No. 2	1/0	4/0
R	0.6140	0.3823	0.1854
X	0.2700	0.2600	0.2400

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 7 of 12)*

Percent Flicker Copper Triplex												
2 - Ton A/C* 61 Amps Starting Current				2-1/2 - Ton A/C 81 Amps Starting Current				3 - Ton A/C 97 Amps Starting Current			
Feet	No. 6	No. 4	No.2	Feet	No. 6	No. 4	No.2	Feet	No. 6	No. 4	No.2
10	0.2	0.1	0.1	10	0.3	0.2	0.1	10	0.3	0.2	0.1
20	0.4	0.3	0.2	20	0.5	0.3	0.2	20	0.6	0.4	0.3
30	0.6	0.4	0.2	30	0.8	0.5	0.3	30	0.9	0.6	0.4
40	0.8	0.5	0.3	40	1	0.7	0.4	40	1.2	0.8	0.5
50	1.0	0.6	0.4	50	1.3	0.8	0.5	50	1.5	1	0.7
60	1.2	0.8	0.5	60	1.5	1	0.7	60	1.8	1.2	0.8
70	1.4	0.9	0.6	70	1.8	1.2	0.8	70	2.2	1.4	0.9
80	1.5	1.0	0.7	80	2.1	1.3	0.9	80	2.5	1.6	1
90	1.7	1.1	0.7	90	2.3	1.5	1	90	2.8	1.8	1.2
100	1.9	1.3	0.8	100	2.6	1.7	1.1	100	3.1	2	1.3
110	2.1	1.4	0.9	110	2.8	1.8	1.2	110	3.4	2.2	1.4
120	2.3	1.5	1.0	120	3.1	2	1.3	120	3.7	2.4	1.6
130	2.5	1.6	1.1	130	3.3	2.2	1.4	130	4	2.6	1.7
140	2.7	1.8	1.2	140	3.6	2.3	1.5	140	4.3	2.8	1.8
150	2.9	1.9	1.2	150	3.9	2.5	1.6	150	4.6	3	2
160	3.1	2.0	1.3	160	4.1	2.7	1.8	160	4.9	3.2	2.1
170	3.3	2.1	1.4	170	4.4	2.8	1.9	170	5.2	3.4	2.2
180	3.5	2.3	1.5	180	4.6	3	2	180		3.6	2.4
190	3.7	2.4	1.6	190	4.9	3.2	2.1	190		3.8	2.5
200	3.9	2.5	1.6	200	5.1	3.3	2.2	200		4	2.6
210	4.1	2.6	1.7	210		3.5	2.3	210		4.2	2.8
220	4.3	2.8	1.8	220		3.7	2.4	220		4.4	2.9
230	4.4	2.9	1.9	230		3.8	2.5	230		4.6	3
240	4.6	3.0	2.0	240		4	2.6	240		4.8	3.1
250	4.8	3.1	2.1	250		4.2	2.7	250		5	3.3
260	5.0	3.3	2.1	260		4.3	2.8	260			3.4
270		3.4	2.2	270		4.5	3	270			3.5
280		3.5	2.3	280		4.7	3.1	280			3.7
290		3.6	2.4	290		4.8	3.2	290			3.8
300		3.8	2.5	300		5	3.3	300			3.9
350		4.4	2.9	350			3.8	350			4.6
400		5.0	3.3	400			4.4	400			5.2
450			3.7	450			4.9	450			
500			4.1	500				500			
550			4.5	550				550			
600			4.9	600				600			
650			5.4	650				650			
700				700				700			

Parameters Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No. 6	No. 4	No. 2
R	0.9470	0.5980	0.3740
X	0.0760	0.0700	0.0660

*Non-A/C home will have their flicker based on a 2-ton A/C flicker.

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 8 of 12)*

Percent Flicker Copper Triplex											
3-1/2 - Ton A/C 111 Amps Starting Current				4 - Ton A/C 122 Amps Starting Current				5 - Ton A/C 142 Amps Starting Current			
Feet	No. 6	No. 4	No.2	Feet	No. 6	No. 4	No.2	Feet	No. 6	No. 4	No.2
10	0.4	0.2	0.1	10	0.4	0.3	0.2	10	0.4	0.3	0.2
20	0.7	0.5	0.3	20	0.8	0.5	0.3	20	0.9	0.6	0.4
30	1.1	0.7	0.4	30	1.2	0.8	0.5	30	1.3	0.9	0.6
40	1.4	0.9	0.6	40	1.5	1	0.7	40	1.8	1.2	0.8
50	1.8	1.1	0.7	50	1.9	1.3	0.8	50	2.2	1.5	1.0
60	2.1	1.4	0.9	60	2.3	1.5	1	60	2.7	1.8	1.2
70	2.5	1.6	1	70	2.7	1.8	1.2	70	3.1	2.0	1.3
80	2.8	1.8	1.2	80	3.1	2	1.3	80	3.6	2.3	1.5
90	3.2	2.1	1.3	90	3.5	2.3	1.5	90	4.0	2.6	1.7
100	3.5	2.3	1.5	100	3.9	2.5	1.6	100	4.5	2.9	1.9
110	3.9	2.5	1.6	110	4.3	2.8	1.8	110	4.9	3.2	2.1
120	4.2	2.7	1.8	120	4.6	3	2	120	5.4	3.5	2.3
130	4.6	3	1.9	130	5	3.3	2.1	130		3.8	2.5
140	4.9	3.2	2.1	140		3.5	2.3	140		4.1	2.7
150	5.3	3.4	2.2	150		3.8	2.5	150		4.4	2.9
160		3.7	2.4	160		4	2.6	160		4.7	3.1
170		3.9	2.5	170		4.3	2.8	170		5.0	3.3
180		4.1	2.7	180		4.5	3	180			3.5
190		4.3	2.8	190		4.8	3.1	190			3.6
200		4.6	3	200		5	3.3	200			3.8
210		4.8	3.1	210			3.5	210			4.0
220		5	3.3	220			3.6	220			4.2
230			3.4	230			3.8	230			4.4
240			3.6	240			4	240			4.6
250			3.7	250			4.1	250			4.8
260			3.9	260			4.3	260			5.0
270			4	270			4.4	270			
280			4.2	280			4.6	280			
290			4.3	290			4.8	290			
300			4.5	300			4.9	300			
350			5.2	350				350			
400				400				400			

Parameter Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No. 6	No. 4	No. 2
R	0.9470	0.5980	0.3740
X	0.0760	0.0700	0.0660

*Non-A/C home will have their flicker based on a 2-ton A/C flicker.

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 9 of 12)*

Percent Flicker Copper Triplex								
6 - Ton A/C 158 **Amps Starting Current**					7 - Ton A/C 172 **Amps Starting Current**			
Feet	**No. 6**	**No. 4**	**No.2**		**Feet**	**No. 6**	**No. 4**	**No.2**
10	0.5	0.3	0.2		10	0.5	0.4	0.2
20	1	0.7	0.4		20	1.1	0.7	0.5
30	1.5	1	0.6		30	1.6	1.1	0.7
40	2	1.3	0.9		40	2.2	1.4	0.9
50	2.5	1.6	1.1		50	2.7	1.8	1.2
60	3	2	1.3		60	3.3	2.1	1.4
70	3.5	2.3	1.5		70	3.8	2.5	1.6
80	4	2.6	1.7		80	4.4	2.8	1.9
90	4.5	2.9	1.9		90	4.9	3.2	2.1
100	5	3.3	2.1		100		3.5	2.3
110		3.6	2.3		110		3.9	2.6
120		3.9	2.6		120		4.3	2.8
130		4.2	2.8		130		4.6	3
140		4.6	3		140		5	3.3
150		4.9	3.2		150			3.5
160		5.2	3.4		160			3.7
170			3.6		170			3.9
180			3.8		180			4.2
190			4.1		190			4.4
200			4.3		200			4.6
210			4.5		210			4.9
220			4.7		220			5.1
230			4.9		230			
240			5.1		240			
250					250			
260					260			
270					270			
280					280			
290					290			
300					300			

Parameter Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No. 6	No. 4	No. 2
R	0.9470	0.5980	0.3740
X	0.0760	0.0700	0.0660

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 10 of 12)*

Percent Flicker Copper Open Wire														
2 - Ton A/C* 61 Amps Starting Current					2-1/2 - Ton A/C 81 Amps Starting Current					3 - Ton A/C 97 Amps Starting Current				
Feet	**No. 4**	**No. 2**	**2/0**	**4/0**	**Feet**	**No. 4**	**No. 2**	**2/0**	**4/0**	**Feet**	**No. 4**	**No. 2**	**2/0**	**4/0**
10	0.2	0.1	0.1	0.1	10	0.2	0.2	0.1	0.1	10	0.3	0.2	0.1	0.1
20	0.3	0.2	0.2	0.1	20	0.4	0.3	0.2	0.2	20	0.5	0.4	0.2	0.2
30	0.5	0.4	0.2	0.2	30	0.7	0.5	0.3	0.2	30	0.8	0.6	0.4	0.3
40	0.7	0.5	0.3	0.2	40	0.9	0.6	0.4	0.3	40	1	0.8	0.5	0.4
50	0.8	0.6	0.4	0.3	50	1.1	0.8	0.5	0.4	50	1.3	0.9	0.6	0.5
60	1.0	0.7	0.5	0.4	60	1.3	0.9	0.6	0.5	60	1.6	1.1	0.7	0.6
70	1.1	0.8	0.5	0.4	70	1.5	1.1	0.7	0.6	70	1.8	1.3	0.9	0.7
80	1.3	0.9	0.6	0.5	80	1.7	1.3	0.8	0.7	80	2.1	1.5	1	0.8
90	1.5	1.1	0.7	0.6	90	2	1.4	0.9	0.7	90	2.3	1.7	1.1	0.9
100	1.6	1.2	0.8	0.6	100	2.2	1.6	1	0.8	100	2.6	1.9	1.2	1
110	1.8	1.3	0.8	0.7	110	2.4	1.7	1.1	0.9	110	2.9	2.1	1.4	1.1
120	2.0	1.4	0.9	0.7	120	2.6	1.9	1.2	1	120	3.1	2.3	1.5	1.2
130	2.1	1.5	1.0	0.8	130	2.8	2	1.3	1.1	130	3.4	2.4	1.6	1.3
140	2.3	1.7	1.1	0.9	140	3	2.2	1.4	1.2	140	3.6	2.6	1.7	1.4
150	2.5	1.8	1.2	0.9	150	3.3	2.4	1.5	1.2	150	3.9	2.8	1.8	1.5
160	2.6	1.9	1.2	1.0	160	3.5	2.5	1.6	1.3	160	4.2	3	2	1.6
170	2.8	2.0	1.3	1.1	170	3.7	2.7	1.7	1.4	170	4.4	3.2	2.1	1.7
180	2.9	2.1	1.4	1.1	180	3.9	2.8	1.8	1.5	180	4.7	3.4	2.2	1.8
190	3.1	2.2	1.5	1.2	190	4.1	3	2	1.6	190	4.9	3.6	2.3	1.9
200	3.3	2.4	1.5	1.2	200	4.3	3.1	2.1	1.7	200	5.2	3.8	2.5	2
210	3.4	2.5	1.6	1.3	210	4.6	3.3	2.2	1.7	210		3.9	2.3	2.1
220	3.6	2.6	1.7	1.4	220	4.8	3.4	2.3	1.8	220		4.1	2.7	2.2
230	3.8	2.7	1.8	1.4	230	5	3.6	2.4	1.9	230		4.3	2.8	2.3
240	3.9	2.8	1.9	1.5	240		3.8	2.5	2	240		4.5	2.9	2.4
150	4.1	3.0	1.9	1.6	250		3.9	2.6	2.1	250		4.7	3.1	2.5
260	4.3	3.1	2.0	1.6	260		4.1	2.7	2.2	260		4.9	3.2	2.6
270	4.4	3.2	2.1	1.7	270		4.2	2.8	2.2	270		5.1	3.3	2.7
280	4.6	3.3	2.2	1.7	280		4.4	2.9	2.3	280			3.4	2.8
290	4.7	3.4	2.2	1.8	290		4.5	3	2.4	290			3.6	2.9
300	4.9	3.5	2.3	1.9	300		4.7	3.1	2.5	300			3.7	3
350		4.1	2.7	2.2	350		5.5	3.6	2.9	350			4.3	3.5
400		4.7	3.1	2.5	400			4.1	3.3	400			4.9	4
450		5.3	3.5	2.8	450			4.6	3.7	450				4.5
500			3.9	3.1	500			5.1	4.1	500				5
550			4.2	3.4	550				4.6	550				
600			4.6	3.7	600				5	600				
650			5.0	4.1	650					650				
700				4.4	700					700				
750				4.7	750					750				
800				5.0	800					800				
850				5.3	850					850				
900				5.9	950					950				

Parameters Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No. 4	No. 2	2/0	4/0
R	0.6119	0.3810	0.1847	0.1155
X	0.2800	0.2700	0.2500	0.2400

*Non-A/C home will have their flicker based on a 2-ton A/C flicker.

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 11 of 12)*

Percent Flicker Copper Open Wire														
3-1/2 - Ton A/C 111 Amps Starting Current					4 - Ton A/C 122 Amps Starting Current					5 - Ton A/C 142 Amps Starting Current				
Feet	**No. 4**	**No. 2**	**2/0**	**4/0**	**Feet**	**No. 4**	**No. 2**	**2/0**	**4/0**	**Feet**	**No. 4**	**No. 2**	**2/0**	**4/0**
10	0.3	0.2	0.1	0.1	10	0.3	0.2	0.2	0.1	10	0.4	0.3	0.2	0.1
20	0.6	0.4	0.3	0.2	20	0.7	0.5	0.3	0.2	20	0.8	0.5	0.4	0.3
30	0.9	0.6	0.4	0.3	30	1	0.7	0.5	0.4	30	1.1	0.8	0.5	0.4
40	1.2	0.9	0.6	0.5	40	1.3	0.9	0.6	0.5	40	1.5	1.1	0.7	0.6
50	1.5	1.1	0.7	0.6	50	1.6	1.2	0.8	0.6	50	1.9	1.4	0.9	0.7
60	1.8	1.3	0.8	0.7	60	2	1.4	0.9	0.7	60	2.3	1.6	1.1	0.9
70	2.1	1.5	1	0.8	70	2.3	1.7	1.1	0.9	70	2.7	1.9	1.3	1.0
80	2.4	1.7	1.1	0.9	80	2.6	1.9	1.2	1	80	3.0	2.2	1.4	1.2
90	2.7	1.9	1.3	1	90	2.9	2.1	1.4	1.1	90	3.4	2.5	1.6	1.3
100	3	2.1	1.4	1.1	100	3.3	2.4	1.5	1.2	100	3.8	2.7	1.8	1.5
110	3.3	2.4	1.5	1.3	110	3.6	2.6	1.7	1.4	110	4.2	3.0	2.0	1.6
120	3.6	2.6	1.7	1.4	120	3.9	2.8	1.9	1.5	120	4.6	3.3	2.2	1.7
130	3.9	2.8	1.8	1.5	130	4.3	3.1	2	1.6	130	5.0	3.6	2.3	1.9
140	4.2	3	2	1.6	140	4.6	3.3	2.2	1.7	140		3.8	2.5	2.0
150	4.5	3.2	2.1	1.7	150	4.9	3.5	2.3	1.9	150		4.1	2.7	2.2
160	4.8	3.4	2.3	1.8	160	5.2	3.8	2.5	2	160		4.4	2.9	2.3
170	5.1	3.7	2.4	1.9	170		4	2.6	2.1	170		4.7	3.1	2.5
180		3.9	2.5	2	180		4.2	2.8	2.2	180		4.9	3.2	2.6
190		4.1	2.7	2.2	190		4.5	2.9	2.4	190		5.2	3.4	2.8
200		4.3	2.8	2.3	200		4.7	3.1	2.5	200			3.6	2.9
210		4.5	3	2.4	210		5	3.2	2.6	210			3.8	3.0
220		4.7	3.1	2.5	220			3.4	2.7	220			4.0	3.2
230		4.9	3.2	2.6	230			3.6	2.9	230			4.1	3.3
240		5.2	3.4	2.7	240			3.7	3	240			4.3	3.5
250			3.5	2.8	250			3.9	3.1	250			4.5	3.6
260			3.7	3	260			4	3.2	260			4.7	3.8
270			3.8	3.1	270			4.2	3.4	270			4.9	3.9
280			3.9	3.2	280			4.3	3.5	280			5.0	4.1
290			4.1	3.3	290			4.5	3.6	290				4.2
300			4.2	3.4	300			4.6	3.7	300				4.4
350			4.9	4	350			5.4	4.4	350				5.1
400				4.5	400				5	400				
450				5.1	450					450				
500					500					500				

Parameter Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No.4	No. 2	2/0	4/0
R	0.6119	0.3810	0.1847	0.1155
X	0.2800	0.2700	0.2500	0.2400

Table 8–9: Flicker through Secondary/Service Conductor — Overhead *(Sheet 12 of 12)*

Percent Flicker Copper Open Wire									
6 - Ton A/C 158 **Amps Starting Current**					7 - Ton A/C 172 **Amps Starting Current**				
Feet	**No. 4**	**No. 2**	**2/0**	**4/0**	**Feet**	**No. 4**	**No. 2**	**2/0**	**4/0**
10	0.4	0.3	0.2	0.2	10	0.5	0.3	0.2	0.2
20	0.8	0.6	0.4	0.3	20	0.9	0.7	0.4	0.4
30	1.3	0.9	0.6	0.5	30	1.4	1	0.7	0.5
40	1.7	1.2	0.8	0.6	40	1.8	1.3	0.9	0.7
50	2.1	1.5	1	0.8	50	2.3	1.7	1.1	0.9
60	2.5	1.8	1.2	1	60	2.8	2	1.3	1.1
70	3	2.1	1.4	1.1	70	3.2	2.3	1.5	1.2
80	3.4	2.4	1.6	1.3	80	3.7	2.7	1.7	1.4
90	3.8	2.8	1.8	1.5	90	4.2	3	2	1.6
100	4.2	3.1	2	1.6	100	4.6	3.3	2.2	1.8
110	4.7	3.4	2.2	1.8	110	5.1	3.7	2.4	1.9
120	5.1	3.7	2.4	1.9	120		4	2.6	2.1
130		4	2.6	2.1	130		4.3	2.8	2.3
140		4.3	2.8	2.3	140		4.7	3.1	2.5
150		4.6	3	2.4	150		5	3.3	2.6
160		4.9	3.2	2.6	160			3.5	2.8
170		5.2	3.4	2.8	170			3.7	3
180			3.6	2.9	180			3.9	3.2
190			3.8	3.1	190			4.1	3.3
200			4	3.2	200			4.4	3.5
210			4.2	3.4	210			4.6	3.7
220			4.4	3.6	220			4.8	3.9
230			4.6	3.7	230			5	4.1
240			4.8	3.9	240				4.2
250			5	4	250				4.4
260				4.2	260				4.6
270				4.4	270				4.8
280				4.5	280				4.9
290				4.7	290				5.1
300				4.9	300				
350					350				
400					400				

Parameter Used for Flicker Tables

1. Motor starting power factor = 0.75
2. Conductor constants (ohms/1,000')

	No.4	No. 2	2/0	4/0
R	0.6119	0.3810	0.1847	0.1155
X	0.2800	0.2700	0.2500	0.2400

5.0 Short-Circuit Duty

This standard provides the criteria and process to determine the available short-circuit duty at the customer's service entrance.

5.1 Criteria

According to the electrical service requirements, the Company's contribution to short-circuit duty, at the customer's service entrance, will be as follows:

For single-family residential, duplexes, or individually metered mobile homes which utilize self-contained type Company meters, the Company's maximum contribution will not exceed 10,000 A. Higher short-circuit duty is available in downtown Long Beach Network. Check with Field Engineering for actual calculation.

Table 8–10 shows the maximum contributions for multi-family (three or more grouped meters), commercial, and industrial installations are:

Table 8–10: MAX Multi-Family and Commercial/Industrial Fault Duty

Phase	Serving Voltage	Service Entrance Ampacity	MAX Fault Duty (Amps)
Single	120/240	600 A or less	42,000
Three	120/208 or 240	800 A or less	42,000
Three	480 (See Note 1.)	1,200 A or less	30,000

Notes:

1. Transformer size greater than 1,000 kVA may have higher fault duty. Consult Field Engineer for actual calculation.
2. Customers may request Edison to provide them the calculated available short-circuit duty. Request Field Engineering to provide this information for you to respond to customer.

All installations with service voltage or service entrance ampacities larger than those stated above will be handled as individual cases, and the Company will provide the customer with the available short-circuit duty for each installation.

5.2 Determining Available Short-Circuit Duty

For standard low-voltage services up to 1,200 A service entrance ampacities the available short-circuit duty can be determined by:

1. Use the "Short-Circuit Duty Tables," Page 8–30, to check if the available current is less than or greater than the limits specified in Section 5.1 above. The tables list, by transformer size, the minimum cable lengths that would be required for each cable size to limit the available duty to within prescribed limits.
2. If the planned cable length is greater than the minimum length listed in the table, the available duty is within specified limits and no further calculations are necessary.

3. If the planned cable length is less than the minimum length listed in the table, request Field Engineering to perform a site-specific calculation. If the calculated available duty is greater than the Company's specified limits, then an alternate method of service must be developed to ensure the maximum fault duty contributions are not exceeded.
4. Customers may request Edison to provide them the calculated available short-circuit duty. Request Field Engineering to provide this information for you to respond to the customer.

For site-specific calculated available short-circuit duty, provide the following information to your Field Engineering office:

- Size, length, and number of service cables
- Size and length of secondary cables/conductors
- Size and secondary voltage of serving transformer
- Primary wire/cable sizes and lengths from substation to transformer
- Substation, circuit name, and voltage

For transformation larger than 1,000 kVA the above information must be provided to System Protection in addition to Field Engineering, for fuse sizing and coordination.

5.3 Response to Available Short-Circuit Duty Request

All responses to the customer, regardless of method, should be made via **Form SCE 15-22**, "**Response to Letter of Request for Short Circuit Current Value**." A copy of this form should be sent to Field Engineering.

Table 8–11: Short-Circuit Duty Tables — Residential Service

Overhead or underground service for single-family residentials, duplexes, or individually metered mobile homes with service entrance ampacities of 200 A or less. The short-circuit amps at the entrance is no more than 10,000 A.

Serving Transformer Size kVA	Transformer Impedance Z% (See Note 3)	S.C.A. Trans Terminals Phase-Phase	Service Conductor Size (Al)	MIN Service Length (Ft)
25	1.0	10,417	4	1
			2	2
			1/0	2
			4/0	5
37.5	1.0	15,625	4	9
			2	14
			1/0	22
			4/0	42
50	1.0	20,833	4	13
			2	20
			1/0	32
			4/0	61
75	1.3	24,038	4	14
			2	23
			1/0	35
			4/0	69
100	1.1	37,879	4	18
			2	28
			1/0	45
			4/0	87
167.5	1.5	46,528	4	19
			2	30
			1/0	48
			4/0	92

Notes:

1. Minimum required service length based on phase-to-phase faults.
2. Minimum required service lengths are for single phase conventional overhead, pad-mounted, or BURD transformer installations.
3. If actual transformer percent Z is higher than shown and the minimum service length cannot be met, contact Field Engineering for an actual calculation. Percent of Z impedance of transformers being purchased can be as high as 2.2 percent.

Table 8–12: Short-Circuit Duty Tables — Commercial or Multi-Family 120/240 V

Commercial or Multi-Family Residential with Group Metering 3 to 36 Meters, in One Location, with 1 Service Point, 120/240 V

Serving Transformer Size kVA	Transformer Impedance Z% (See Note 4)	S.C.A. Trans Terminals Phase-Phase	Service Conductor Size (Al)	Switch Short-Circuit Duty		
				10,000	18,000	22,000
				MIN Service Length (ft)	MIN Service Length (ft)	
25	1.0	10,417	2	2	0	0
			1/0	2	0	0
37.5	1.0	15,625	2	14	0	0
			1/0	22	0	0
50	1.0	20,833	2	20	3	0
			1/0	32	5	0
			4/0	61	9	0
75	1.3	24,038	2	23	5	1
			1/0	35	8	2
			4/0	69	16	5
			350	106	25	7
100	1.1	37,879	2	28	11	7
			1/0	45	18	12
			4/0	87	34	22
			350	134	53	35
			700	215	85	56
167.5	1.5	46,528	2	30	13	9
			1/0	48	21	15
			4/0	92	40	28
			350	143	62	44
			700	230	100	70

Notes:

1. Minimum required service length based on phase-to-phase faults.
2. Minimum required service lengths are for single-phase conventional overhead, pad-mounted, or BURD transformer installations.
3. Calculations based on serving transformer and service conductor capacity.
4. If actual transformer impedance percent Z is higher than shown and the minimum service length can not be met, contact Field Engineering for an actual calculation. percent Z impedance of transformers being purchased can be as high as 2.2 percent.

Table 8–13: Short-Circuit Duty Tables — Multi-Family, Commercial, Industrial *(Sheet 1 of 3)*

Multi-Family Residential, Commercial, and Industrial 208 and 240 V, Three-Phase Services

Serving Transformer Size kVA	Transformer Impedance Z% (See Note 4)	S.C.A. Trans Terminals Phase-Phase	Service Conductor Size (Al)	Switch Short-Circuit Duty				
				10,000	18,000	22,000	42,000	65,000
				MIN Service Length (ft)				
75	1.0	20,818	1/0	32	5	0	0	0
3-25			4/0	61	9	0	0	0
150	1.0	41,636	1/0	46	19	13	0	0
3-50			4/0	89	37	25	0	0
			350	138	57	39	0	0
225	1.3	48,041	1/0	48	21	15	2	0
3-75			4/0	93	41	29	4	0
			350	144	63	45	5	0
			2-350	288	126	90	11	0
			700	232	102	72	9	0
300	1.3	64,055	1/0	51	24	18	5	0
3-100			4/0	99	47	35	10	0
			350	153	73	54	15	0
			2-350	(Note 4)	145	109	30	0
			700	247	117	87	24	0
			2-700	(Note 4)	234	175	48	0
			3-700	(Note 4)	(Note 4)	262	72	0
500	1.5	92,524	1/0	54	27	21	8	3
3-167			4/0	105	53	41	15	5
			350	162	81	63	24	8
			2-350	(Note 4)	163	126	47	17
			700	261	131	101	38	13
			2-700	(Note 4)	262	203	76	27
			3-700	(Note 4)	(Note 4)	(Note 4)	114	40
			4-700	(Note 4)	(Note 4)	(Note 4)	152	54
			5-700	(Note 4)	(Note 4)	(Note 4)	190	67
			6-700	(Note 4)	(Note 4)	(Note 4)	228	80

Notes:

1. Minimum required service length based on phase-to-phase faults.
2. Minimum required service lengths are for three-phase conventional, three-phase pad-mounted, and single-phase banked transformers.
3. Calculations based on serving transformer and service conductor capacity.
4. If actual transformer impedance percent Z is higher than shown and the minimum service length cannot be met, contact Field Engineering for an actual calculation. Percent Z impedance of transformers being purchased at this time can be higher than shown.
5. New installation not recommended for 120/208 V, three-phase. Consult Field Engineering.

Table 8–13: Short-Circuit Duty Tables — Multi-Family, Commercial, Industrial *(Sheet 2 of 3)*

Multi-Family Residential, Commercial, and Industrial 208 and 240 V, Three-Phase Services

Serving Transformer Size kVA	Transformer Impedance Z% (See Note 4)	S.C.A. Trans Terminals Phase-Phase	Service Conductor Size (Al)	Switch Short-Circuit Duty				
				10,000	18,000	22,000	42,000	65,000
				MIN Service Length (ft)				
3-250	2.0	104,090	1/0	55	28	22	9	4
			4/0	106	54	42	17	7
			350	164	84	65	26	11
			2-350	(Note 4)	167	130	52	21
			700	265	135	105	42	17
			2-700	(Note 4)	269	210	83	34
			3-700	(Note 4)	(Note 4)	(Note 4)	125	51
			4-700	(Note 4)	(Note 4)	(Note 4)	166	68
			5-700	(Note 4)	(Note 4)	(Note 4)	208	85
			6-700	(Note 4)	(Note 4)	(Note 4)	250	101
			7-700	(Note 4)	(Note 4)	(Note 4)	291	118
			8-700	(Note 4)	(Note 4)	(Note 4)	(Note 4)	135
			9-700	(Note 4)	(Note 4)	(Note 4)	(Note 4)	152
750	5.5	37,851	1/0	45	18	12	0	0
			4/0	87	34	22	0	0
			350	134	53	35	0	0
			2-350	268	106	69	0	0
			700	215	85	56	0	0
			2-700	(Note 4)	171	111	0	0
			3-700	(Note 4)	256	167	0	0
			4-700	(Note 4)	(Note 4)	223	0	0
			5-700	(Note 4)	(Note 4)	279	0	0
3-333 (Note 5)	2.5	111,029	1/0	55	28	22	9	4
			4/0	107	55	43	17	8
			350	166	85	66	27	12
			2-350	(Note 4)	169	133	54	23
			700	266	136	107	43	19
			2-700	(Note 4)	273	213	87	37
			3-700	(Note 4)	(Note 4)	(Note 4)	130	56
			4-700	(Note 4)	(Note 4)	(Note 4)	173	75
			6-700	(Note 4)	(Note 4)	(Note 4)	260	112
			7-700	(Note 4)	(Note 4)	(Note 4)	(Note 4)	131

Notes:

1. Minimum required service length based on phase-to-phase faults.
2. Minimum required service lengths are for three-phase conventional, three-phase pad-mounted, and single-phase banked transformers.
3. Calculations based on serving transformer and service conductor capacity.
4. If actual transformer impedance percent Z is higher than shown and the minimum service length cannot be met, contact Field Engineering for an actual calculation. Percent Z impedance of transformers being purchased at this time can be higher than shown.
5. New installation not recommended for 120/208 V, three-phase. Consult Field Engineering.

Table 8–13: Short-Circuit Duty Tables — Multi-Family, Commercial, Industrial *(Sheet 3 of 3)*

Multi-Family Residential, Commercial, and Industrial 208 and 240 V, Three-Phase Services

Serving Transformer Size kVA	Transformer Impedance Z% (See Note 4)	S.C.A. Trans Terminals Phase-Phase	Service Conductor Size (Al)	Switch Short-Circuit Duty				
				10,000	18,000	22,000	42,000	65,000
				MIN Service Length (ft)				
			8-700	(Note 4)	(Note 4)	(Note 4)	(Note 4)	149
			9-700	(Note 4)	(Note 4)	(Note 4)	(Note 4)	168
1,000 (Note 5)	5.5	50,468	1/0	49	22	16	2	0
			4/0	94	42	30	5	0
			350	146	65	47	7	0
			2-350	292	130	93	15	0
			700	235	105	75	12	0
			2-700	(Note 4)	209	150	23	0
			3-700	(Note 4)	(Note 4)	225	35	0
			4-700	(Note 4)	(Note 4)	300	47	0
			6-700	(Note 4)	(Note 4)	(Note 4)	70	0
			7-700	(Note 4)	(Note 4)	(Note 4)	82	0
			8-700	(Note 4)	(Note 4)	(Note 4)	94	0
			9-700	(Note 4)	(Note 4)	(Note 4)	105	0

Notes:

1. Minimum required service length based on phase-to-phase faults.
2. Minimum required service lengths are for three-phase conventional, three-phase pad-mounted, and single-phase banked transformers.
3. Calculations based on serving transformer and service conductor capacity.
4. If actual transformer impedance percent Z is higher than shown and the minimum service length cannot be met, contact Field Engineering for an actual calculation. Percent Z impedance of transformers being purchased at this time can be higher than shown.
5. New installation not recommended for 120/208 V, three-phase. Consult Field Engineering.

Table 8–14: Commercial and Industrial 480 V, Three-Phase Services

Serving Transformer Size kVA	Transformer Impedance Z%	S.C.A. Trans Terminals Phase-Phase	Service Conductor Size (Al)	Switch Short-Circuit Duty				
				14,000	18,000	30,000	35,000	50,000
				MIN Service Length (ft)				
75 3-25	1.1	8,201	1/0	0	0	0	0	0
150 3-50	1.1	16,402	1/0 4/0	15 28	0 0	0 0	0 0	0 0
— —	1.1	24,603	1/0 4/0 350	43 84 129	21 41 63	0 0 0	0 0 0	0 0 0
300 3-100	1.1	32,804	1/0 4/0 350 700	57 111 172 277	35 68 105 169	4 8 12 19	0 0 0 0	0 0 0 0
500 3-167	1.4	42,958	1/0 4/0 350 2-350 700	67 131 203 (Note 4) (Note 4)	45 88 136 271 218	14 27 42 85 68	7 14 22 45 36	0 0 0 0 0
3-250	2.0	45,105	1/0 4/0 350 2-350 700 2-700 3-700	69 134 207 (Note 4) (Note 4) (Note 4) (Note 4)	47 91 140 281 226 (Note 4) (Note 4)	16 30 47 94 75 151 226	9 17 27 54 43 87 130	0 0 0 0 0 0 0
750	5.5	16,402	1/0 4/0 350 2-350 700 2-700 3-700	15 28 44 88 71 141 212	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
3-333	2.5	48,113	1/0 4/0 350 2-350 700 2-700 3-700 4-700 5-700	71 138 213 (Note 4) (Note 4) (Note 4) (Note 4) (Note 4) (Note 4)	49 95 146 292 235 (Note 4) (Note 4) (Note 4) (Note 4)	18 34 53 106 85 170 254 (Note 4) (Note 4)	11 21 33 65 53 105 158 210 263	0 0 0 0 0 0 0 0 0
1,000	5.5	21,869	1/0 4/0 350 2-350 700 2-700 3-700 4-700 5-700	36 70 108 216 174 (Note 4) (Note 4) (Note 4) (Note 4)	14 27 41 83 66 133 199 266 (Note 4)	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

Notes:

1. Minimum required service length based on phase-to-phase faults.
2. Minimum required service lengths are for three-phase conventional, three-phase pad-mounted, and single phase banked transformers.Calculations based on serving transformer and service conductor capacity.
3. Calculations based on serving transformer and service conductor capacity.
4. Consult Field Engineering for actual calculation.

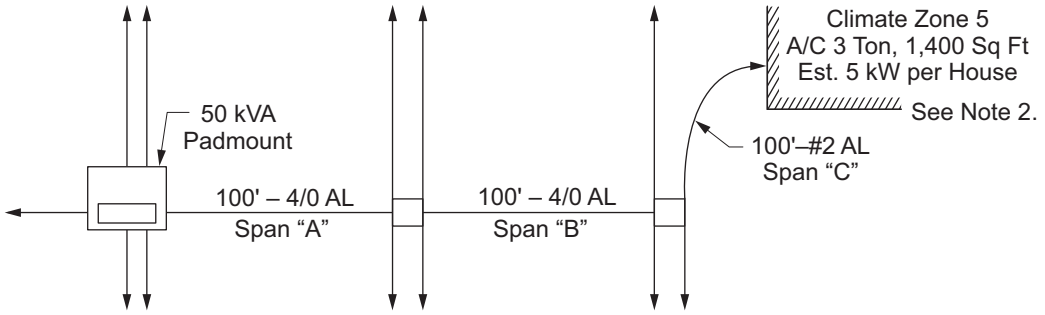
EXAMPLE 2

Developing a secondary and service plan that minimizes cable sizes and meets allowable voltage drop and flicker criteria is an iterative process. The first trial-design results are to be compared to the following design criteria and process:

A. If the percent voltage drop is less than or equal to three percent or the flicker less than or equal to five percent, reduce the secondary and/or service cable sizes and repeat the calculations to arrive at the most economical system; however, maintain the three percent voltage and the five percent flicker design standard.

B. If the percent voltage drop is greater than three percent or the flicker more than five percent, increase the secondary and/or service cable sizes and repeat the calculations to arrive at the most economical alternative.

Determine the total percentage of voltage drop and flicker using the appropriate voltage drop and flicker tables for the system below:



Notes:

1. Each arrow designates a service to a customer for the purpose of determining the number of customers fed by each span of cable.
2. From Table 4–5 (Page 4–19), the kW demand for a 1,400 square feet for a Single-Family home in Climate Zone 5 is 5 kW.

Percent Voltage Drop*

Conductor Size (AWG or kcmil)	Residential Single-Phase 120/240 Volt	
	Per Amp	Per kW
No. 2	0.0243	0.1125
4/0	0.0084	0.0389
350	0.0055	0.0256

* Partial table extracted from Table 8–1.

SOLUTION:

1. Determine the total kW load on each span:

   Span "A" 8 customers × 5 kW per customer = 40 kW
   Span "B" 4 customers × 5 kW per customer = 20 kW
   Span "C" 1 customer × 5 kW per customer = 5 kW

2. Determine the percentage voltage drop for each span:

$$\% \text{ Voltage Drop} = \frac{\text{Feet x kW x (per kW Constant)}}{100}$$

$$\text{Span A \% Voltage Drop} = \frac{100 \text{ x } 40\text{kW x } 0.0256 = 1.0\%}{100}$$

$$\text{Span B \% Voltage Drop} = \frac{100 \text{ x } 20 \text{ kW x } 0.0389 = 0.8\%}{100}$$

$$\text{Span c \% Voltage Drop} = \frac{100 \text{ x } 5 \text{ kW x } 0.1125 = 0.6\%}{100}$$

Total Voltage Drop = 3.0%

Percent Flicker through Secondary and Service Cable**
Three Ton A/C
93 Amps Starting Current

Feet	#2	1/0	4/0	350
80	1.6	1.1	0.6	0.4
90	1.8	1.2	0.7	0.5
100	2.0	1.4	0.8	0.5
110	2.2	1.5	0.8	0.6

**Partial table extracted from Table 8–7.

Percent Flicker through Transformer*
A/C Tons (Locked Rotor Current)

Transformer	2	2.5	3	3.5	4	5	6	7
kVA	(61)	(86)	(97)	(111)	(122)	(142)	(158)	(172)
25	1.4	1.8	2.2	2.5	2.8	3.2	3.6	3.9
50	0.7	0.9	1.1	1.3	1.4	1.6	1.8	1.9
75	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.3
100	0.3	0.5	0.5	0.6	0.7	0.8	0.9	1.0

***Partial table extracted from Table 8–6.

3. Determine the percentage of flicker for a three-ton A/C for each span and the transformer:

Span "A"	100 feet of 4/0 cable	=	0.8%
Span "B"	100 feet of 4/0 cable	=	0.8%
Span "C"	100 customer feet of #2 cable	=	2.0%
50 kVA Transformer with a 3-ton A/C		=	1.1%
	Total Flicker	=	4.7%

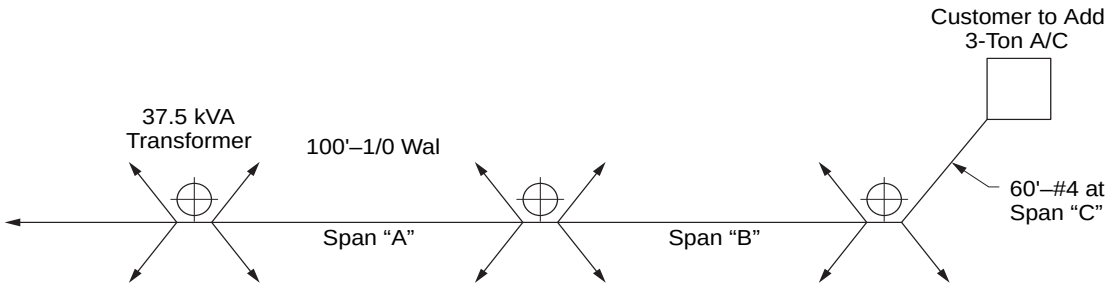
4. The resultant percent voltage drop is 3.0 percent and the percent flicker is 4.7 percent. Since the voltage drop is the maximum allowed, 4/0 cable should be used on spans "A," "B," and #2 cable should be used on Span "C."

Note: If the voltage drop and flicker calculated are less than the maximum allowable standards (three percent VD and five percent flicker), an alternate secondary and service plan that decreases the cable size should be evaluated to determine if there is a more economical design. (Labor cost should be considered. For example, if the calculation shows that 100 feet of 4/0, 100 feet of 1/0, and 100 feet of #2 could be used, in reality, judgment can be made to decide that 100 feet of 4/0, and 200 feet of 1/0 should be used to reduce the number of cable reels required).

EXAMPLE 3

A customer on the existing overhead system shown below plans to remodel and add a three-ton air conditioner. Determine the total percentage of voltage drop and flicker using the appropriate voltage drop and flicker tables for the system below. Assume a 3 kW average demand for each home on the system.

Note: Each arrow designates a service to a customer for the purpose of determining the number of customers fed by each span of cable.



VOLTAGE DROP SOLUTION:

Percent Voltage Drop*

Conductor Size (AWG or kcmil)	Residential Single-Phase 120/240 Volt	
	Per Amp	Per kW
Al Triplex #4	0.0380	0.1761
WAL Open Wire 1/0	0.0191	0.0884

* Partial table extracted from Table 8–3.

1. Determine the total kW load on each span:

   Span "A" 8 customers x 3 kW per customer = 24 kW
   Span "B" 4 customers x 3 kW per customer = 12 kW
   Span "C" 1 customer x 3 kW per customer = 3 kW

2. Determine the percentage voltage drop for each span:

$$\%\ \text{voltage drop} = \frac{\text{Feet} \times \text{kW} \times (\text{per kW constant})}{100}$$

$$\text{Span A}\quad \%\ \text{voltage drop} = \frac{100 \times 24\text{kW} \times 0.0884}{100} = 2.1\%$$

$$\text{Span B}\quad \%\ \text{voltage drop} = \frac{100 \times 12\text{kW} \times 0.0884}{100} = 1.1\%$$

$$\text{Span C}\quad \%\ \text{voltage drop} = \frac{60 \times 3\text{kW} \times 0.1761}{100} = 0.3\%$$

Total Voltage Drop = 3.5%

FLICKER SOLUTION:

Determine the percentage of flicker for a three-ton A/C for each span using Table 8–9 and for the transformer using Table 8–8:

Span "A"—100 feet of 1/0 WAL =	1.9%
Span "B"—100 feet of 1/0 WAL =	1.9%
Span " feet of #4 Al Triplex =	1.9%
37.5 kVA transformer with a 3-ton A/C =	1.5%
Total Flicker =	7.2%

CONCLUSION:

The resultant percent voltage drop is 3.5 percent and the percent flicker is 7.2%. The percent flicker exceeds the five percent criteria; therefore, this design would not meet flicker standards.

Appendix 8–3: Commercial Voltage Drop Examples — Underground

Aluminum CLP Cable										
Conductor Size (AWG or kcmil)	Residential Single-Phase 120/240 Volt		C/I Single-Phase 120/240 Volt		C/I Three-Phase 240 Volt		C/I or Res. (Apartment) Three-Phase 208 Volt		C/I Three-Phase 480 Volt	
	Per Amp	Per kW	Per Amp	Per kW	Per Amp	Per kW	Per Amp	Per kW	Per Amp	Per kW
No. 2	0.0243	0.1125	0.0233	0.1141	0.0202	0.0571	0.0233	0.0760	0.0100	0.0143
1/0	0.0158	0.0731	0.0152	0.0746	0.0132	0.0373	0.0152	0.0497	0.0066	0.0094
4/0	0.0084	0.0389	0.0082	0.0404	0.0071	0.0202	0.0082	0.0269	0.0036	0.0050
350	0.0055	0.0256	0.0055	0.0270	0.0048	0.0135	0.0055	0.0180	0.0024	0.0034
700	0.0033	0.0152	0.0034	0.0165	0.0029	0.0082	0.0034	0.0110	0.0015	0.0021

Notes:

1. Based on 65 degrees Celsius conductor temperature.
2. Based on residential load power factor PF = 0.9 and C/I load power factor PF = 0.85.

FORMULAS:

$$\%\ \text{voltage drop} = \frac{\text{feet} \times \text{amps} \times (\text{per amp constant})}{100 \times N}$$

$$\%\ \text{voltage drop} = \frac{\text{feet} \times \text{kW} \times (\text{per kW constant})}{100 \times N}$$

where N = number of parallel runs

SAMPLE CALCULATIONS

(1) Given 125 A on a set of 4/0 Al, 120/240 single-phase secondaries 175 feet long in duct:

$$\%\ \text{voltage drop} = \frac{175 \times 125 \times .0082}{100} = 1.79\%$$

(2) Given 300 kW at 208 V on a three-phase 120-foot service consisting of two runs of 700 Al in duct:

$$\%\ \text{voltage drop} = \frac{120 \times 300 \times 0.0110}{100 \times 2} = 1.98\%$$

SOUTHERN CALIFORNIA EDISON
TRANSMISSION AND DISTRIBUTION

Section DDS–9: Cables and Conductors

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1.0 Scope

This chapter provides standards for economic cable/conductor loading, duct bank loading, cable pulling, and cable splicing.

2.0 Economic Cable/Conductor Loading

Primary 12 kV and 16 kV underground cables will be sized in accordance with Table 9–1, overhead conductors will be sized in accordance with Table 9–2. These standards are based on "economic considerations" of installation costs and energy losses. For 25 kV and 33 kV underground cable applications, contact Field Engineering.

Table 9–1: Underground Cable Loading

Aluminum **Cable Size (AWG or kcmil)**	Forecasted Peak Load within Five Years		**Normal Operating Rating**	**8-Hour Emergency Loading**
	(1)	**(2)**		
1/0	1-67 A	1-67 A	See Table 9–8.	See Table 9–9.
350	68-179 A	68-250 A	See Table 9–8.	See Table 9–9.
750	N/A	251-390 A	See Table 9–8	See Table 9–9
1,000	above 180 A	above 390 A	See Table 9–8.	See Table 9–9.

Underground Cable Selection Steps:

The underground cable loading standards provide two installation ranges (Column 1 and Column 2). Please follow the steps below to determine when to use each column.

Step 1: Does this new cable installation require new infrastructure regardless of the cable size?

a. If YES, size underground cable using Column 1.

b. If NO, go to Step 2.

Step 2: Using Column 1, determine if the underground cable size selected can be supported by the existing conduit size and/or structure spacing.

a. If YES, size underground cable using Column 1.

b. If NO, go to Step 3.

Step 3: Using Column 2, determine the size of underground cable needed and whether it can be supported by the existing conduit size and/or structure spacing.

a. If YES, size underground cable using Column 2.

b. If NO, install new infrastructure and size underground cable using Column 1.

Exception to Table 9–1:

Due to equipment bushing limitations, certain transformer sizes and protective equipment required installation of 1/0 AWG JCN. The affected equipment includes the following:

- Equipment associated with a loadblock.
- At 12 kV, both 1,500 kVA and 2,500 kVA transformers
- At 16 kV, both 2,500 kVA and 3,750 kVA transformers.

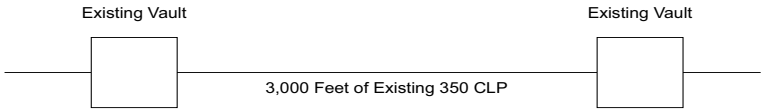
For these installations, 1/0 AWG JCN will be installed between the protective equipment and the next upstream structure, and from the protective device to the primary of the transformer.

Table 9-1 Examples

Example 1:

Using Table 9–1, consider the following cable replacement scenario:

- Straight pull of 3,000 feet of existing 350 JCN cable in five-inch duct between two vaults
- Forecasted peak load within next five years is 275 A



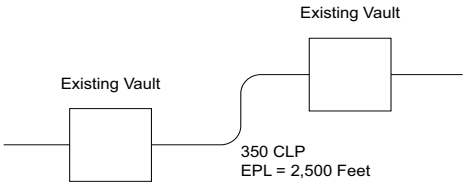
Question: What table should be used to determine the appropriate cable size?

Answer: Table 9–1, Column 1, would be used in this scenario. When using Column 2, the structure spacing exceeds the maximum equivalent pull length indicated in Table 9–14 for 750 JCN cable. Therefore, Column 1, 1,000 JCN cable, and new infrastructure would be installed.

Example 2:

Using Table 9–1, consider the following cable replacement scenario:

- Existing 350 CLP in five-inch duct with an Equivalent Pull Length (EPL) of 2,500 feet between two vaults
- Forecasted peak load within next five years is 325 A



Question: Which table should be used to determine the appropriate cable size?

Answer: Table 9–1, Column 2, would be used in this scenario. When using Column 1, the structure spacing exceeds the maximum equivalent pull length indicated in Table 9–14 for 1,000 JCN cable. However, when using Column 2, the maximum equivalent pull length in Table 9–14 for 750 JCN cable would not be exceeded. Therefore, Column 2 and 750 JCN cable could be installed.

Table 9–2: DOH ACSR Conductor Economic Loading Standard, 4 kV,12 kV, and 16 kV

Conductor Size (AWG or kcmil)	Conductor Economic Loading Range Based on Estimated Annual Peak Demand within Five Years	Normal Operating Rating	8-Hour Emergency Loading
#4 (See Note 3)	1-55 A	160 A	205
1/0	56-125 A	280 A	355
336.4	126-210 A	605 A	800
653.9	Above 210 A	920 A	1,200

Notes:

1. As a consideration of high-fault duty, Number 4 ACSR shall **not** be installed new within one-half mile of substation in urban areas.
2. ACSR Conductor Normal Operating Rating Criteria:
   - Ambient Temperature = 40°C
   - Conductor Temperature = 90°C
   - Wind Speed = 4 ft/sec
   - Coefficient of Emissivity = 0.5
   - Coefficient of Solar Absorption 0.5
   - Latitude = 34°
   - Elevation of Conductor above Sea Level = 0 ft
   - Atmosphere = Clear
   - Local Sun Time = 1:00 PM
3. Not approved for use on new installations.

Table 9–3: DOH Copper Conductor Economic Loading Standard, 4 kV,12 kV, and 16 kV

Conductor Size (AWG or kcmil)	Forecasted Peak Load within Five Years	Normal Operating Rating	8-Hour Emergency Loading
#4	1-60 A	195 A	260
#2	61-95 A	265 A	355
2/0	96-150 A	405 A	550
4/0	Above 150 A	540 A	745

Notes:

1. Due to the corrosive environment in the beach area within ONE MILE of the ocean, only copper conductor sizes 2/0 and smaller, and greased ACSR conductor sizes 336.4 and larger should be used for overhead construction. Any specific area that experiences accelerated corrosion because of unique circumstances should contact Field Engineering for review.
2. As a consideration of high-fault duty, #4 and #2 shall not be installed new within one-half mile of a substation in urban areas.
3. Stranded Copper Conductor Thermal Rating Criteria:
    - Ambient Temperature = 40°C
    - Conductor Temperature = 85°C
    - Wind Speed = 4 ft/sec
    - Coefficient of Emissivity = 0.5
    - Coefficient of Solar Absorption 0.5
    - Latitude = 34°
    - Elevation of Conductor above Sea Level = 0 ft
    - Atmosphere = Clear
    - Local Sun Time = 1:00 PM

The standards in Table 9–1, Table 9–2, and Table 9–3 are to be used for all new cable or conductor installations, including the following:

- New substation getaways
- Feeders through new residential or C/I developments
- Replacement of overhead feeder with underground
- Replacement of cables/conductors due to overload

3.0 600 Volt Cable Ampacity

Single and three-phase services often require parallel runs of cable. Table 9–4 through Table 9–8 should be used to determine cable ampacity when multiple sets of service and secondary cables are used. All tables are for 600 V, aluminum (CLP) cable.

Table 9–4: Single-Phase Service Secondary Cables (Load Factor 75 Percent)

Size (AWG or kcmil)	Single Run in a Duct	Number of Runs in Duct Bank				Direct Buried	In Riser	In Air
		One	Three	Six	Nine			
#2 (See Note 7)	131	131	117	102	96	150	113	136
1/0	172	172	154	133	125	194	153	184
4/0	258	258	229	197	183	281	238	287
350	350	350	306	259	242	371	330	397
700	525	525	454	377	354	543	520	626

Notes:

1. Maximum conductor temperature 90°C
2. Earth Temperature 25°C
3. Air Temperature 40°C
4. Load Factor of Cables in Duct Bank 75 percent (Loss Factor 62 percent) or 100 percent (Loss factor 100 percent)
5. Soil RHO 120°C — CM/watt
6. For Climate Zone 9 areas, multiply the given ampacity by 0.96
7. Not approved for use on new installations.

Table 9–5: Three-Phase Service or Secondary Cables (Load Factor as Shown)

Size (AWG or kcmil)	Number of Runs in Duct Bank								Direct Buried		In Riser	In Air
	One		Three		Six		Nine					
	75%	100%	75%	100%	75%	100%	75%	100%	75%	100%		
#2 (See Note 8)	108	102	95	85	81	70	73	62	150	134	102	123
1/0 (See Note 8)	146	137	126	112	105	90	95	79	194	173	139	167
4/0	223	208	188	165	155	131	138	114	286	253	217	262
350	304	281	252	219	204	171	181	149	380	333	303	364
700	457	449	367	315	292	242	256	211	554	479	469	570

Notes:

1. Maximum conductor temperature 90°C
2. Earth Temperature 25°C
3. Air Temperature 40°C
4. Load Factor of Cables in Duct Bank 75 percent or 100 percent
5. Soil RHO 120°C — CM/watt
6. For Climate Zone 9 areas, multiply the given ampacity by 0.96
7. Refer to Distribution Apparatus Engineering for numbers of runs or load factor not shown in this table
8. Not approved for use on new installations

Table 9–6: C/I 3Ø Service Cable Ampacities Installed in 4"Conduits

Sets of Cables (Cable Size)	1(See Note 2) (1/0 AWG)	1 (4/0 AWG)	1 (350 kcmil)	1 (700 kcmil)	2 (350 kcmil)	2 (700 kcmil)	3 (700 kcmil)	4 (700 kcmil)	5 (700 kcmil)	6 (700 kcmil)	7 (700 kcmil)	8 (700 kcmil)	9 (700 kcmil)
Load Factor 75% or Less	153	229	304	450	545	800	1085	1330	1600	1760	1955	2130	2300
Load Factor over 75%	144	214	282	415	488	710	940	1135	1315	1475	1630	1765	1900

Note:

1. For Climate Zone 9 areas, multiply the given ampacity by 0.96.
2. Not approved for use on new installations.

Table 9–7: C/I 3Ø Service Cable Ampacities Installed in Trenches

Sets of 700 kcmil Cables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12″ × 24″ Trench	460	850	1120	1400	1650	1880	—	—	—	—	—	—	—	—
24″ × 30″ Trench	485	920	1235	1575	1880	2160	2430	2680	2915	3145	3360	3555	3755	3945

Notes:

1. Ampacity for cable in trenches is based on 100 percent load factor.
2. For Climate Zone 9 areas, multiply the given ampacity by 0.96

4.0 Duct Bank Loading

4.1 Duct Bank Loading Criteria

Circuits shall be planned, so that loads do not exceed the ampacity of the cable. For underground cables, the ampacity is affected by the loading of all the circuits in a common duct bank. The critical portion of most circuits is the getaway cable as it leaves the substation carrying the entire circuit load in a duct bank common to other loaded cables.

Circuits shall be planned, so that the loading of individual cables in a duct bank will not exceed the planned loading limits. Circuits shall also be planned, so as to support substation N-1 contingency plans without exceeding the emergency operating ratings.

Table 9–8 and Table 9–9 provide planned and emergency loading limits based on the number of circuits in a common duct bank. These tables assume that all circuits are loaded to the maximum and can be used for duct banks with more than one cable size. Example problems follow in Section 4.2. If cable loading for each individual circuit in the duct bank does not exceed the loading limits in

Table 9–8 and Table 9–9, the duct bank cable loading is acceptable. If the loading exceeds the values in the tables, the ampacity diagrams in Figure 9–1 through Figure 9–5 are used to determine a load redistribution which will result in an acceptable duct bank loading. Figure 9–6 through Figure 9–10 provide guidelines for emergency operating limits.

Table 9–8: Normal Operating Loading (Planned) Limits

Voltage (kV)	Type	Size	One Circuit in Duct Bank				Two Circuits in Duct Bank			
			60% LF	75% LF	85% LF	100% LF	60% LF	75% LF	85% LF	100% LF
4/12/16	JCN	2 AWG (See Note 2)	139	137	133	127	128	123	117	109
		1/0 AWG	177	167	162	154	162	158	150	140
		350 kcmil	355	346	333	314	318	302	286	264
		750 kcmil (See Note 3)	559	520	499	467	492	448	422	387
		1,000 kcmil-Al	651	602	576	539	569	516	485	443
		1,000 kcmil-Cu	787	738	706	660	693	631	593	542
34.5	JCN	4/0 AWG	270	261	252	238	246	231	219	203
		750 kcmil (See Note 3)	531	515	494	464	474	447	421	387
		1,500 kcmil	722	715	683	638	639	613	576	526

Voltage (kV)	Type	Size	Three Circuits in Duct Bank				Four Circuits in Duct Bank			
			60% LF	75% LF	85% LF	100% LF	60% LF	75% LF	85% LF	100% LF
4/12/16	JCN	2 AWG (See Note 2)	119	112	105	97	112	104	97	89
		1/0 AWG	150	143	135	124	141	133	124	113
		350 kcmil	293	271	254	231	272	249	232	210
		750 kcmil (See Note3)	449	397	370	335	413	363	337	303
		1,000 kcmil	516	456	424	383	473	416	385	346
		1,000 kcmil-Cu	624	557	519	469	576	509	471	423
34.5	JCN	4/0 AWG	226	209	196	179	211	193	181	164
		750 kcmil (See Note 3)	426	399	373	338	391	367	341	307
		1,500 kcmil	564	543	506	457	514	497	460	413

Voltage (kV)	Type	Size	Five Circuits in Duct Bank				Six Circuits in Duct Bank			
			60% LF	75% LF	85% LF	100% LF	60% LF	75% LF	85% LF	100% LF
4/12/16	JCN	2 AWG (See Note 2)	106	97	91	82	101	92	85	77
		1/0 AWG	135	124	115	104	127	117	109	98
		350 kcmil	258	232	215	193	243	218	201	180
		750 kcmil (See Note 3)	390	336	311	278	366	316	291	259
		1,000 kcmil	446	385	355	317	418	361	332	296
		1,000 kcmil-Cu	537	471	434	388	506	441	406	361
34.5	JCN	4/0 AWG	198	180	167	150	188	171	158	142
		750 kcmil (See Note 3)	365	341	316	283	343	321	296	265
		1,500 kcmil	476	461	425	380	447	433	398	354

Voltage (kV)	Type	Size	In Riser Pole		Voltage (kV)	Type	Size	In Riser Pole	
4/12/16	JCN	2 AWG (See Note 2)	120		34.5	JCN	4/0 AWG	240	
		1/0 AWG	153				750 kcmil	510	
		350 kcmil	313				(See Note 2)	684	
		750 kcmil (See Note 3)	486				1,500 kcmil		
		1,000 kcmil	574						
		1,000 kcmil-CU	706						

Cables			Number of Circuits in Duct Bank						
			Cable Ampacity per Duct (AMPS)						
Voltage (kV)	Type	Size	1	2	3	4	5	6	In Pole Riser
4/12/16	PILC	4/0 AWG (See Note 2)	293	273	257	244	234	224	216
		350 kcmil (See Note 2)	394	363	342	322	308	294	296
		500 kcmil (See Note 2)	476	436	416	384	367	349	367
		750 kcmil (See Note 3)	590	537	501	468	452	422	465

Note:

1. For Climate Zone 9 areas, multiply the given ampacity by 0.96.
2. Not approved for use on new installations.
3. 750 JCN cable will only be utilized as specified in Table 9–1.
4. Consult Field Engineering to determine which daily Load Factor (LF) to use.

Table 9–9: Emergency Loading Limits (Based on Eight-Hour Loading Period)

Voltage (kV)	Type	Size	One Circuit in Duct Bank				Two Circuits in Duct Bank			
			60% LF	75% LF	85% LF	100% LF	60% LF	75% LF	85% LF	100% LF
4/12/16	JCN	2 AWG (See Note 2)	165	163	158	150	152	150	143	133
		1/0 AWG	213	205	198	188	196	193	184	170
		350 kcmil	427	413	397	374	386	371	350	322
		750 kcmil (See Note 3)	671	643	616	576	599	551	518	474
		1,000 kcmil-Al	782	747	714	666	695	636	597	545
		1,000 kcmil-Cu	987	923	882	822	866	786	737	672
34.5	JCN	4/0 AWG	324	319	307	291	297	281	267	247
		750 kcmil (See Note 3)	639	633	607	569	571	547	516	473
		1,500 kcmil	934	891	850	792	824	759	712	650

Voltage (kV)	Type	Size	Three Circuits in Duct Bank				Four Circuits in Duct Bank			
			60% LF	75% LF	85% LF	100% LF	60% LF	75% LF	85% LF	100% LF
4/12/16	JCN	2 AWG (See Note 2)	141	136	128	118	133	126	118	107
		1/0 AWG	184	174	164	150	172	161	151	137
		350 kcmil	358	330	309	281	334	303	282	254
		750 kcmil (See Note 3)	551	487	453	409	510	444	411	369
		1,000 kcmil	637	560	521	470	587	511	472	423
		1,000 kcmil-Cu	776	692	643	579	715	630	582	522
34.5	JCN	4/0 AWG	278	254	238	217	260	235	219	198
		750 kcmil (See Note 3)	523	488	455	412	485	447	415	373
		1,500 kcmil	749	671	624	563	689	613	567	508

Voltage (kV)	Type	Size	Five Circuits in Duct Bank				Six Circuits in Duct Bank			
			60% LF	75% LF	85% LF	100% LF	60% LF	75% LF	85% LF	100% LF
4/12/16	JCN	2 AWG (See Note 2)	123	118	110	99	120	111	103	93
		1/0 AWG	165	151	140	126	156	142	132	118
		350 kcmil	316	282	261	234	299	265	244	218
		750 kcmil (See Note 3)	482	411	379	338	454	385	354	315
		1,000 kcmil	555	471	434	387	522	441	405	360
		1,000 kcmil-Cu	665	582	536	478	626	545	500	445
34.5	JCN	4/0 AWG	248	219	204	183	236	207	191	172
		750 kcmil (See Note 3)	457	416	384	344	432	391	360	321
		1,500 kcmil	647	568	523	567	610	532	489	435

Voltage (kV)	Type	Size	In Riser Pole		Voltage (kV)	Type	Size	In Riser Pole	
4/12/16	JCN	2 AWG (See Note 2)	142		34.5	JCN	4/0 AWG	289	
		1/0 AWG	184				750 kcmil	613	
		350 kcmil	376				(See Note 2)		
		750 kcmil (See Note 3)	583				1,500 kcmil	828	
		1,000 kcmil	690						
		1,000 kcmil-CU	845						

Cables			Number of Circuits in Duct Bank						
			Cable Ampacity per Duct (AMPS)						
Voltage (kV)	Type	Size	1	2	3	4	5	6	In Pole Riser
4/12/16	PILC	4/0 AWG (See Note 2)	353	330	313	297	286	273	260
		350 kcmil (See Note 2)	475	317	299	283	271	258	357
		500 kcmil (See Note 2)	519	480	459	426	408	389	400
		750 kcmil (See Note 3)	643	591	555	521	504	472	507

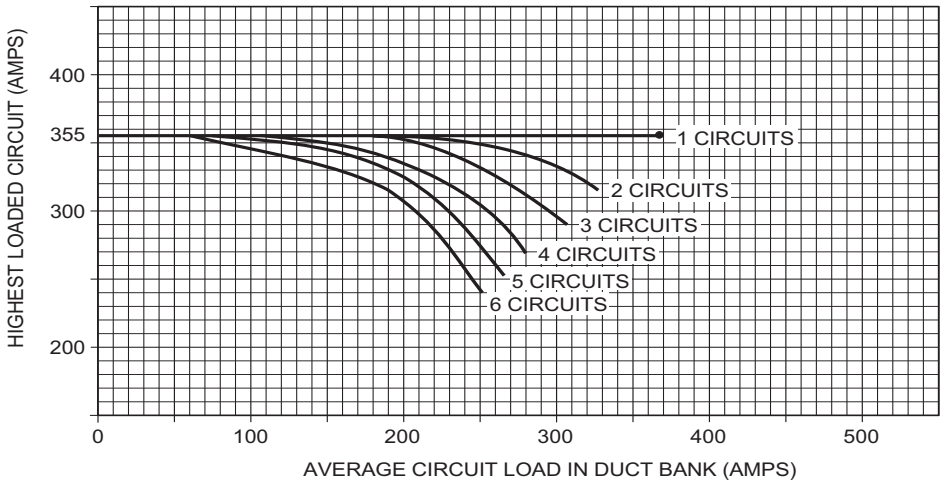
Notes:

1. For Climate Zone 9 areas, multiply the given ampacity by 0.96.
2. Not approved for use on new installations.
3. 750 JCN cable will only be utilized as specified in Table 9–1.
4. Consult Field Engineering to determine which daily Load Factor (LF) to use.

If cable loading for each individual circuit in the duct bank does not exceed the loading limits in Table 9–8 and Table 9–9, the duct bank cable loading is acceptable. If the loading exceeds the values in the tables, the ampacity diagrams in Figure 9–1 through Table 9–5 are used to determine a load redistribution which will result in an acceptable duct bank loading. Figure 9–6 through Figure 9–10 provide guidelines for emergency operating limits.

When comparing the actual circuit loads to the ampacities in the tables or the diagrams, the circuit amps need to be adjusted according to the base cable size by multiplying them by the effective load multipliers found at the bottom of the ampacity diagrams. Examples of the use of the duct bank loading tables and ampacity diagrams are provided beginning in Section 4.2.

Figure 9–1: Normal Operating Loading Ampacities 350 kcmil 4/12/16KV JCN[b/] Cable (Planned) in a Duct Bank

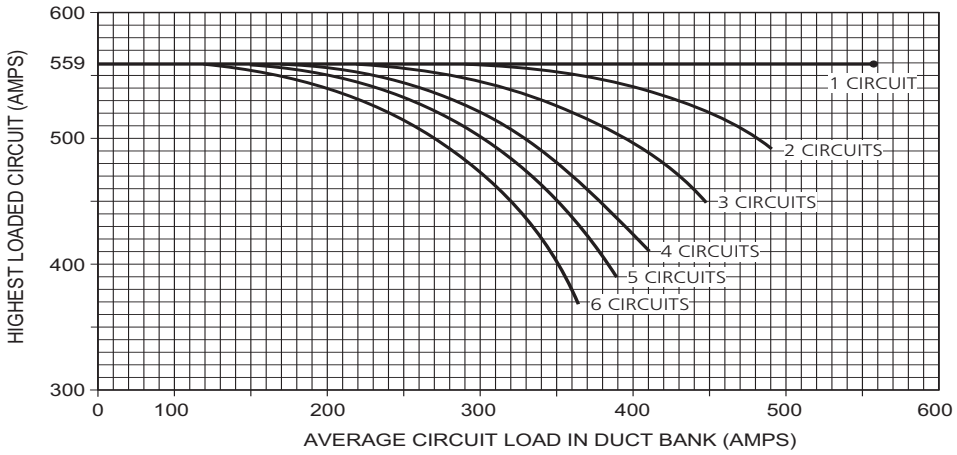


Parameters Used on Duct Bank Loading
Conductor Temperature = 90°C
Load Factor = 60%
Soil RHO = 120°C * CM/Watt
Earth Temperature = 25°C

Effective load multipliers.
4/12/16 kV Cable: 750 JCN[b/] = 0.7, 1,000 JCN = 0.6, 350 PILC[a/] = 0.9, 500 PILC[a/] = 0.6, 750 PILC[a/] = 0.6
34.5 kV Cable: 4/0 JCN = 1.4, 750 JCN[b/] = 0.6, 1,500 JCN = 0.5

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

Figure 9–2: Normal Operating Loading Ampacities 750 kcmil 4/12/16/KV JCN[b/] Cable (Planned) in a Duct Bank

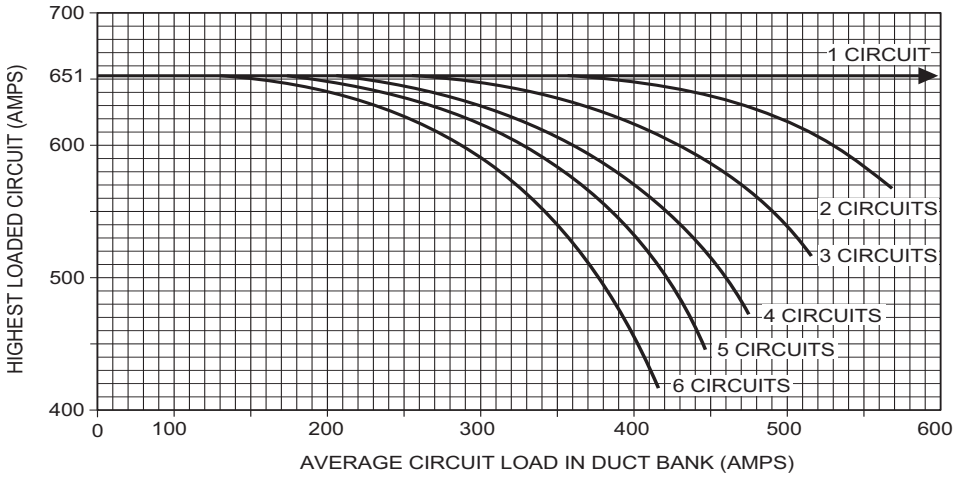


Parameters Used on Duct Bank Loading
Conductor Temperature = 90°C
Load Factor = 60%
Soil RHO = 120°C * CM/Watt
Earth Temperature = 25°C

NOTE: Effective load multipliers.
4/12/16 kV Cable: 350 JCN = 1.5, 1,000 JCN = 0.8, 350 PILC[a/] = 1.4, 500 PILC[a/] = 1.1, 750 PILC[a/] = 0.9
34.5 kV Cable: 4/0 JCN = 2.1, 750 JCN[b/] = 1.0, 1,500 JCN = 0.7

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

Figure 9–3: Normal Operating Loading Ampacities 1,000 kcmil 4/12/16/KV JCN[b/] Cable (Planned) in a Duct Bank



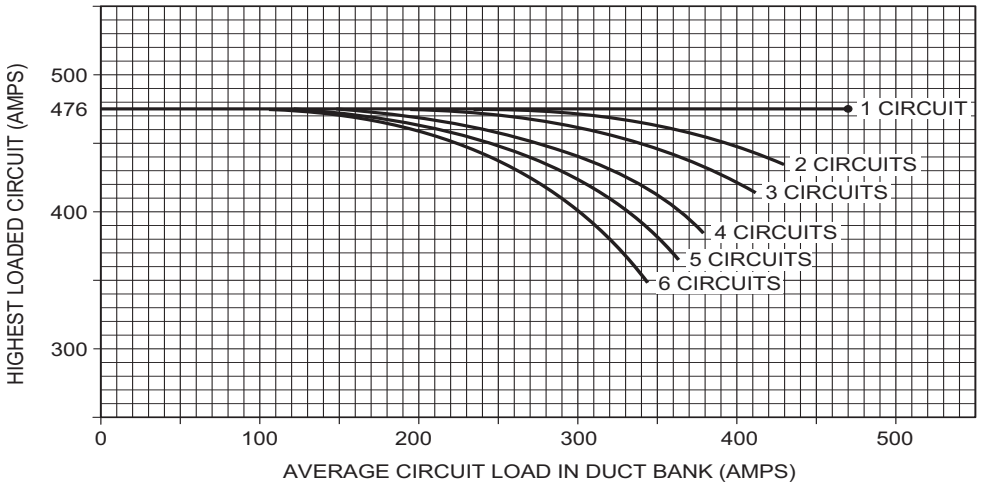
Parameters Used on Duct Bank Loading

Conductor Temperature	= 90°C
Load Factor	= 60%
Soil RHO	= 120°C * CM/Watt
Earth Temperature	= 25°C

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

NOTE: Effective load multipliers.
4/12/16 kV Cable: 350 JCN = 1.7, 750 JCN[b/] = 1.1, 350 PILC[a/] = 1.6, 500 PILC[a/] = 1.3, 750 PILC[a/] = 1.1
34.5 kV Cable: 4/0 JCN = 2.4, 750 JCN[b/] = 1.0, 1,500 JCN = 0.8

Figure 9–4: Normal Operating Loading Ampacities 500 kcmil 4/12/16/KV PILC Cable (Planned) in a Duct Bank



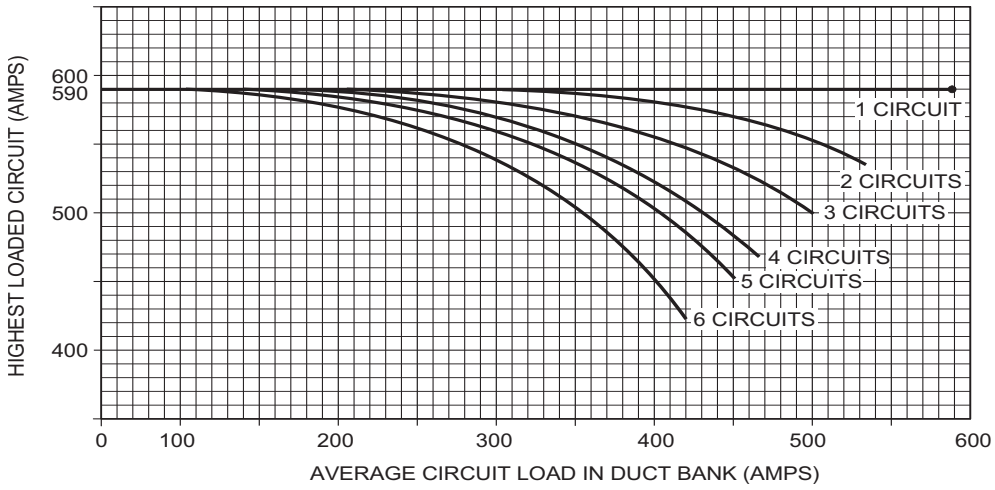
Parameters Used on Duct Bank Loading

Conductor Temperature	= 90°C
Load Factor	= 60%
Soil RHO	= 120°C * CM/Watt
Earth Temperature	= 25°C

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

NOTE: Effective load multipliers.
350 JCN = 1.4, 750 JCN[b/] = 0.9, 1,000 JCN = 0.7
350 PILC[a/] = 1.2, 750 PILC[a/] = 0.8

Figure 9–5: Normal Operating Loading Ampacities 750 kcmil 4/12/16/KV PILC Cable (Planned) in a Duct Bank

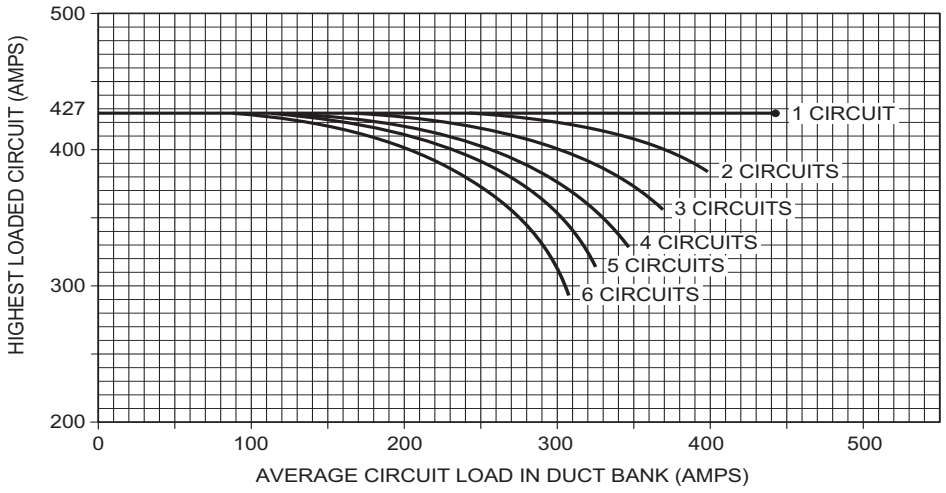


Parameters Used on Duct Bank Loading
Conductor Temperature = 90°C
Load Factor = 60%
Soil RHO = 120°C * CM/Watt
Earth Temperature = 25°C

NOTE: Effective load multipliers.
350 JCN = 1.7, 750 JCN[b/] = 1.1,
1,000 JCN = 0.9
350 PILC[a/] = 0.9, 500 PILC[a/] = 1.2

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

Figure 9–6: Emergency Loading Ampacities 350 kcmil 4/12/16/KV JCN[b/] Cable in a Duct Bank

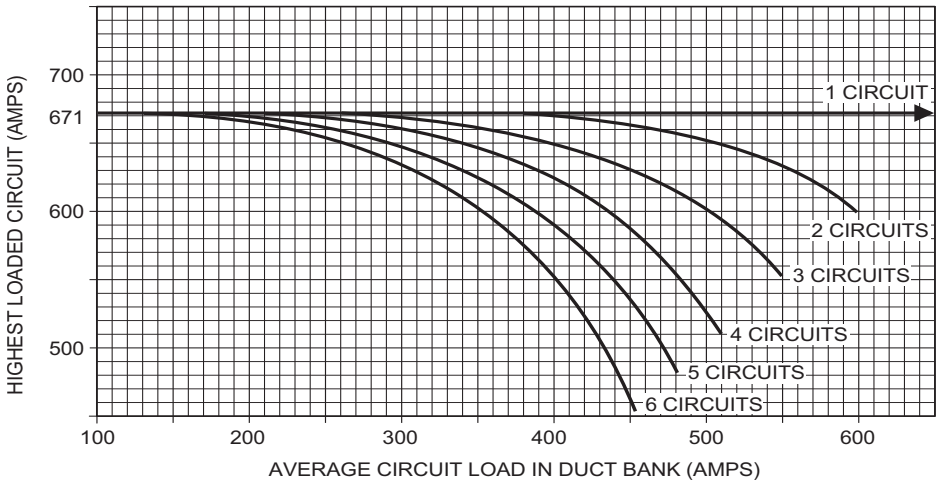


Parameters Used on Duct Bank Loading
Conductor Temperature = 130°C
Load Factor = 60%
Soil RHO = 120°C * CM/Watt
Earth Temperature = 25°C

NOTE: Effective load multipliers.
4/12/16 kV Cable: 750 JCN[b/] = 0.7, 1,000 JCN = 0.6,
350 PILC[a/] = 0.9, 500 PILC[a/] = 0.8,
750 PILC[a/] = 0.6
34.5 kV Cable: 4/0 JCN = 1.4, 750 JCN[b/] = 0.6
1,500 JCN = 0.5

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

Figure 9–7: Emergency Loading Ampacities 750 kcmil 4/12/16/KV JCN[b/] Cable in a Duct Bank



Parameters Used on Duct Bank Loading

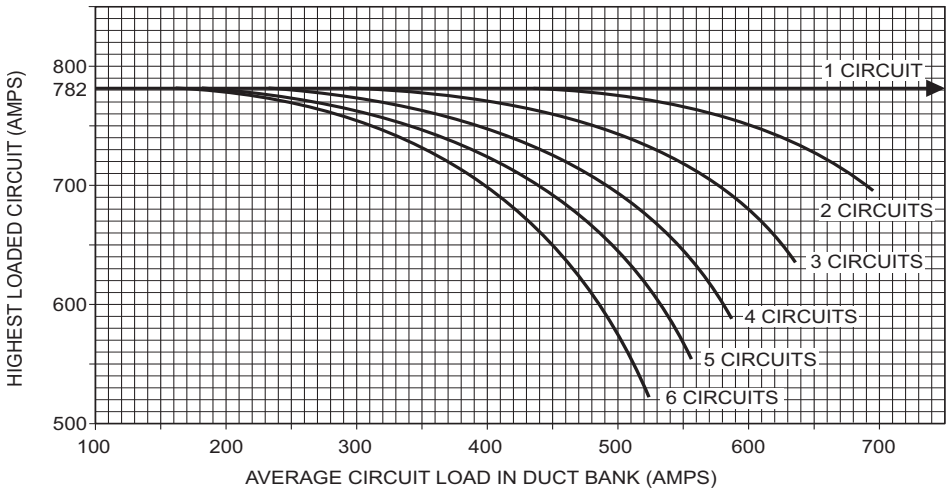
Conductor Temperature	= 130°C
Load Factor	= 60%
Soil RHO	= 120°C * CM/Watt
Earth Temperature	= 25°C

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

NOTE: Effective load multipliers.

4/12/16 kV Cable:	350 JCN =1.5, 1,000 JCN = 0.8, 350 PILC[a/] = 1.4, 500 PILC[a/] = 1.1, 750 PILC [a/]= 0.9
34.5 kV Cable:	4/0 JCN = 2.1, 750 JCN[b/] = 1.0, 1,500 JCN = 0.7

Figure 9–8: Emergency Loading Ampacities 1,000 kcmil 4/12/16/KV JCN[b/] Cable in a Duct Bank



Parameters Used on Duct Bank Loading

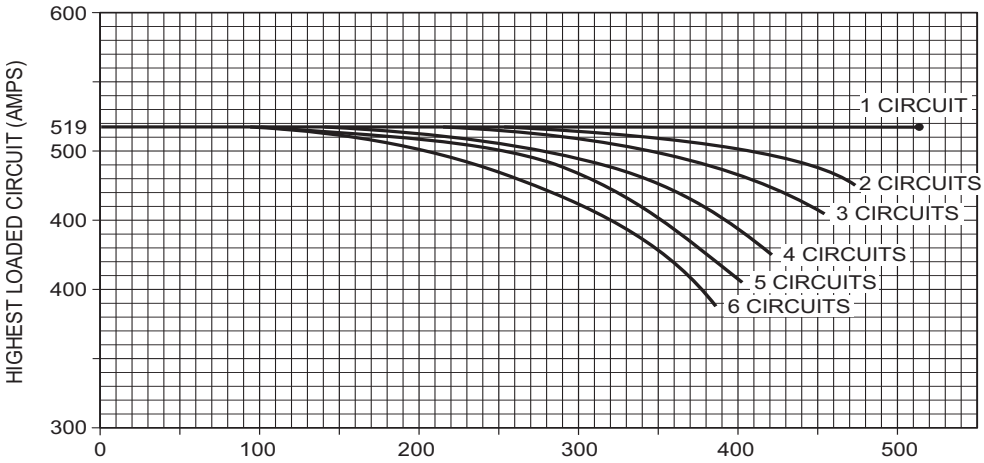
Conductor Temperature	= 130°C
Load Factor	= 60%
Soil RHO	= 120°C * CM/Watt
Earth Temperature	= 25°C

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

NOTE: Effective load multipliers.

4/12/16 kV Cable:	350 JCN = 1.7, 750 JCN[b/]= 1.1, 350 PILC[a/] = 1.6, 500 PILC[a/] = 1.3, 750 PILC[a/] = 1.1
34.5 kV Cable	4/0 JCN = 2.4, 750 JCN[b/]= 1.1 1,500 JCN = 0.8

Figure 9–9: Emergency Loading Ampacities 500 kcmil 4/12/16/KV PILC Cable in a Duct Bank

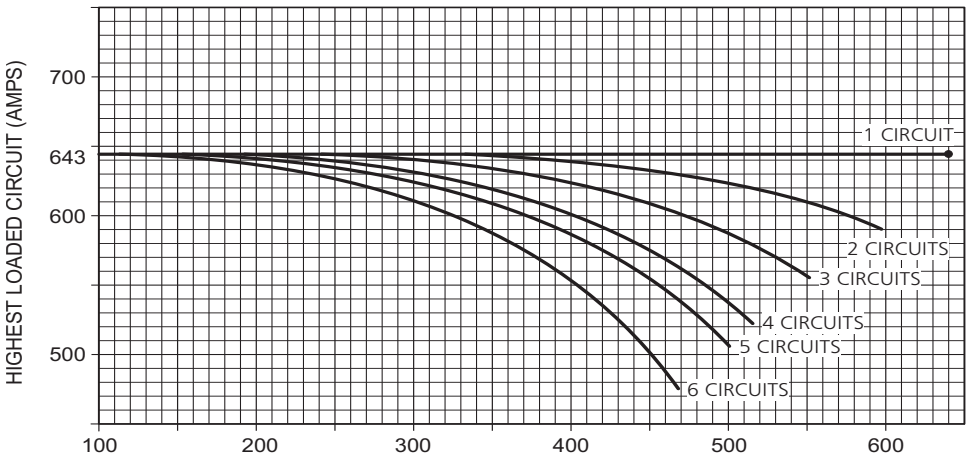


Parameters Used on Duct Bank Loading	
Conductor Temperature	= 110°C
Load Factor	= 60%
Soil RHO	= 120°C * CM/Watt
Earth Temperature	= 25°C

NOTE: Effective load multipliers.
350 JCN = 1.4, 750 JCN[b/] = 0.9,
1,000 JCN = 0.7
350 PILC[a/] = 1.2, 750 PILC[a/] = 0.8

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

Figure 9–10: Emergency Loading Ampacities 750 kcmil 4/12/16/KV PILC Cable in a Duct Bank



Parameters Used on Duct Bank Loading	
Conductor Temperature	= 110°C
Load Factor	= 60%
Soil RHO	= 120°C * CM/Watt
Earth Temperature	= 25°C

NOTE: Effective load multipliers.
350 JCN = 1.7, 750 JCN[b/] = 1.1,
1,000 JCN = 0.9
350 PILC[a/] = 1.5, 500 PILC[a/] = 1.2

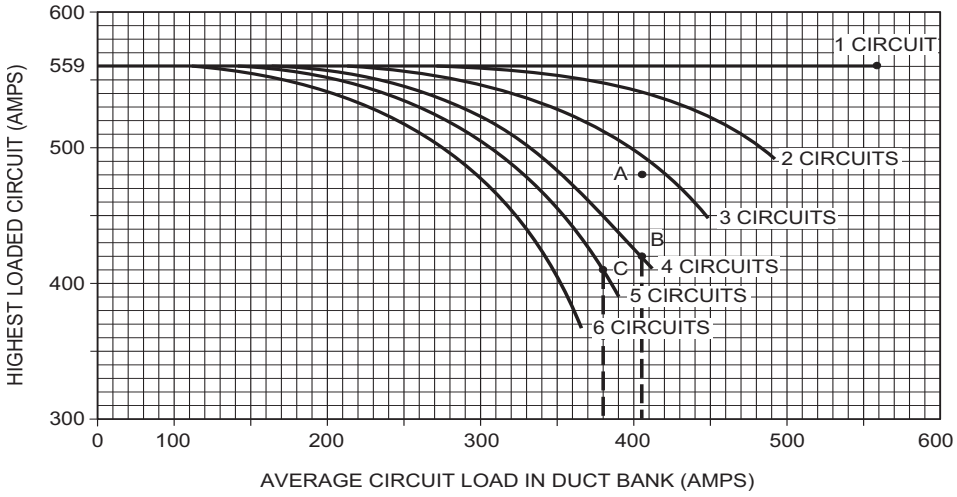
a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

4.2 Duct Bank Loading Examples

The use of Table 9–8, *Normal Operating (Planned) Loading Limits*, Table 9–9, *Emergency Loading Limits*, and the *Ampacity Diagrams*, Figure 9–1 through Figure 9–10 is explained through the examples that follow.

Figure 9–11: Illustration for Using Figure 9–2

Normal Operating Loading Ampacities 750 kcmil 4/12/16/KV JCNb/ Cable (Planned) in a Duct Bank



Parameters Used on Duct Bank Loading	
Conductor Temperature	= 90°C
Load Factor	= 60%
Soil RHO	= 120°C * CM/Watt
Earth Temperature	= 25°C

NOTE: Effective load multipliers
4/12/16 kV Cable: 350 JCN = 1.5, 1,000 JCN = 0.8, 350 PILC[a/] = 1.4, 500 PILC[a/] = 1.1, 750 PILC[a/] = 0.9
34.5 kV Cable: 4/0 JCN = 2.1, 750 JCN[b/] = 1.0, 1,500 JCN = 0.7

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

Example 1: — Normal Operating (Planned) Loading

A substation getaway with four circuits of 750 kcmil CLP cable in one duct bank has the following projected loads: 350 A, 380 A, 410 A, and 480 A. Checking the Normal Operating (Planned) Loading Limits, Table 9–8, the guideline ampacity is 413 A for four circuits of 750 kcmil JCN in a duct bank. Since **one** circuit is above this guideline, the ampacity diagram is used to determine changes which will result in acceptable duct bank cable loading.

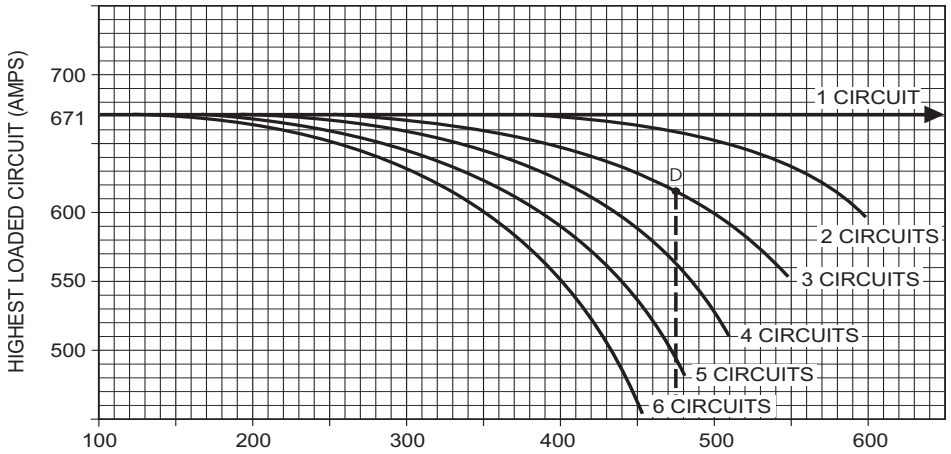
The average circuit load in the duct bank is (350 + 380 + 410 + 480) ÷ 4 = 405 A. Using the Normal Operating (Planned) Loading Ampacity Diagram for 750 kcmil JCN cable, Figure 9–2 (reproduced above) to illustrate its use, the duct bank is operating at Point A. This point is above the "4 circuits" curve and thus exceeds the guideline. To bring the intersecting point below the "4 circuits" curve, it must move **down** (by redistributing the amperage among the four circuits) and/or move to the **left** (by reducing the total load on the four circuits).

If 60 A can be transferred from the highest to the lowest loaded circuit, then the loads will be 410 A, 380 A, 410 A, and 420 A, and the duct bank will operate at Point B. Average load will remain the same but the high circuit will be 420 A. This point is on the "4 circuits" curve and meets the guideline.

Note that if the circuit with 480 A had been a 1,000 kcmil JCN cable, then an effective load current must be calculated as described in the footnote of the figure below. The effective circuit current for the 1,000 kcmil JCN cable is the actual load multiplied by the effective load multiplier shown in the figure. In this case, the effective load would be 480 A × 0.8 = 384 A and the effective average load would be (350 A + 380 A + 410 A + 384 A) ÷ 4 = 380 A. The duct bank would operate at Point C which falls within the guideline.

Figure 9–12: Illustration for Using Figure 9–7

Emergency Loading Ampacities 750 kcmil 4/12/16/KV JCNb/ Cable in a Duct Bank



Parameters Used on Duct Bank Loading
Conductor Temperature = 130°C
Load Factor = 60%
Soil RHO = 120°C * CM/Watt
Earth Temperature = 25°C

NOTE: Effective load multipliers.
4/12/16 kV Cable: 350 JCN = 1.5, 1,000 JCN = 0.8, 350 PILC[a/] = 1.4, 500 PILC[a/] = 1.1, 750 PILC[a/] = 0.9
34.5 kV Cable: 4/0 JCN = 2.1, 750 JCN[b/] = 1.0, 1,500 JCN = 0.7

a/ Not approved for use on new installations.
b/ 750 JCN cable will only be utilized as specified in Table 9-1.

Example 2: — Emergency Loading

For this example, assume that the load transfer was made in the duct bank of Example 1 and the loads are 410 A, 380 A, 410 A, and 420 A. Assuming that the highest loaded circuit is faulted, a check is made to see if the entire 420 A can be picked up on the three remaining circuits.

The total load that must be carried is 1,620 A, or an average of 540 A for three circuits. Checking the Emergency Loading Limits, Table 9–9, the guideline ampacity is 551 A for three circuits of 750 kcmil JCN in a duct bank. If the load can be split and picked up on the remaining circuits so that none of the circuits exceeds 551 A, the emergency is resolved.

Since it is unlikely that the load can be split that precisely, some load should be transferred to a circuit outside this duct bank. Assuming 200 A can be transferred, that would leave 1,420 A, or an average of 475 A, for the three remaining circuits. The Emergency Loading Ampacity Diagram Figure 9–7, reproduced above to illustrate its use), can then be used to determine the maximum load that can be carried on the highest loaded circuit remaining in the duct bank. Point "D" on the curve for "3 circuits" illustrates that with, an average of 475 A, the highest loaded circuit can operate at 615 A and still meet guidelines.

5.0 Cable Pulling

Underground manholes and vaults for mainline installation shall be laid out based on the pulling length for the largest size cable that could be installed based on the circuit voltage. For all other non-mainline structure installations, the structure shall be laid out to accommodate the maximum pulling lengths of the cable currently being installed.

The method shown here should be used to determine the equivalent straight pull length where cable turns are included in the cable run. This method is applicable to aluminum primary JCN, 600 V CLP cable and three conductor PILC cable. The Planner shall specify the direction of the calculated cable pull on the work-order sketch for **all** primary cable installations. The Planner shall specify secondary/service cable pull direction anytime the calculated "Maximum Equivalent Pull Length" exceeds the table value in one of the cable pull directions.

The difference between **bends** and **sweeps** is determined by their **radii**. The radius of each bend is determined by conduit size, as shown below:

- 36 inches for conduit three-inches in diameter or smaller
- 48 inches for conduit four-inches and five-inches in diameter
- 60 inches for conduit six-inches in diameter

The **minimum** radius for all sweeps of all size conduits is 12-1/2 feet. **Sweeps** shall be used for all three-phase primary horizontal turns. **Bends** are used at the bases of primary risers and for secondary or service horizontal and vertical turns other than mainline trench. For single-phase residential cable runs bends may be used for primary horizontal turns. Use **sweeps** when installing 600 V, 700 CLP. See DDS-6, Underground Structure Applications, Table 6–1, for Recommended Conduit Installation Selection Criteria.

5.1 Cable Pulling Criteria

The equivalent straight pull length should be calculated for cable run where sweeps and riser bends are included using the method illustrated in 5.2 Cable Pulling Examples for JCN Cable (Page 9–32). For each straight pull, use the actual straight pull footage added to the value obtained from the previous sweep or bend. For sweeps or bends, multiply the equivalent footage at the start of the sweep or bend by the appropriate multiplying value from Table 9–10 to obtain the equivalent footage through the sweep or bend.

The equivalent straight pull footage should be calculated at the exit of each riser bend, sweep and "Y" fitting to ensure that it does not exceed the limits based on sidewall pressure shown in Table 9–11 and Table 9–12. The total equivalent straight pull footage at the pulling end must then be checked against the limits shown in Table 9–13, Table 9–14 or *Distribution Underground Construction Standards (DUG) Manual* for the appropriate pulling method.

When replacing existing cable run with jacketed cable, the following conditions shall be considered:

- Follow the cable pulling procedure outlined above to calculate the maximum equivalent pulling length.
- Cable pulling should not exceed limits shown on Table 9–11, Table 9–12, and Table 9–14; contact Distribution Apparatus Engineering for deviation to these tables.
- Pre-lubing conduit and applying more cable pulling lubrication will reduce friction significantly. For cable pulling lubricant instructions, refer to IC 200.1 and IC 200.2 in the *DUG Manual*.

If the above conditions cannot be met, contact Field Engineering for consideration of adding an intercepting structure or replacing the existing cable run with non-jacketed cable.

Table 9–10: Multiplying Values for Standard Conduit Angles

JCN Three-Phase Primary in PVC, Fiberglass or HDG (See Notes 1 & 4)

Voltage (kV)	Phase Conductor Size	11.25°	22.50°	30°	45°	90°
3" Duct						
4/12/16	1/0 AWG	1.12	1.26	1.36	1.59	2.51
4" Duct						
4/12/16	1/0 AWG	1.09	1.19	1.26	1.42	2.02
	350 kcmil	1.12	1.25	1.34	1.55	2.41
5" Duct						
4/12/16	1/0 AWG	1.08	1.17	1.23	1.37	1.88
	350 kcmil	1.09	1.19	1.27	1.43	2.03
	750 kcmil (See Note 2)	1.12	1.25	1.34	1.55	2.41
	1,000 kcmil, AL, CU	1.13	1.29	1.40	1.66	2.75
34.5	4/0 AWG	1.11	1.23	1.31	1.51	2.27
6" Duct						
34.5	4/0 AWG	1.09	1.19	1.26	1.42	2.02
	750 kcmil (See Note 2)	1.12	1.26	1.36	1.59	2.52
	1,500 kcmil	1.14	1.31	1.43	1.72	2.95

CLP Commercial/Industrial Three Phase in PVC (See Notes 1 & 2)

Voltage (V)	Phase Conductor Size	11.25°	22.50°	30°	45°	90°
600	All Sizes **(See Note 1)**	1.10	1.21	1.29	1.47	2.16

3/C EPR — PILC Replacement in PVC, Fiberglass, or HDG (See Note 1 & 3)

Voltage (kV)	Phase Conductor Size	11.25°	22.50°	30°	45°	90°
4/12/16	All Sizes **(See Note 1)**	1.15	1.32	1.44	1.58	2.10

Table 9–10: Multiplying Values for Standard Conduit Angles *(Continued)*

CLP Residential Single Phase in PCV (See Notes 1)

Voltage	Phase Conductor Size	11.25°	22.50°	30°	45°	90°
2" Duct						
12/16 kV	1-#2 AWG	1.07	1.15	1.20	1.32	1.73
	1-1/0 AWG	1.07	1.15	1.20	1.32	1.73
600 V	2-1/0 AWG	1.09	1.18	1.25	1.39	1.94
	2-#2 AWG	1.08	1.16	1.22	1.35	1.84
	1-#8 AWG	1.07	1.15	1.20	1.32	1.74
2.5" Duct						
12/16 kV	1-#2 AWG	1.07	1.15	1.20	1.32	1.73
	1-1/0 AWG	1.07	1.15	1.20	1.32	1.73
600 V	2-4/0 AWG	1.09	1.19	1.26	1.41	2.00
	2-1/0 AWG	1.08	1.17	1.23	1.36	1.86
	2-#2 AWG	1.08	1.16	1.22	1.34	1.80
3" Duct						
12/16 kV	1-#2 AWG	1.07	1.15	1.20	1.32	1.73
	1-1/0 AWG	1.07	1.15	1.20	1.32	1.73
	2-#2 AWG	1.11	1.24	1.33	1.53	2.33
	2-1/0 AWG	1.12	1.26	1.36	1.59	2.51
600 kV	2-350 kcmil	1.09	1.19	1.26	1.42	2.01
	2-4/0 AWG	1.08	1.17	1.23	1.37	1.87
	2-1/0 AWG	1.08	1.16	1.22	1.34	1.80
	2-#2 AWG	1.07	1.15	1.21	1.33	1.77
4" Duct						
12/16 kV	2-#2 AWG	1.09	1.18	1.25	1.40	1.97
	2-1/0 AWG	1.09	1.19	1.26	1.42	2.02
600 V	2-700 kcmil	1.09	1.19	1.27	1.42	2.03
	2-350 kcmil	1.08	1.17	1.23	1.36	1.85

Notes:

1. The multiplying values are based on Schedule 80 conduit.
2. 750 JCN cable will only be utilized as specified in Table 9–1.
3. Commercial/Industrial (C/I) cables do not require multiplying values for every cable size, since four cables are being pulled, the weight JP correction factor is the same for all C/I cable sizes.
4. Three conductor EPR cables do not require multiplying values for every cable size, since the three conductors are underneath one overall jacket.
5. For half conduit sizes, use the cable multipliers value of the next half size smaller. For example, when calculating the equivalent pull length in 3-1/2 inch conduit, use the cable multiplier value for three-inch conduit.

Table 9–11: MAX Equivalent Length through Riser Bend or Split "Y" Based on Sidewall Pressure for Jacketed Cable

Type of Riser	12/16 kV ft (lb)					34.5 kV ft (lb)		
	1/0 AWG	350 kcmil	750 kcmil (See Note 4)	1,000 kcmil Al	1,000 kcmil Cu	4/0 AWG	750 kcmil (See Note 4)	1,500 kcmil
6" HDG	1,523 (1,267)	2,841 (4,200)	1,877 (4,829)	1,286 (4,241)	663 (4,241)	1,456 (2,539)	831 (3,396)	848 (4,555)
5" HDG	1,523 (1,267)	2,841 (4,174)	951 (2,861)	591 (2,377)	304 (2,377)	1,248 (2,539)	— —	— —
4" HDG	1,365 (1,267)	1,752 (2,965)	— —	— —	— —	— —	— —	— —
3" HDG	1,041(1,267)	— —	— —	— —	— —	— —	— —	— —
6" Fiberglass	1,523 (1,267)	2,841 (4,200)	2,090 (5,195)	1,466 (4,626)	755 (4,626)	1,456 (2,539)	986 (3,793)	1,049 (5,199)
5" Fiberglass	1,523 (1,267)	2,841 (4,200)	1,146 (3,229)	741 (2,741)	382 (2,741)	1,248 (2,539)	— —	— —
4" Fiberglass	1,365 (1,267)	2,146 (3,385)	— —	— —	— —	— —	— —	— —
3" Fiberglass	1,041 (1,267)	— —	— —	— —	— —	— —	— —	— —

Notes:

1. Sidewall pressure is not a critical factor for secondary cable or single-phase residential primary cable(s).
2. PVC may be substituted for fiberglass risers for straight runs of 150 feet or less, of four inch or less conduit size.
3. For existing installations, verify the type of riser bend installed.
4. 750 JCN cable will only be utilized as specified in Table 9–1.

Table 9–12: MAX Equivalent Length through Sweep Based on Sidewall Pressure for Jacketed Cable

Type of Riser (in)	12/16 kV ft (lb)					34.5 kV ft (lb)		
	1/0 AWG	350 kcmil	750 kcmil (See Note 2)	1,000 kcmil Al	1,000 kcmil Cu	4/0 AWG	750 kcmil (See Note 2)	1,500 kcmil
6	1,523 (1,267)	2,841 (4,200)	2,778 (9,000)	2,172 (9,600)	1,119 (9,600)	1,456 (2,539)	2,025 (9,000)	1,603 (9,600)
5	1,523 (1,267)	2,841 (4,200)	2,778 (9,000)	2,172 (8,567)	1,119 (8,567)	1,248 (2,539)	— —	— —
4	1,365 (1,267)	2,294 (4,200)	— —	— —	— —	— —	— —	— —
3	1,041 (1,267)	— —	— —	— —	— —	— —	— —	— —

Note:

1. Sidewall pressure is not a critical factor for secondary cable or single-phase residential primary cable(s).
2. 750 JCN cable will only be utilized as specified in Table 9–1.

Table 9–13: MAX Equivalent Pull Length for Residential Single-Phase Cable Pulls

Residential Conductor Type	Phase Conductor	Number of Phase Conductors	Size of Neutral Conductor	MAX Allowable Equivalent Cable Pull Length ft and Tension (lb)												MAX Available Length (ft)
				1″		1-1/2″		2″ (See Note 6)		2-1/2″ (See Note 6)		3″		4″		
				ft (lb)		ft (lb)		ft (lb)		ft (lb)		ft (lb)		ft (lb)		
Primary (12/16 kV)	1/0 AWG	1	—	—	—	—	—	2,415	(584)	2,415	(548)	2,415	(584)	—	—	2,500
	#2 AWG	2	—	—	—	—	—	—	—	—	—	1,025	(600)	1,284	(600)	2,700
	1/0 AWG	2	—	—	—	—	—	—	—	—	—	740	(600)	970	(600)	2,700
Secondary (600 V)	700 kcmil	2	350 kcmil	—	—	—	—	—	—	—	—	—	—	657	(600)	1,000
	350 kcmil	2	4/0 AWG	—	—	—	—	—	—	—	—	1,223	(600)	See Note 3		1,500
	4/0 AWG	2	1/0 AWG	—	—	—	—	—	—	2,030	(600)	2,243	(600)	—	—	2,000
	1/0 AWG	2	#2 AWG	—	—	—	—	3,704	(600)	3,966	(600)	4,174	(600)	—	—	3,000
Service (600 V)	350 kcmil	2	4/0 AWG	—	—	—	—	—	—	—	—	204	(100)	—	—	1,500
	4/0 AWG	2	1/0 AWG	—	—	—	—	—	—	338	(100)	374	(100)	—	—	2,000
	1/0 AWG	2	#2 AWG	—	—	—	—	617	(100)	661	(100)	696	(100)	—	—	3,000
Streetlight	#8 AWG	1	#8 AWG	1,818	(50)	2,091	(50)	2,154	(50)	—	—	—	—	—	—	1,000

Notes:

1. For recommended conduit sizes refer to Table 6–1.
2. For 700 CLP secondary cable installed in 5″ conduit (see Table 6–3, Note 5), the equivalent pulling length is 608′.
3. For C/I type service runs (condos, apartments) use the values found in the secondary portion of the table. If 350 CLP installed in 4″ conduit for C/I type single-phase service, the equivalent pulling length is 1,379′ (600 lb).
4. For Streetlight, the approved conduit is 1-1/2″, per Table 6–1.
5. For jacketed primary cable only.
6. Not approved for use on new installations.

Table 9–14: MAX Equivalent Pull Length Based on MAX Allowable Pull Strength for Three-Phase Cable Pulls

Cable Size	MAX Equivalent Straight Pull in Feet for Jacketed Cable		MAX Available Cable Length in Feet
	Structure Lift Plate Rating		
	10,000 lb Swivel	20,000 lb Swivel	
	ft (lb)	ft (lb)	
12/16 kV			
5″ Duct			
#2 AWG	1,244 (796)	1,244 (796)	2,700
1/0 AWG	1,523 (1,267)	1,523 (1,267)	1,500
350 kcmil	2,841 (4,200)	2,841 (4,200)	3,000
750 kcmil (See Note 6)	1,543 (5,000)	2,778 (9,000)	2,000
1,000 kcmil AI	1,131 (5,000)	2,172 (9,600)	1,700
1,000 kcmil Cu	583 (5,000)	1,119 (9,600)	1,700
4″ Duct			
#2 AWG	1,135 (796)	1,135 (796)	2,700
1/0 AWG	1,365 (1,267)	1,365 (1,267)	1,500
350 kcmil (See Note 2)	2,294 (4,200)	2,294 (4,200)	3,000
3″ Duct			
1/0 AWG (See Note 2)	1,041 (1,267)	1,041 (1,267)	1,500
34.5 kV			
6″ Duct			
4/0 AWG	1,456 (2,539)	1,456 (2,539)	2,000
750 kcmil (See Note 6)	1,125 (5,000)	2,025 (9,000)	1,200
1,500 kcmil	835 (5,000)	1,603 (9,600)	1,000
5″ Duct			
4/0 AWG	1,248 (2,539)	1,248 (2,539)	2,000

Notes:

1. Verify standard cable length on reel, lengths may be subject to change.
2. Not recommended for new installations.
3. The values given above pertain to using Kellems grips and pulling noses.
4. The structure lift plate rating is determined by the structure size and type. In general, 10,000 pounds swivel is applicable for pull boxes, and manholes smaller than 6′ × 8′. In general, the 20,000 pound swivel is applicable for vaults and manholes of 6' x 8' and larger (for further details, refer to the *Underground Standards [UGS] Manual*).
5. For half conduit sizes, use the maximum equivalent pull length of the next half size smaller. For example, when pulling cable in a 3-1/2 inch conduit, use the maximum equivalent pull length for three-inch conduit.
6. 750 JCN cable will only be utilized as specified in Table 9–1.

Table 9–15: MAX Equivalent Pull Length 600 V, Three-Phase, All Sizes

One Grip over Four Conductors (ft) (lb)	Four Grips, One over Each Conductor, or Pulling Noses (ft) (lb)	MAX Available Cable Length (ft)
721 ft 1,000 lb	1,443 ft 2,000 lb	1,000

1. Based on three, 700 kcmil phase conductors and one, 350 kcmil neutral conductor.

5.2 Cable Pulling Examples for JCN Cable

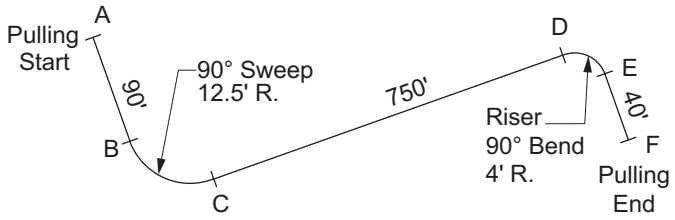
Example 1: — 350 JCN in a Riser Run

Install three 1/C paralleled 12/16 kV 350 kcmil JCN Al cables in the five-inch riser run shown. Calculate the equivalent lengths as shown, using values from Table 9–11. Then compare the equivalent footage after each sweep or bend for limiting values, as shown in Table 9–13, Table 9–14, and Table 9–15.

Equivalent lengths:

Pull "A" to "F"

A = 0'
B = 90'
C = 90' x 2.03 = 183'
D = 183' + 750' = 933'
E = 933' x 2.03 = 1,894'
F = 1,894' + 40' = 1,934'



Points to check:

- Point “C” is less than 2,936 feet, as shown for 350 kcmil in a sweep in Table 9–14;
- Point “E” is less than 2,936 feet, as shown for 350 kcmil in a fiberglass riser bend in Table 9–12; and,
- Point “F” is less than the 2,841 feet, as shown for parallel 350 kcmil in Table 9–14.

Conclusion:

The Planner shall specify on the work order sketch the direction of the pull to use a five-inch fiberglass riser bend.

Note: Because the **direction of pull** and/or **type of pulling device** are both critical, they must be indicated on the work order drawing with the reason for the indication.

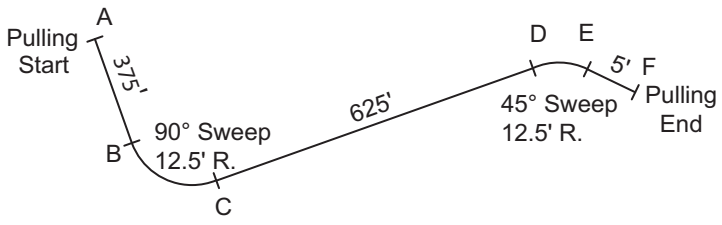
Example 2: — 1,000 JCN in a Run with Two Sweeps

Install three 1/C paralleled 12/16 kV 1,000 kcmil JCN in the five-inch PVC duct run shown. Calculate the equivalent lengths as shown, using values from Table 9–9. Then compare the equivalent footage after each sweep or bend for limiting values, as shown in Table 9–12, and Table 9–14.

Equivalent lengths:

Pull "A" to "F"

A = 0'
B = 375'
C = 375' x 2.75 = 1,031'
D = 1,031' + 625' = 1,656'
E = 1,656' x 1.66 = 2,749'
F = 2,749' + 5' = 2,754'



Points to check:

- Point "C" is less than 1,847 feet as shown for 1,000 kcmil in a sweep in Table 9–12
- Point "E" is greater than the 1,847 feet
- Point "F" is greater than the 2,172 feet, as shown for 1,000 kcmil Table 9–14

Because the pull exceeds the allowable equivalent footage at Points "E" and "F," recalculate pulling from the opposite directions. (This should **always** be a consideration to determine the easiest pull.)

Equivalent lengths:

Pull "F" to "A"

F = 0'
E = 5'
D = 5' × 1.66 = 8'
C = 8' + 625' = 633'
B = 633' × 2.75 = 1,741'
A = 1,741' + 375' = 2,116'

Points to check:

- Point "D" is less than the 1,847 feet for 1,000 kcmil through a sweep in Table 9–13.
- Point "B" is less than the 1,847 feet.
- Point "A" is less than the 2,172 feet for 1,000 kcmil, as shown in Table 9–14.

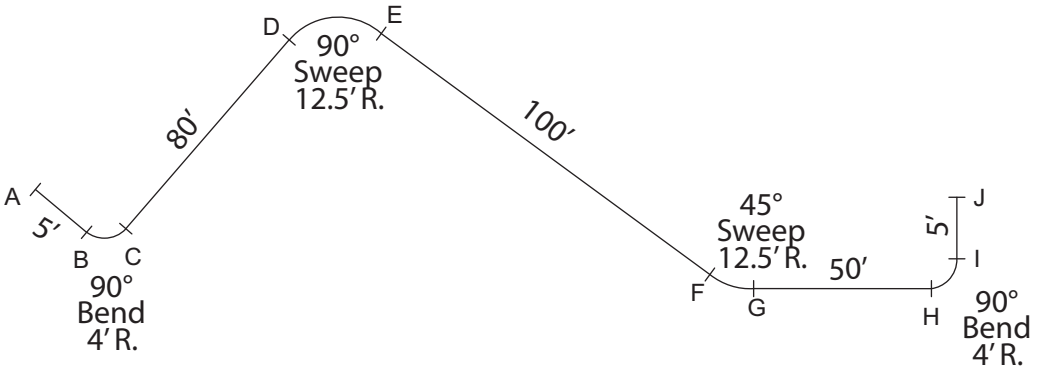
Conclusion:

The Planner shall specify on the work order sketch to pull cable from Point "F" to Point "A."

Note: Because the **direction of pull** and/or **type of pulling device** are both critical, they **must** be indicated on the work order drawing with the reason for the indication.

Example 3: — Three Phase: Service Cable

The service run shown below exceeds the rule-of-thumb criteria for allowable length and number of bends in a service conduit run (see Chapter DDS–3, 5.5, C.8.). Evaluate the equivalent cable pull lengths to determine if an intermediate pull box is required in the service conduit run.



Equivalent Length Calculation:

Pull "A" to "J"

A = 0'
B = 5'
C = 5' x 2.16 = 11'
D = 11' + 80' = 91'
E = 91' x 2.16 = 197'
F = 197' + 100' = 297'
G = 297' x 1.47 = 437'
H = 437' + 50' = 487'
I = 487' x 2.16 = 1,052'
J = 1,052' + 5' = 1,057'

Points to check:

- For 600 V secondary cable, sidewall pressure is not a concern. Therefore, it is only necessary to determine if the total equivalent straight pull is less than the maximum allowed per Table 9–14 for the type of grip to be used.
- At point "J," the equivalent straight pull of 1,057 feet is less than the 1,443 feet allowed for all types of secondary cable using three grips, (one over each conductor) or a pulling eye. Using one grip over all conductors can **only** be used if the equivalent straight pull is less than 721 feet.

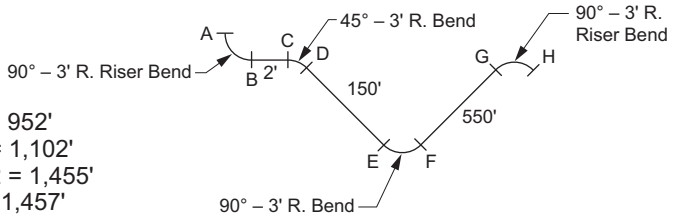
Conclusion: The Planner shall specify on the work order sketch that the cable can be pulled safely with one grip over each cable or a pulling eye. There is no need for an intermediate pull box.

Example 4: — Single Phase: Residential Primary, Secondary, and Service Cable

A. PRIMARY CABLE PULL: Install one 1/C 6.9/9.4 kV 1/0 JCN Al primary cable in the three-inch conduit run shown below. Calculate the equivalent footage to limiting values as shown in Table 9–10. Then compare the calculated equivalent footage to limiting values as shown in Table 9–13.

Equivalent Length Calculation:

Pull at "H"	Pull at "A"
B = 0'	G = 0'
C = 2'	F = 550'
D = 2' x 1.32 = 3'	E = 550' x 1.73 = 952'
E = 3' + 150' = 153'	D = 952' + 150' = 1,102'
F = 153' x 1.73 = 265'	C = 1,102' x 1.32 = 1,455'
G = 265' + 550' = 815'	B = 1,455' + 2' = 1,457'
H = 815' x 1.73 = 1,410'	A = 1,457' x 1.73 = 2,521'

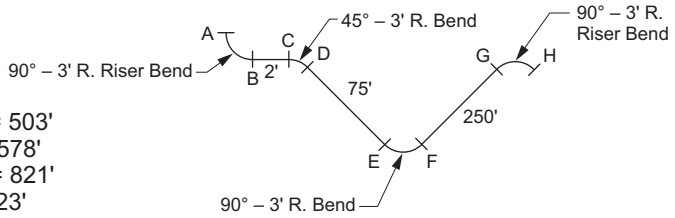


Conclusion: The calculated equivalent length for pulling at "H" is less than the limiting value of 2,415 equivalent feet from Table 9–13. Therefore, the Planner shall specify on the work-order drawing that cables must be pulled at "H".

B. Secondary Cable Pull: Install two 1/C 350 kcmil and one 1/C 4/0 CLP Al cables in the three-inch PVC conduit run shown below. Calculate the equivalent lengths as shown, using values from Table 9–10. Then compare the calculated equivalent footage to limiting values as shown in Table 9–13.

Equivalent Length Calculation:

Pull at "H"	Pull at "A"
B = 0'	G = 0'
C = 2'	F = 250'
D = 2' x 1.42 = 3'	E = 250' x 2.01 = 503'
E = 3' + 75' = 78'	D = 503' + 75' = 578'
F = 78' x 2.01 = 157'	C = 578' x 1.42 = 821'
G = 157' + 250' = 407'	B = 821' + 2' = 823'
H = 407' x 2.01 = 818'	A = 823' x 2.01 = 1,654'

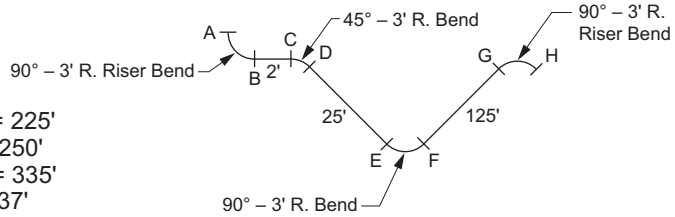


Conclusion: The calculated equivalent length for pulling at "H" is less than the limiting value of 1,223 equivalent feet from Table 9–13. Therefore, the Planner shall specify on the work-order drawing that cables must be pulled at "H."

C. Service Cable Pull: Install two 1/C 1/0 and one 1/C #2 CLP Al cables in the three-inch PVC conduit run shown below. Calculate the equivalent lengths as shown, using values from Table 9–9. Then compare the calculated equivalent footage to limiting values as shown in Table 9–13.

Equivalent Length Calculation:

Pull at "H"	Pull at "A"
B = 0'	G = 0'
C = 2'	F = 125'
D = 2' x 1.34= 3'	E = 125' x 1.80 = 225'
E = 3' + 25' = 28'	D = 225' + 25' = 250'
F = 28' x 1.80 = 50'	C = 250' x 1.34 = 335'
G = 50' + 125' = 175'	B = 335' + 2' = 337'
H = 175' x 1.80 = 315'	A = 337' x 1.80 = 607'



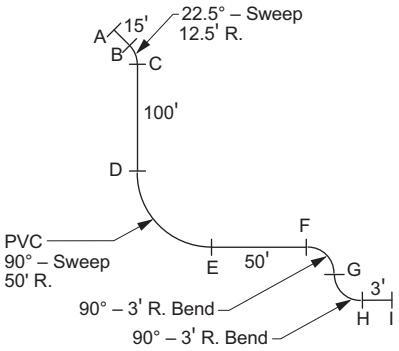
Conclusion: The calculated equivalent length in both cases is less than the limiting value of 696 equivalent feet from Table 9–13.

Example 5: — Single Phase: Residential Primary Cable with a Large Radius Sweep

A. Install two 1/C 6.9/9.4 kV 1/0 JCN Al primary cable in the three-inch run shown below. Calculate the equivalent footage to limiting values as shown in Table 9–10. Then compare the calculated equivalent footage to limiting values as shown in Table 9–13. There is a pull box at point "A" and a pad at point "I".

Equivalent Length Calculation:

Pull at "I"	Pull at "A"
A = 0'	I - 0'
B = 15'	H = 3'
C = 15' x 1.26 = 19'	G = 3' x 2.51 = 8'
D = 19' + 100' = 119'	F = 8' x 2.51 = 20'
E = 119' x 2.51 = 299'	E = 20' + 50' = 70'
F = 299' + 50' = 349'	D = 70' x 2.51 = 176'
G = 349' x 2.51 = 876'	C = 176' + 100' = 276'
H = 876' x 2.51 = 2,199'	B = 276' x 1.26 = 348'
I = 2,199' + 3' = 2,202'	A = 348' + 15' = 363'



Conclusion: The calculated equivalent length for pulling at "A" is less than the limiting value of 740 equivalent feet from Table 9–13. Therefore, the Planner shall specify on the work-order drawing that cables must be pulled at "A". Even though the sweep with the 50-foot radius is larger than the regular 12.5′ sweep it is still treated as a normal sweep and will use a multiplier from Table 9–10. This example also corresponds to three-phase cables using Table 9–14 instead of Table 9–13.

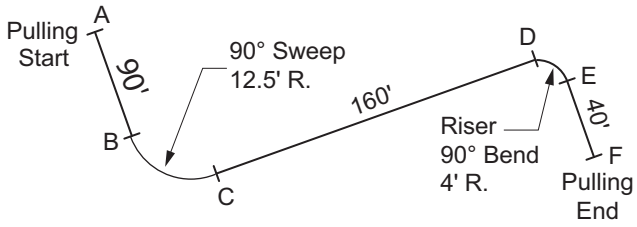
Example 6: — 3/c 500 EPR Cable

Install one 3/C 12/16 kV 500 kcmil EPR Cu cable in the four-inch duct run shown. Calculate the equivalent lengths as shown, using values from Table 9–11. Then compare the calculated equivalent footage after each sweep or bend for limiting values, as shown in Table 9–19, Table 9–20, and Table 9–21.

Equivalent lengths:

Pull at "F"

A = 0'
B = 90'
C = 90' x 2.10 = 189'
D = 189' + 160' = 349'
E = 349' x 2.10 = 733'
F = 733' + 40' = 773'



Points to Check:

- Point "C" is less than 2,665 feet, as shown for 500 kcmil in a sweep in Table 9-22;
- Point "E" is less than 853 feet, as shown for 500 kcmil in a riser bend in Table 9-21; and,
- Point "F" is less than 2,843 feet, as shown for 500 kcmil in Table 9-20.

Conclusion: The Planner shall specify on the work order drawing that cables must be pulled at "A" using a pulling nose and a 10,000 pound swivel.

Note: Because the **direction of pull** and/or **type of pulling device** are both critical, they must be indicated on the work order drawing with the reason for the indication.

6.0 Cable Splicing

This standard provides the criteria for selecting cable splices. The development of this standard was based on three factors: cost, operating flexibility, and space requirements. Consideration must be given to each of these factors when designing an underground distribution system.

6.1 200 A Splicing Standards (2-Way, 3-Way, and 4-Way)

A. Permanent Splices

Applications where this alternative should be used are:

- All permanent straight splices

B. Load-break Feed-through Insert

Load-break feed-through inserts offer advantages over the other methods for applications requiring feeding additional equipment. Applications where this alternative should be used are:

- On equipment bushings when feeding additional equipment (load-break feed-through insert) such as: single-phase minipad transformers (6.9 kV, 9.4 kV, and 12/16 kV), single-phase BURD transformers, and load-break fuse cabinets (6.9 kV and 9.4 kV).

Do not install load-break feed-through inserts in the fuse compartments of 200 A PME switches due to the dimensions of the PME enclosure, and do not install load-break feed-through inserts on single-phase and three-phase BURD switches due to the potential for overcrowded structures or circuit overloading.

C. Load-Break Junctions

Junctions are the highest cost alternative. However, they do have field operating advantages (single hotstick operation). Recommended applications where this alternative should be used are:

- Where frequent operation will be required (more than once per year).
- Load-break junctions are the preferred method for single-phase locations where some operational flexibility is required.
- Heavy-vehicle traffic areas where surface operating time should be minimized.
- Load-break junctions is the only option available where four positions are required.
- Where the number of positions is exceeded it may be necessary to cascade junction bars.

D. Component Ts

Component Ts are the preferred method for three-phase locations that require some operational flexibility. They require more time and space to operate than dead-break junctions, but are lower in cost. Applications where this alternative should be used are:

- Aerial Cable applications where grounding is required.

6.2 600 A Splicing Standards (2-Way, 3-Way, and 4-Way)

A. 600 A Dead-Break Junctions

Junctions are the preferred splicing method. They offer the most flexibility for grounding and isolating. However, they are the highest cost splicing alternative. Applications where this alternative should be used are:

- Where frequent grounding or isolating is required.
- Where space is available per DDS-6.
- Structures where operation can be performed with underground hot sticks.

Note: Use 600 A junction positions for 600 A cables only. 200 A cable components and cable should be stacked on 600 A components.

B. 600 A T-Bodies Splices and Stacked 600 A T-Body Separable Connectors

600 A T-Bodies Splices and Stacked 600 A T-Body Separable Connectors are alternate designs that offer operational flexibility. Applications where this alternative should be used are:

- Structures where operation can be performed with underground hot sticks.
- When making a 600 A splice with a tap (600 A or 200 A).

Note: A 600 A splice with 2-200 A taps (4-way splice) is not recommended. The preferred method would be a 2-way 600 A dead-break junction with 200 A taps stacked on 600 A components.

C. Straight Splice

Permanent Splices are the least preferred splicing method due to their limited operational flexibility. Applications where this alternative should be used are:

- Where structure space is limited.
- When frequent grounding or isolating is not required.

7.0 Replacement of Paper-Insulated Lead-Covered (PILC) Cable and Cable Installed in Small Conduit

7.1 Overview

The majority of PILC cable was installed in the SCE service territory from the 1920s to the 1960s. Utilizing sectored conductors and thick lead sheath, PILC cable was designed to have minimal overall diameter, while providing adequate ampacity and shield fault current-carrying capability. Consequently, relatively small conduit was installed to accommodate PILC cable. The existing small duct is, however, a challenge for replacing cable with larger standard Jacketed Concentric Neutral (JCN) cable.

A new cable has been specially designed with Ethylene Propylene Rubber (EPR) insulation and full compact copper conductor strands to replace cable in existing small conduits. EPR cable is a 3-conductor (3/C) design with an overall jacket. Each conductor also has an individual jacket and 5-mil copper tape shield. In addition, three solid copper ground conductors are included in the overall jacket.

7.2 Cable Replacement Criteria

The following process shall be considered in designing cable replacement.

A. Where existing duct provides adequate clearance for pulling, standard (JCN) cable shall be used in accordance with Section 4.0 (Page 9–10).

B. Where existing duct does not have adequate clearance but empty duct is available in the duct bank, parallel runs of smaller standard JCN cable shall be used to meet loading criteria. For example, double runs of 350 kcmil standard JCN cable can be used to replace one equivalent run of 500 kcmil PILC cable.

C. Where existing duct does not have adequate clearance for pulling standard JCN cable, no empty duct is available, and there is a high cost to perform civil construction, then 3/C EPR cable shall be used to replace PILC cable and cable installed in small conduit. Due to the high cost of this cable, other options must first be considered.

Note: Use standard JCN aluminum cable to replace 1/C PILC cable.

7.3 3/C EPR Cable Information and Loading

Table 9–16 includes general information on 3/C EPR cable. Table 9–17 and provide planned and emergency loading limits for 3/C EPR cable based on the number of circuits in a common duct bank.

Table 9–16: 3/C EPR Cable Information

System Voltage (kV)[a/]	Size	Insulation Thickness (mils)	Cable Nom. OD (in)	Cable MAX OD (in)	MIN Duct Size (in)	SAP No.
4/12/16	1/0	220	2.36	2.40	3	10110270
4/12/16	4/0	220	2.66	2.70	3–3.5	10110271
4/12/16	350	220	3.08	3.10	3.5–4	10110273
4/12/16	500	220	3.33	3.35	4	10110274

[a/] 4 kV, 3/C EPR cable with 115-mil insulation wall thickness is available for special order. Please contact TDBU Distribution Apparatus Engineering. For an expanded list, refer to the *Distribution Underground Construction Standards (DUG)*, Section IC 125.

Table 9–17: Normal Operating Loading (Planned) Limits for 3/C EPR

3/C EPR Cable		Number of Circuits in Duct Bank						
		Amperage						
Voltage	Size	1	2	3	4	5	6	In Riser Pole
4/12/16	1/0 AWG	222	205	192	182	169	161	171
4/12/16	4/0 AWG	330	300	279	264	245	233	273
4/12/16	350 kcmil	437	394	365	344	318	301	372
4/12/16	500 kcmil	530	475	438	411	379	359	445

Parameters Used on Duct Bank Loading Calculation
Conductor Temperature= 90°C
Soil RHO= 120°C × CM ÷ Watt
Fill RHO (concrete)= 60°C × CM ÷ Watt
Earth Temperature= 25°C
Load Factor= 60%

Note:

1. For Climate Zone 9 areas, multiply the given ampacity by 0.92.

Table 9–18: Emergency Loading Limits for 3/C EPR (Based on Eight-Hour Loading Period)

3/C EPR Cable		Number of Circuits in Duct Bank						
		Amperage						
Voltage	Size	1	2	3	4	5	6	In Pole Riser
4/12/16	1/0 AWG	273	252	235	222	207	197	225
4/12/16	4/0 AWG	407	369	342	323	299	284	355
4/12/16	350 kcmil	540	485	448	421	388	368	475
4/12/16	500 kcmil	656	586	539	505	464	440	580

Parameters Used on Duct Bank Loading Calculation
Conductor Temperature= 130°C
Soil RHO= 120°C × CM ÷ Watt
Fill RHO (concrete)= 60°C × CM ÷ Watt
Earth Temperature= 25°C
Load Factor= 60%

Note:

1. For Climate Zone 9 areas, multiply the given ampacity by 0.92.

7.4 3/C EPR Cable Pulling

Refer to Section 5.0 (Page 9–23) for general cable pulling design. Table 9–19 provides the maximum equivalent pulling length for 3/C EPR cable.

Table 9–19: MAX Equivalent Pull Length Based on MAX Allowable Pull Strength of 3/C EPR Cable Pulls

Cable Size	One Grip over Three Conductors	Three Grips – One over Each	Pulling Nose Attached to Conductors		MAX Available Cable Length
			Structure Lift Plate Rating		
			10,000 lb Swivel	20,000 lb Swivel	(ft)
4" Duct					
1/0 AWG	943 (1,000)	1,593 (1,690)	1,593 (1,690)	1,593 (1,690)	800
4/0 AWG	657 (1,000)	1,314 (2,000)	2,225 (3,386)	2,225 (3,386)	800
350 kcmil	457 (1,000)	914 (2,000)	2,286 (5,600)	2,560 (5,600)	800
500 kcmil	355 (1,000)	711 (2,000)	1,777 (5,000)	2,843 (8,000)	800
3.5" Duct					
1/0 AWG	943 (1,000)	1,593 (1,690)	1,593 (1,690)	1,593 (1,690)	800
4/0 AWG	657 (1,000)	1,314 (2,000)	2,225 (3,386)	2,225 (3,386)	800
350 kcmil	457 (1,000)	914 (2,000)	2,286 (5,000)	2,560 (5,600)	800
500 kcmil	—	—	—	—	—
3" Duct					
1/0 AWG	943 (1,000)	1,593 (1,690)	1,593 (1,690)	1,593 (1,690)	800
4/0 AWG	657 (1,000)	1,314 (2,000)	2,225 (3,336)	1,225 (3,386)	800
350 kcmil	—	—	—	—	—
500 kcmil	—	—	—	—	—

Table 9–20: MAX Equivalent Pull Length through Riser Bend or Split "Y" Based on Sidewall Pressure for 3/C EPR Cable Pulls

Conduit Size	4/12/16 kV (ft) (lb)			
(in)	1/0 AWG	4/0 AWG	350 kcmil	500 kcmil
4	1,593 (1,690)	1,577 (2,400)	1,097 (2,400)	853 (2,400)
3.5	1,593 (1,690)	1,380 (2,100)	960 (2,100)	746 (2,100)
3	1,593 (1,690)	1,183 (1,800)	823 (1,800)	640 (1,800)

Table 9–21: MAX Equivalent Length Based through Sweep Based on Sidewall Pressure for 3/C EPR Cable Pulls

Conduit Size	4/12/16 kV (ft) (lb)			
(in)	1/0 AWG	4/0 AWG	350 kcmil	500 kcmil
4	1,593 (1,690)	2,225 (3,386)	2,560 (5,600)	2,665 (7,500)
3.5	1,593 (1,690)	2,225 (3,386)	2,560 (5,600)	2,665 (7,500)
3	1,593 (1,690)	2,225 (3,386)	2,560 (5,600)	2,665 (7,500)

7.5 3/C EPR Cable Splicing

3/C EPR cable can be spliced to 3/C EPR, 3-1/C CLP, or 3/C PILC cables. The basic kit required for splicing 3/C EPR cable is comprised of a Raychem heat-shrink splice, appropriate connector, break-out boot, and ground braid with solder block.

For material codes of appropriate splice kits, refer to *Distribution Underground Construction Standards (DUG),* Section JJ 507.

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Southern California Edison
Transmission and Distribution

Chapter DDS–10: Overhead Systems

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1.0 Scope

This chapter establishes design criteria to be used in designing overhead systems. Specific criteria are given to provide for the structural design of an overhead pole line. The pole-line design criteria provided ensures that minimum clearances and structural strength requirements are maintained as required by *General Order No. 95*.

The following design criteria for overhead systems are covered in this chapter:

5.1 Conductors on Page 10–12
5.2 Poles on Page 10–12
5.3 Crossarms/Insulators on Page 10–26
5.4 Guying on Page 10–27
5.5 Grounding and Neutrals on Page 10–30
5.6 Construction Practices on Page 10–32
5.7 Special Conditions on Page 10–69

Other overhead design issues are addressed in various chapters of this manual, for example: line route, conductor size, and circuit ties. Construction Standards from the *Distribution Overhead (DOH) Construction Standards* are also referred to providing additional information for consideration when designing overhead systems.

2.0 Key Definitions

See Chapter DDS–GL.

3.0 Design Concept

3.1 Primary Distribution System Voltages

All plans for new pole lines and major rebuilding shall include provisions for the complete Primary Distribution System serving the entire area, including: feeders, tie lines, street-lighting circuits, and so forth.

A. 2.4/4.16 kV Primary Distribution System (4 kV)

The 2.4/4.16 kV Primary Distribution System is a feeder system that primarily uses three-phase feeder or bus-voltage regulation at the substation to maintain desired voltage at the load center. The maximum capacity (200 A, 300 A or 400 A) of the circuit is limited by the regulator.

At one time, the 2.4/4.16 kV system was designed such that the feeding point and the load center were the same. Generally, no load was connected to the feeder between the substation and the feeding point. Mainlines radiate from the center of distribution and all loads are supplied by these mainlines. The mainlines generally running back parallel to the feeder are called the feedback. Due to the containment of the 4 kV system, consult with Field Engineering to determine if a feedback is still required.

B. 4.8 kV Primary Distribution System

The 4.8 kV Primary Distribution System differs from the standard 4 kV systems in that it is a delta system and loads may be supplied from a 4.8 kV circuit at any point on the circuit. This system has individual feeder regulators. The 4.8 kV system is to be contained and cut over to a higher voltage when it is economical.

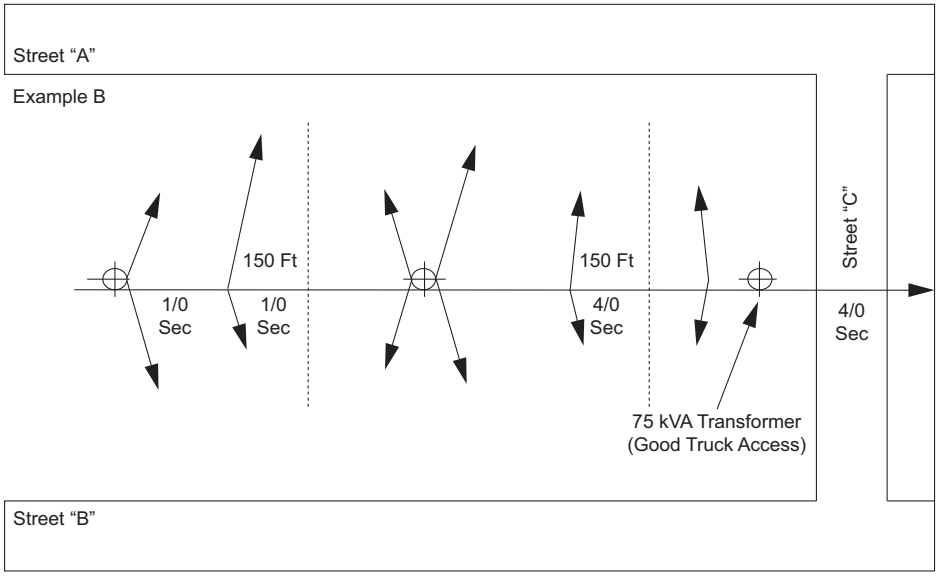
C. 4 kV to 12/16 kV Distribution System Cutovers

All 4 kV to 12/16 kV cutover projects will include the upgrading of the primary and secondary systems. The following design criteria must be followed in order to accommodate anticipated load growth (includes Plug-in Electric Vehicles):

- A maximum of three percent (3%) voltage drop and five percent (5%) flicker (per DDS-8) shall be used for 4 kV cutover system rebuilds with established loads.
- Utilize actual customer Transformer Load Management (TLM) demands for sizing secondary and service conductors for each property in the cutover area.
- In an effort to reduce the number of rear property line transformer installations, the Planner will first locate transformers at locations where truck access is available. These locations may not be central to the load, but their use will reduce the number of rear property line installations without truck access.
- The Planner may include 4/0 AT secondaries where truck access is available, guying is sufficient and the required clearance can be maintained without having to replace the pole.
- Due to the weight of the transformers, and the need to limit unnecessary pole replacements, rear property line transformers should be limited to 50 kVA units. The installation of multiple transformers is preferable to installing a 75 kVA in a rear property line situation.

  For example: Upsizing from 50 kVA transformer to 75 kVA transformer requires replacing the existing pole with a Class 3 pole per Table 10–1 requirements. Consider using multiple transformers in the design in lieu of pole replacement.
- Refer to Figure 10–1 for example of 4 kV Cutover Scenario with Truck Access.

Figure 10–1: 4 kV Cutover Example: Transformers Located on Rear Property Lines in Areas with Truck Access



Note: 4/0 secondaries are utilized in each direction where transformer is located on the street.

D. 7 kV Primary Distribution System

The 7 kV Primary Distribution System differs from the standard 4 kV system in that it is a delta system and loads may be supplied from a 7 kV circuit at any point on the circuit. The 7 kV circuits do not have regulators. There are bus regulators on the source side of the substations that feed the 7 kV systems. The 7 kV system is to be contained in existing areas.

E. 12 kV and 16 kV Primary Distribution Systems

The 12 kV and 16 kV Primary Distribution Systems supply new residential and commercial areas where these voltages are available.

Emergency tie lines and disconnect switches between adjacent primary circuits may be installed to provide a flexible system using design criteria in Chapter DDS–2 Feeder Systems.

In many cases, existing 12 kV or 16, three-wire circuits will be converted to four-wire (12/6.9 and 16/9.4) circuits by the addition of the neutral conductor. Construction of four-wire circuits should be considered for future planning and/or rebuilds. Field Engineering approval is required.

The present economic advantage of the four-wire systems lies primarily in their use in the Underground Distribution System where single bushing 6.9 and 9.4 transformers and associated apparatus can be used. It is not intended that phase-to-ground connected overhead transformers be used on these four-wire overhead systems. Loads may be supplied from a 12 or 16 circuit at any point on that circuit.

F. 14.4/25 kV Primary Distribution System

The 14.4/25 kV Primary Distribution System is used in Barstow and Yucca Valley service centers. It is a four-wire wye system that has individual circuit regulators and loads may be supplied from a 14.4/25 kV circuit at any point on that circuit. This system should be contained in the area where it is now being used.

All single-phase transformers shall be connected between phase and neutral, except that the primary neutral connections of a three-phase wye-delta bank shall not be connected to either the circuit's neutral wire or to ground, that is, it will be floated so that it cannot be a source of ground-fault current.

A small number of three-phase 25 kV padmount transformers are delta-wye grounded configuration. This configuration can create a possible ferroresonance condition. An overhead gang operated switch shall be installed ahead of the underground dip and the padmount transformer. Consult DDS–2, Section 5.13: Guidelines for Elimination of Ferroresonance (Page 2–32) for methods of mitigating ferroresonance.

A description of SCE secondary systems can be found in the *Distribution Overhead Construction Standards (DOH) Manual*, Section DC.

G. 33 kV Primary Distribution System

The 33 kV Primary Distribution System is used in portions of the following service centers:

- Arrowhead
- Barstow
- Blythe
- Foothill
- Mammoth
- Menifee
- Ontario
- Palm Springs
- Redlands
- Ridgecrest
- Victorville
- Wildomar
- Yucca Valley

It is a three-wire delta system that has bus regulation. All transformer installations (single-phase or three-phase banks) are connected phase-to-phase.

The 33 kV circuits are mostly used as source lines to small substations and pole tops; thereby, used more often as a subtransmission system than a distribution system. However, occasionally, it is necessary to connect a single-phase transformer to a 33 kV circuit in order to feed a single-phase load. Three-phase transformation to customers is also occasionally warranted.

Use of the 33 kV primary as a distribution system is dependent on economics and availability of other distribution voltages in the area. When serving large motor loads (500 hp units or greater), it is appropriate to consider the benefits and economics of serving the load from a nearby 33 kV circuit rather than from an adjacent 12 kV circuit. Field Engineering is to be consulted for any such application.

3.2 Pole Design

Poles used to support overhead conductors and equipment must be designed to meet the economic and operational needs of the Company.

A. Wood Poles

Wood poles are the preferred material for overhead structures due to lower cost compared with other available materials.

Note: SCE's Primary Distribution System shall be designed to Grade A and B construction only. All joint pole attachments shall be designed to Grade A construction.

Refer to *Distribution Overhead Construction Standards Manual*, Section PO 100 for wood pole installation details.

B. Composite Poles

The octagonal, composite, non-tapered poles are approved for use on the Edison System. The octagonal poles have eight flat sides with a 10-inch outside diameter. Different class composite poles have different wall thickness to meet strength. These poles are available in two colors: brown and gray.

Composite poles are preferred in lieu of wood poles under the following conditions:

- Rear property lines
- Areas subject to pole shrinkage and constant winds (causing hardware to loosen, such as occurs in Tehachapi and Palm Springs)
- Areas of restricted vehicle access (such as areas with environmental and/or archeological concerns)
- When helicopter installation is necessary
- To reduce or avoid the need for a crane
- In areas where severe or accelerated pole degradation has occurred in 15 years or less due to factors such as animals (for example, woodpeckers and bears), insects, fungus, moisture, and/or other severe environmental conditions.

Pole-loading of composite poles will be performed in the same practice as wood poles of the same class and size.

Refer to *Distribution Overhead Construction Standards Manual*, Section PO 100 for composite pole installation details and PO 370 for composite pole hardware.

3.3 Routing and Location of Overhead Lines

When planning the construction of any overhead lines, the following shall be carefully considered:

- Will the City allow overhead construction?
- Could this line become a future Rule 20 conversion?
- When developing the routing of the line, has the restriction pertaining to Scenic Highways been considered?
- Has the routing of the future transmission been taken into consideration?

The route should be selected, so that the total cost of the completed line will be a minimum, while at the same time, giving due consideration to accessibility for maintenance, and the effect of local climate conditions on insulators and other parts of the structures.

When a line is to be built or rebuilt, either adjacent to, or crossing any transmission line, the Transmission Division must be advised during the planning stages. This will allow time to eliminate any possible clearance problems between transmission and distribution prior to construction.

Tree hazards should be avoided unless permission can be obtained to cut or trim, and keep trimmed, all trees that will be an obstruction to the line. The probable future extension of the circuits and additional circuits on poles should be kept in mind when selecting the route. Temporary routes should be avoided.

3.4 Attachments to SCE Poles or Structures

New or additional attachments to SCE poles or structures by a Foreign Utility, (*such as,* an Owner/Member of Southern California Joint Pole Committee [SCJPC]); the Tenant of a Foreign Utility; an SCE Tenant; or any other Third Party, shall not be made except when permission is granted by an authorized SCE representative, as outlined in the *SCJPC Routine Handbook*, or SCE's Joint Pole Organization's "Request for Access – Guidelines to CATV and Third Party Attachments." In all cases involving a tenant, a wind-load calculation must be submitted by either the Foreign Utility or Third Party Representative for the requested attachment(s). The following information must also be provided: type, diameter, span, quantity of cable, and/or nature of attachment. An intrusive inspection must also be performed, for all poles greater than 15 years (of age), to determine pole integrity or remaining strength of the wood structure. SCE or an approved contractor will perform the intrusive inspection. In an emergency situation, where an intrusive inspection is required and cannot be performed prior to the wind-load calculation, the calculation shall be made assuming zero deterioration, or 100 percent pole strength. The intrusive inspection shall be completed as soon as practical. If the results show less that 100 percent pole strength, another wind-load calculation shall be performed, using the new value, and if overloaded, the pole shall be scheduled for replacement. A "field meet" is strongly recommended. Contact SCE's Central Program Management Office or Joint Pole Organization for more information.

3.5 Foreign Poles or Structures

SCE attachments to poles or structures owned by a Foreign Utility (Owner/Member of SCJPC), shall not be made except when permission is granted as outlined in the *SCJPC Routine Handbook*. If the company owning the pole is not a party to the SCJPC, proper authorization must be obtained via a Third Party Agreement or other satisfactory basis and approved by SCE's Joint Pole Organization Manager. In all instances, the SCE representative proposing the attachment(s) must be prepared to submit a pole-load calculation, including intrusive inspection record and calculation allowance for any deterioration, and pole contact information to the Foreign Utility or Third Party. Refer to the *Edison Policy & Procedure Central (EPPC)* for information on contact or blanket rental agreements.

3.6 Tree Trimming and Clearing of Rights-of-Way

It is essential for the safe and uninterrupted operation of high-voltage lines that they be free from possible short circuiting or grounding in trees. It is, therefore, important that tree branches interfering, or likely to interfere, with the lines should be cut away.

Before any tree trimming is done, the consent of the owner of the trees shall be obtained as well as a permit from the proper authorities. The Foreman on site is responsible for ensuring that the trimming is done with care and good judgment and by qualified personnel. When branches are cut, they must not be left to litter the streets, nor be left on private property. They must be removed by the agency doing the trimming.

Brush and other debris that has been cleared from the Company's private rights-of-way should be disposed.

4.0 Prerequisite Information

The Service Planner should have a good knowledge of the following:

A. California Public Utilities Commission rules

B. SCE *Distribution Overhead Construction Standards* (DOH)

C. General Order 95, and 128

D. *Electrical Service Requirements* (ESR)

E. Customer Service Department, Order #1

F. Rights-of-way and Franchise Agreements

G. Joint Pole procedures and practices

H. Policies, procedures, and restrictions of governmental agencies

I. Policies and procedures of the Transmission/Substation Division and Construction Field Forces Region

J. The Distribution Section of the "EMF Design Guidelines for New Electrical Facilities: Transmission, Substation, Distribution"

5.0 Design Criteria

5.1 Conductors

Primary conductor sizes are determined by the economic loading limits (Chapter DDS–9), and mainline conductor sizes are reviewed by Field Engineering. Secondary conductors are sized based on customer demand, voltage drop, flicker, and motor starting load (Chapter DDS–8).

The number, size, height requirements, pole loading, and dead-ending tension of conductors, supported by an overhead pole, are the primary factors used in determining the pole-strength requirements. Typical overhead construction will utilize crossarm construction for primary voltages and rack or multiplex construction for secondary voltages. The maximum span lengths for various conductors and the type of construction necessary to provide adequate support are found in the *Distribution Overhead Construction Standards* (DOH). General conductor information, for example, use of copper wire in beach areas, weight, amperage, and diameter, and so on, may be found in the *DOH Manual*, Section CO.

A. Insulated Overhead Wire Spacers

The purpose of insulated overhead wire spacers is to prevent wires from coming in contact with each other. They shall be used in high-wind areas and where galloping conductor conditions exist. Line guard or armor rod protection must be installed on all conductors to which the wire spacers are attached. The number of spacers required is determined by the span length. For installation instructions and line guard or armor rod material codes, refer to the *DOH Manual*, Section CO.

5.2 Poles

Selection of the proper pole for a job must consider height and strength requirements based on the following:

- Terrain
- Number, voltage, and configuration of distribution circuits
- Pole loading
- Equipment to be placed on the pole
- Possible joint use by other utilities
- Minimum conductor ground clearance required by such other governmental agencies as Caltrans or Flood Control Districts
- Fire hazard

A. Pole Height

The conductor sag tables in the *DOH Manual*, Section CO provide the maximum sag for a given span and conductor size. The terrain, maximum sag, and pole space requirements (*DOH Manual*, sections AP and DC) must be known to determine the pole height that will meet the minimum clearances specified in *G.O. 95* (Tables 1 and 2).

B. Pole Strength/Pole Loading

Poles must be capable of supporting horizontal loads caused by pole loading on the pole itself, plus the wind on the conductors supported by the pole, plus dead loads caused by the equipment.

Usable pole strengths, which have already accounted for the wind on the pole, are listed in Table 10–18 through Table 10–20. Usable pole strengths are listed for 6 lb, 8 lb, 12 lb and 18 lb winds, for Grade A (SF-4), and for Grade B (SF-3) construction. The usable pole strengths for 8 lb winds should be used when determining pole strengths for pole loading in 6 lb heavy-loading areas. See Table 10–18 through Table 10–20. These tables can be used to calculate the required class of pole for a given span, or the maximum span for a given pole class and the number/size of conductors.

General Order 95 defines areas of California above and below the 3,000-foot level as heavy-and light-loading areas, respectively. The Conductor Pole Loading Table, Table 10–21, provides the horizontal wind pressure in pounds-per-linear-foot for various conductor types and sizes. Pole loading for heavy-loading areas is calculated using a 6 lb wind and assuming 1/2" of ice on the conductor. Pole loading in light-loading areas is normally based on an 8 lb wind (57 mph); however, a 12 lb wind is used in areas subject to winds up to 70 mph. An 18 lb wind is used in areas subject to winds up to 90 mph. The Thomas Guide® pole load design spreadsheets can be used to determine the area's proper pole load design criteria for their given area. The Thomas Guide® pole load design spreadsheets can be found in the Planning Support area of the Transmission and Distribution Business Unit's (TDBU) Web site. Examples dealing with pole strength and pole loading are included in Appendix 10–1 beginning on Page 10–77.

C. Heavy-Loading Areas above 5,000 Feet

Special construction requirements have been established for heavy-loading areas above 5,000 feet (normal heavy-loading areas are above 3,000 feet). Higher strength requirements in these areas are needed to eliminate damage to pole lines caused by extremely heavy ice formation on conductors, or extreme shock loads due to ice or snow "*unloading*." These special requirements and maps are shown in the *DOH Manual*, Section DC.

D. Pole Strength/Weight Limits

The maximum weight of a transformer(s) installed on a pole is limited by the diameter of the pole at the point where the transformer(s) is bolted. Table 10–1 will be used as a precursor to performing pole-loading calculations and will be used to determine the pole class based on the maximum weight of a single pole-mounted transformer and size of the primary conductor. Table 10–2 and Table 10–3 will be used to determine the pole class based on the maximum weight of the single-phase transformers mounted on crossarms or brackets on a wood pole. When transformer weights exceed the maximum allowable pole-mounted values as specified in the *DOH Manual*, AP 106 tables, then the proper 17'-4" platform rack (2-pole or 3-pole) may be installed in accordance with Section E.

It is recommended to use the actual weight of equipment if it is available from the manufacturer's nameplate. If nameplate information is not available, Table 10–4 (Page 10–19) will be used to determine dimensions and weights of various types of equipment.

To calculate the load on a piece of equipment use the following formula:

$$woe \times hoe \times qoe \times (pld - lb) \times hoa = \text{load on equipment}$$

where:

woe	=	width of equipment
hoe	=	height of equipment
qoe	=	quantity of equipment
pld	=	pole load design
lb	=	pound(s)
hoa	=	height of attachment

E. 17'-4" Platform Rack on Poles

Install the 17'-4" platform rack for new construction applications only. Depending on the overall equipment weight, install the 17'-4" platform rack onto a 2-pole or 3-pole design configuration. For proper rack selection, refer to sub-sections 1 and 2 shown below. **Only install the 17'-4" platform rack on Class H5 poles**.

1. 17'-4" Platform Rack (2-Pole Design)

   The 17'-4" platform rack for 2-pole design can support an overall equipment weight up to a maximum of 10,000 pounds. Install the platform rack onto each pole with an end-mounting bracket connector. Refer to DOH, DC 640 for 17'-4" platform rack details.

2. 17'-4" Platform Rack (3-Pole Design)

   The 17'-4" platform rack for 3-pole design can support up to a maximum of 15,000 pounds. Install the platform rack onto each end pole with an end-mounting bracket connector and provide an additional center mounting bracket for the connection to the middle (third) pole. Refer to DOH, DC 640 for 17'-4" platform rack details.

F. H-Frames

Consider H-frame construction when pole spacing exceeds 500 feet (for example, freeway crossings or canyons) and/or when conductor spacing requirements exceed the limitations of normal construction (for example, incidental wire contact due to wind). Contact Field Engineering when considering installation of an H-frame structure. For H-frame construction details, see DOH, DC 630.

G. Smith Corners

Use Smith Corner construction when two circuits in vertical construction approach a 90-degree corner and the pole does not have enough space to construct the corner using the standard line arm and buck arm arrangement. This is common where one circuit is distribution and the other is sub-transmission. For Smith Corner construction details, see DOH, DC 635.

H. Pole-Top Extension/Replacement versus Pole Replacement

Fiberglass and wood pole-top extension/replacement shall be used in the Distribution System wherever possible to avoid pole replacement. Fiberglass pole top is the preferred method. The alternate wood extension shall be used if the fiberglass pole-top extension does not meet construction requirements. For application guidelines, refer to the *DOH Manual*, Section PO.

Fiberglass or wood pole-top extension/replacement shall be installed under the following conditions:

- When minimum clearance is impaired
- When the existing pole top is deteriorated per the *Distribution Operation and Maintenance Policy and Procedures (DOM) Manual*, Section IM-2, Attachment 2

Non-SCE Antennas may be installed onto Pole-Top Extensions only if the conditions and guidelines per DOH, DC 222, and DOH, PO 150 are met.

Replace the pole if the installation of the pole-top extension does not remedy the above conditions.

I. Pole Spotting

When spotting a pole location in a franchise area, for example, parkway, sidewalk, clearances to a driveway, fire hydrant, and face-of-curb shall be considered. The face-of-curb to face-of-pole shall not be less than 18 inches. For new pole and pole replacements, if space permits or can be provided at no additional cost or low cost minor work, maintain a minimum clearance of 36 inches for pedestrian right-of-way access. Avoid pole replacement in wheelchair ramp locations. A four-foot clearance shall be maintained from top of slope of a commercial driveway and two-foot clearance from top of slope of a residential driveway.

Table 10–1: Single-Phase Transformer Pole Mounting and Weight Limitations on Wood Poles

Pole Length (ft)	Transformer Attachment Guidelines									Transformer Size (kVA) (See Note 4)	Equipment Weights (lb) (See Notes 2 and 3)
	Light Primary Conductor (1/0 ACSR, 1/0 BC, 1/0 WP Al, No. 1 BC, No. 2 All Al, No. 2 ACSR, No. 2 WP Al, No. 4 All Al, No. 4 ACSR, No. 4 BC, No. 4 WP Cu, No. 6 BC, No. 6 WP Cu, No. 8 BC, or No. 8 WP Cu)			Medium Primary Conductor (2/0 WP Cu, 2/0 ACSR, 2/0 All Al or BC, 4/0 WP Cu, 4/0 BC, 4/0 ACSR, 4/0 All Al, 336.4 ACSR, or 477 All Al)			Heavy Primary Conductor (653 ACSR or larger)				
	MIN Class Pole	MIN DIA (in)	MIN CIRCUM (in)	MIN Class Pole	MIN DIA (in)	MIN CIRCUM (in)	MIN Class Pole	MIN DIA (in)	MIN CIRCUM (in)		
	New Install	In-Service	In-Service	New Install	In-Service	In-Service	New Install	In-Service	In-Service		
40	4	7.0	22.0	3	7.7	24.2	2	8.3	26.1	10, 15, 25, 37.5, 50	Up to 650
40	3	7.7	24.2	2	8.3	26.1	1	9.0	28.3	75	651 to 1,025
40	2	8.3	26.1	1	9.0	28.3	H1	9.6	30.1	100	1,026 to 1,500
40	H2	10.3	32.3	H3	10.9	34.2	H4	11.6	36.4	167	1,501 to 1,850
40	H4	11.6	36.4	H5	12.3	38.6	H6	12.5	39.3	—	1,851 to 2,200
40	H5	12.3	38.6	H6	12.5	39.3	H6	12.5	39.3	—	over 2,201
45	4	7.0	22.0	3	7.7	24.2	2	8.4	26.4	10, 15, 25, 37.5, 50	Up to 650
45	3	7.7	24.2	2	8.3	26.1	1	9.0	28.3	75	651 to 1,025
45	2	8.4	26.4	1	9.0	28.3	H1	9.7	30.5	100	1,026 to 1,500
45	H2	10.3	32.3	H3	10.9	34.2	H4	11.6	36.4	167	1,501 to 1,850
45	H4	11.6	36.4	H5	12.3	38.6	H6	12.5	39.3	—	1,851 to 2,200
45	H5	12.3	38.6	H6	12.5	39.3	H6	12.5	39.3	—	over 2,201
50	4	7.0	22.0	3	7.7	24.2	2	8.3	26.1	10, 15, 25, 37.5, 50	Up to 650
50	3	7.7	24.2	2	8.3	26.1	1	9.0	28.3	75	651 to 1,025
50	2	8.3	26.1	1	9.0	28.3	H1	9.6	30.1	100	1,026 to 1,500
50	H2	10.3	32.3	H3	10.9	34.2	H4	11.6	36.4	167	1,501 to 1,850
50	H4	11.6	36.4	H5	12.3	38.6	H6	12.9	40.5	—	1,851 to 2,200
50	H5	12.3	38.6	H6	12.5	39.3	H6	12.9	40.5	—	over 2,201
55	3	7.7	24.2	3	7.7	24.2	2	8.4	26.4	10, 15, 25, 37.5, 50	Up to 650
55	3	7.7	24.2	2	8.4	26.4	1	9.0	28.3	75	651 to 1,025
55	2	8.4	26.4	1	9.0	28.3	H1	9.7	30.5	100	1,026 to 1,500
55	H2	10.4	32.7	H3	11.0	34.5	H4	11.7	36.7	167	1,501 to 1,850
55	H4	11.7	36.7	H5	12.3	38.6	H6	13.0	40.8	—	1,851 to 2,200
55	H5	12.3	38.6	H6	13.0	40.8	H6	13.0	40.8	—	over 2,201
60	2	8.3	26.1	2	8.3	26.1	1	9.0	28.3	10, 15, 25, 37.5, 50	Up to 650
60	2	8.3	26.1	2	8.3	26.1	1	9.0	28.3	75	651 to 1,025
60	2	8.3	26.1	1	9.0	28.3	H1	9.6	30.1	100	1,026 to 1,500
60	H2	10.3	32.3	H3	10.9	34.2	H4	11.6	36.4	167	1,501 to 1,850
60	H4	11.6	36.4	H5	12.2	38.3	H6	12.9	40.5	—	1,851 to 2,200
60	H5	12.2	38.3	H6	12.9	40.5	H6	12.9	40.5	—	over 2,201

Note:

1. Use Table 10–1 to select the pole class prior to performing pole-loading calculations.
2. These values are based on the minimum pole diameter at the point of attachment.
3. See Table 10–4 (Page 10–19) through Table 10–9 (Page 10–20) for transformers and other equipment weights and dimensions.
4. 10 kVA and 15 kVA transformers are not available and not approved for use on new installations or replacements.

Table 10–2: Weight Limitation of Three-Phase Transformers — Crossarm or Bracket Mounted on Wood Pole

Transformer Size (kVA) (See Note 6)	Transformer Individual MAX Weight (lb)	Transformer Weight (Times 3) (lb)	MIN Pole DIA / CIRCUM at Point of Attachment (in)	Transformer Mounting Bracket / Crossarm MAX Weight (lb) (See Note 1)	Transformer Banks Crossarm Mounted and Prefabricated Bracket per AP 132 (See Note 2 and Note 3)
(a)	(b)	(c)	In-Service (d)	(e)	MIN Class for New Pole
10	286	858	7.9 / 24.8	1,620	3
15	313	939	7.9 / 24.8	1,620	3
25	450	1,350	7.9 / 24.8	1,620	3
37.5	500	1,500	7.9 / 24.8	1,620	3
50	650	1,950	8.6 / 27.0	2,300	1
75	1,000	3,000	10.0 / 31.4	3,100	H2
100	1,300	3,900	11.1 / 34.9	4,200	H4
167	1,500	4,500	11.6 / 36.4	4,200	(See Note 4)

Notes:

1. A pole-load calculation must be performed whenever any equipment is installed or removed on a wood pole.
2. These values are based on the minimum pole diameter at the point of attachment.
3. If a combination of three transformers are used (for example: 2 - 50 kVA and 1 - 100 kVA) which are not shown on this Table, add the total weight of the transformers using columns (a) and (b) to determine total weight. Then find the weight in column (e) that is more than the weight and follow the row to the right to locate the required class of the pole for this installation.
4. All 167 kVA transformer banks must be placed on a 17'4" rack.
5. Existing poles must have the minimum measurements shown in column d at the point-of-attachment in order to install transformers on them.
6. 10 kVA and 15 kVA transformers are not available and not approved for use on new installations or replacements.

Table 10–3: Weight Limitation of 2-Single-Phase Transformers — Open Delta Bracket on Wood Pole

Single Transformer Installations					Three-Phase Transformer Banks (Total Weight) Open Delta Bracket per AP 122 (See Note 1 and Note 2)																			
Transformer Size (kVA) (See Note 4)	Transformer Individual MAX Weight (lb)	MIN Pole Class	MIN Pole DIA / Circum At Point of Attachment	Transformer Bracket / Mount MAX	Total Weight (lb)	572	599	736	786	936	1286	626	763	813	963	1313	900	950	1100	1450	1000	1150	1500	1300
		New Install	In-Service (in)	MAX Weight (lb)	Pole Length	10 & 10 kVA	10 & 15 kVA	10 & 25 kVA	10 & 37.5 kVA	10 & 50 kVA	10 & 75 kVA	15 & 15 kVA	15 & 25 kVA	15 & 37.5 kVA	15 & 50 kVA	15 & 75 kVA	25 & 25 kVA	25 & 37.5 kVA	25 & 50 kVA	25 & 75 kVA	37.5 & 37.5 kVA	37.5 & 50 kVA	37.5 & 75 kVA	50 & 50 kVA
(a)	(b)	(c)	(d)	(e)	(ft)	MIN Class for New Pole																		
10	286	3	7.7 / 24.2	1,600	40	3	3	2	2	2	1	3	2	2	2	1	2	2	2	1	2	1	1	1
15	313	2	8.3 / 26.1	1,600	45	3	3	2	2	2	1	3	2	2	2	1	2	2	2	1	2	1	1	1
25	450	1	9.0 / 28.3	1,600	50	3	3	2	2	2	1	3	2	2	2	1	2	2	2	1	2	1	1	1
37.5	500	—	—	1,600	55	3	3	2	2	2	1	3	2	2	2	1	2	2	2	1	2	1	1	1
50	650	—	—	1,600	60	2	2	2	2	2	1	2	2	2	2	1	2	2	2	1	2	1	1	1
75	1,000	—	—	1,600																				

Notes:

1. A pole-load calculation must be performed when a single or multiple transformers are added or removed to a structure.
2. If a combination is not listed above or exceeds the maximum allowable weight limits on the mounting bracket (1,600 lb), then use the mounting bracket found in AP 132 and use column (e) from Table 10-2 to determine the minimum class and size.
3. Column (c) and (d) are used to list the class of the pole and its minimum diameter/circumference. Any existing poles must have these minimum measurements at the point of attachment in order to install transformers on them.
4. 10 kVA and 15 kVA transformers are not available and not approved for use on new installations or replacements.

Table 10–4: Single-Phase OH Transformer Weight and Dimensions

Transformer Size (kVA) (See Note 1)	MAX Weight (lb)	W x H Dimensions (ft)
10	286	1.5 x 3.5
15	313	1.5 x 3.5
25	450	1.5 x 3.5
37.5	500	1.5 x 3.5
50	650	1.75 x 3.5
75	1000	2 x 4
100	1300	2.08 x 4
167	1500	2.08 x 4.5

Note(s):

1. 10 kVA and 15 kVA transformers are not available and not approved for use on new installations or replacements.
2. The transformer weights are applicable to 4 kV, 12 kV, 16 kV, and 25 kV systems. Refer to DOH AP 108 for 33 kV installations.

Table 10–5: OH Capacitor Weight and Dimensions

OH Capacitors		
Size (kVAR)	MAX Weight (lb)	L x W x H Dimensions (ft)
< 600	530	6.4 x 2.4 x 4.9
900	580	6.4 x 2.4 x 4.9
1200	630	6.4 x 2.4 x 4.9

Table 10–6: Voltage Regulator Weight and Dimensions

Voltage Regulators		
Size (kVAR)	MAX Weight (lb)	L x W x H Dimensions (ft)
5	3050	2.3 x 2.3 x 7.3
14.4	5000	2.6 x 2.6 x 8.2
19.9	3950	2.3 x 2.3 x 7.5

Table 10–7: Automatic Recloser Weight and Dimensions

Automatic Reclosers	Type	MAX weight (lb)	L x W x H Dimensions (ft)
Type with Oil	17 kV	Obsolete	No longer use
Type with Oil	34.5 kV	Obsolete	No longer use
Solid Dielectric	Nova 25 kV	300	3.5 x 1.5 x 2.5
Solid Dielectric	Viper 27 kV	500	5.2 x 4.6 x 2.9
Solid Dielectric	Viper 38 kV	600	5.2 x 4.6 x 2.9

Table 10–8: Power Control Transformer Weight and Dimensions

Power Control Transformers	Size (kVA)	MAX Weight (lb)	L x W x H Dimensions (ft)
Oil	0.5	180	1.4 x 1.0 x 2.8
Oil	10 (See Note 1)	230	1.5 x 1.3 x 2.5
Dry	0.5	100	1.2 x 0.8 x 1.8
Dry	1	185	1.3 x 1.2 x 1.3

Note(s):

1. 10 kVA oil-type control power transformers are not approved for use on new installations.

Table 10–9: OH Switch Weight and Dimensions

Switches	Size (kV)	MAX Weight (lb)	L x W x H Dimensions (ft)
KPF	—	Obsolete	No longer use
Omni-Rupter®	17	250	9.4 x 2.1 x 1.5
Alduti-Rupter®	38	461	12.0 x 3.5 x 3.0

J. Requirements for Distribution Circuits Installed on Subtransmission Engineered Tubular Steel Poles (TSP) with Welded Step Bases, Pull-Out Steps, or Slip-In Pocket Steps

All of the features of these poles and the attachments of all lines to each pole are individually engineered, and drawings are provided to crews working on the installation of each pole. Construction crews shall attach lines to these poles as indicated in the drawings. Contact the Transmission Estimator for specific construction requirements.

All phases on steel arms shall be covered with Avian Hoods or constructed using suspension-type build. Refer to DOH, DC 530, and DC 535, for avian-safe construction on TSP.

K. Requirements for Distribution Circuits Installed on Subtransmission Lightweight Steel (LWS) Poles (with Pre-drilled Holes for Steps Revealing a Maximum Wall Thickness of Less than One-Quarter Inch)

1. Distribution construction on subtransmission LWS poles have different grounding, neutral connection, and transformer bonding requirements than on wood poles. Refer to the Distribution Overhead Construction Standards PO 100 and GR 111, *Distribution Underground Construction Standards (DUG) Manual* (Section CR 141) and *Transmission Overhead (TOH) Manual* for construction drawings and details.

   a. Each LWS pole shall be a grounded structure. All ground connections shall be made to the grounded steel pole.

CAUTION

b. All distribution primary and secondary neutrals (except for primary neutrals on circuits with floating neutral protection schemes) shall be connected to the pole. Primary distribution circuits with floating neutrals (neutrals on circuits with protection requiring the neutral be grounded only at the substation or Automatic Recloser (AR) and not along the circuit) may be built on LWS poles, but the floating neutral shall not be electrically connected to the LWS pole.

   Check with Field Engineering before connecting a 4 kV circuit neutral or the neutral of any primary circuit beyond an AR to a LWS pole to ensure it is not a floating neutral.

c. Bond transformer tanks to the grounded LWS pole.

d. Transformer, surge arrester, and all other distribution grounds will be bonded directly to LWS poles at the equipment's attachment level.

e. Refer to Section 5.3: Crossarms/Insulators (Page 10–26) for special requirements of crossarms and insulators on LWS poles.

f. Distribution equipment installed on LWS poles will be bolted to the pole, hanger, or crossarm in the same fashion as on wood poles unless otherwise provided in this section of special requirements for LWS poles.

g. Refer to DOH, DC 530, and DC 535, for avian-safe construction on LWS poles.

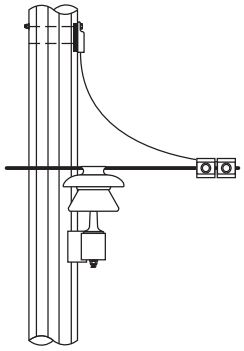
2. Each subtransmission LWS pole with distribution attachment requires an electrical connection through a continuous metallic path to a substation ground-grid. This path to the substation ground-grid is called the pole Fault Return Conductor (FRC). The Transmission Estimator will consult with the area E&TS Field Engineer and then designate each pole's FRC to be either:

   a. 336 ACSR or larger primary neutral conductor (usually installed by distribution crews and the preferred installation if one is available or planned in the future for the location) or

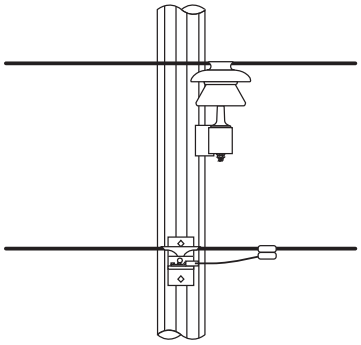
   b. 4/0 ACSR pole-bond wire (usually installed by Subtransmission crews).

   Detailed criteria for designation of the FRCs are included in the *Transmission Overhead Construction Standards (TOH) Manual*. See Figure 10–2 for typical connections to the FRC.

Figure 10–2: Typical Connection of LWS Pole to the FRC



LWS Pole with Connection to Primary Neutral FRC



LWS Pole with Connection to Pole Bond Wire FRC

3. Design Considerations

Field Engineering must approve each primary neutral FRC design prior to installation.

If the Transmission Estimator designates the primary neutral as the FRC, verify the primary neutral size from the LWS pole attachment back to the substation ground-grid. If the primary neutral is not 336 ACSR or larger, install a 336 ACSR primary neutral conductor from the line section containing LWS poles back to the source substation ground-grid (see Figure 10–3). All poles requiring new or upgraded neutral conductor or other reinforcement must be checked to ensure they also meet pole strength and pole-loading requirements. Connect the new primary neutral to the substation ground-grid. The connection between the riser pole and the ground-grid should be with #4/0 Cu wire. If #4/0 Cu wire is not available, then it must be installed using available blank ducts. If there is no room in the duct bank for a #4/0 Cu to be installed, contact Field Engineering to design the connection to the substation ground-grid.

All primary neutral conductors attached to wood poles set among LWS poles, must be grounded every 1,200 feet measured from the source substation.

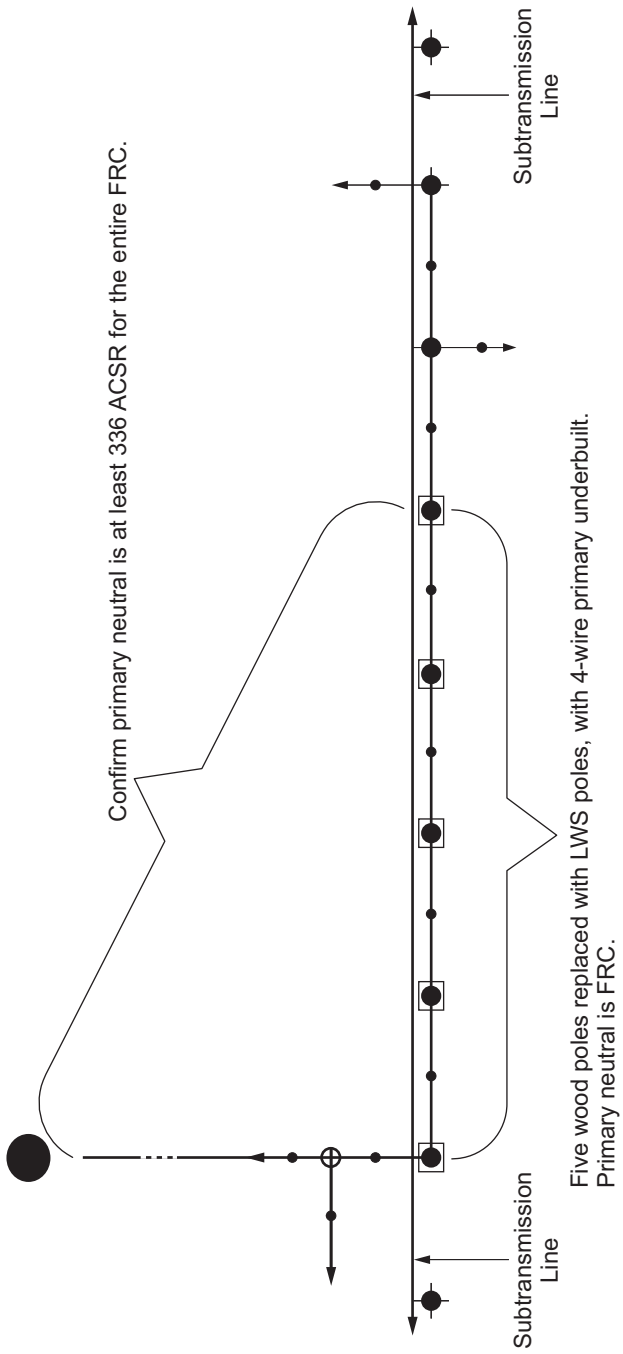


Figure 10–3: Example of Primary Neutral FRC

4. Underground Conversion Projects — Design Considerations

Field Engineering must approve each primary neutral FRC design prior to installation.

Rule 20 jobs may call for the conversion of a portion of a four-wire distribution line on subtransmission LWS poles to underground distribution that runs in parallel with existing LWS poles. In these cases, the Transmission Estimator's design shall install a pole-bond wire on the non-riser LWS poles as the FRC and connected at ONLY **ONE** of the riser poles. The preferred connection point is on the riser pole that is closest to the substation. This riser pole shall also be connected to the primary neutral as its FRC. Refer to the *Distribution Underground Construction Standard (DUG) Manual*, Section CR 141, Figure CR-3, for construction details.

The other riser pole will ONLY connect to the primary neutral as its FRC. This will leave a gap of one-pole span in the pole-bond wire FRC so it does not become a parallel path for the flow of distribution primary neutral current. During design, Field Engineering shall verify that there is no parallel path.

If a third-party attachment, such as those from Joint Pole users, will be made to the poles that span this gap in the pole-bond wire FRC, then E&TS Field Engineers and/or Planners shall coordinate with the third-party attaches to verify that a parallel path is not created for neutral current under normal operating conditions. This may require isolating the third-party attaches from the LWS pole.

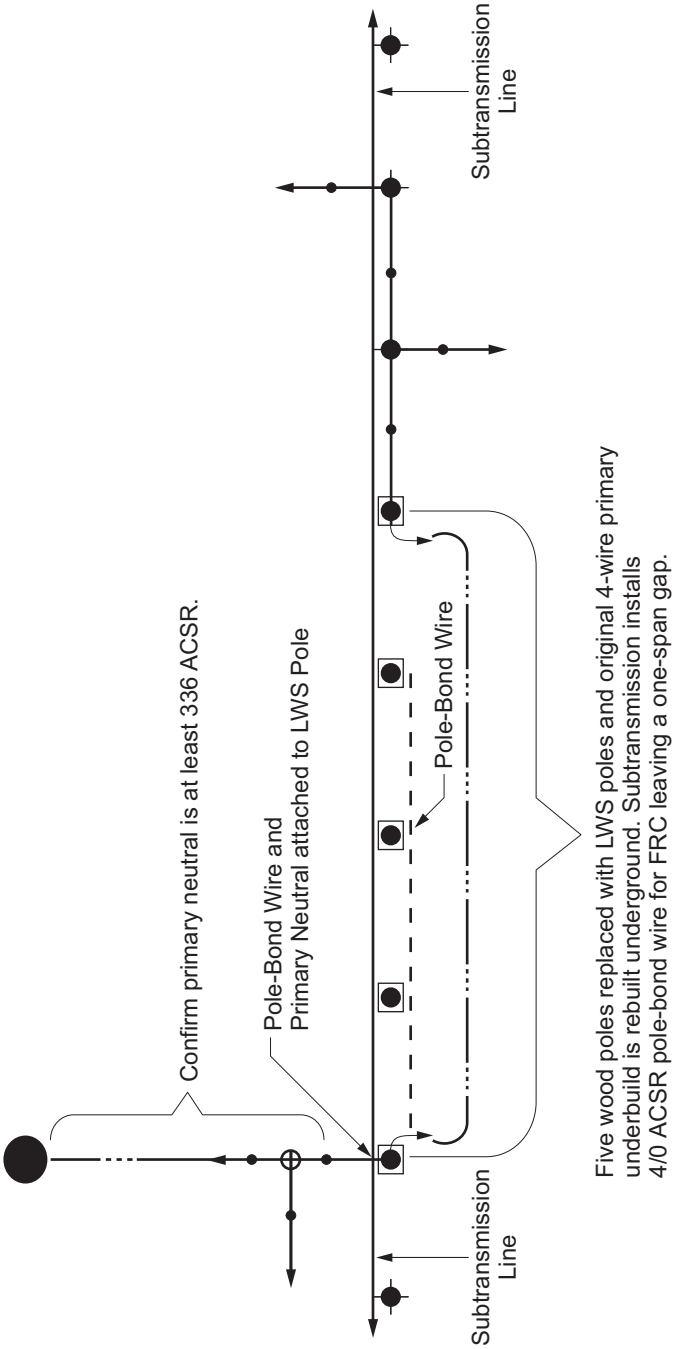


Figure 10–4: Example of FRC for Rule 20 Job

5. When work is to be performed on LWS poles with joint owners and/or tenants, the Distribution Planner or the Transmission Estimator who has overall responsibility for the job shall also assume responsibility for coordination with joint-pole attaches. Notify impacted joint owners and tenants in advance of LWS pole installation. Communication circuits on steel poles may not connect to the FRC or any other SCE conductors. Communication circuits may be grounded to the steel pole unless the situation shown in Figure 10–4 of DDS-10 exists. Under this situation, communication circuits should not be grounded to the steel pole unless a breaker, for example, insulator, is installed in the communication messenger wire that connects the open span, for example, the span where the FRC is not installed, to prevent the flow of distribution neutral currents. If it is desirable to install communication equipment messengers on the steel poles in this situation, the messengers must be installed on insulators.
6. Use Douglas-fir strength information when making strength and wind-load calculations on the LWS poles. Pole length and ANSI size class, shown in Appendix 10–1, will be marked on the steel pole.

5.3 Crossarms/Insulators

Flat braces are installed on wood crossarms where conductors of four #2 str Cu or 4-1/0 ACSR or smaller conductors are to be installed. V-braces are used on crossarms supporting larger conductors. The illustrations in the DC Section of the *DOH Manual* specify the maximum span lengths for various types of construction.

Distribution equipment installed on LWS poles will use the same construction practices as for equipment installed on wood poles with the exceptions provided in Section 5.2 (Page 10–12), *Distribution Overhead Construction Standards* (DOH) sections PO 100 and GR 111, and *Distribution Underground Construction Standards* (DUG), Section CR 141.

Use composite crossarms with mounting brackets on LWS poles.

All primary conductors must be attached to insulators using a Universal Conductor Clamp (see *Distribution Overhead Construction Standards Manual*, Section CO 510); tie wire or grip-type conductor clamps are not acceptable. Refer to *Distribution Overhead Construction Standards Manual*, Section GR 111 to determine when COMMON NEUTRAL signs (SAP 10135292) must be installed on primary crossarms.

Crossarm requirements for dead-ending conductors are illustrated in Table 10–22. Distribution circuits crossing divided state highways of four lanes or more, or free-ways, shall be dead-ended at the crossing poles.

Dead-end construction is also required on angle poles where the maximum line deviation angle is exceeded. Table 10–23 through Table 10–27 in Appendix 10–2, beginning on Page 10–104, provide a method for determining the limiting line-deviation angle for various types of construction.

Dead-end construction requirements to minimize radio and television interference (RTVI) shall be used on all reduced tension dead-end spans or unguyed dead-ends, and on all dead-ends (full or reduced tension). Refer to the *DOH Manual*, Section CO.

Insulator requirements are identified in the *DOH Manual*, Section GR and are designated by the insulation area map, which identifies high, moderate, and light areas of contamination.

Use pin-type polymer insulators in construction up to 5000 feet elevation. For any construction involving angles with polymer pin-type insulators, use an angle pin (refer to DOH GR 200 for insulator details). For pin-type polymer clamp top insulators, install Nylon inserts in conjunction with covered conductor, aluminum inserts in conjunction with bare aluminum conductor, and bronze inserts in conjunction with bare copper conductor.

Use post-type polymer insulators in construction above 5000 feet elevation or when there is an upward vertical strain in the line. For any construction involving angles with polymer post-type insulators, use an angle base (refer to DOH GR 205 for insulator details).

While armless construction is no longer an active construction standard, every effort should be made to retain this type of construction in areas where it already exists. General pole-line aesthetics tend to suffer when crossarm and armless construction are mixed.

5.4 Guying

Where mechanical loads to be imposed on poles *(bending moment)* are greater than can be safely supported by the pole *(usable pole strength)*, additional strength shall be provided by the use of guys. This applies particularly to angles, dead-end poles, or where the conductor stresses are sufficiently unbalanced to make guying necessary. The use of anchor rods and downguys are the main method of balancing dead-end strain on poles. Sidewalk anchors are used where guy leads of 10 feet on less must be used due to obstacles such as fences, houses, flood controls, and so on. Span guys/arm guys (from pole-to-pole or from crossarm-to-pole) can be installed to carry dead-end or unbalanced tension to an adjacent pole where proper guy anchoring can be made with a downguy and anchor rod, or to a pole with enough usable pole strength to support the strain.

More information and examples on overhead guys, anchor guys, and span wires are in the *Distribution Overhead (DOH) Manual*, Section PO.

When using composite poles, pole bands are required for use on downguys. For pole band installation instructions, refer to the *DOH Manual*, Section PO 300.

A. Guy Determination

Prior to determining the method of guying, a Service Planner should have the following information available:

- Conductor size
- Height of conductors from ground
- Anchor locations (lead)/Span guy locations

Determining the available anchor locations will usually require plan and field checks to verify that there are no hazards, obstacles, or *G.O. 95* infractions, for example, fences, houses, driveways, flood control channels, and so on. For new pole and pole replacements, if space permits or can be provided at no

additional cost or low cost minor work, maintain a minimum clearance of 36 inches for pedestrian right-of-way access. Avoid pole and/or guy placement in wheelchair ramp locations.

Guying is accomplished by one of three methods as follows: (1) Downguys, (2) Sidewalk Guys, or (3) Span Guys or Arm Guys. Tables and examples of these guying methods are included in Appendix 10–3, beginning on Page 10–111.

1. Downguys

   Downguys are the most common method used for guying. The following steps should be followed to determine the proper number and size of guy wires to be used.

   a. Determine the unbalanced conductor strain on the pole. To determine the strain caused by dead-ended conductors, add the tensions for all dead-ended conductors. Table 10–28 lists dead-end tensions for each conductor type and size.

      To determine the resultant strain on an angle pole, first calculate the deviation angle of the conductors by using Table 10–30, then locate this deviation angle on Table 10–29 to determine the resultant strain for each conductor size.

   b. Determine the angle created by the guy-to-the pole from Table 10–31 using the height of the guy attachment to ground and the guy lead.

   c. Determine the number and size of guy wires from Table 10–33 or Table 10–34 required to support the conductor strain. One guy or a combination of guys may be required.

2. Sidewalk Guys

   Sidewalk Guys are installed where the guy lead of ten feet or less is required because of obstacles or obstructions, for example, fences, streets, sidewalks, and so on. The following steps should be followed to determine the proper number and size of guy wires:

   a. Determine the unbalanced conductor strain on the pole. To determine the strain caused by dead-ended conductors, add the tensions for all dead-ended conductors. Table 10–28 lists dead-end tensions for each conductor type and size.

      To determine the resultant strain on an angle pole, first calculate the deviation angle of the conductors by using Table 10–30, then locate this deviation angle on Table 10–29 to determine the resultant strain for each conductor size.

   b. Determine the angle created from guy-to-pole from Table 10–32 using the height of the guy attachment above the queenpost and the guy lead (length of queenpost).

   c. Determine the number and size of guy wires from Table 10–33 or Table 10–34 required to support the conductor strain. One guy or a combination of guys may be required.

3. Span Guys

Span Guys or **Arm Guys** are installed from pole-to-pole or from a crossarm-to-pole when it is not feasible to install a downguy or sidewalk guy. The following steps should be taken to determine the proper number and size of guy wires:

a. Determine the unbalanced conductor strain on the pole or crossarm. To determine the strain caused by dead-ended conductors, add the tensions for all dead-ended conductors. Table 10–28 lists dead-ended tensions for each conductor type and size.

   To determine the resultant strain on an angle pole, first calculate the deviation angle of the conductors by using Table 10–30, then locate this deviation angle on Table 10–29 to determine the resultant strain for each conductor size.

b. Determine the number and size of guy wires from Table 10–33 or Table 10–34 required to support the conductor strain. Use the row for "Level (Overhead Guy)."

c. Usable pole strength or downguy tensions may then be calculated using the conductor dead-end tension.

B. Anchors and Rods for Guying

Three types of anchors are used by Edison.

1. Power-Installed Screw Anchor (PISA) — This anchor is installed with the auger shaft of the line truck. Edison purchases five sizes of anchors. Sheer pins on the installation tool are used to determine the holding strength of this anchor.
2. Anchor Rod and Plate — The holding strength for a rod and plate is based on the size of anchor rod.
3. Expanding Rock Anchor — Edison purchases only one rock anchor and its holding strength is fixed.

Table 10–35 lists the holding strength based on the number of shear pins required for the various holding strengths of different size Power Installed Screw Anchors (PISAs). Maximum holding strengths for the rod and plates, and the rock anchors are also included in this table.

The most cost-effective screw anchor should be installed that will exceed the total working strength of the guy wires attached to the anchor. The working strength of a guy wire will be equal to the values listed in Tables 10–33 or 10–34, or Page 10–116, for a guy wire installed in a level position. In urban areas having existing conflicting underground facilities, an anchor rod and plate (hand dug) may need to be installed.

Anchors and rod installations for joint use with other utilities shall be made as specified under "Stubs, Anchors, and Guys," and as may be agreed upon under the *Joint Pole Routine Agreement.* When sizing anchors and rods for joint use, allow enough holding strength to accommodate the incoming utilities' tension requirements.

C. Pole Push Brace

Pole Push Brace shall be used when conventional guying is not adequate or feasible. Wind-load calculation and intrusive inspection is required prior to installation. For further details, refer to the *DOH Manual*, Section PO.

D. Unguyed Spans

Unguyed Spans may be considered when the use of downguys or span guys is not feasible. The resultant (bending) moment created by the unguyed strain must be equalled or exceeded by the usable pole strength Table 10–19. A breast block and pole key (*DOH Manual*, Section PO) must be installed on all unguyed dead-end poles.

If the resultant moment exceeds either the usable pole strength or the pole key resisting moment, the strain should be guyed or the resultant moment reduced. The moment may be reduced by (1) reducing the height of the conductors, or (2) increasing the conductor sag, thereby reducing the dead-ending tension.

Appendix 10–5, beginning on Page 10–125, Table 10–37 through Table 10–40, shows the dead-end tension for unguyed conductors based on span and final sag. These dead-end tensions are used to calculate the resultant moment of the conductors on the pole. Examples are provided in Appendix 10–5 beginning on Page 10–125.

5.5 Grounding and Neutrals

Grounds are applied on Edison's Distribution System in the following applications:

A. Primary Grounds/Neutrals — (2.4/4.16 kV) Four-Wire Systems

- The neutral conductor of all four-wire primary circuits shall be grounded (#6 BC minimum) at intervals of approximately 1,200 feet. This spacing applies to the entire circuit including the feeder and all tap lines. Each tap line, two spans or longer on 4 kV, shall be grounded at its outer ends. On circuits or tap lines having sensitive ground protection, the neutral conductor shall not be grounded beyond the power circuit breaker or automatic recloser. Refer to the *DOH Manual*, Section GR for specific construction practices.
- When serving single-phase loads on the 4 kV, the primary of the transformer will be connected phase-to-neutral. However, when serving three-phase or combination three-phase and single-phase loads, the primary of the transformer bank may be connected delta (phase-to-phase) or wye (phase-to-neutral). If the transformer bank is connected in wye-wye, the transformer bank primary neutral is to be connected to the system neutral. The neutral on the primary side of the wye-delta connected transformer banks is to be floated.
- The neutral conductor of the 4 kV circuits must be large enough to carry at least 40 percent of the current in the phase wires. Usually, a 1/0 ACSR or No. 2 copper neutral will be used with a 336.4 kcmil ACSR or a 4/0 copper feeder. A No. 4 copper neutral should be used with No. 2 copper mains. A No. 4 copper neutral should be used with No. 4 copper mains, and a 1/0 ACSR, or No. 6 copper neutral should be used with 1/0 ACSR or No. 6

copper phase wires. One neutral may be run for two or more primary circuits on the same pole, for example, one 336.4 kcmil ACSR neutral is adequate for two 336.4 kcmil ACSR feeders and a 1/0 ACSR feed back. In every case, there must be a neutral on the same pole with the phase wires. It must **never** be isolated on another pole line.

- The neutral conductor of a 4 kV primary circuit shall not be interconnected with the neutral conductor of a 120/240 volt secondary circuit, except on existing "common-neutral" systems. No new "common-neutral" system shall be established without Field Engineering approval. Extension from existing "common-neutral" systems shall be reviewed by Field Engineering to determine "common-neutral" requirements. Where surge arresters are present with "common-neutral" construction, the surge arrester ground shall be separately grounded from the "common-neutral" ground.
- The grounds on the 4 kV primary neutral shall not be interconnected with secondary neutral grounds.

B. Primary Grounds/Neutrals — (12/6.9 kV and 16/9.4 kV) Four-Wire Systems

The following notes are pertinent to the planning and construction of four-wire, 12 kV and 16 circuits:

1. Maximum Required Overhead Neutral Wire
   - 336.4 ACSR neutral with 653.9 ACSR phase conductors
   - 2/0 BC neutral with 4/0 BC phase conductors
   - Match neutral conductor to phase conductor on all other wire sizes and on all single-phase taps
2. Twin Circuits

   A single-neutral conductor may be use where two circuits of the same voltage are installed on the same pole line.
3. Neutral Path

   The path of the neutral shall always be the same as the phase conductors serving any given load. The neutral must never be isolated on a pole line other than the line used for the phase conductors. For emergency operation, refer to the *DOM Manual* for alternate neutral.
4. Neutral Grounds

   The neutral conductor of four-wire circuits shall be multi-grounded at intervals of approximately 1,200 feet. This spacing applies to the entire circuit including the mainline and all side taps. Each side tap, one span or longer, shall be grounded at its outer end.
5. Primary and Secondary Neutral

   The primary-neutral conductor shall not be interconnected with any secondary neutral conductor on the overhead system, except on steel poles.

C. Transformer Grounds

Secondary ground (#6 BC minimum) is required on all single and three-phase transformer installations less than 250 volts-to-ground. It is to be installed at the transformer pole (preferably), or at the first adjacent pole from the transformer. Refer to the *DOH Manual*, Sections AP, GR and T for specific construction practices. Four-wire delta, 120/240 V, three-phase transformer banks are installed with a midpoint transformer ground. Three-phase, three-wire banks serving three-wire load only have a corner (phase) ground to the delta connection. Four-wire, Y-connected, 277/480 V, three-phase transformer banks are to be midpoint-grounded when serving four-wire load. A secondary ground will not be installed on transformer banks serving 480 V, three-phase, three-wire load.

D. Surge (Lightning) Arrester Grounds

Grounds shall be included with all surge arrester installations. Special details regarding installation practices are in the *DOH Manual*, Section AP. In four-wire systems, connect arrester ground to the fourth wire (primary neutral). Surge (lightning) arresters, when placed on a pole for the protection of apparatus or transformers, shall be located on the same pole. In this case, a secondary neutral ground should be placed on an adjacent pole whenever possible. If it is impossible to place the secondary neutral on an adjacent pole and both grounds are installed on the same pole, the grounds must maintain a six-inch minimum clearance. Refer to the *DOH Manual*, Section GR for details.

For RCS and AR installations with dedicated transformers, the surge arresters, secondary neutral, and any utility supply equipment cases shall be connected to a common ground. Refer to the equipment-specific installation standards for further details.

E. Pothead Grounds

All pothead installations are to be grounded and connected to the surge arrester ground. Special installation practices are in the *DUG Manual*, Section TP.

F. Cases and Equipment Grounds

The cases and frames of all transformers, including instrument transformers for meters, and all apparatus located less than eight feet from the surface of the ground or within reach of a grounded surface, shall be grounded.

Cases of 33 kV transformers, 12/16 and 33 reclosers shall be grounded.

Other special grounding practices are described in the *DOH Manual*, sections AP and GR.

5.6 Construction Practices

This chapter provides Service Planners with the general construction practices used throughout the system. Also addressed are some of the specific construction practices requiring special consideration, for example, high fire-hazard areas, or environmentally sensitive areas, and so forth.

A. Climbing Space

Climbing space means, the space reserved along the surface of a climbable pole or structure to permit ready access for linemen to reach equipment and conductors located on the pole or structure. Climbing space shall be maintained from the ground level. Non-wood poles having provisions for installing steps are considered climbable.

Climbing space dimensions and examples are found in *G.O. 95*, Rules 54.7 and 54.9. Examples of climbing space and working space clearances are shown in Section DC of the *DOH Manual*.

The Planners must meet and confer with the phone company and any other third-party attaching to the pole to ensure climbing space infractions are mitigated by proper design criteria identified above and incorporated by reference through *G.O.95* requirements. Planners should add a project note to the distribution work order file and follow through with project correspondence where the phone company and/or third-party indicates that they require additional engineering information to determine placement of their facilities in the appropriate quadrant of the pole.

Since the climbing space must be maintained from the ground level, it is important for the Planner to work with other utilities or joint-pole users to avoid climbing-space infractions prior to construction. Phone company, CATV conflicts, and costly job delays can be avoided if anticipated in the design stage of planning rather than during construction. Underground risers are a good example of a possible infraction.

Climbing space as defined in *G.O. 95* shall be maintained on all non-wood poles, even if steps are not installed. These poles are capable of being stepped and are considered climbable by *G.O. 95*.

B. Grade A/B Construction

- For the purpose of recognizing relative hazards, *G.O. 95* segregates lines into classes. Distribution circuits are either Class "H" (5,000 V and above), or Class "L" (below 5,000 V). Communication circuits are Class "C." These class lines and the relation of lines to each other, and to objects over which they are constructed, determine the grade of construction. The type of construction required is segregated into Grades A, B, and C.
- The grade of construction (A, B, or C) determines the ultimate strength requirements of material and a required safety factor designated by *G.O. 95*. The minimum construction grade for a Class "H" circuit is Grade B, and minimum grade for a Class "L" circuit is Grade C. The design shall consider the structural loading requirements of all supply and communication facilities planned to occupy the structure. Planned facilities are those that are intended to occupy the structure and are actually known to the constructing utility at the time of design. All joint poles and their attachments shall be designed to Grade A construction only. Supply conductors are to be constructed to Grade A when a Class "H" circuit crosses a conflicting major Class "C" circuit, or where a Class "H" and/or "L" circuit crosses a major railway. *G.O. 95* and the *DOH Manual*, Section PO, should be reviewed for Grade A requirements.

- Grade A crossing (refer to *G.O. 95*) requires that double crossarms be used. For maximum conductor sizes of #2 str cu and 1/0 ACSR, the use of double pins or post-type insulators is approved for Grade A crossings. For larger conductor sizes, excessive angles, or natural dead-ends, the conductors should be dead-ended using dead-end insulators. (refer to the *DOH Manual*, Section PO for illustrations of these requirements.) Table 10–10 shows the maximum span for Grade A crossings for various conductor sizes under light- and heavy-loading conditions.

Table 10–10: MAX Span for Grade A Crossings

Conductor Size		MAX Span (ft)	
Copper	**ACSR**	**Light Loading**	**Heavy Loading**
No. 6	No. 4[a/]	300	150
No. 4	No. 2[a/]	Normal Span of Line	Normal Span of Line
and Larger			

[a/] Not approved for use on new construction.

The various conductor sizes and configurations will require case-specific guying. The various cases may be reviewed in the *DOH Manual*, Section PO.

C. Equipment and Conductor Clearance on Poles

When planning a job which involves the installation of new poles or the replacement of deteriorated poles, the Planner will verify that the pole selected will meet the conductor and equipment clearances shown in the *Distribution Overhead Construction Standards* (DOH) and *Distribution Underground Construction Standards* (DUG) manuals. Refer to DOH Sections DC 200 and DC 220 for polehead conductor clearances and grade clearances. Refer to DOH Sections DC 500, DC 510, and DC 540 for vertical clearance between conductors for 12/16/33 kV circuits. Refer to DUG TP 209 for pothead clearances.

D. UG Risers

The first 8 feet above ground level of an UG riser must be a minimum of 2-1/2 inches, Schedule 80 PVC or equivalent. Schedule 40 PVC may be used above the 8-foot level. One riser of any size or two (2) 4-inch risers may be installed directly on the pole. If additional risers or larger risers are needed, unistrut or power strut should be used. (Refer to the *DUG Manual*, Section CR for details.)

Pole steps are required on all riser poles except solely-owned Edison poles with one low-voltage riser (3 inches or less). Review the *DUG Manual*, Section CR for two-stranded conduit sizes and typical construction requirements. Typical pothead termination requirements are found in the *DUG Manual*, Section TP.

A two-stranded copper primary neutral is installed in conjunction with two-stranded or 1/0 Al CLP three-phase primary tap lines, while 4/0 copper is used in conjunction with all other sizes of feeder cables.

Table 6–2, "Guide for Sizing Risers," may be used to determine the proper riser size for the various sizes of service and primary cable.

E. High Fire-Hazard Areas

High Fire-Hazard Areas (HFHAs) are defined by the State of California's Public Resource Code, Section 4292. Map of HFHAs must be maintained by the service center. A copy of these maps can be obtained by contacting GIS or Real Property Mapping. Firebreak clearing (weed abatement) and line clearing around poles is mandated by state law in HFHAs.

Firebreak clearing (weed abatement) around poles is not required for poles with all exempt equipment and material. For new construction, use all exempt equipment to avoid firebreak clearing around poles.

Nonexempt Equipment:

- Arm-mounted fuseholder with nonexempt fuses include open cutout, enclosed cutout, Bay-O-Net cutout, and SMD-1A designs
- In-line disconnect
- Surge arrester
- Split-bolt connector

Exempt Equipment:

Note: Refer to the Power Line Fire-Prevention Field Guide (published by the California Department of Forestry and Fire Protection) for the most current list of approved exempt equipment.

- Arm-mounted fuseholder with exempt fuses: Liquid, SMU-20, CLD, LR, Fault Tamer, ELF, X-Limiter, ECD cutout device
- Conventional Transformers with Exempt Fuses: Liquid, SMU-20, CLD, LR, Fault Tamer, ELF, X-Limiter, ECD cutout device
- Capacitor Bank with Arm-mounted Cutout and SMU-20 Fuse
- 600 A KPF Air Switch Cross-Arm Mounted
- Automatic Recloser
- Voltage Regulator
- Hot-Tap Clamp (Spring Tension)
- Line Poles, where conductors are continuous, and any primary ground connections are made with parallel groove or compression connectors
- Dead-end or corner poles with no taps or connections
- Dead-end or corner poles with taps or connections made with parallel groove or compression connectors
- Line splices, automatic splices, automatic dead-ends
- S&C Omni-Ruptor

Bulletin 322:

In addition to the State-defined HFHAs, Edison has some special operating practices in areas covered by System Operation Bulletin 322. These areas may not be the same as the State's defined HFHAs.

F. Distribution Facilities in National Forest Areas

U.S. Forest Service written permission is required prior to the construction, extension, or addition of power lines within the national forests. Procedures to be followed in the construction of lines, connection of new services, eradication of weeds, and completion of required reports are:

1. Line Construction

   Prior to any new construction or work-order preparation, the service center Superintendent or his representative shall contact the local forest ranger or forest supervisor's office to obtain approval as to the physical location of the proposed line. When the work order is prepared, this prior approval with the date obtained, and the name of the forest officer shall be included.

   The Corporate Real Estate Department will then apply for the written permit. When the permit is received, a copy will be forwarded to the service center, with the original going to the General Office Record Department vault files. When other required approvals have been obtained, construction may begin in accordance with the limitations and/or stipulations of the permit.

2. Contract Work

   Prior to the commencement of any Edison contract work within national forest lands, the local forest ranger shall be notified in order that the contract crews may be instructed regarding fire hazards and their equipment inspected.

3. New Service Connection

   No service to any cabin, house, or structure within the National Forest shall be connected until the customer has furnished the Company with evidence that the wiring of such structure has been approved by the forest supervisor or his authorized representative.

4. Weed Eradication

   The Vegetation Management Manager or an authorized representative shall contact Local Representatives of the Office of the State Fire Marshall annually to familiarize themselves with any special requirements or conditions in conjunction with each line in the State Forest, and to arrange for such clearing as may be necessary. The clearing shall be in accordance with the current Power Line Fire Prevention Field Guide issued by the Office of the State Fire Marshall.

5. Reports Required

   Each service center operating distribution lines within national forest lands shall maintain maps of all such lines, indicating all line extensions and/or removals. Copies of an up-to-date map shall be furnished to the Corporate Real Estate Department by October 15, for their use in preparing the annual report to the U.S. Forest Service, due on November 10th of each year.

G. Overhead Apparatus

All overhead capacitor banks and transformer installations (single-phase or three-phase banks) shall be connected per existing construction methods for 12 kV and 16 kV, three-wire circuits. This requires transformers to be connected phase-to-phase and capacitor banks to be connected phase-to-neutral with the neutral floated.

H. Connecting Underground Transformers

1. Single-phase transformers serving single-phase loads that are fed from a four-wire system should have a primary voltage rating requiring a phase-to-neutral connection.
2. Single-phase transformers to be used in a bank and to be fed from a four-wire system should have a primary voltage rating which requires a phase-to-phase connection. If each of the three, single-phase transformers in a bank has a primary that requires a phase-to-neutral connection, the transformer neutral shall not be connected to the system neutral if the secondary is connected in delta. The transformer neutral shall be connected to the system neutral if the secondary is connected in wye.
3. Three-phase transformers, which are to be fed from a four-wire system, shall have a primary voltage rating requiring a phase-to-phase connection.

I. Fusing

Fusing in overhead distribution systems is utilized to interrupt and clear a fault current downstream of the fuse. A fuse operation, in addition to protecting or minimizing damage to downstream conductors/equipment, is intended to prevent upstream operation of the circuit breaker.

Two types of fuses are currently approved for overhead distribution systems:

1. Expulsion fuses (SMU-20 and Fuse Links)
2. Current-Limiting fuses (ELF, Fault Tamer, and X-Limiter)

Fusing is installed on overhead systems for the following applications: transformers, capacitor banks, branch-line fusing, and underground residential subsystems.

Fusing practices for residential subsystems from an overhead source can be found in Figure 4–14 and Figure 4–15.

Branch-line fusing has been expanded to include overhead 4 kV as well as 12 kV and 16 kV tap lines. Application of branch-line fusing is primarily intended to improve reliability. The branch-line fusing tables are included in DDS–2, Page 2–22.

The types of fuses, by voltage classification, to be installed on overhead distribution systems are shown in Table 10–12. Note that the table differentiates between areas located inside and outside fire-hazard areas.

J. Fusing Application

For information on fusing applications based on economic preferences, see Table 10–11.

1. Open Style Fuse Cutout (up to 100 A) — 4 kV, 12 kV, 16 kV, and 25 kV

Open style fuse cutout is the least expensive option. The following conditions must be met when using fuse cutouts:

- Fault duty must be below 7,500 A (symmetrical) at the point of application. This can be assured by any one of the following, considering possible increases in fault duty, such as new substations, load rolling, and so on.
- There must be 3/4-mile of overhead conductor between the point of application and the substation.

  Exceptions are the Barre, Rector, and MacArthur substations where one mile of overhead conductor is required.
- There must be two miles of either underground cable or combination of overhead conductor and underground cable between the point of application and any substation.
- For exceptions, contact Field Engineering for certification that fault duty is less than 7,500 A.

Maximum ampere rating is 100 A. (SMU-20 is available for requirements above 100 A.)

Open style fuse cutout with Emission Control Device (ECD) is generally used in the fire-hazard areas. This type of fuse is the most expensive option. Preference should be given to SMU-20 or current-limiting fuses for fusing application in fire-hazard areas. ECD is the only option for three-phase or single-phase line-to-line applications in the 25 kV system in fire-hazard areas. Fault Tamer, SMU-20, ELF or X-limiter fuse should be used for single-phase (14.4 kV) applications. For 4 kV systems, an 8 kV ELF may be used in fire-hazard areas. Refer to the *DOH Construction Standards*, Section DC 605 for overhead construction line requirements in fire-hazard areas.

2. Fault Tamer (3 A – 20 A) — 12 kV, 16 kV and 14.4/25 kV Systems, 34.5 kV Fault Tamer (3A—15A) — 33 kV Systems

Fault Tamer is a combination of fuse cartridge and partial-range current-limiting fuse in an assembly which mounts in a standard open (universal) fuse cutout mounting. The fuse cartridge will operate for both low- and high-current faults (similar to a cutout link). A partial-range current-limiting fuse called the limiter will operate only after a high-current fault, such as a high-side transformer or external phase-to-phase fault, occurs. Operation of the limiter fuse is determined by a continuity check (similar to a CLD), and is also field-replaceable. The Exhaust Control Device prevents the expulsion of particles during fuse operation. The Fault Tamer fuse is provided as a complete assembly, including the mounting, fuse tube, and limiter. The fuse cartridge must be ordered separately and is available in sizes 3 A through 20 A for 12 kV, 16 kV, and 14.4/25 kV systems. For 33 kV systems, the 34.5 kV Fault Tamer is available in sizes 3A through 15A.

The Fault Tamer can be installed as follows:

- Anywhere on 12 kV and 16 kV overhead distribution circuits, and on single-phase 25 kV (14.4 kV-to-ground) applications, including fire-hazard areas where the maximum allowable fault duty for Fault Tamer is 14,000 A (symmetrical). The ELF fuse can be used for higher fault duty and in fusing applications beyond the 20 A size limitation of the Fault Tamer.
- For 33 kV overhead distribution circuits, the 34.5 kV Fault Tamer can be used in fire-hazard areas where the maximum allowable fault duty is not greater than 12,000 (three years historical).
- As a replacement for Size One Liquid Fuses for load requirements up to 20 A. (Note: the Fault Tamer can only be mounted in the 27 kV open style universal cutout.)

3. ELF Fuse — 8 kV and 15 kV

The 8 kV and 15 kV ELF are full range current-limiting fuses. The 8 kV ELF fuse is available in sizes from 6 A up to 80 A, while the 15 kV ELF fuse is available in sizes from 6 A up to 50 A. The 8 kV ELF fuse can only be mounted in the 15 kV open style universal cutout, while the 15 kV ELF fuse can only be mounted in the 27 kV open style universal cutout.

The 8 kV ELF fuse can be installed:

- In 4 kV overhead distribution circuits, including fire-hazard areas, and in fusing applications where current limitation is desired.

The 15 kV ELF fuse can be installed as follows:

- Anywhere on 12 kV and 16 kV overhead distribution circuits, and on single-phase 25 kV (14.4 kV-to-ground) applications, including fire-hazard areas.
- In the 25 A to 50 A range where current limitation is desired and in fusing applications beyond the 20 A size limitation of the Fault Tamer
- Where the fault duty exceeds 14,000 A maximum allowable for the Fault Tamer

4. SMU-20 Fuses — 12 kV, 16 kV, 1Ø 14.4/25 kV and 33 kV

The SMU-20 is a non—current-limiting power fuse and is available in sizes from 3 A up to 200 A. The SMU-20 can only be mounted in an SMD-20 fuseholder. The SMU-20 14.4 kV fuse is utilized on systems 16 kV and lower, and on 25 kV system for single phase application. The SMU-20 25 kV fuse is utilized on wye to delta transformer banks, and on delta to wye transformer banks on the 25 kV system. The SMU-20 34.5 kV fuse is used on the 33 kV system.

SMU-20 fuses can be installed as follows:

- Anywhere on the 2.4 kV, 4.16 kV, 4.8 kV, 16 kV, and 33 kV and single-phase 25 kV (14.4 kV-to-ground), including fire-hazard areas where the maximum fault duty is 14,000 A (symmetrical). The 25 kV SMU-20 fuse is to be used on 25 kV delta to wye transformer banks and on 25 kV wye to delta transformer banks.Other cost-effective options must be reviewed before using SMU-20 fuses.
- Emission Control Devices (ECD) is the only option for 3-phase, or single-phase line-to-line applications in the 25 kV system in fire-hazard areas. SMU-20, ELF, or X-limiter fuses may also be used for single-phase (14.4 kV) applications. Refer to the *Distribution Overhead Construction Standards (DOH) Manual*, Section DC 605, for overhead construction line requirements in fire-hazard areas.

  Note: The SMD-20 mounting for 25 kV and for 33 kV uses a larger fuse than is used for 12 kV and 16 kV. Refer to the *Distribution Overhead Construction Standards (DOH) Manual*, Section PR 134.

5. X-Limiter — 12 kV, 16 kV and 1Ø 14.4/25 kV

   The X-limiter is a full range current-limiting fuse and is available in sizes from 10 A to 100 A. The X-limiter can only be mounted in an SMD-20 fuseholder. This type of installation is the most expensive option.

   The X-Limiter can be installed as follows:

   - Anywhere on 12 kV and 16 kV overhead distribution circuits and on single-phase 25 kV (14.4 kV-to-ground) applications, including fire-hazard areas.
   - On the overhead system ahead of load-break elbows. This application eliminates the need for adding more expensive fusing in underground circuits where the fault duty is in excess of the 10,000-A rating of the load-break elbows. The cost of the X-limiter should be compared with other options, for example, fuse cabinets, PME w/CL fuse compartments, and BURD/pad-mounted fused switches, and so on.
   - On underground dips, consult with Field Engineering for exceptions.

6. Liquid Replacement Fuses

   Cooper Power ELF-LR or Bushman Type "LRB" fuse (formerly type FDSH) is the replacement fuse for Size One Liquid Fuse and is available in sizes 6 A and 12 A for Cooper Power ELF-LR and 6 A and 15 A for Bussman LRB. Refer to the *Distribution Overhead Construction Standards (DOH) Manual*, Section PR 127.

7. Liquid Fuse Size 3 and 4

   Size 3 and 4 Liquid Fuses are no longer available. Replacement of size 3 or 4 Liquid Fuses and fuseholders must be performed in accordance with the Distribution Design Standards.

K. Fusing Underground Dips from Overhead Circuits

All single-phase or three-phase underground dips feeding a single transformer or a single bank of transformers should be fused for the transformer or bank size with current-limiting fuses (preferred). SMU-20 fuses may be used if the fault duty at the riser pole is less than 10,000 A. The open style cutout may also be used if the fault duty at the riser pole is less than 7,500 A.

Table 10–11: Fusing Selection Listed in Order of Economic Preference *(Sheet 1 of 3)*

Voltage Class: 4 kV	Mounting Type	Fire Hazard Area Exempt	MAX Fault Duty Symm. Amperes	Current Limiting	Remarks
1. Open Style Fuse Cutout (1 A—100 A)	15 kV Open Style Universal Cutout	No	6,250	No	Preferred
2. Enclosed Cutout (1 A—100 A)	Enclosed (Box Type) Cutout	No	10,000	No	Used on congested poles with limited vertical space.
3. 8 kV ELF Fuse (6 A—80 A)	15 kV Open Style Universal Cutout	Yes	31,000	Yes	The only Current-limiting fuse that can be used in4 kV systems.
4. SMU-20 (3A – 200 A)	SMD-20	Yes	14,000	No	Non-current–limiting expulsion fuse. Used for 4 kV branch line fusing and in fire hazard areas.

Voltage Class: 12 kV and 16 kV	Mounting Type	Fire Hazard Area Exempt	MAX Fault Duty Symm. Amperes	Current Limiting	Remarks
1. Open Style Fuse Cutout (1 A—100 A)	27 kV Open Style Universal Cutout	No	7,500	No	Preferred
2. Fault Tamer (3 A—20 A)	27 kV Open Style Universal Cutout	Yes	14,000	Yes	Used as replacement for liquid and SMD-20 fuses in fire-hazard areas for load requirements up to 20 A.
3. 15 kV ELF Fuse (6 A—50 A)	27 kV Open Style Universal Cutout	Yes	43,000	Yes	Used as an alternative fuse for specific application beyond the 20 A maximum loading and/or 14,000 A maximum fault duty of the Fault Tamer.
4. SMU-20 (3 A—200 A)	SMD-20	Yes	14,000	No	Noncurrent-limiting expulsion type.
5. X-Limiter (10 A—100 A)	SMD-20	Yes	43,000	Yes	Used to replace SMU-20 expulsion fuse to current limiting in SMD-20 fuseholder, where fault duty is in excess of 10,000 A rating for load-break elbow application.

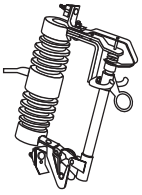
Table 10–11: Fusing Selection Listed in Order of Economic Preference *(Sheet 2 of 3)*

Voltage Class: 25 kV	Mounting Type	Fire Hazard Area Exempt	MAX Fault Duty Symm. Amperes	Current Limiting	Remarks
1. Open Style Fuse Cutout (1 A—100 A)	27 kV Open Style Universal Cutout	No	7,500	No	Preferred
2. Fault Tamer (3-20A)	27 kV Open Style Universal Cutout	Yes	14,000	Yes	Single-phase 14.4 kV phase-to-ground applications. Used in Fire-Hazard areas for load requirements up to 20 A.
3. ELF Fuse (6 A—50 A)	27 kV Open Style Universal Cutout	Yes	43,000	Yes	Single-phase 14.4 kV phase-to-ground applications. Used as an alternative fuse for specific application beyond the 7,500 A maximum fault duty of the Open Style Fuse Cutout.
4. Open Style Fuse Cutout with ECD (1 A—100 A)	27 kV Open Style Universal Cutout (for ECD)	Yes	7,500	No	ECD is designed to fit in a universal fuse cutout with two holes for mounting the ECD basket. SAP 10107430.
5. SMU-20 (3 A—200 A)	SMD-20	Yes	14,000	No	The 14.4 kV SMU-20 fuse is used for single-phase 14.4 kV phase-to-ground applications. The 25 kV SMU-20 fuse is to be used on wye-delta and delta-wye banks. Non-current–limiting expulsion type.
6. X-Limiter (10 A—100 A)	SMD-20	Yes	43,000	Yes	Single-phase 14.4 kV phase-to-ground applications. Used to replace SMU-20 expulsion fuse to current limiting in SMD-20 fuseholder, where fault duty is in excess of 10,000 A.

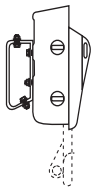
Table 10–11: Fusing Selection Listed in Order of Economic Preference *(Sheet 3 of 3)*

Voltage Class: 33 kV	Mounting Type	Fire Hazard Area Exempt	MAX Fault Duty Symm. Amperes	Current Limiting	Remarks
SMU-20 (3 A—125A)	38 kV SMD-20	Yes	10,000	No	Expulsion type. Used where fault duty is 10,000 A or less.
SMD-1A (3A—200 A)	38 kV SMD-1A	No	17,500	No	Expulsion type. Used where fault duty is more than 10,000, but less than 17,500 A.
Fault Tamer® (3A—15A)	38 kV Cutout Type XS	Yes	12,000	Yes	The only current-limiting fuse that can be used in the 33 kV systems. For use in High-Fire Hazard areas.

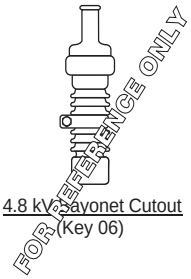
Figure 10–5: Overhead Distribution Transformer Fuses



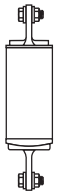
15 kV Open Cutout
See DOH, Table PR 107-1
(See Notes 5, 8 and11 Page 10–46.)



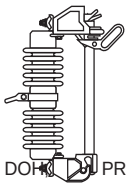
4.8 kV Enclosed Cutout
See DOH, Table PR 107-1
(See Notes 5 and 9 Page 10–46.)



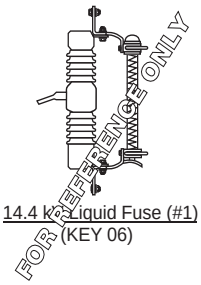
4.8 kV Bayonet Cutout
(Key 06)



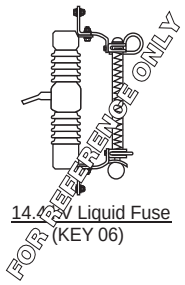
8.3 kV CLD
See DOH, Section PR-126
(See Note 4 Page 10–46)



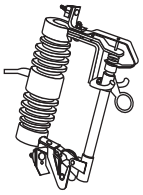
See DOH, Table PR 107-3
14.4–17 kV SMU 20
(See Notes 2 and 5 Page 10–46.)



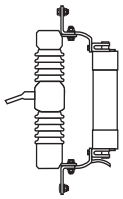
14.4 kV Liquid Fuse (#1)
(KEY 06)



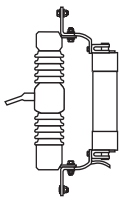
14.4 kV Liquid Fuse
(KEY 06)



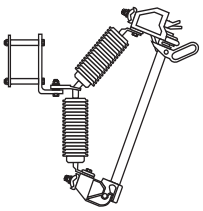
27 kV Open Cutout
for use on 12/16/25 kV
See DOH, Table PR 107-1
(See Notes 5 and
11 Page 10–46.)



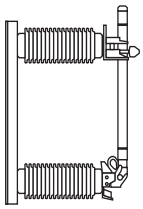
20.5 kV LR Fuse (Kearney)
for use on 12/16/25 kV
(KEY 06)
(See Note 6 Page 10–46.)



23 kV LRB Fuse (Bussman)
for use on 12/16/25 kV
See DOH, Section PR 127
(Formerly FDSH)
(See Note 6 Page 10–46.)



34.5 kV SMU 20
See DOH, Table PR 107-7
(See Notes 3, 5, and
14. (page 10–46).)



34.5 kV SMD 1A
See DOH, Table PR 107-8
(See Note 5 Page 10–46.)



27 kV Cutout with ECD
See DOH, Table PR 107-1
(See Note 10 Page 10–46.)



15 kV Fault Tamer
for use on 12 kV, 16 kV, and
14.4/25 kV only. See DOH
Table PR 107-4 and
Section PR 128
(See Notes 5 and 12 Page 10–46.)



15 kV ELF Fuse
6 Amp to 50 Amp
See DOH, Table PR 107-5
(See Note 13 Page 10–46.)

8 kV ELF Fuse
6 Amp to 80 Amp
See DOH, Table PR 107-2
(See Note 15 Page 10–46.)



17 kV X-Limiter Fuse
10 Amp to 100 Amp
See DOH, Table PR 107-6
(See Note 14 Page 10–46.)



34.5 kV Fault Tamer® Fuse
See DOH, Table PR 107-9
and Section PR 128
(See Note 5 Page 10–46.)



25 kV SMU-20
See DOH, Table PR 107-3
and PR 107-7
(See Note 5 Page 10–46.)

Table 10–12: Fuse Applications

Fuse Applications by Voltage (See Note 1.)			
2.4/4.16/4.8 kV	**7/12/16 kV**	**14.4/25 kV**	**33 kV**
Enclosed Cutout (See Notes 5 and 9.) Bay-O-Net Cutout (Key 6) Open Cutout (See Notes 5 and 8.) CLD's (See Note 4.) 8 kV ELF Fuse (See Note 15.) 14.4 kV SMU-20 (See Note 16.)	14.4 kV SMU-20 (See Notes 2 and 5.) CLDs (See Note 4.) LR Fuse or LRB Fuse (See Notes 6.) Open Cutout (See Notes 5 and 11.) Fault Tamer (See Notes 5 and 12.) 15 kV ELF (See Note 13.) X–Limiter (See Note 14.) Liquid Fuse (Key 6) (See Note 7.)	14.4 kV SMU–20 (See Notes 2 and 5.) 25 kV SMU-20 (5) (17) Open Cutout (See Notes 5 and 11.) Cutout with ECD (See Note 10.) 15 kV ELF (See Note 13.) X–Limiter (See Note 14.) Liquid Fuse (Key 6) (See Note 7.) Fault Tamer (See Notes 5 and 12.)	34.5 kV SMU–20 up to 500 MVA Duty (See Notes 3 and 5.) SMD–1A Over 500 MVA Duty (See Note 5.) 34.5 kV Fault Tamer® (See Note 5.) CLD (See Note 4.)
Fuse Applications in Fire-Hazard Areas			
Firebreak clearing around poles is not required for poles with all exempt equipment and material. Refer to the *DOH Manual*, Section DC. Exempt fuses include liquid, SMU-20, CLD, LR, FDSH, Fault Tamer, X-Limiter, ELF, and ECD cutout designs. Nonexempt fuses include open cutout, enclosed cutout, Bay-O-Net cutout, and SMD-1A designs.			

Notes:

1. Fuse sizes for each type of installation are shown in the fuse tables (*DOH Manual*, Section PR).
2. Use fuseholders with 17-inch creepage distance on 7 kV and 12 kV circuits in contamination areas "A" and "B" per Insulation Area Map (*DOH Manual,* Section GR), and on all 16 kV and 25 kV circuits.
3. Use fuse adapter (SAP 10107599) when using newer type SMU-20 fuses on old 34.5 kV SMD-20 fuseholder, (SAP 10107515 – Key 6).
4. Refer to the *DOH Manual,* Section PR for CLD application.
5. Do **not** leave fuse hanging in the holder in an open position. Moisture may enter through the exhaust end and damage the fuse.
6. Refer to the *DOH Manual*, Section PR for LR and FDSH fuse application.
7. Liquid fuses and fuseholders have been discontinued by the manufacturer. The Kearney LR (Key 06) and Bussman LRB (formerly FDSH) fuses can be used in Size 1 liquid fuseholders.
8. 4.16 kV through 14.4 kV rated, but limited to use on 4 kV and 4.8 kV systems.
9. For use on 4 kV or 4.8 kV on congested poles (limited vertical space).
10. The cutout with ECD (Emission Control Device) is identical to a 27 kV open cutout, except a device (ECD) is attached to contain all expulsion particles during a fuse operation.
11. Restricted to nonfire-hazard areas where the available fault current does not exceed 7,500 A (sym).
12. Includes open cutout mounting. For 12 kV, 16 kV, and 14.4/25 kV systems where the available fault current is above 7,500 A (sym). Refer to *DOH Manual*, Section PR.
13. The 15 kV ELF is a current-limiting fuse which mounts in a 27 kV open style cutout mounting. This fuse is designed for the 12 kV, 16 kV and 25 kV (single-phase, 14.4 kV line-to-ground) overhead systems, and is available with the cutout mounting or as individual fuses for retrofitting in existing 27 kV open cutout mountings.
14. The X-Limiter is a current-limiting fuse designed specifically for use in a SMD-20 mounting (SAP 10107506).
15. The 8 kV ELF fuse is a current-limiting fuse which mounts in a 15 kV open-style cutout fuseholder. The fuse is intended for the 4 kV, 6.9 kV, and 9.4 kV fusing application.
16. For use in Bulletin 322 Areas in the 2.4/4.16/4.8 kV systems where current limitation is not required, and in 4.16 kV branch line fusing.

Current-limiting devices shall be used when installing 12 and 16 kV single-phase Type FI transformers (with internal weak-link fuses), control transformers of switched capacitor banks, and on conventional transformers with liquid fuseholders. Refer to *DOH Manual*, Section PR for details the various construction practices when using CLDs for the applications above.

All new secondary systems are to be radial and do not require secondary fusing. Existing banked secondaries should be isolated when possible and the secondary fusing eliminated. Refer to *DOH Manual*, Section DC.

For more detailed information on overhead fusing requirements for 4 kV through 33 kV are described in the *DOH Manual*, Section PR. Bulletin 22 fusing is also included in the *DOH Manual*, sections PR and DC.

L. Surge Arresters

For the purpose of lightning protection, service centers will be divided into two categories: low/medium and high lightning-density areas. Individual standards have been developed for both categories.

1. Low and Medium Lightning-Density Service Centers

Catalina	Montebello	Long Beach	Thousand Oaks	Ventura
Covina	Tehachapi	Ontario	Valencia	Santa Barbara
Santa Monica	Kernville	Santa Ana	Huntington Beach	Monrovia
Compton	Saddleback	Arrowhead	South Bay	Foothill
Redlands	Fullerton	Whittier	San Joaquin	

For these service centers, surge protection standards apply as follows: (1) for lightning protection, only Metal-Oxide Varistor (MOV) type surge arresters will be installed; and (2) surge arresters will be installed for the following applications:

- Underground dips from overhead lines
- On reclosers, sectionalizers, remote-controlled switches (RCS), PE gear, capacitor banks, and pole-top substations
- Overhead transformer installations of 750 kVA and larger

Silicon carbide arresters will be replaced with the equivalent MOV arrester, if (1) the above criteria for installation have been met and (2) the crew is performing major construction, for example: replacing or rebuilding equipment, reconductoring, or facility rearrangement, on or adjacent to the pole with the silicon carbide arrester.

When installing MOV arresters, a minimum of two grounds must be installed in accordance with proper construction practices for multiple ground rods.

2. High Lightning-Density Service Centers

- Antelope Valley
- Barstow
- Bishop
- Blythe
- Menifee
- Palm Springs
- Ridgecrest
- Shaver Lake
- Victorville
- Wildomar
- Yucca Valley

For these service centers, lightning protection standards apply as follows: (1) for lightning protection only, MOV type-surge arresters will be installed and (2) MOV arresters will be installed for the following applications:

- Underground dips from overhead lines
- On all new overhead equipment installations

Silicon carbide arresters will be replaced with the equivalent MOV arrester, if (1) the above criteria for installation have been met and (2) the crew is performing major construction, for example; replacing or rebuilding equipment, reconductoring, or facility rearrangement, on or adjacent to the pole with the silicon carbide arrester.

When installing MOV arresters, a minimum of two grounds must be installed in accordance with proper construction practices for multiple ground rods.

In cases of a large overhead rebuild where a portion of the circuit is being reconstructed and five or more poles are involved, it is important for the distribution engineers and planners to contact Field Engineering for a more in-depth analysis with specific location requirements.

3. On distribution lines where repeated storm damage has occurred: (1) install arresters where the pole line is on a ridge or in an exposed location and (2) install arresters on dead-end poles.

4. Aerial Cable

Aerial cable shall not be used for new installations. Aerial Bundled Cable (ABC) is preferred for replacement of existing rubber-like 5/12/16 aerial cable or for replacement of existing conventional overhead systems where heavy tree or snow and ice conditions exist. Refer to the *DOH Manual*, Section AC for details.

Install arresters at both ends of all aerial cable sections on the system.

Surge arresters, when placed on a pole for the protection of apparatus or transformers, shall be located on the same pole. In this case, a secondary neutral ground should be placed on an adjacent pole whenever possible. If it is impossible to place the secondary neutral ground on an adjacent pole, and both grounds are installed on the same pole, refer to the *DOH Manual*, Section GR for details.

Table 10–13: MOV-Type Surge Arresters for Distribution Applications

Circuit Voltage (kV)	Nominal Arrester Rating (kV)	MCOV Rating (kV) (See Note 1.)	SAP No.
			Polymer Housing
2.4 and 4.16/2.4	3	2.6	10109138
4.8	6	5.1	10109139
7.2	9	7.7	10109140
12/6.9 and 12	15	12.7	10109142
16/9.5 and 16 and 24.9/14.4	18	15.3	10109143
33	36	29	10109144

Notes:

1. MCOV—Maximum Continuous Operating Voltage (applied to a MOV arrester)
2. Use 18 kV rated arresters on the 16/9.5 and 16 kV circuits and 15 kV rated arresters on 12/6.9 and 12 kV circuits.
3. In animal-problem areas use Wildlife Protector (SAP 10067758.)
4. For overhead and underground (riser pole) installations, refer to the *DOH Manual*, Section AP.

M. Pole Switches and Disconnects

The preferred single-arm, horizontal-type and vertical-type, gang-operated overhead switches for 12kV and 16kV systems, is the 600 A Omni-Rupter® load-break switch. The Omni-Rupter® switch is considered exempt equipment (refer to *Power Line Fire Prevention Field Guide*) in regards to High Fire Hazard Areas (HFHA). Therefore, if the switch is to being stalled in a fire-hazard area, a firebreak clearing around the pole is not required. Refer to the *DOM Manual*, Section IM. The Omni-Rupter® switch has a dead-ending capability of 8,000 pounds per conductor where equal tensions are applied to both sides of the switch and a rating of 700 pounds per conductor where pull-off forces are applied to only one side of the switch. See Table 10–28 for conductor tensions. The Omni-Rupter® switch has the following applications:

1. May be used on riser poles to switch underground systems in place of underground switches
2. Ability to switch ferroresonant cable and transformer systems
3. Ability to switch unloaded cable sections up to ten miles in length
4. Ability to switch at system parallel locations
5. Ability to drop up to 900 A load during emergency conditions such as when SCE is called upon by the ISO to drop load.
6. The Omni-Rupter® switch is the only allowable OH switch for all midpoint RCSs and the preferred switch for all other RCSs.

   The Omni-Rupter® switch should not be installed to switch a capacitor bank. Refer to the *DOH Manual*, Section AP for details on the Omni-Rupter® load-break switch. The preferred single-arm, horizontal-type, gang-operated overhead switch for 33 kV systems is the 600 A Alduti-Rupter® load-break switch. The Alduti-Rupter® switch is considered Non-Exempt Equipment.

Therefore, if the switch is to be installed in a fire-hazard area, a firebreak clearing around the pole is required. Refer to *DOM Manual*, Section IM-6. The Alduti-Rupter® switch has a dead-ending capability of 8,000 pounds per conductor where equal pull-off forces are applied to both sides of the switch and a rating of 700 pounds per conductor where pull-off forces are applied to only one side of the switch. See Table 10–28 for conductor tensions.

The Alduti-Rupter® switch has the following applications:

1. Ability to switch ferroresonant cable and transformer systems
2. Ability to switch unloaded cable sections up to ten miles in length
3. Ability to switch at system parallel locations

The 12 kV, 16 kV, and 33 kV systems can be switched using the 600 A line torsion switch (KPF) on all conductor sizes. The 12 kV system uses a 23 kV class switch except in "A" contamination areas where the 34.5 kV class switch is used. All 16 kV and 33 kV systems use the 34.5 class switch. These switches are designed to parallel and sectionalize only, they are not designed for load dropping.

Five basic types of overhead line switches are used on the 12 kV, 16 kV, and 33 kV systems. Construction practices and switch illustrations may be found in the *DOH Manual*, Section AP.

1. Single-arm, horizontal Omni-Rupter®, horizontal Alduti-Rupter®, and vertical-mounted KPF switches are to be used wherever possible, as they are the most economical to install. All other types are designed for special applications.
    a. Single-arm Omni-Rupter® load-break switches may be installed in the line for horizontal construction. They can also be installed under a double-line arm for Grade A crossings, line-angle poles or on riser poles to switch underground systems when pole space is available.
    b. Single-arm Alduti-Rupter® load-break switches may be installed in the line for horizontal construction.
    c. Single-arm KPF switches are designed for proper operation under line tension and should be installed in the line for vertical construction.
2. The double-arm KPF switch can be used where Grade A crossings are required with vertical construction. It can also be used for horizontal construction when adequate pole height is not available to install Omni-Rupter® under a double-line arm. The double-arm KPF does not require tension on either side for satisfactory operation. The stationary side may be used for unguyed (reduced tension) dead-ends, or underground dips.
3. The line-angle KPF switch should be installed where the maximum allowable line deviation angle exceeds those specified for the other types and where there is not adequate pole height to install an Omni-Rupter® under an angle-line arm. The maximum angle permitted for the line-angle KPF is 45 degrees. This switch can also be used for underground dips or unguyed (reduced tension) span applications without modification as it is designed for use with tension on the rotating side only.

Table 10–26 has been included in Appendix 10–2. This table gives the allowable line angle for KPF-type switches and for various conductor sizes. Table 10–27 should be used to calculate the line angle.

Pole switches and single-blade disconnects are used on the distribution system to:

1. Isolate long single-phase, and three-phase tap lines where required
2. Isolate pole-top installations of sensitive ground equipment, regulators, reclosers, and preferred emergency equipment only
3. Bypass and/or isolate switches within consumer substations

Single-blade disconnects are used on 4 kV and 4.8 kV systems to parallel and sectionalize. Single-blade disconnects are not designed to drop load. Refer to the *DOH Manual*, Section AP.

N. Corporate Environmental Services (CES)/Avian

Environmental sensitivity is an important issue. Preservation of protected species of plants and animals is a subject that must be addressed as a design issue for any planned job activity. A review of the *Endangered Species Alert Manual* and a check with CES prior to planning surface-disturbing activities will identify any special permits or construction requirements needed.

An Environmental Screening Form (ESF) must be filled out for all projects and activities that will involve ground disturbance (for example, excavation, grading, offroading), vegetation removal, or installation, replacement, or removal of oil-filled electrical equipment and/or petroleum tanks on either private or public lands. Based on the answers to each of the questions, a more comprehensive environmental review may be required to ensure the project activities comply with local, state, and federal environmental protection laws. Both the latest versions of the ESF and further information about the Environmental Screening for Ground Disturbing Activities Directive are located on the Portal at:

My Company/Safety & Environment/Environment, Health & Safety/A-E/Environmental Screening/Ground Disturbing Activities/

One or more state and federal laws protect most species of birds in SCE's service territory. In order to ensure Company compliance with these laws and regulations, the Company has created procedures for reporting avian mortalities on power lines and developed construction standards for avian protection. Refer to EN-5 and DOH, DC 535 for further details.

Avian Protection Requirements

New poles, lines, equipment, apparatus, and pole replacements shall be constructed per DOH DC 535.

1. Standard Construction

- 36 inches of horizontal phase-to-phase/ground separation and 36 inches of vertical phase-to-phase/ground separation
- Overhead equipment shall have bushing covers
- Overhead equipment shall be connected with covered conductors
- Overhead arresters shall utilize vendor supplied covers

- All overhead taps, leads, and jumper wires that do not maintain the required clearances shall utilize covered conductors
- On all riser poles, potheads shall utilize covers and all phase jumpers shall be covered
- All new overhead switches shall be inverted

2. Eagle Zone Construction

Portions of the SCE service territory are designated as Eagle Zones (refer to DOH DC 535, Section 5.0).

- In addition to areas defined in DOH DC 535, Section 5.0, all Public Lands (Forest Service, BLM, NPS, and State Parks) are designated as Eagle Zones.

In addition to the above requirements for Standard Construction, the following applies for Eagle Zone Construction:

- 60 inches of horizontal phase-to-phase/ground separation and 40 inches of vertical phase-to phase/ground separation.
- In the absence of sufficient separation, avian protection material shall be used (for example, Avian Hoods, Avian Hood Extenders, and Protective Tubing).

3. Eagle Zones with Exceptions Rules

a. Standard Construction

1) Development on both sides of the street or pole line
2) Less than approximately 40 acres of open space on either side of a street or pole line
3) Open space such as groomed parkland or golf courses

b. Eagle Construction

1) Greater than approximately 40 acres of open space on either side of a street or pole line
2) In situations that aren't clearly defined above as Standard Construction (when in doubt)

Exceptions to Avian Protection Standards and Retrofits

- For a pole replacement with a working non-inverted OMNI or Alduti switch, the switch may be transferred to the new pole. Per Section 5.6, P (Page 10–53), all obsolete switches must be replaced with the appropriate inverted switch.
- Apparatus crews performing maintenance
- Troublemen performing normal duties
- When installing necessary avian protection creates an unsafe working condition. This exception shall require an explanation and documentation submitted to CHS.

Refer to DOH DC 535, Section 5.0 to identify which districts or portions of districts that have been designated as Eagle Zones. In addition, contact the Manager of Government Lands in Real Properties for further information on Public Lands.

O. Heavy-Loading Areas above 5,000 Feet

Special construction requirements have been established for heavy-loading areas above 5,000 feet (normal heavy-loading areas are above 3,000 feet). Higher strength requirements in these areas are needed to eliminate damage to pole lines caused by extremely heavy ice formation on conductors, or extreme shock loads due to ice or snow "unloading." These special requirements and maps are shown in the DOH Manual, Section DC.

P. Deteriorated Poles

General Information — The Planner must look at identifying ways to minimize the cost of the current replacement while maximizing the longevity of the new pole. A like-for-like approach may not be acceptable in all cases.

The Planner will inspect (intrusive inspection for poles older than 15 years of age per the *Pole Loading Manual*) or have tested existing wood poles when adding equipment, risers, or changing the strain to the pole. Maintenance Programs are in place for identifying deteriorated poles. Maintenance records as well as visual inspection should be used to determine the appropriate action.

All poles deemed deteriorated shall be submitted to the Deteriorated Pole Program Group for approval to replace the pole with Program funding. The request must be submitted with pictures of the site as well as pole loading results. During the design process, the Planner will review field conditions one span in each direction from the originally scoped deteriorated pole.

- Any construction or design violations such as impaired clearances, either from fixed objects or other conductors, and open-wire secondaries that are bare or passing through trees shall be mitigated and any necessary rearrangement will be completed on the deteriorated pole work order.
- Obsolete equipment, such as obsolete transformers, Current Protected (CP) transformers, KPF/Cole switch, and damaged disconnects shall be replaced and not be transferred.

If the Planner is working on another type of project and a pole is found to be deteriorated, the Planner can replace the deteriorated pole on the correct product type (using program funding) without waiting for the Deteriorated Pole Program to identify the deteriorated pole.

Spliced poles (Mod Poles) or stub reinforced poles shall not be used in crossings or clearance conflicts where Grade "A" construction is required. Additional applications and/or limitations for each method of pole reinforcement are found in the *DOH Manual*, Section PO, which should be reviewed when overhead design involves deteriorated facilities.

The following sections focus on poles that shall be replaced.

1. Methods of Identifying a Deteriorated Pole

   a. **Visual Inspection** — The Planner may inspect a pole and recommend replacement based on a visual inspection for any of these conditions:

- Aboveground condition of the pole
- Woodpecker area
- Major splitting of pole

b. **As-Found Deteriorated Pole** — Does not pass pole loading

- Third-party request for attachment.
- Pole does not have proper mid-point attachment circumference based on DDS-10, Table 10–1 through Table 10–4.

c. Intrusive Inspection (for poles greater than 15 years of age per *Pole Loading Manual*)

- "Intrusive" inspection involve drilling into the pole's interior in order to measure the extent of any internal decay, which is typically undetectable with external observation only.
- Pole is repaired/replaced based on its remaining strength.
- Request Wood Pole Intrusive Inspection if needed by going to the Intrusive Inspection Pole Request Letter in Design Support Planning Tools on SCE Portal.

2. Pole Loading Requirements

Transverse (often referred to as "bending or pole loading") and vertical load calculations will be performed in advance of constructing new and replacement poles. These load calculations will also be performed when adding conductors (including service wires), equipment to in-service structures, and Communications and CATV attachments. SCE's distribution facilities shall be designed to meet or exceed Grade "A" or "B" safety factors. Planners are responsible for performing pole-loading calculations in accordance with designated, current wind maps during the design process for the following:

a. New and replacement pole supporting only SCE facilities (SCE-only pole)

b. New and replacement poles supporting SCE facilities and facilities owned/operated by a Southern California Joint Pole Committee (SCJPC) member (jointly-owned pole)

c. New and replacement poles supporting SCE facilities and facilities owned/operated by Licensee/Tenant of SCE (joint-use pole)

d. Adding SCE facilities to SCE-only poles

e. Adding SCE facilities to jointly-owned or joint-use poles

Refer to DDS-10, Section 5.2 B., C., D., and Appendix 10–1 for details.

Exceptions

- Calculations are not required when replacing existing service wire with service wire that is equal sized and equal length (or no more than 25 feet longer than the original service).

- Calculations are not required when adding risers, switches (except Omni-Rupter®), fuseholders, surge arrestors, 13'-6", 15'-6" racks and crossarm(s).
- Calculations are not required for 13'-6", 15', and 17'-4" equipment racks.

Grandfather Rule — For poles set prior to January 1, 2003, apply the appropriate eight-pound (light) or six pound (heavy) loading criteria when performing the load calculation. See Table 10–14: Pole Loading — Grandfather Clause and New Design Criteria.

Table 10–14: Grandfather Clause and New Design Criteria

District Number	District Name	Prior to 1977 Design Criteria (Grandfather Clause) (lb)	1977-2002 Design Criteria (Grandfather Clause) (lb)	Starting January 1, 2003, New Design Criteria (Use Thomas Brothers Map) (lb)
Metro West				
32	Dominguez Hills	6 and 8 lb	6 and 8 lb	6 and 8 lb
42	Santa Monica	6 and 8 lb	6 and 8 lb	6 and 8 lb
44	South Bay	6 and 8 lb	6 and 8 lb	6 and 8 lb
46	Long Beach	6 and 8 lb	6 and 8 lb	6 and 8 lb
47	Whittier	6 and 8 lb	6 and 8 lb	6 and 8 lb
North Coast				
35	1,000 Oaks	6 and 8 lb	6 and 8 lb	6 and 8, and 12 lb
36	Antelope Valley	6 and 8 lb	6 and 8 lb	6 and 8, and 12 lb
39	Ventura	6 and 8 lb	6 and 8 lb	6 and 8, and 12 lb
49	Santa Barbara	6 and 8 lb	6 and 8 lb	6 and 8 lb
59	Valencia	6 and 8 lb	6 and 8 lb	6 and 8, and 12 lb
Rurals				
40	Arrowhead	6 and 8 lb	6 and 8 lb	6 and 8 lb
50	Shaver Lake	6 and 8 lb	6 and 8 lb	6 and 12 lb
52	Tehachapi	6 and 8 lb	6 and 8 lb	6 and 12 lb
53	Kernville	6 and 8 lb	6 and 8 lb	6 and 12 lb
72	Barstow	6 and 8 lb	12 lb	6 and 12 lb
84	29 Palms/Yucca Vly	6 and 8 lb	12 lb	12 lb
85	Bishop	6 and 8 lb	12 lb	6 lb
86	Ridgecrest	6 and 8 lb	12 lb	6 and 12 lb
87	Blythe	6 and 8 lb	12 lb	12 lb
San Joaquin				
51	San Joaquin	6 and 8 lb	6 and 8 lb	6 and 8 lb

Table 10–14: Grandfather Clause and New Design Criteria *(Continued)*

District Number	District Name	Prior to 1977 Design Criteria (Grandfather Clause) (lb)	1977-2002 Design Criteria (Grandfather Clause) (lb)	Starting January 1, 2003, New Design Criteria (Use Thomas Brothers Map) (lb)
Orange				
29	Santa Ana	6 and 8 lb	6 and 8 lb	6 and 8 lb
33	Huntington Beach	6 and 8 lb	6 and 8 lb	6 and 8 lb
43	Saddleback	6 and 8 lb	6 and 8 lb	6 and 8 lb
48	Fullerton	6 and 8 lb	6 and 8 lb	6 and 8 and 12 lb
61	Catalina	6 and 8 lb	6 and 8 lb	6 and 8 lb
Metro East				
22	Montebello	6 and 8 lb	6 and 8 lb	6 and 8 lb
26	Covina	6 and 8 lb	6 and 8 lb	6 and 8, 12 and 18 lb
27	Monrovia	6 and 8 lb	6 and 8 lb	6 and 8 and 12 lb
34	Ontario	6 and 8 lb	6 and 8 lb	6 and 8, 12 and 18 lb
Desert				
30	Foothill	6 and 8 lb	6 and 8 lb	6 and 8, 12 and 18 lb
31	Redlands	6 and 8 lb	6 and 8 lb	6 and 8, 12 and 18 lb
73	Victorville	6 and 8 lb	12 lb	6 and 8, and 12 lb
79	Palm Springs	6 and 8 lb	12 lb	8 and 12, and 18 lb
San Jacinto Valley				
77	Menifee	6 and 8 lb	6 and 8 lb	6 and 8 lb
88	Wildomar	6 and 8 lb	6 and 8 lb	6 and 8 lb

Note:

1. For poles set between January 1, 1977, and December 31, 2002, and located in the Barstow, Bishop, Blythe, Palm Springs, Ridgecrest, 29 Palms/Yucca Valley, or Victorville districts, apply the current 12 pound or 18 pound criteria when performing a pole-loading calculation. Elevation and heavy/light loading are not to be considered for this exception.

3. Design Criteria

   a. Pole Location

      When replacing a pole, the Planner must identify where the new pole is to be installed. When determining the new location, issues must be addressed, such as:

      - Pedestrian and Americans with Disabilities Act of 1990 (ADA) accommodations – Maintain a 36-inch minimum clearance, if space permits or at no additional cost or low cost minor work, between pole, attachments, and any obstructions.
      - Avoid pole placement in wheelchair ramp locations.
      - Obstructions at base of pole
      - Configuration of conductors, equipment and guys
      - Configuration of underground risers

- Positioning the pole to accommodate the riser transfer so as to avoid any civil construction.
- The location and number of risers may require for the new pole to be set in the same hole.
- Other utility cable and equipment
- Location of telephone and CATV junction boxes
- Planner must meet with other utilities and SCE telecom/Edison Carrier Solutions
- Risers with PILC will not be transferred. See DDS-13, Section 5.3.9 A for details.
- Location of easement and public rights-of-way
- Considering the heavy tree growth, a notation on the work order indicating that a tree crew will be required.

b. Clearances

Resolve impaired clearances in conjunction with pole replacements. These may include reduced clearances between rooftops and SCE conductors, low-service drops, and secondary conductors sagging into communication conductors. The placement of the pole or installing a taller pole may be required to resolve the issue.

c. Secondary Conductors

Secondary conductors, limited to one span in each direction of the scoped deteriorated pole, may be replaced through the Deteriorated Pole work order in the following situations:

- Open-wire secondary through trees.
- Bare, racked, secondaries.
- Multiple splices on a single span.
- Overloaded open-wire conductors.
- Maximum 1/0 AT shall be utilized in rear property lines if at all possible where truck access is not available.

d. Guying Adequacy

Guying is a General Order 95 (G.O. 95) compliance requirement. Each pole must comply with current guying calculations. Refer to DDS-10, Section 5.4.

e. Like-for-Like Pole Replacement

In many cases, a like-for-like pole replacement may be inappropriate. The following situations may require the Planner to modify the existing construction configuration to comply with G.O. 95, DDS, or DOH construction requirements.

1. **Pole Top Extension Installations** – When replacing a pole that has an existing pole-top extension, the new pole shall typically be taller than the existing pole to compensate for the extension.

2. **Combination Arms** — Generally, combination arm poles may require a one class stronger of a pole. Combination arms were installed to allow different voltages to occupy the same elevation on the pole. On 4 kV systems, the secondaries may have been installed at the 4 kV level. Often times, 12 kV and 4 kV conductors have been installed on each side of the same arm. While combination arms are an acceptable construction practice, consider eliminating combination arms when replacing the pole. Include the elimination of a combination arm when economically and physically possible in the design.

f. Transformers and Equipment

Where a deteriorated pole supports a transformer, the Planner must verify voltage drop and flicker to the End-of-Line (EOL) customer before proceeding with the actual design. In many situations, the work required to maintain EOL voltage drop will be outside the scope of the Deteriorated Pole Program, and the design will require the creation of associated work orders. Generally, the Deteriorated Pole Program budget is limited for work scope that is located one span in each direction form the originally scoped deteriorated pole. The Planner must take the following design criteria into consideration:

- Review the Transformer Load Management (TLM) and bring into compliance all transformers and overloaded transformers.
- Limit rear property line transformers to 50 kVA units due to the weight and handling of the units and the need to limit unnecessary pole replacements. If the pole has boom truck access, then a larger transformer can be installed.
- The installation of multiple transformers is preferable in installing a 75 kVA in a rear property line situation, if it requires a pole replacement.
- If multiple transformers are required, the Planner will determine appropriate transformer replacement based on meeting existing customer voltage drop and flicker criteria.
- Replacement transformers that are overloaded, underloaded, or 25 years or older based on the install range in DDS-7, Table 7–6.
- Obsolete equipment such as obsolete transformers, transformers over 25 years old, CP transformers, KPF/Cole switch, and damaged disconnects shall be replaced and not be transferred. Refer to DOH, PO 147 for details.
- The Planner must determine if transformers/equipment should be transferred to the new pole, removed, or replaced. Transferring equipment reduces the cost of the work order by lowering material costs.

- Limit transformers size for rear property line installations with no truck access to 50 kVA. Refer to DDS-10, Table 10–1 and Table 10–2 for details. For example, upsizing from a 50 kVA transformer to a 75 kVA transformer requires replacing the existing pole with a Class 3 pole per Table 10–1 requirements. Consider using multiple transformers in the design instead of pole replacement.

g. Avian Protection

For Avian-Safe Construction, refer to DDS-10, Section 5.6, N., and DOH, DC 535.

Where existing switches are replaced, an inverted Omni-Rupter® or Alduti-Rupter® switch shall be utilized. Before proceeding with a switch replacement, the Planner will first determine if the switch is required based on current DDS Standards. Detailed clearances required for Omni-Rupter® and Alduti-Rupter® switches can be found in DOH, AP 336.

An Environmental Screening Form is required for every work order and for each pole location within the work order. The Planner designing the project must complete the Environmental Form in the field.

If an Environmental Review is required, the competed form with requested documentation (including pictures) should be submitted for review immediately.

h. Work Order Accounting

If a pole-loading calculation indicates that an in-service pole must be replaced, it is important to know how the applicable replacement expenses are to be allocated.

An as-found, in-service pole that fails pole-loading calculations, a visual inspection, an intrusive inspections, or does need meet the criteria found in Table 10–1 through Table 10–4 is considered a **deteriorated pole** and expenses shall be allocated in the following manner:

- Emergency Wood Pole Replacement

  During storms, emergencies, or other events where it is impractical to perform load calculations in advance of installation, every effort will be made to utilize a suitable structure. However, load calculations must be performed by the Local Planning Department within 15 to 20 business days following the event.

  For all priority one conditions that require immediate pole change out, an Emergency Wood Pole Replacement work order will need to be issued to capture all costs associated with the change out. The pole change out will be planned and performed by the district personnel and is not subject to any scheduling constraints associated with the Deteriorated Pole Program. The Planner will need to notify the Deteriorated Pole Program Group of the required change out and submit a SCE Pole Inspection Form (26-571) and copy of the loading results page to the Deteriorated Pole Program Group.

•As-Is Poles

If an as-found, in-service pole fails pole loading or the criteria shown in DDS-10, Table 10–1 through Table 10–4, that pole shall be changed out on the Deteriorated Pole Program.

If an as-found, in-service pole passes pole loading and the criteria shown in DDS-10, Tables 10-1 through 10-4, but fails after the new equipment is added, the pole shall be changed out on the program responsible for the new equipment.

4. Deteriorated Pole Program Requirements

To facilitate the efficient replacement of thousands of poles each year, the work order designs must follow a consistent set of criteria. In this case, the Deteriorated Pole Project Manager has established the following exceptions:

a. Number of Poles

Poles should be grouped geographically and each work order will include eight (8) to ten (10) poles. Each pole and its replacement will be on a separate drawing. Each pole shall have an accompanying Environmental Screening Form as well as a Pedestrian Traffic Control Form.

b. Required Pictures

The following pictures are required for each pole:

- A close-up identifying the construction at the top of the pole.
- A close-up identifying the construction at the communications level.
- Photo of base of pole.
- Other pictures showing unusual conditions.
- Wide angle view picture depicting the following, if applicable — Environmental Surroundings, Point of Access, Roadway/Sidewalk, Pedestrian Traffic, and/or any unusual conditions.
- Pedestrian Traffic Control Plan where sidewalks existing showing traffic implications, if pedestrians have access to get on or get off.

c. Exception Poles

Poles that are not routine in nature and require special handling shall be separated from routine poles and labeled as "exception poles." To the extent that these poles are in the same geographical area, and involve similar environmental considerations, they may be grouped into a single work order.

For example, if six poles are all on the same public land and they have no foreseen issues, but a seventh pole is located in a stream bed, the six pole should be grouped together in a single work order and the seventh should be placed on its own work order.

The following are considered exception poles:

- Environmental Review

Based on the results of the Environmental Screening Form, the pole may require further assessment by an Environmental Specialist. Poles that require an Environmental Review are automatically considered, "Exception Poles." Poles found to inhabit endangered or protected species, or are located in environmentally sensitive areas, shall be deemed Environmental Poles and will require Environmental Review. If a Woodpecker-damaged pole will be replaced with a composite pole, refer to DDS-10, Section 3.2 B. All Woodpecker-damaged poles require an Environmental Review and each must be classified as an Environmental Pole.

- Riser with PILC

Transferring a PILC riser to a new pole is hazardous and shall not be done. The Planner, in conjunction with Engineering, will have to determine the most cost-effective approach to eliminate the PILC riser. This will require replacing the PILC with EPR cable or JCN cable and constructing a new riser on the new pole.

The cable replacement must be reviewed by Field Engineering, the Planning Supervisor, and the Deteriorated Pole Project Manager prior to proceeding with a design. Depending on the circuitry, it may be necessary to install new conduits from the riser pole to the first structure. This will involve looking up maps, permits, and coordination of the civil construction.

All of the costs associated with this rearrangement will be charged to the Deteriorated Pole Program or associated work orders. Once a PILC pole is identified, the following steps should be taken.

- Planner field visits the site and obtains all information and pictures. Planner realizes that this situation has created an "Exception Pole" and a separate work order is created for this pole.
- Planner contacts Field Engineering and Planning Supervisor to determine the scope of replacement. The scope will determine the appropriate cable and civil work necessary to replace existing PILC.
- Based on Engineering's recommendations, the Planner determines the extent of civil construction required to proceed with the pole replacement and completes the design.
- The Planner submits a scope change to the Deteriorated Pole Project Manager identifying the extent of work required, the estimated cost of the work, and a proposed due date for the completed design.
- Once the Deteriorated Pole Project Manager approves the scope change, the Planner Productivity Report and Tracker must be updated to indicate the agreed upon due date.

All PILC riser projects will be completed by the Technical Design Hub. Distribution of costs might have to be negotiated between infrastructure Replacement, District, and/or Engineering.

- "H" Frames

"H" Frames are normally utilized in areas where span lengths exceed standard single pole construction limitations. For these structures, if one pole has been identified as a deteriorated and the other pole is of the same vintage, then replace both poles. If vintages are different, and the non-deteriorated pole is greater than 15 years old, then proceed with replacement of both poles.

See construction standards for "H" frames in the *Transmission Overhead Construction (TOC) Standards Manual*.

- 13'-6", 15', and 17'-4" Racks (2-pole and 3-pole)

13'-6", 15', and 17'-4" racks are installed due to transformer/equipment weight limits exceeding single-pole construction.

When a deteriorated pole has been identified on a 13'-6", 15', and 17'-4" rack, the entire structure must be dissembled and replaced. The **13'-6" and 15' racks are obsolete and will not be reinstalled**. For retrofitting 13'-6" or 15' racks, contact Distribution Civil/Structural Engineering. The cost to replace the entire structure will be shared between the Deteriorated Pole Program and the appropriate Preventative Maintenance funding.

Before proceeding with the replacement, the Planner must first determine if the customer(s) load (TLM) still warrants the size of the equipment.

If the customer(s) load has been reduced, it may be possible to eliminate the rack and install a three-phase bank on a single pole.

For other equipment on 13'-6", 15', and 17'-4" racks, for example, regulators, capacitors, or pole-tope substations, consult Field Engineering.

Obsolete transformers/equipment should be replaced and brought into compliance.

Where a deteriorated pole has been identified on existing racks, the following criteria will apply:

- If one pole has been identified as deteriorated and the other pole or poles (for 3-pole applications) is of the same vintage, then replace the entire structure, including poles and racks.
- For 2-pole applications, if vintages are different and the non-deteriorated pole is greater than 15 years old, proceed with replacement of the entire structure, including poles and rack.
- For 3-pole applications, if vintages are different and any one of the non-deteriorated poles is greater than 15 years old, proceed with replacement of the entire structure, including poles and rack.

Refer to DOH, DC 640, for details on the 17'-4" racks.

- Helicopter Set Poles

Poles requiring a helicopter must be treated as Exception Poles. If multiple Helicopter poles are located within the same geographical area, they may be grouped into a single work order. For helicopter projects, the Planner must include the following additional information in the work order.

- **Located A Potential Lay-Down Area** — The Planner must identify a potential lay-down area that will provide sufficient space for delivery of the pole as well as landing of the helicopter. The Planner must make contact with the owner of the proposed lay-down area, discuss the specifics of the project, and obtain preliminary approval to utilize the site. The contact information will be included on the work order drawing. This area should be identified on the work order map along with the site's GPS coordinates.
- **Contact Aircraft Operations** — The Planner will contact Aircraft Operations and discuss the project with the Pilot/Manager on duty. Aircraft Operations can be contacted at PAX 11607. Based on the GPS coordinates, the size/weight of the pole, the Aircraft Operations Representative will provide advice on any possible helicopter limitations. The Planner will request a cost estimate from Aircraft Operations and include this amount in the work order estimate. If vintages are different, and the non-deteriorated pole is greater than 15 years old, proceed with replacement of the entire structure, including poles and rack.

- Pole Replacement that Require Difficult Permits

  Poles requiring difficult and lengthy permits will be considered Exception Poles. The following list provides examples of this situation.

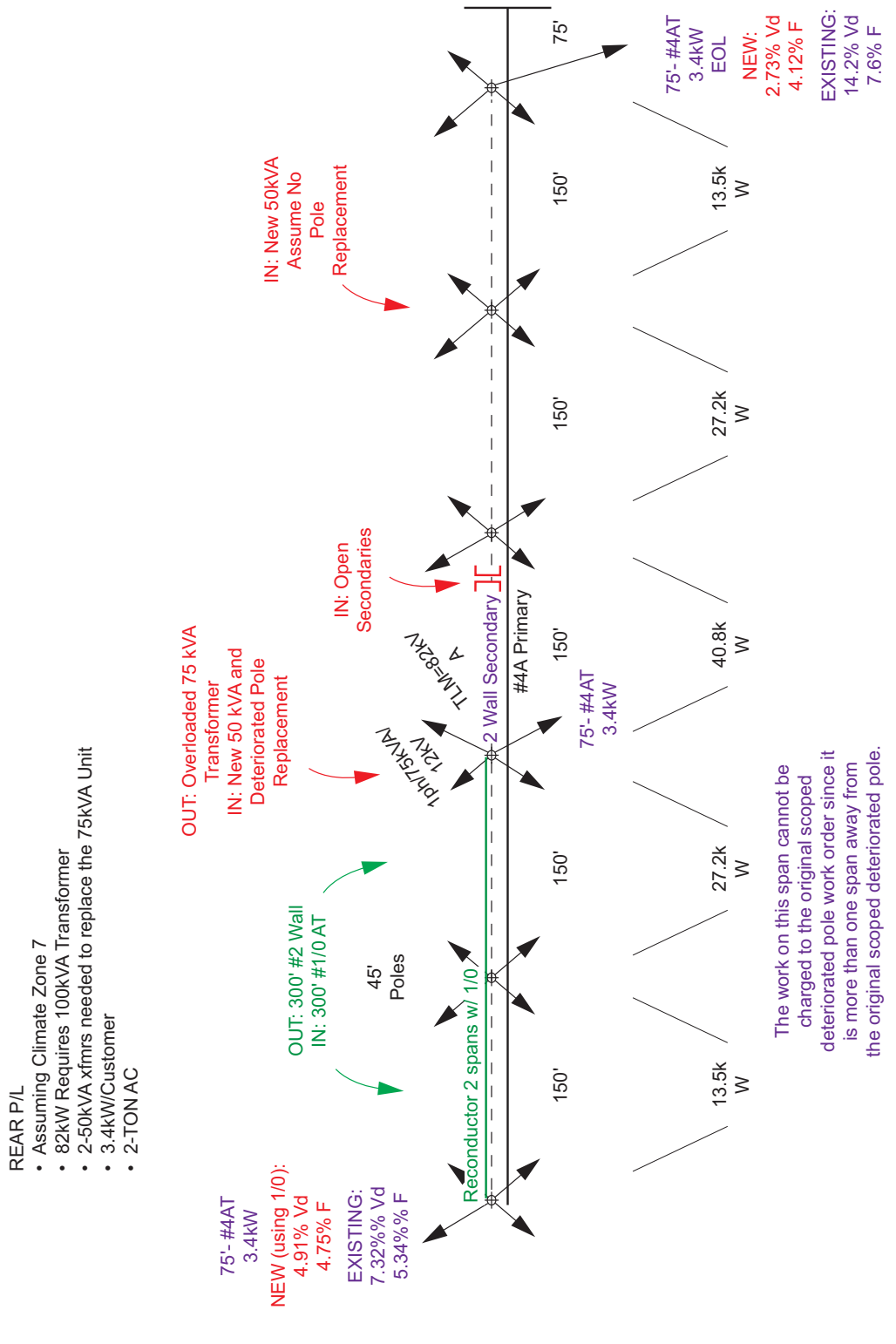
  - Rights Check
  - Public Rights-of-Way
  - Pedestrian Traffic Areas
  - Railroad
  - Flood control
  - Governmental Properties
  - Cal Trans
  - Forestry
  - Coastal Commission
  - Bureau of Land Management (BLM)
  - Native American Properties and Agencies
  - Bureau of Indian Affairs

The work order drawing for the permit shall include the following:

- Location of existing/new structure
- Accurate tie down
- Defined property lines and center lines
- Proximity to nearest intersection, curb face, and sidewalks

Example of EOL Considerations — Figure 10–6 shows a rear property line deteriorated pole that is scoped to be removed. The scoped pole has an existing 75 kVA transformer on it. After checking TLM, the Planner finds that the transformer must be replaced. The Planner chooses to install two 50 kVA units: one unit will be installed on the pole replacing the originally scoped deteriorated pole and the other 50 kVA transformer will be installed two spans away to the right. Furthermore, in checking voltage drop to the EOL customer, the customer electrically furthest from their service transformer, the Planner finds that the voltage drop is outside the criteria limits and, therefore, creates a separate work order to mitigate the voltage drop issues. However, the only work that is to be allocated to the Deteriorated Pole work order is the work within one span in each direction of the originally scoped deteriorated pole.

Figure 10–6: Example of Deteriorated Pole Scope with Other Associated Work



Q. Heavy Tree or Heavy Snow/Ice Loading Areas

Aerial abrasion resistance cable may be considered for heavy tree concentration areas. Consult Field Engineering for application.

R. Distribution Lines Subject to Government Jurisdiction

Note: DISTRIBUTION LINES INSTALLED AND OPERATED ON FEDERAL LANDS REQUIRE GOVERNMENTAL APPROVAL.

Permits and easements may be issued by the United States Department of the Interior. Permits may also be obtained from the Corps of Engineers, Department of the Army. These authorizations permit the Company to construct distribution facilities in accordance with specifications and location prints filed with these agencies. No physical changes in these facilities are permitted without first obtaining their permission.

To enable our Corporate Real Estate, and Law departments to prepare the data for addition, abandonment, modification, or revision when changes are proposed in the above-mentioned facilities, the following instructions are to be followed:

1. The supervisory and clerical forces should be acquainted with the facilities and their locations that are under license, permit, or easement.
2. Service Center Inventory Maps are marked to show the facilities that are under license, permit, or easement, and a statement noted on the map that no extensions, removals, or relocations are to be made on these facilities without prior government or management approval. The map supervisor arranges to have the Service Center Inventory Maps show this information.
3. Any proposed changes in the facilities under **license**, **permit**, or **easement** shall be recorded on the Distribution System Work Order forms and forwarded to management with a letter of explanation. The name of the government agency having jurisdiction over the facilities involved and the agency's file or designation number, if any, along with an explanation of the proposed changes, and the reasons therefore, should be **clearly stated** in the body of the, Distribution System Work Order.
4. Annually, the Service Center Superintendent will receive prints from the Corporate Real Estate Department showing line locations under distribution area permits from the United States Department of Agriculture. These prints are to be reviewed and corrected to show the current status of the line. Correction and return of the prints should be expedited, to ensure that the records of lines under jurisdiction of the Department of Agriculture are accurate for the prompt, correct, annual rental payments by the Right-of-Way and Land Department.

S. Combination Grounds-Power and Communication

Agreements have been made between the Southern California Edison Company and the communication companies listed below, and with the governmental agencies that grant the right to attach their facilities to Edison's secondary neutral ground wires.

- Pacific Telephone and Telegraph Company
- General Telephone Company

- Interstate Telephone Company
- California Water and Telephone Company
- Los Angeles County

The procedure for establishing combination grounds requires the telephone companies to submit copies of the Joint Pole Organization for approval by the Operation and Engineering Manager prior to any combination ground wire attachments.

T. Edison Communication Facilities on Distribution Poles

The following procedure is established for the handling of Edison communication facilities on distribution poles by distribution crews.

1. Scope of Work

These instructions cover (primarily) those cases where a distribution pole carrying Edison communications facilities is being replaced and, in a relatively few other cases where it may become necessary to relocate Edison communication facilities or an existing pole to provide clearance for additional distribution facilities. Communications crossarms carrying communication open-wire circuits may be transferred or relocated, and the open-wire conductors spliced, if necessary, by distribution crews.

2. Procedure

Service center management will notify the Transmission Division Superintendent and the Telecommunications Division Wire Chief before any work is performed on Edison open-wire communication lines. Upon receipt of such notification, it will be the responsibility of the Transmission and Telecommunications Divisions to issue any instruction necessary to prevent or minimize difficulties that may result from such work.

3. Open-Wire Splices

Every effort shall be made to avoid the cutting and splicing of communications open-wire conductors. If it is necessary to splice communication open- wire conductors, only approved splices or their electrical equivalent will be used.

U. Joint Use Applications, Joint Crossing Over and Extensions along Railroad Rights-of- Way

When Edison installs poles, in order to crossover or extend along railroad rights-of-way with conductor and/or guy wires, the railroad companies require that SCE formally execute agreements assuming certain conditions of liability and usually certain charges. The same requirements apply for conductors and/or guys supported on poles located adjacent to railroad rights-of-way.

The ruling is that such agreements provide for our poles and/or equipment only. When more than one facility owner is on the same poles, each facility owner involved in crossings or extensions is required to enter into its own agreements with the railroads.

Applications from any pole user requesting permission to purchase equities in poles under the Southern California Joint Pole Agreement, or to occupy poles under any other type of licenses or agreement, should not be approved until

the incoming party furnishes proof of granted permission for the encroachment. In the case of proposed joint ownership, SCE will consider that such evidence has been established if a statement is made in the authorization that the crossing permit has been granted. Any other types of proposed encroachment must be certified by letter from the other user. This letter should be forwarded to the Joint Pole Organization manager with the request for use of poles.

SCE must be certain to obtain its own crossing agreements when making crossings over, or extensions along, railroad rights-of-way, if they are to be supported on poles owned by another company.

5.7 Special Conditions

A. EMF Reduction

Electro-Magnetic Fields (EMFs) are an important issue in the area of environmental awareness. Edison is committed to reasonable, low-cost steps to install new facilities in a way that minimizes electric and EMFs in areas accessible to the general public.

Chapter DDS–11 and the "EMF" *Design Guidelines for New Electrical Facilities*: *Transmission, Substation, Distribution*," explain the policy of the Company regarding EMFs and outline measures for minimizing EMF exposure.

B. Right-of-Way Permits

Right-of-Way permits, easements, or other special construction permits may be required when installing, relocating, or rebuilding facilities along state highways, on private property, near airports, through national forests, on government lands, and along or crossing railroads. In all cases, the necessary easements, licenses, and permits shall be obtained from the proper authorities prior to starting construction. Other permits that may be required for the construction or relocation of facilities are listed below.

1. Hauling permits
2. Digging permits
3. Highway permits — state and county
4. Flood control permits
5. Coastal Zone Commission
6. Traffic control permits

C. Joint Pole

The proposed installation of poles, removal, relinquishment, replacement, and maintenance of joint poles shall be planned with all utilities and tenants operating in the area (members of the Joint Pole Committee). The purpose of joint planning is for all the utilities concerned to determine the most practical and economical method for accomplishing the desired results helping ensure that all utilities derive the maximum possible service at minimum costs. Participation in joint practices, shall be in accordance with The Joint Pole Agreement (refer to The *Joint Pole Routine Handbook Pole Prices and Salvage Values Authorized Costs*, Form SCE 14-413).

Rental agreements (with nonmembers) are made with agencies, for example, Cable TV companies, to rent space for facilities when enough surplus space and strength is available on the pole. These rental agreements are handled through Edison's Joint Pole Organization, a subset of the TDBU Design Organization.

"Request for Access" applications submitted by nonmember utilities for seeking attachment to solely-owned Edison poles and Edison space on jointly-owned poles will be approved, providing surplus space and strength is available and all requirements of *G.O. 95* are met. This policy includes attachment to transmission facilities.

Jointly used composite poles may require stepping by the telecommunication company. Contact the corresponding phone representative for requirements. Refer to the *Distribution Overhead Construction Standards (DOH) Manual*, Section PO 100 for pole stepping instructions.

D. Inductive Coordination

Under the provision of *G.O. 52*, *Notice of Intention* must be filed in certain cases with the Communication Utilities involved when Class H (5,000 V or greater) lines are to be built or rebuilt parallel to communication lines, or when crossing communication lines at an angle of 30 degrees or less. A notice is **not** required for communication lines in cable. Refer to the *Edison Policy & Procedure Central (EPPC)* 15.400.10 for instructions and examples for those communication lines where a *Notice of Intention* is required. Where the supply lines and communication lines are separated by the following minimum distance, a *Notice of Intention* is not required.

5,000 to 50,000 V — 600 feet
50,000 to 75,000 V — 750 feet

E. Crossings and Conflicts

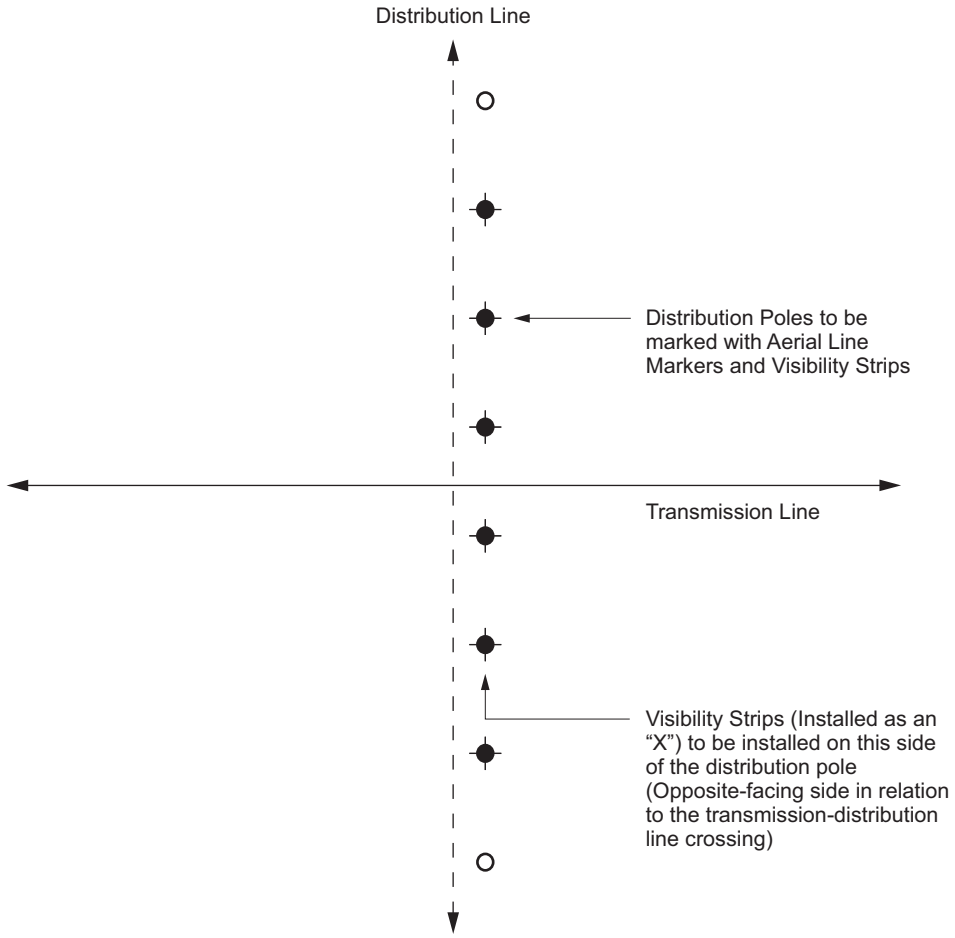
Distribution circuit conductors crossing divided state highways of four lanes or more, or freeways, shall be dead-ended at the crossing poles.

In the construction of new lines, care shall be taken to avoid all unnecessary crossings over other lines.

Conflicts (refer to the definition *G.O. 95*, Rule 21.7A) should not be created with the lines of other companies. Where it is not reasonably practical to maintain a sufficient separation of the lines, conflicts may, in many cases, be avoided by means of joint point construction.

Where transmission lines cross over distribution lines, Aerial Line Markers and 'X' Markers (visibility strips configured as an 'X', refer to DOH, Figure DC 538-2) shall be installed on the three (3) distribution poles immediately preceding and following the transmission-distribution line crossing to aid Air Ops during aerial line patrols. Planners shall contact the Air Ops Manager during the design stage to confirm the identified distribution poles that should be marked. Refer to Figure 10–7 and DOH, DC 538 for details.

Figure 10–7: Distribution Poles that Shall Be Marked at An Overhead Transmission-Distribution Line Crossing



F. Construction Near Airports

It is the obligation of the Southern California Edison Company to file a Notice of Proposed Construction or Alteration with governmental aviation agencies when it is the Company's intent to construct or alter a pole line, tower line, or any structure within the vicinity of an airport, heliport, or landing area that may affect navigable airspace.

Any aboveground construction or alteration of existing facilities within four miles of an airport, or one mile of a heliport, should be referred to Field Engineering to determine if the Company's Aeronautical Consultant in the Public Affairs Department should be contacted for an evaluation of its affect on the airspace and determination of necessary Federal Aviation Administration (FAA) permits except when:[1/]

1/ Always contact Field Engineering when constructing or altering overhead distribution lines spanning rivers, freeways, and canyons, or if in doubt.

1. No lateral or height change to the structure or lines is made
2. The structure or line height is decreased
3. In a congested urban area, the proposed construction/alteration is shielded by a structure or topographic feature of equal or greater height, for example, high-rise, trees, hill, and so on, such that the proposed construction/alteration would exist within 50 feet of the shield
4. If the land around the airport is flat, Field Engineering must be contacted only if the pole height exceeds the height shown in Table 10–15. (If the construction location is in hilly terrain, then contact Field Engineering regardless of pole height).

G. Non-SCE Antennas

1. These policies are applicable to poles at the time of construction or reconstruction and to non-SCE entities seeking to install an antenna or antenna site on SCE poles as either a Joint Owner (member of Southern California Joint Pole Committee) or as a Licensee.
   a. The terms "antenna" and "antenna site" means one device, or a combination of devices, that emit and/or receive radio frequency signals, including the support elements described in DOH, DC 222.
   b. Microwave antennas are prohibited on wood and light weight steel distribution poles.
   c. Antenna(s) that individually or collectively emit RF energy in excess of the FCC's General Population/Uncontrolled limits as set forth in 47 (C.F.R.) and described in OET Bulletin 65 are prohibited.
2. Installation Management Services manages non-SCE antenna attachments to TDBU poles.
3. TDBU Design Support administers policies and procedures for non-SCE attachments to distribution poles.
4. Joint Owners seeking to install antennas below SCE facilities (e.g. lines, equipment, guys) must seek access in accordance with the Southern *California Joint Pole Committee Agreement and Routine Handbook*.
5. Licensees seeking to install antennas below SCE facilities (e.g. lines, equipment, guys) must seek access in accordance with SCE's Pole License Agreement and Request for Access process.
6. All entities seeking to install antennas above SCE facilities (e.g. lines, equipment, guys) must seek access in accordance with the provisions of SCE's Pole-top License Agreement and Request for Access process.
7. Joint Owners and Licensees are responsible for inspecting and maintaining their antennas and associated facilities.
   a. SCE reserves the right to inspect non-SCE antenna installations and notify the Owner or Licensee at any time of unsafe work conditions and construction that is not compliant with SCE standards or GO 95 requirements.

b. Entities failing to correct unsafe conditions in a timely manner, may be reported to the California Public Utilities Commission's Consumer Protection and Safety Division; and/or billed for necessary remedial action undertaken by SCE.

H. SmartConnect Communication Devices

SmartConnect communication devices provide a solution to capture and transfer meter data information from SmartConnect meters located in RF Isolated locations. The SmartConnect Operations Center (SOC) will determine the geographical placement of these devices to achieve the required extended coverage. In all cases, it is necessary to maintain safe approach distances on the pole as determined by T&D.

SmartConnect has developed the following communication device options:

1. SmartConnect Socket Based Cell Relay

The Socket Based Cell Relay is an interim solution to support the Edison SmartConnect 2% Solution Project. These devices are mounted to a distribution pole and have the option to be placed either:

- Below the secondary voltage level; or,
- Above the secondary voltage level, provided all clearances are maintained from apparatus and conductors.

For further details on Socket Based Cell Relay, refer to DOH AP 720.

2. SmartConnect Broadband Global Area Network (BGAN) Satellite and Cell Relay (CR)

The BGAN Satellite assembly extends coverage for smart meters located in cellular isolated locations. Both the BGAN and CR shall be installed onto an assembly mounting bracket with an AC circuit breaker on the feed side of the device and a DC RF shut-off disconnect switch on the load side in the uninterruptible power supply (UPS) cabinet which powers the satellite terminal. Mount the complete communication device assembly onto a distribution wood pole at the secondary voltage level. Maintain all minimum construction and clearance requirements as specified in DOH AP 715.

Table 10–15: Pole Height Construction near Airports
Contact Field Engineering if Construction Exceeds Height Shown

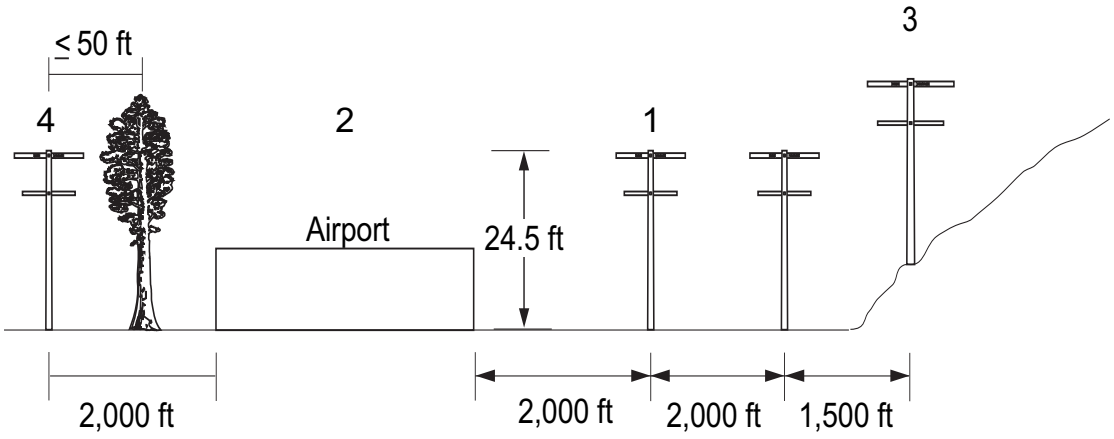
Distance from Airport/Heliport to Construction Site (ft)	Airport Pole Height above Ground (ft)	Heliport Pole Height above Ground (ft)
Under 500	Contact Field Engineering	Contact Field Engineering
500	Contact Field Engineering	20
1,000	Contact Field Engineering	40
1,500	Contact Field Engineering	60
2,000	20	80
2,500	25	100
3,000	30	120
3,500	35	140
4,000	40	160
4,500	45	180
5,000	50	200
6,000	60	No Contact Necessary
7,000	70	No Contact Necessary
8,000	80	No Contact Necessary
9,000	90	No Contact Necessary
10,000	100	No Contact Necessary
15,000	150	No Contact Necessary
20,000	200	No Contact Necessary
over 20,000	No Contact Necessary	No Contact Necessary
Note: Always contact Field Engineering when constructing or altering overhead distribution lines spanning rivers, freeways, and canyons, or if in doubt.		

EXAMPLE 1:

Thirty-foot poles are being placed as shown in Figure 10–8. According to Appendix 10–1, 24.5 feet of the pole will be aboveground. Pole number is determined by the following factors:

1. Pole height 24.5 feet — Table 10–15 indicates to contact Field Engineering when the pole is 2,000 feet from the airport and 20 feet or more aboveground
2. Pole height 24.5 feet — It is not necessary to contact Field Engineering as the pole is less than 40 feet aboveground. Table 10–15 indicates to contact Field Engineering if the pole is 4,000 feet from the nearest edge of the airport and 40 feet or more aboveground
3. Regardless of pole height, Field Engineering must be contacted since pole is not at same level as airport
4. Pole Height 24.5 feet — Not necessary to contact Field Engineering because of shielding from tree

Figure 10–8: Overhead Line Construction near Airports



I. Occupying Both Sides of Thoroughfares with Class H Circuits

In accordance with the last paragraph of Rule 31.3 of *General Order 95* of the Public Utilities Commission, Class H circuits shall not occupy both sides of thoroughfares except where special permission is obtained from the Public Utilities Commission. An exception might be when prior to such construction, the pole-setting line operator shall have filed with the CPUC a description of the route and configuration of the lines involved and copies of letters showing mutual consent for such occupancy by all pole-using line operators having service areas or routes in the vicinity of the thoroughfare concerned.

In order to comply with Rule 31.3 where it is contemplated that Class H circuits will occupy both sides of thoroughfares, contact the TDBU *G.O. 95* Representative and provide the following:

1. A sketch of the lines involved showing their general location with respect to other thoroughfares in the area. The sketch shall show existing and proposed Class H circuits, and shall show any communication lines occupying the thoroughfare under consideration.
2. An explanation of our desire to occupy both sides of the thoroughfare. Some of the reasons may be continuity of service (such as separate routes desirable to supply a given load or bad tree conditions along other alternate routes), no available alternate routes, or excessive mechanical loading of poles, if all wire facilities are placed on one pole line.
3. The names of the communication utilities serving in the area under consideration.

It should be noted that normally several weeks are required for the necessary correspondence with communication utilities and the CPUC. Therefore, the information required above should be submitted in writing at the earliest opportunity.

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 1 of 27)*

POLE LOADING GUIDELINES

- Pole-loading calculation will be performed and retained by the responsible SCE personnel when installing or replacing poles, increasing conductor size and/or span length (including service wire), or increasing equipment size.
- Pole-loading calculations must be performed by Joint Owners and Licensees when adding/upgrading their facilities (equipment, cables, and so forth); however, SCE's validation of these pole-loading calculations is not required.

Pole-loading calculation will **NOT** be required under the following circumstances:

- Replacing equipment or attachment of exact size and weight.
- For additions of risers, switches (except Omni-Rupters®), fuseholders, and/or crossarms.
- When changing existing service wire with new service wire that is the same length; however, when the replacement service wire exceeds the original length of wire by 25 feet, then a pole-load calculation must be performed. This holds true for any of SCE's service wire types.

An intrusive pole inspection will be performed when:

- No online record exist.
- Online existing record is older than 20 years.

NEW POLE DESIGN

Table 10–19, "Unguyed Composite Fiberglass Poles — Usable Strength" (Page 10–86) and Table 10–20, "Pole Strengths for Unguyed Western Red Cedar — Class 1-5 TDBU Standard" (Page 10–87) identifies the different types, sizes, and classes of poles purchased by Edison. It identifies the top and ground-line circumference; and the usable pole strength for six-, eight-, twelve-, and eighteen-pound wind areas. The usable strength values are for accommodating conductor pole loading. Loads on the pole itself have already been accounted for in the tables. Table 10–21 lists the conductor sizes, diameters, and pole loading per-linear-foot for the various pole-loading conditions. These tables may be used to calculate the class of pole required for a given span, or the maximum span for a given pole class and conductors.

Three examples using Table 10–19, Table 10–20 and Table 10–21 are included in this appendix beginning on Page 10–94.

Table 10–16: Safety Factors for Composite Poles — New and In-Service Construction

Type of Construction	Grade A Construction	Grade B Construction
New Construction	Safety Factor 4.0	Safety Factor 3.0
In-Service, including measured deterioration	Safety Factor 2.67	Safety Factor 2.0

Table 10–17: Safety Factors for Wood and Light Weight Steel (LWS) Poles — New and In-Service Construction

		New Construction		In-Service Construction	
Pole Type	Design Criteria (lb)	Construction Grade A Pole Load Safety Factor	Construction Grade B Pole Load Safety Factor	Construction Grade A Pole Load Safety Factor	Construction Grade B Pole Load Safety Factor
Wood	6	4.00	3.00	2.67	2.00
	8	4.00	3.00	2.67	2.00
	12	3.00	3.00	2.67	2.00
	18	3.00	3.00	2.67	2.00
LWS	6	2.50	1.88	1.50	1.50
	8	2.50	1.88	1.50	1.50
	12	2.50	1.88	1.50	1.50
	18	2.50	1.88	1.50	1.50
Guying Requirements		2.00	2.00	2.00	2.00

IN-SERVICE POLE DESIGN

Poles must be capable for supporting the dead load of the pole itself, crossarms, any attachments and equipment dead load, and the horizontal live loads caused by wind on the pole itself, plus the wind on the conductors, other attachments, and any equipment supported by the pole. **A new pole-load calculation, including allowances for deterioration, must be performed when the following scenarios occur:**

- Replacing a deteriorated wood structure
- SCE adds new equipment (for example, single or multiple transformers, capacitor banks, automatic reclosers), or adds/upgrades conductors
- SCE tenants transferring attachments
- Installing "Third Party" communication facilities (wire line or wireless)
- Pole-loading calculations must be performed by Joint Owners and Licensees when adding/upgrading their facilities (equipment, cables, and so forth); however, SCE's validation of these pole-loading calculations is not required.

The following items are needed in order to conduct a proper pole-load calculation:

- Perform an intrusive inspection — Record proper shell thickness or remaining section modulus (from below ground line up to 96 inches (eight feet) above ground line).

  Note: If there are no voids (pole passes), then consider the original bending moment to be equal to 100 percent of allowable strength.

  In order to determine if an online inspection record exists, go to the Passport (WMS) menu; enter D030. Type in "pole" in the equipment box, then tab over and enter the structure number, and hit Enter. Click on the reading tab, and hit Enter. Page up and down to locate inspection findings. If the pole passes, you can assume that the section modulus is equal to 100 percent. If there is no online inspection record then an intrusive inspection will have to be performed. Contact the Intrusive Inspection Program Manager in the Deteriorated Pole Program Group of the Distribution Project Management Organization for additional information.
- Determine remaining strength from intrusive inspection. An electronic remaining section modulus can be used to determine remaining strength from intrusive inspection. Use either the In-Service Loading Program or New Construction Loading Program as applicable.
- Determine the class and length of the existing structure. (You can locate this information on the brand located on the face of the wood pole or on similar adjacent poles.)
- Determine the length of the span between wood structures.
- Determine the height of each piece of equipment and conductor on the wood structure.

- Determine the size of each piece of equipment and conductor type(s).
- The preferred method to perform a pole-load calculation is by using SCE's Pole-Loading Software. The software can determine section modules on deteriorated wood poles. The software will determine the safety factor for a tangent and/or guyed structure.
- Determine conductor pole loading from Appendix 10–1, Table 10–21 (Page 10–88). Two examples using Table 10–19 and Table 10–20 are included in this appendix beginning on Page 10–94.
- Use new Pole Load Form to capture information to perform pole-load calculation, see Figure 10–9.

FORMULAS

$$\text{Wood bending moment} = 0.000264 \times \text{average fiber stress} \times \text{ground-line circumference}^3$$

$$\text{Safety Factor} = 3 \text{ for Grade B, 4 for Grade A construction}$$

$$\text{Moment from wind on pole} = \frac{PH^2[D + 2d]}{72}$$

P = wind load in pounds (lb) usually 8

H = height of pole above ground (feet)

D = ground-line diameter (inches)

d = top diameter (inches)

The Douglas-fir tree has a fiber stress value of 8,000 psi (average). Western red cedar tree has a fiber stress value is 6,000 psi (average).

Table 10–18: Unguyed Douglas-Fir Poles — Usable Strength Tables — Pole Strengths

Pole Length (ft)	ANSI Size Class	Setting Depth (ft)	Height above Ground (ft)	MIN Ground-Line Circumference/ DIA (in)	Top Circumference (in)	6 lb Pole Load		8 lb Pole Load		12 lb Pole Load	18 lb Pole Load
						Usable ft-lb Grade A	Usable ft-lb Grade B	Usable ft-lb Grade A	Usable ft-lb Grade B	Usable ft-lb Grade A & Grade B	Usable ft-lb Grade A & Grade B
						SF-4	SF-3	SF-4	SF-3	SF-3	SF-3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11 & 12)	(13 & 14)
25	5	5	20.0	25.8/8.2	19	8,430	11,465	8,204	11,240	10,788	10,111
30	5	5.5	24.5	27.7/8.8	19	10,142	13,872	9,794	13,523	12,826	11,780
35	5	6	29.0	29.0/9.2	19	11,376	15,666	10,878	15,168	14,171	12,677
40	H3	6	34.0	48.5/15.4	33	56,693	76,761	55,522	75,590	73,250	69,739
	H2	6	34.0	46.0/14.6	31	48,054	65,176	46,950	64,072	61,864	58,552
	H1	6	34.0	43.5/13.9	29	40,325	54,805	39,288	53,767	51,692	48,580
	1	6	34.0	41.0/13.1	27	33,458	45,581	32,487	44,610	42,668	39,755
	2	6	34.0	38.5/12.3	25	27,401	37,439	26,497	36,535	34,726	32,012
	3	6	34.0	36.0/11.5	23	22,107	30,314	21,268	29,475	27,799	25,285
	4	6	34.0	33.5/10.7	21	17,525	24,138	16,753	23,366	21,823	19,507
	5	6	34.0	31.0/9.9	19	13,605	18,846	12,900	18,140	16,730	14,614
45	H5	6.5	38.5	55.8/17.8	37	86,369	116,860	84,669	115,159	111,758	106,656
	H4	6.5	38.5	53.3/17.0	35	74,893	101,472	73,277	99,857	96,626	91,780
	H3	6.5	38.5	50.8/16.2	33	64,465	87,483	62,934	85,953	82,892	78,301
	H2	6.5	38.5	48.3/15.4	31	55,036	74,827	53,591	73,382	70,491	66,156
	H1	6.5	38.5	45.3/14.4	29	44,958	61,297	43,604	59,943	57,236	53,175
	1	6.5	38.5	42.8/13.6	27	37,554	51,340	36,285	50,072	47,534	43,729
	2	6.5	38.5	40.3/12.8	25	30,992	42,506	29,809	41,323	38,956	35,405
	3	6.5	38.5	37.3/11.9	23	24,141	33,280	23,049	32,188	30,004	26,729
	4	6.5	38.5	34.8/11.1	21	19,259	26,686	18,252	25,679	23,665	20,645
	5	6.5	38.5	32.3/10.3	19	15,062	21,005	14,141	20,083	18,240	15,475

Notes:

1. "Third Party" communication facilities (wire line or wireless) shall be pole loaded to Grade "A" Construction.
2. All solely owned SCE facilities (with no "Third Party" communications facilities attached to structure) shall be pole loaded to Grade "B" Construction.

Table 10–18: Unguyed Douglas-Fir Poles — Usable Strength Tables — Pole Strengths — *Continued*

Pole Length (ft)	ANSI Size Class	Setting Depth (ft)	Height above Ground (ft)	MIN Ground-Line Circumference/ DIA (in)	Top Circumference (in)	6 lb Pole Load		8 lb Pole Load		12 lb Pole Load	18 lb Pole Load
						Usable ft-lb Grade A	Usable ft-lb Grade B	Usable ft-lb Grade A	Usable ft-lb Grade B	Usable ft-lb Grade A & Grade B	Usable ft-lb Grade A & Grade B
						SF-4	SF-3	SF-4	SF-3	SF-3	SF-3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11 & 12)	(13 & 14)
50	H5	7	43.0	58.0/18.5	37	96,549	130,891	94,391	128,732	124,416	117,941
	H4	7	43.0	55.0/17.5	35	81,829	111,150	79,785	109,106	105,018	98,885
	H3	7	43.0	52.5/16.7	33	70,746	96,266	68,808	94,328	90,452	84,638
	H2	7	43.0	50.1/15.9	31	60,693	82,757	58,861	80,925	77,261	71,765
	H1	7	43.0	47.1/15.0	29	49,914	68,270	48,196	66,552	63,116	57,962
	1	7	43.0	44.6/14.2	27	41,953	57,549	40,341	55,937	52,713	47,878
	2	7	43.0	41.6/13.3	25	33,535	46,211	32,037	44,713	41,718	37,224
	3	7	43.0	38.6/12.3	23	26,285	36,430	24,901	35,047	32,279	28,128
	4	7	43.0	36.1/11.5	21	21,093	29,401	19,815	28,123	25,568	21,735
55	H5	7.5	47.5	59.8/19.0	37	104,734	142,314	102,065	139,645	134,307	126,301
	H4	7.5	47.5	57.3/18.2	35	91,641	124,727	89,101	122,187	117,108	109,490
	H3	7.5	47.5	54.3/17.3	33	77,411	105,615	75,011	103,215	98,414	91,213
	H2	7.5	47.5	51.4/16.4	31	64,699	88,526	62,437	86,265	81,742	74,958
	H1	7.5	47.5	48.9/15.6	29	55,205	75,739	53,073	73,607	69,343	62,947
	1	7.5	47.5	45.9/14.6	27	45,062	62,076	43,069	60,083	56,097	50,118
	2	7.5	47.5	42.9/13.7	25	36,201	50,122	34,347	48,268	44,560	38,998
	3	7.5	47.5	40.0/12.7	23	28,538	39,766	26,824	38,051	34,621	29,477
60	H6	8	52.0	64.5/20.5	39	131,505	178,747	128,097	175,339	168,525	158,302
	H5	8	52.0	61.6/19.6	37	113,361	154,389	110,120	151,148	144,666	134,943
	H4	8	52.0	58.6/18.7	35	96,928	132,312	93,854	129,238	123,089	113,865
	H3	8	52.0	56.1/17.9	33	84,469	115,545	81,550	112,626	106,787	98,028
	H2	8	52.0	53.1/16.9	31	70,966	97,375	68,213	94,621	89,115	80,856
	H1	8	52.0	50.2/16.0	29	58,940	81,174	56,354	78,587	73,414	65,654
	1	8	52.0	47.2/15.0	27	48,309	66,833	45,889	64,413	59,572	52,312
	2	8	52.0	44.3/14.1	25	38,991	54,242	36,738	51,988	47,481	40,720

Notes:

1. "Third Party" communication facilities (wire line or wireless) shall be pole loaded to Grade "A" Construction.
2. All solely owned SCE facilities (with no "Third Party" communication facilities attached to structure) shall be pole loaded to Grade "B" Construction.

Table 10–18: Unguyed Douglas-Fir Poles — Usable Strength Tables — Pole Strengths — ***Continued***

Pole Length (Ft)	ANSI Size Class	Setting Depth (Ft)	Height above Ground (Ft)	MIN Ground-Line Circumference/ DIA (in)	Top Circumference (in)	6 lb Pole Load		8 lb Pole Load		12 lb Pole Load	18 lb Pole Load
						Usable ft-lb Grade A	Usable ft-lb Grade B	Usable ft-lb Grade A	Usable ft-lb Grade B	Usable ft-lb Grade A & Grade B	Usable ft-lb Grade A & Grade B
						SF-4	SF-3	SF-4	SF-3	SF-3	SF-3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11 & 12)	(13 & 14)
65	H6	8.5	56.5	66.3/21.1	39	141,523	192,770	137,450	188,697	180,552	168,333
	H5	8.5	56.5	63.3/20.2	37	122,439	167,128	118,563	163,252	155,499	143,870
	H4	8.5	56.5	60.4/19.2	35	105,109	143,826	101,429	140,146	132,786	121,746
	H3	8.5	56.5	57.4/18.3	33	89,452	122,753	85,968	119,269	112,302	101,851
	H2	8.5	56.5	54.5/17.3	31	75,385	103,800	72,098	100,513	93,939	84,077
	H1	8.5	56.5	51.5/16.4	29	62,826	86,859	59,735	83,768	77,587	68,314
	1	8.5	56.5	48.5/15.5	27	51,694	71,820	48,800	68,926	63,137	54,453
	2	8.5	56.5	45.6/14.5	25	41,907	58,574	39,209	55,876	50,480	42,385
70	H6	9	61.0	67.6/21.5	39	148,604	202,928	143,813	198,138	188,558	174,187
	H5	9	61.0	65.1/20.7	37	131,978	180,547	127,401	175,970	166,816	153,085
	H4	9	61.0	62.2/19.8	35	113,725	155,982	109,377	151,634	142,937	129,892
	H3	9	61.0	59.2/18.9	33	97,189	133,705	93,070	129,586	121,347	108,988
	H2	9	61.0	55.8/17.8	31	79,968	110,499	76,093	106,624	98,874	87,248
	H1	9	61.0	52.8/16.8	29	66,864	92,798	63,217	89,152	81,859	70,920
	1	9	61.0	49.9/15.9	27	55,218	77,042	51,801	73,624	66,789	56,536
	2	9	61.0	46.9/14.9	25	44,950	63,122	41,761	59,933	53,555	43,989
75	H6	9.5	65.5	69.4/22.1	39	159,443	218,181	153,852	212,590	201,409	184,637
	H5	9.5	65.5	66.4/21.2	37	138,702	190,263	133,375	184,936	174,282	158,301
	H4	9.5	65.5	63.5/20.2	35	119,791	164,785	114,728	159,722	149,595	134,405
	H3	9.5	65.5	60.5/19.3	33	102,629	141,638	97,829	136,838	127,239	112,839
	H2	9.5	65.5	57.6/18.3	31	87,133	120,713	82,597	116,177	107,105	93,496
	H1	9.5	65.5	54.2/17.2	29	71,054	98,993	66,799	94,738	86,229	73,466
	1	9.5	65.5	51.2/16.3	27	58,883	82,502	54,892	78,511	70,529	58,556
	2	9.5	65.5	47.8/15.2	25	46,444	65,634	42,734	61,925	54,506	43,378

Notes:

1. "Third Party" communication facilities (wire line or wireless) shall be pole loaded to Grade "A" Construction.
2. All solely owned SCE facilities (with no "Third Party" communication facilities attached to structure) shall be pole loaded to Grade "B" Construction.

Table 10–18: Unguyed Douglas-Fir Poles — Usable Strength Tables — Pole Strengths — *Continued*

Pole Length (ft)	ANSI Size Class	Setting Depth (ft)	Height above Ground (ft)	MIN Ground-Line Circumference/ DIA (in)	Top Circumference (in)	6 lb Pole Load		8 lb Pole Load		12 lb Pole Load	18 lb Pole Load
						Usable ft-lb Grade A	Usable ft-lb Grade B	Usable ft-lb Grade A	Usable ft-lb Grade B	Usable ft-lb Grade A & Grade B	Usable ft-lb Grade A & Grade B
						SF-4	SF-3	SF-4	SF-3	SF-3	SF-3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11 & 12)	(13 & 14)
80	H6	10	70.0	70.7/22.5	39	167,079	229,214	160,637	222,772	209,888	190,562
	H5	10	70.0	67.7/21.6	37	145,635	200,320	139,493	194,179	181,897	163,474
	H4	10	70.0	64.8/20.6	35	126,051	173,909	120,211	168,069	156,388	138,868
	H3	10	70.0	61.9/19.7	33	108,249	149,871	102,710	144,332	133,254	116,636
	H2	10	70.0	58.4/18.6	31	89,630	124,725	84,412	119,507	109,071	93,418
	H1	10	70.0	55.5/17.7	29	75,398	105,448	70,482	100,531	90,697	75,947
	1	10	70.0	52.5/16.7	27	62,691	88,204	58,075	83,588	74,356	60,509
	2	10	70.0	49.1/15.6	25	49,665	70,515	45,371	66,220	57,631	44,748
85	H6	10.5	74.5	72.5/23.1	39	178,762	245,734	171,377	238,349	223,580	201,426
	H5	10.5	74.5	69.5/22.1	37	156,289	215,430	149,245	208,386	194,298	173,166
	H4	10.5	74.5	66.1/21.1	35	132,506	183,355	125,826	176,675	163,315	143,275
	H3	10.5	74.5	63.2/20.1	33	114,052	158,409	107,713	152,069	139,391	120,372
	H2	10.5	74.5	59.8/19.0	31	94,712	132,259	88,737	126,283	114,332	96,406
	H1	10.5	74.5	56.8/18.1	29	79,900	112,168	74,265	106,533	95,264	78,359
	1	10.5	74.5	53.4/17.0	27	64,567	91,360	59,296	86,089	75,548	59,735
	2	10.5	74.5	50.0/15.9	25	51,206	73,181	46,299	68,274	58,460	43,739
90	H6	11	79.0	73.8/23.5	39	186,963	257,661	178,587	249,284	232,531	207,401
	H5	11	79.0	70.9/22.6	37	163,756	226,335	155,763	218,342	202,355	178,374
	H4	11	79.0	67.4/21.5	35	139,157	193,127	131,572	185,543	170,373	147,619
	H3	11	79.0	64.5/20.5	33	120,039	167,254	112,837	160,052	145,649	124,044
	H2	11	79.0	61.1/19.5	31	99,965	140,079	93,172	133,287	119,701	99,323
	H1	11	79.0	57.7/18.4	29	82,141	115,905	75,757	109,521	96,754	77,603
	1	11	79.0	54.3/17.3	27	66,442	94,564	60,467	88,589	76,640	58,715
	2	11	79.0	51.3/16.3	25	54,608	78,402	49,016	72,811	61,627	44,851

Notes:

1. "Third Party" communication facilities (wire line or wireless) shall be pole loaded to Grade "A" Construction.
2. All solely owned SCE facilities (with no "Third Party" communications facilities attached to structure) shall be pole loaded to Grade "B" Construction.

Table 10–18: Unguyed Douglas-Fir Poles Usable Strength Tables Pole Strengths — *Continued*

Pole Length (ft)	ANSI Size Class	Setting Depth (ft)	Height above Ground (ft)	MIN Ground-Line Circumference/ DIA (in)	Top Circumference (in)	6 lb Pole Load		8 lb Pole Load		12 lb Pole Load	18 lb Pole Load
						Usable ft-lb Grade A	Usable ft-lb Grade B	Usable ft-lb Grade A	Usable ft-lb Grade B	Usable ft-lb Grade A & Grade B	Usable ft-lb Grade A & Grade B
						SF-4	SF-3	SF-4	SF-3	SF-3	SF-3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11 & 12)	(13 & 14)
95	H6	11	84.0	75.3/24.0	39	196,945	272,160	187,379	262,594	243,461	214,761
	H5	11	84.0	72.4/23.1	37	172,814	239,551	163,680	230,418	212,152	184,752
	H4	11	84.0	69.0/22.0	35	147,178	204,908	138,507	196,237	178,896	152,884
	H3	11	84.0	65.6/20.9	33	124,090	173,661	115,882	165,453	149,037	124,413
	H2	11	84.0	62.6/19.9	31	106,243	149,432	98,468	141,658	126,108	102,784
	H1	11	84.0	59.2/18.9	29	87,564	124,064	80,251	116,751	102,127	80,191
	1	11	84.0	55.3/17.6	27	68,854	98,625	62,034	91,805	78,165	57,705
	2	11	84.0	52.4/16.7	25	56,639	81,906	50,252	75,519	62,745	43,585
100	H6	11	89.0	76.9/24.5	39	207,182	287,090	196,336	276,243	254,550	222,009
	H5	11	89.0	73.9/23.5	37	182,117	253,183	171,757	242,822	222,102	191,021
	H4	11	89.0	70.5/22.5	35	155,433	217,084	145,592	207,244	187,562	158,041
	H3	11	89.0	67.1/21.4	33	131,360	184,467	122,039	175,147	156,505	128,542
	H2	11	89.0	63.7/20.3	31	109,772	155,164	100,971	146,363	128,760	102,357
	H1	11	89.0	60.2/19.2	29	90,542	129,004	82,261	120,723	104,160	79,315
	1	11	89.0	56.8/18.1	27	73,543	105,820	65,782	98,058	82,534	59,249
	2	11	89.0	53.4/17.0	25	58,650	85,442	51,408	78,200	63,715	41,989

Notes:

1. "Third Party" communication facilities (wire line or wireless) shall be pole loaded to Grade "A" Construction.
2. All solely owned SCE facilities (with no "Third Party" communication facilities attached to structure) shall be pole loaded to Grade "B" Construction.

Table 10–19: Unguyed Composite Fiberglass Poles — Usable Strength

Pole Length (ft)	ANSI Size Class	Height above Ground (ft)	Ground-Line Circumference/ DIA (in)	Top Circumference (in)	Usable Strength a/		Usable Strength b/	
					ft-lb Grade A Construction	ft-lb Pole Load Grade B Construction	ft-lb Grade A Construction	ft-lb Pole Load Grade B Construction
					SF-4	SF-3	SF-4	SF-3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
25	5	20.0	35/11.1	30	8,072	11,063	7,621	10,612
30	5	24.5	38/12.1	27	9,714	13,416	9,018	12,720
35	5	29.0	38/12.1	25	10,887	15,177	9,889	14,181
40	1	34.0	51/16.2	35	32,506	44,636	30,564	42,694
	2	34.0	50/15.9	34	26,513	36,557	24,704	34,748
	3	34.0	50/15.9	34	21,281	29,493	19,605	27,817
	4	34.0	48/15.3	32	16,764	23,381	15,220	21,837
	5	34.0	48/15.3	32	12,909	18,152	11,498	16,741
45	1	38.5	52/16.6	34	36,593	50,484	34,053	47,944
	2	38.5	52/16.6	34	30,359	41,660	27,686	39,287
	3	38.5	52/16.6	34	23,234	32,437	21,045	30,248
	4	38.5	52/16.6	34	16,198	22,943	16,380	23,858
	5	38.5	52/16.6	34	14,254	20,238	12,406	18,390
50	3	43.0	51/16.2	31	25,258	35,531	22,497	32,752
55	1	47.5	51/16.2	26	44,021	61,360	40,024	57,363
55	3	47.5	51/16.2	26	27,386	38,807	23,947	35,368
60	2	52.0	51/16.2	29	37,734	53,327	33,212	48,805
65	1	56.5	50/15.9	26	50,398	71,072	44,585	65,259
70	2	61.0	50/15.9	23	43,310	62,017	36,903	55,610

a\ Numerals indicate size classes normally stocked by Edison. Other sizes are available by special order only.

b\ Use columns 8 and 9 for 6-lb wind.

Table 10–20: Pole Strengths for Unguyed Western Red Cedar — Class 1-5 TDBU Standard

Pole Length (ft)	ASA Size Class	Height above Ground (ft)	Ground-Line Circumference \DIA (in)	Top Circumference \DIA (in)	Usable Strength ft-lb 8-lb Pole Load		Usable Strength ft-lb 12-lb Pole Load	
					Grade A Construction	Grade B Construction	Grade A Construction	Grade B Construction
					SF-4	SF-3	SF-4	SF-3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
25	5 a/	20.0	28.4/9.0	19/6.0	8,113	11,130	7,643	10,660
30	5 a/	24.5	30.2/9.6	19/6.0	9,449	13,081	8,725	12,357
35	5 a/	29.0	32.0/10.2	19/6.0	10,894	15,220	9,853	14,178
40	1	34.0	45.0/14.3	27/8.6	32,038	44,066	30,014	42,042
40	2	34.0	42.5/13.5	25/8.0	26,617	36,750	24,726	34,859
40	3	34.0	39.5/12.6	23/7.3	20,910	29,045	19,163	27,298
40	4	34.0	36.5/11.6	21/6.7	16,047	22,486	14,474	20,893
40	5 a/	34.0	34.0/10.8	19/6.0	12,621	17,809	11,149	16,337
45	1	38.5	47.3/15.1	27/8.6	36,622	50,599	33,963	47,940
45	2	38.5	44.3/14.1	25/8.0	29,507	40,991	27,031	38,515
45	3	38.5	41.3/13.1	23/7.3	23,339	32,645	21,047	30,353
45	4 a/	38.5	38.3/12.1	21/6.7	18,055	25,477	15,946	23,368
45	5	38.5	35.8/11.4	19/6.0	14,315	20,377	12,381	18,442
50	1	43.0	49.1/15.6	27/8.6	40,189	55,832	36,817	52,461
50	2	43.0	46.1/14.7	25/8.0	32,562	45,511	29,418	42,367
50	3	43.0	43.1/13.7	23/7.3	25,921	36,504	23,007	33,590
50	4 a/	43.0	39.6/12.6	21/6.7	19,291	27,501	16,623	24,832
55	1	47.5	50.9/16.2	27/8.6	43,941	61,379	39,754	57,192
55	2	47.5	47.9/15.2	25/8.0	35,788	50,322	31,881	46,415
55	3 a/	47.5	44.4./14.1	23/7.3	27,515	39,093	23,907	35,485
60	1	52.0	52.7/16.8	27/8.6	47,884	67,248	42,780	62,144
60	2 a/	52.0	54.1/17.2	25/8.0	39,193	53,545	33,041	48,800
65	1 a/	56.5	54.1/17.2	27/8.6	50,330	71,173	44,230	65,073
65	2 a/	56.5	50.6/16.1	25/8.0	39,799	56,849	34,123	51,173
70	1 a/	61.0	55.4/17.6	27/8.6	52,795	75,190	45,598	67,993
70	2 a/	61.0	51.9/16.5	25/8.0	41,827	60,238	35,124	53,535
75	1 a/	65.5	56.7/18.0	27/8.6	55,277	79,300	46,880	70,903
75	2 a/	65.5	53.2/16.9	25/8.0	43,870	63,711	36,042	55,884
80	1 a/	70.0	58.0/18.5	27/8.6	57,778	83,506	48,074	73,803
80	2 a/	70.0	54.5/17.3	25/8.0	45,927	67,271	36,873	58,218
85	1 a/	74.5	59.3/18.9	27/8.6	60,296	87,808	49,176	76,688
85	2 a/	74.5	55.3/17.6	25/8.0	46,264	68,574	35,929	58,240
90	1 a/	79.0	60.60/19.3	27/8.6	6,283	92,208	50,184	79,560
90	2 a/	79.0	56.60/18.0	25/8.0	48,273	72,208	36,509	60,444
95	1 a/	84.0	61.60/19.6	27/8.6	63,714	94,569	49,290	80,145
95	2 a/	84.0	57.60/18.3	25/8.0	48,825	74,050	35,399	60,625
100	1 a/	89.0	63.10/20.1	27/8.6	66,686	99,849	50,283	83,447
100	2 a/	89.0	59.10/18.8	25/8.0	51,120	78,428	35,893	63,147

a/ Numerals indicate size classes normally stocked by Edison. Other sizes are available by special order only. Western Red Cedar Class 1—5 are for reference only. Douglas-fir Class 1—5 will be standard for all new poles.

Table 10–21: Conductor Pole Loading

Conductor Size	DIA (in)	Pole Loading per Foot (lb/ft)			
		6-lb Heavy Load (above 3,000 ft)	8-lb Light Load	12-lb Light Load (See Note 1)	18-lb Light Load
954 kcmil All Al	1.124	1.062	0.753	1.124	1.686
795 kcmil All Al	1.026	1.013	0.687	1.026	1.539
795 kcmil ACSR	1.108	1.054	0.742	1.108	1.662
636 kcmil All Al	0.918	0.959	0.615	0.918	1.377
653.9 kcmil ACSR	0.953	0.977	0.639	0.953	1.430
477 kcmil All Al	0.793	0.897	0.531	0.793	1.190
336.4 kcmil All Al	0.666	0.833	0.446	0.666	0.999
336.4 kcmil ACSR	0.684	0.842	0.458	0.684	1.026
4/0 ALL Al	0.527	0.764	0.353	0.527	0.791
4/0 ACSR	0.563	0.782	0.377	0.563	0.845
4/0 Bare Copper	0.528	0.764	0.354	0.528	0.792
4/0 WP Copper	0.678	0.839	0.454	0.678	1.017
2/0 All Al or BC	0.419	0.710	0.281	0.419	0.629
2/0 ACSR	0.447	0.724	0.299	0.447	0.671
2/0 WP Copper	0.570	0.785	0.382	0.570	0.855
1/0 ACSR	0.398	0.699	0.267	0.398	0.597
1/0 Bare Copper	0.373	0.687	0.250	0.373	0.560
1/0 WP Al or Cu	0.493	0.747	0.330	0.493	0.740
No. 1 Bare Copper	0.332	0.666	0.222	0.332	0.498
No. 2 All Al or BC	0.292	0.646	0.196	0.292	0.438
No. 2 ACSR	0.316	0.658	0.212	0.316	0.474
No. 2 WP Al or Cu	0.386	0.693	0.259	0.386	0.579
No. 4 All Al	0.232	0.616	0.155	0.232	0.348
No. 4 ACSR	0.250	0.625	0.168	0.250	0.325
No. 4 Str BC	0.232	0.616	0.155	0.232	0.348
No. 4 Bare Copper	0.204	0.602	0.137	0.204	0.306
No. 4 WP Copper	0.329	0.665	0.220	0.329	0.494

Notes:

1. Each area is responsible for keeping a map on file that designates high-wind areas. Areas designated for 12-pound (70 mph) wind-loading design for new and rebuild projects should be known as "high-wind" areas, where 8-pound designs have proven inadequate. Line orientation (direction) with respect to the prevailing wind and sheltering features should be considered in determining which lines are designated for 12-pound design.
2. Horizontal pole loading per foot of conductor for conductors not listed above is determined by the following formulae:
   6-lb Light Loading = (Diameter + 1.0) × 0.5
   8-lb Light Loading = (Diameter ÷ 12) × 8
   12-lb Light Loading = (Diameter ÷ 12) × 12
   18-lb Light Loading = Diameter ÷ 12) × 18
3. Heavy-loading areas computed with 6-pound wind.
   Light-loading areas computed with 8-pound wind, 12-pound wind, or 18-pound wind.

Table 10-21: Conductor Pole Loading — *Continued*

Conductor Size	DIA (in)	Pole Loading per Foot (lb/ft)			
		6-lb Heavy Load (above 3,000 ft)	8-lb Light Load	12-lb Light Load (See Note 1)	18-lb Light Load
No. 6 Bare Copper	0.162	0.581	0.109	0.162	0.243
No. 6 WP Copper	0.287	0.644	0.192	0.287	0.431
No. 8 Bare Copper	0.1285	0.564	0.086	0.1285	0.193
No. 8 WP Copper	0.254	0.627	0.170	0.254	0.381
No. 6 Al Dup	0.450	0.725	0.302	0.450	0.675
No. 4 Al Dup	0.565	0.783	0.379	0.565	0.848
No. 4 Al Triplex	0.640	0.820	0.429	0.640	0.960
No. 2 Al Triplex	0.760	0.880	0.509	0.760	1.140
1/0 Al Triplex	0.990	0.995	0.663	0.990	1.485
4/0 Al Triplex	1.341	1.171	0.898	1.341	2.012
No. 4 Al Quad	0.848	0.924	0.568	0.848	1.272
1/0 Al Quad	1.120	1.060	0.750	1.120	1.680
4/0 Al Quad	1.490	1.245	0.998	1.490	2.235
No. 6 Cu Triplex	0.548	0.774	0.367	0.548	0.822
No. 4 Cu Triplex	0.646	0.823	0.433	0.646	0.969
No. 2 Cu Triplex	0.772	0.886	0.517	0.772	1.158
1/0 Aerial Cable	3.088	3.588	2.059	3.088	4.632
350 Aerial Cable	3.884	4.384	2.589	3.884	5.826
4/0 Aerial Cable	4.440	4.940	2.960	4.440	6.660
700 Aerial Cable	5.200	5.700	3.467	5.200	7.800
No. 2 Str. Aerial	3.040	3.540	2.027	3.040	5.100
No. 8 B.C. Aerial	3.040	3.540	2.027	3.040	5.100
Tree Wire Cable 1/0	0.661	1.161	0.441	0.661	0.992
Guys					
7/32 inch	0.219	0.610	0.147	0.219	0.329
1/4 inch	0.250	0.625	0.168	0.250	0.375
9/32 inch	0.281	0.641	0.188	0.281	0.422
5/16 inch	0.313	0.657	0.210	0.313	0.470
3/8 inch	0.375	0.688	0.251	0.375	0.563
7/16 inch	0.438	0.719	0.293	0.438	0.657

Notes:

1. Each area is responsible for keeping a map on file that designates high-wind areas. Areas designated for 12-pound (70 mph) wind-loading design for new and rebuild projects should be known as "high-wind" areas, where 8-pound designs have proven inadequate. Line orientation (direction) with respect to the prevailing wind and sheltering features should be considered in determining which lines are designated for 12-pound design.
2. Horizontal pole loading per foot of conductor for conductors not listed above is determined by the following formulae:
   6-lb Light Loading = (Diameter + 1.0) × 0.5
   8-lb Light Loading = (Diameter ÷ 12) × 8
   12-lb Light Loading = (Diameter ÷ 12) × 12
   18-lb Light Loading = Diameter ÷ 12) × 18
3. Heavy-loading areas computed with 6-pound wind.
   Light-loading areas computed with 8-pound wind, 12-pound wind, or 18-pound wind.

Table 10-21: Conductor Pole Loading — *Continued*

Conductor Size	DIA (in)	Pole Loading per Foot (lb/ft)			
		6-lb Heavy Load (above 3,000 ft)	8-lb Light Load	12-lb Light Load (See Note 1)	18-lb Light Load
Telephone Cable (Cont'd)	(Includes Messenger)				
25 Pair-5/16 Msgr	0.943	0.972	0.632	0.943	1.415
50 Pair-5/16 Msgr	1.153	1.077	0.773	1.153	1.730
100 Pair-5/16 Msgr	1.513	1.257	1.014	1.513	2.270
200 Pair-7/16 Msgr	1.938	1.469	1.298	1.938	2.907
400 Pair-7/16 Msgr	2.538	1.769	1.700	2.538	3.807
600 Pair-7/16 Msgr	2.938	1.969	1.968	2.938	4.407
900 Pair-7/16 Msgr	3.438	2.219	2.303	3.438	5.157
No. 9 Iron Wire	0.148	0.574	0.099	0.148	0.222
No. 12 Iron Wire	0.109	0.555	0.073	0.109	0.164
1/2" DIA - 1/4" Msgr	0.750	1.250	0.500	0.750	1.125
1/2" DIA - 5/16" Msgr	0.810	1.310	0.540	0.810	1.215
1/2" DIA - 7/16" Msgr	0.940	1.440	0.627	0.940	1.410
1/2" DIA - 1/2" Msgr	1.000	1.500	0.667	1.000	1.500
3/4" DIA - 1/4" Msgr	1.000	1.500	0.667	1.000	1.500
3/4" DIA - 5/16" Msgr	1.060	1.560	0.707	1.060	1.590
3/4" DIA - 7/16" Msgr	1.190	1.690	0.793	1.190	1.789
3/4" DIA - 1/2" Msgr	1.250	1.750	0.833	1.250	1.875
1" DIA - 1/4" Msgr	1.250	1.500	0.667	1.250	1.875
1" DIA - 5/16" Msgr	1.310	1.810	0.873	1.310	1.965
1" DIA - 7/16" Msgr	1.440	1.940	0.960	1.440	2.160
1" DIA - 1/2" Msgr	1.500	2.000	1.000	1.500	2.250
1.25" DIA - 1/4" Msgr	1.500	2.000	1.000	1.500	2.250
1.25" DIA - 5/16" Msgr	1.560	2.060	1.040	1.560	2.340
1.25" DIA - 7/16" Msgr	1.690	2.190	1.127	1.690	2.535
1.25" DIA - 1/2" Msgr	1.750	2.250	1.167	1.750	2.625
1.5" DIA - 1/4" Msgr	1.750	2.250	1.167	1.750	2.625
1.5" DIA - 5/16" Msgr	1.810	2.310	1.207	1.810	2.715

Notes:

1. Each area is responsible for keeping a map on file that designates high-wind areas. Areas designated for 12-pound (70 mph) wind-loading design for new and rebuild projects should be known as "high-wind" areas, where 8-pound designs have proven inadequate. Line orientation (direction) with respect to the prevailing wind and sheltering features should be considered in determining which lines are designated for 12-pound design.
2. Horizontal pole loading per foot of conductor for conductors not listed above is determined by the following formulae:
   6-lb Light Loading = (Diameter + 1.0) × 0.5
   8-lb Light Loading = (Diameter ÷ 12) × 8
   12-lb Light Loading = (Diameter ÷ 12) × 12
   18-lb Light Loading = Diameter ÷ 12) × 18
3. Heavy-loading areas computed with 6-pound wind.
   Light-loading areas computed with 8-pound wind, 12-pound wind, or 18-pound wind.

Table 10-21: Conductor Pole Loading — *Continued*

Conductor Size	DIA (in)	Pole Loading per Foot (lb/ft)			
		6-lb Heavy Load (above 3,000 ft)	8-lb Light Load	12-lb Light Load (See Note 1)	18-lb Light Load
Telephone Cable (Cont'd)	(Includes Messenger)				
1.5" DIA - 7/16" Msgr	1.940	2.440	1.293	1.940	2.910
1.5" DIA - 1/2" Msgr	2.000	2.500	1.333	2.000	3.000
2" DIA - 1/4" Msgr	2.250	2.750	1.500	2.250	3.375
2" DIA - 5/16" Msgr	2.310	2.810	1.540	2.310	3.465
2" DIA - 7/16" Msgr	2.440	2.940	1.627	2.440	3.660
2" DIA - 1/2" Msgr	3.000	3.500	2.000	3.000	4.500
2.5" DIA - 1/4" Msgr	2.750	3.250	1.833	2.750	4.125
2.5" DIA - 5/16" Msgr	2.810	3.310	1.873	2.810	4.215
2.5" DIA - 7/16" Msgr	2.940	3.440	1.960	2.940	4.410
2.5" DIA - 1/2" Msgr	3.000	3.500	2.000	3.000	4.500
3" DIA - 1/4" Msgr	3.250	2.750	1.500	2.250	3.375
3" DIA - 5/16" Msgr	3.310	3.810	2.207	3.310	4.965
3" DIA - 7/16" Msgr	3.440	3.940	2.293	3.440	5.160
3" DIA - 1/2" Msgr	3.500	4.000	2.333	3.500	5.250
3.5" DIA - 1/4" Msgr	3.750	4.250	2.500	3.750	5.625
3.5" DIA - 5/16" Msgr	3.810	4.310	2.540	3.810	5.715
3.5" DIA - 7/16" Msgr	3.940	4.440	2.627	3.940	5.910
3.5" DIA - 1/4" Msgr	4.000	4.500	2.667	4.000	6.000
4" DIA - 1/4" Msgr	4.250	4.750	2.833	4.250	6.375
4" DIA - 5/16" Msgr	4.310	4.810	2.873	4.310	6.465
4" DIA - 7/16" Msgr	4.440	4.940	2.960	4.440	6.660
4" DIA - 1/2" Msgr	4.500	5.000	3.000	4.500	6.750

Notes:

1. Each area is responsible for keeping a map on file that designates high-wind areas. Areas designated for 12-pound (70 mph) wind-loading design for new and rebuild projects should be known as "high-wind" areas, where 8-pound designs have proven inadequate. Line orientation (direction) with respect to the prevailing wind and sheltering features should be considered in determining which lines are designated for 12-pound design.
2. Horizontal pole loading per foot of conductor for conductors not listed above is determined by the following formulae:
   6-lb Light Loading = (Diameter + 1.0) × 0.5
   8-lb Light Loading = (Diameter ÷ 12) × 8
   12-lb Light Loading = (Diameter ÷ 12) × 12
   18-lb Light Loading = Diameter ÷ 12) × 18
3. Heavy-loading areas computed with 6-pound wind.
   Light-loading areas computed with 8-pound wind, 12-pound wind, or 18-pound wind.

Figure 10–9: Pole Loading Worksheet No. 1

Color Code:
Orange 3/8 Blue 9/32
Green 7/32

Pole Loading Worksheet

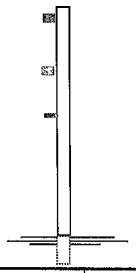
SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company

Wood Pole Information

District Name _____ City _____
Pole Number Ex. _____ NEW _____
Substation _____
Circuit Name _____ ___kV
Planner Name _____ T.G. Pg. _____
Date Perf. Pole loading _____
Wood Species Ex_____New_____
Length of Pole Ex_____New_____
Class of Pole Ex_____New_____
Year Set Ex_____New_____

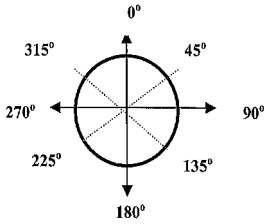
Ahead - Feet Back - Feet





Dimensions

Brand Location Height _____
G.L. Circumference (in.) Ex_____New____
Previously Inspected _____
Shell Thickness @____ _____
W/L Design to (lbs) _____
Line Direction _____



Latitude _____ Longitude _____ Elevation _____

Assign Guy #	Owner	Attachments		Span Length		Angle (in Degrees)		Attachments
	CATV &/or Comm.	Type/Size	Height (Ft.) Off Set /	Ahead (Ft.)	Back (Ft.)	Ahead	Back	Quantity

Equipment Type	Size & Description	Attachment Height	Transverse Offset	Number of Attachments

Guy #	Size	Angle From Line	BI or DE	Attach Height	Queen Post Height	Lead of Length	Guys

Pole Loading Worksheet form W/Xarms / MS Word.doc – Rev. 5/9/2010

Figure 10–10: Pole Loading Worksheet No. 2

Pole Loading Worksheet Addendum

Pole Number from Front Page _____

Additional Attachment Entries

Assign Guy #	Size	Attachments		Span Length		Angle (in Degrees)		Attachments
	CATV &/or Comm.	Type/Size	Off Set / Height (Ft.)	Ahead (Ft.)	Back (Ft.)	Ahead	Back	Quantity

Additional Guying Entries

Guy #	Size	Angle From Line	BI or DE	Attach Height	Queen Post Height	Lead of Length	Guys

Pole Loading Worksheet form W/Xarms / MS Word.doc – Rev. 5/9/2010

The first three examples are for new pole sets only. Example 4 (Page 10–97) and Example 5 (Page 10–100) are for in-service pole attachments.

The following three examples show how these formulas are used with Table 10–19 and Table 10–21.

EXAMPLE 1:

To use a 55-foot pole under the following conditions, what class of pole is necessary?

1. Light-loading area (eight-pound wind)
2. Grade A construction
3. Length of span (1/2 of each adjacent span) = 150 feet
4. Conductors/cables

Level	Size	Number	Height above Ground
Top	653.9 kcmil ACSR	3	48'
Second	336 ACSR	3	44'
Communications	100 pr. 24 AWG Cable	1	29'-6"

Calculation(s):

To calculate the total horizontal loading of conductors on a pole, use the following formula:

From Table 10–19, "Unguyed Composite Fiberglass Poles — Usable Strength" (Page 10–86), Column 6, a 55-foot pole meeting the minimum dimensions of ASA Class 3 will have a usable strength of 27,386 ft-lb with a safety factor of 4 for Grade A construction. This is adequate to support the calculated load of 27, 210 ft-lb.

Conductor Size	Load per Foot[a/] (lb)	×	No. of Conductors	×	Span (ft)	×	Height above Ground (ft)	=	Total Horizontal Load (ft-lb)
653.9 kcmil	0.635	×	3	×	150	×	48	=	13,716
336 ACSR	0.456	×	3	×	150	×	44	=	9,029
100 pair AWG	1.009	×	1	×	150	×	29.5	=	4,465
								Total	**27,210**

[a/] See Table 10–21.

EXAMPLE 2:

Determine the maximum span that a Class 4, 45-foot pole will support under the following conditions:

1. Heavy-loading area (6-pound wind)[a/]
2. Grade B construction
3. Conductors

Level	Size	Number	Height above Ground
Top	336 ACSR	3	38'-6"
Second	#2 ACSR	3	34'-6"

Calculations:

To determine the maximum span, first calculate the horizontal load per foot of span. Use the following formula:

Conductor Size	Load-per-Foot[a/]	×	No. of Conductors	×	Height above Ground (ft)	=	Horizontal Load per Foot of Span (lb)
336 ACSR	0.842	×	3	×	38.5	=	97.25
#2 ACSR	0.658	×	3	×	34.5	=	68.10
						Total	**165.35**

[a/] See (Table 10–21).

Calculation(s):

Once the total horizontal load-per-foot of span has been calculated, then the maximum span is calculated using the formula below.

Usable Pole Strength (ft-lb)	÷	Total Horizontal Load-per-Foot of Span (lb)	=	MAX Span
22,943[a/]	÷	165.35	=	139 ft

[a/] Usable pole strength for 8-lb wind Table 10–19, Columns 8 and 9 are used for 6-lb wind.

From Table 10–19, "Unguyed Composite Fiberglass Poles — Usable Strength" (Page 10–86), Column 7, select a 45-foot, Class 4 pole with a usable pole strength of 22,943 ft-lb in Grade B construction. Divide the usable pole strength by 165.35, the Total Horizontal load-per-foot of span. This equals a maximum span of 139 feet.

EXAMPLE 3:

Determine the class of a 45-foot wood pole to be used under the conditions listed below.

1. Light-loading area (12-lb wind)
2. Grade A construction
3. Length of span (1/2 of each adjacent span) = 250 feet
4. Conductors/Cables

Level	Size	Number	Height above Ground
Top	#4 ACSR[a/]	3	38'
Second	1/0 ACSR	4	32'
Communication(s)	200 pair	1	24'

[a/] No approved for use on new construction.

Calculation(s):

To determine the class of pole, first calculate the total horizontal loading on the pole. Use the following formula:

Conductor Size	Load-per-Foot[a/]	×	No. of Conductors	×	Height above Ground (ft)	×	Span (ft)	=	Total Horizontal Load (ft-lb)
4 ACSR	0.250	×	3	×	38	×	250	=	7,125
1/0 ACSR	0.398	×	4	×	32	×	250	=	12,736
200 Pair	1.938	×	1	×	24	×	250	=	11,628
								Total	**31,489**

[a/] See Table 10–21.

From the pole strength Table 10–19, a Class 2, 45-foot pole with a usable strength of 38,956 ft-lb in a 12-pound wind area would be required for this job. The new Safety Factor requirement for a new wood pole installation is 3.00 in a 12 pound design area. See Table 10–15.

Note: The SAP Number for a Class 2, 45-foot pole is 10060852.

EXAMPLE 4:

To use an 80-foot pole under the following conditions, determine if the pole still meets minimal safety factor.

1. Light loading area (8-lb wind)
2. Grade A construction (because it includes communications)
3. Length of span (1/2 of each adjacent span) = 182 feet
4. Number of conductors and/or cables (visual identification)
5. Class and Length = 2/80 (pole brand)
6. Ground-line Circumference = 50.5 inches (online record or physical measurement), top circumference = 25 inches from Table 10–18
7. Species of wood = Douglas-fir
8. Shell thickness at ground line = 1 inch (intrusive inspection record)
9. Fiber stress average value for Douglas-fir = 8,000 (6,000 for Western Red Cedar)
10. Wood moment formula = (0.000264) × (average fiber stress value) × (groundline circumference)^3
11. Equipment-load formula = (width of equipment) × (height of equipment) × (quantity of equipment) × (pole-load design [lb]) × (height of attachment)
12. For CATV and fiberoptics, estimate the load per foot by visually estimating the cable diameter in inches and then multiplying a factor of 0.67 for 8-lb pole load. See Notes of Table 10–21.

Calculation Example 4:

Moments from Wind on Conductors

Conductor Size	Load-per-Foot[a/]	×	No. of Conductors	×	Height above Ground (ft)	×	Span (ft)	=	Total Horizontal Load (ft-lb)
653.9 ACSR	0.635	×	1	×	69	×	182	=	7,974
653.9 ACSR	0.635	×	1	×	65	×	182	=	7,512
653.9 ACSR	0.635	×	1	×	61	×	182	=	7,050
653.9 ACSR	0.635	×	2	×	51	×	185	=	11,788
336.4 ACSR	0.436	×	1	×	51	×	182	=	4,233
653.9 ACSR	0.635	×	2	×	46	×	182	=	10,632
653.9 ACSR	0.635	×	2	×	41	×	182	=	9,477
Fiberoptics[b/]	0.335	×	2	×	25	×	182	=	3,049
25 pair	0.629	×	1	×	25	×	182	=	2,862
100 pair[c/]	1.009	×	1	×	24	×	75	=	1,816
								Total	**66,393**

a/ See Table 10–22.
b/ Visual estimate of cable diameter is 0.5 inch. Load-per-foot = diameter × 0.67 for an eight pounds pole load = 0.335
c/ New attachment

Moments from Wind on Pole

$$\text{Moments from Wind on Pole} = \frac{P(H_{op})^2[C + 2c]}{72\pi}$$

P = 8-lb pole load

(H_{op}) = 70 feet (height of pole above ground). See Table 10–19.

C = 50.5 inches (ground-line circumference)

c = 25 inches (top circumference)

$$\text{Moments from Wind on Pole} = \frac{8 \times 70^2[50.5 + 2 \times 25]}{226.2}$$

$$= 17{,}417 \text{ ft-lb}$$

Calculations Example 4: [Page 10–97] — *Continued*

Wood Pole Moment

$$\text{Wood Pole Moment} = 0.000264 \times (A_{fs})C^3$$

(A_{fs}) = 8,000 - lb average fiber stress for Douglas Fir

C = 50.5 inches, ground line circumference

$$\text{Wood Pole Moment} = 0.000264 \times 8{,}000 \times 50.5^3$$
$$= 272{,}000 \text{ ft-lb}$$

Void Moment

$$\text{Void Moment} = 0.000264 \times (A_{fs})[C - 2\pi(S_t)]^3$$

(A_{fs}) = 8,000 - lb average fiber stress for Douglas fir

C = 50.5 inches, ground line circumference

(S_t) = 1 inch, Shell thickness

$$\text{Void Moment} = 0.000264 \times 8{,}000 \times [50.5 - 6.2832 \times 1]^3$$
$$= 182{,}581 \text{ ft-lb}$$

Safety Factor

$$\text{Safety Factor} = \frac{\text{Wood Pole Moment} - \text{Void Moment}}{\text{Moments from Wind on (Conductor + Pole)}}$$
$$= \frac{272,000 - 182,581}{66,393 + 17,417}$$
$$= 1.07$$

Result

The minimum in service safety factor for Grade A construction, including measured deterioration is 2.67. See Table 10–16.

The calculated 1.07 Safety Factor is below 2.67; therefore, replace the pole.

EXAMPLE 5:

To use a 55-foot pole under the following conditions, determine if pole still meets minimal safety factor.

1. Light-loading area (8-pound wind)
2. Grade A construction (because it includes communications)
3. Length of span (1/2 of each adjacent span) = 150 feet
4. Number of Conductors and/or Cables (visual identification)
5. Class and Length = 3/55
6. Groundline circumference = 41 inches (online record or physical measurement), top circumference = 23 inches from Table 10–18.
7. Species of wood = Douglas-fir
8. Shell thickness = 1.5 inches (intrusive inspection record)
9. Fiber stress average value for Douglas-fir = 8,000
10. Wood Moment Formula = (0.000264) × (average fiber stress value) × (ground-line circumference^3)
11. Equipment-load Formula = (width of equipment) × (height of equipment) × (quantity of equipment) × (pole load design-lb) × (height of attachment)
12. For CATV and fiberoptics, estimate the load-per-foot by visually estimating the cable diameter in inches and then multiplying a factor of 0.67 for 8-pound pole load. See the Notes of Table 10–21.

Calculations Example 5:

To calculate the total horizontal loading of conductors on a pole, use the following formula:

Moments from Wind on Conductors

Conductor Size	Load-per-Foot[a/]	×	No. of Conductors	×	Height above Ground (ft)	×	Span (ft)	=	Total Horizontal Load (ft-lb)
653.9 ACSR	0.635	×	3	×	48	×	150	=	13,716
336.4 ACSR	0.436	×	3	×	44	×	150	=	9,029
100 pair	1.009	×	1	×	29.5	×	150	=	4,465
								Total	**27,210**

[a/] See Table 10–22.

Moments from Wind on Pole

$$\text{Moment from Wind on Pole} = \frac{P(H_{op})^2[C + 2c]}{72\pi}$$

P = 8-pound pole load

(H_{op}) = 47.5 feet, height of pole above ground. See Table 10–19.

C = 41 inches, ground-line circumference

c = 23 inches, top circumference

$$\text{Moment from Wind on Pole} = \frac{8 \times 47.5^2[41 + 2 \times 23]}{226.2}$$

$$= 6{,}942 \text{ ft-lb}$$

Calculations Example 5: [Page 10–100] — *Continued*

Moment from Wind on Equipment

Moment from Wind on Equipment $= (W_e) \times (H_e) \times P \times (H_a) \times Q$

W_e = 2.5 feet, width of equipment. See Table 10–2.

H_e = 2.5 feet, height of equipment. See Table 10–2.

P = 8-pound pole load

H_a = 38 feet, height of attachment

Q = 2, quantity of equipment (2–37.5 kVA transformers)

Moment from Wind on Equipment $= 2.5 \times 2.5 \times 8 \times 38 \times 2$

$= 3{,}800$ ft-lb

Wood Pole Moment

Wood Pole Moment $= 0.000264 \times (A_{fs})C^3$

(A_{fs}) = 8, 000-pound average fiber stress for Douglas fir

C = 41 inches, ground-line circumference

Wood Pole Moment $= 0.000264 \times 8{,}000 \times 41^3$

$= 145{,}561$ ft-lb

Void Moment

Void Moment $= 0.000264 \times (A_{fs})[C - 2\pi(S_t)]^3$

(A_{fs}) = 8, 000-pound average fiber stress for Douglas fir

C = 41 inches, ground-line circumference

(S_t) = 1.5 inches, shell thickness

Void Moment $= 0.000264 \times 8{,}000 \times [41 - 6.2832 \times 1.5]^3$

$= 66{,}486$ ft-lb

Safety Factor

$$\text{Safety Factor} = \frac{\text{Wood Pole Moment} - \text{Void Moment}}{\text{Moments from Wind on (Conductor + Pole + Equipment)}}$$

$$= \frac{145{,}561 - 66{,}486}{27{,}210 + 6{,}942 + 3{,}800}$$

$$= 2.08$$

Result

The minimum in service Safety Factor for Grade A construction, including measured deterioration, is 2.67. See Table 10–16.

The calculated 2.08 Safety Factor is below 2.67, therefore, replace the pole.

DEAD-END REQUIREMENTS

Table 10–22, when used with Figure 10–11, provides the data necessary to determine crossarm requirements for dead-ending.

Table 10–22: Crossarm Dead-Ending Requirements for Copper and ACSR Conductors

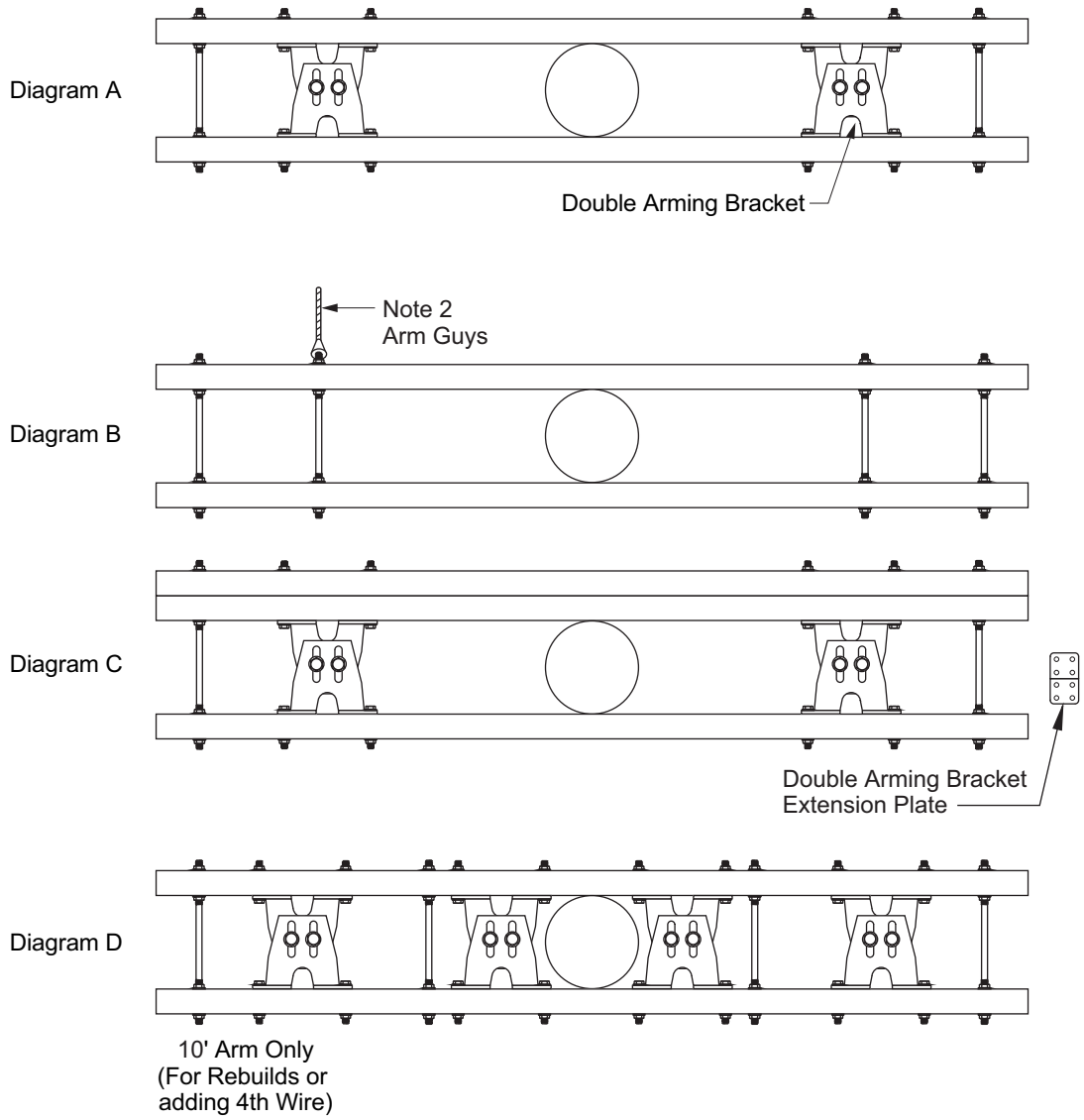
Wire Size	6 Conductor 10' Arm	4 Conductor 10' Arm	4 Conductor 8' Arm	2 Conductor 5' Arm	3 Conductor 10' Arm	3 Conductor 8' Arm
No. 4 b/ ACSR	Double Arm	Double Arm	Double Arm	Single Arm	Single a/ Arm	Single a/ Arm
No. 2 ACSR	Double Arm	Double Arm	Double Arm	Single Arm	Double Arm	Single a/ Arm
1/0 ACSR	Dia. A	Double Arm	Double Arm	Double Arm	Double Arm	Double Arm
4/0 ACSR	Dia. B	Dia. C or Dia D	Dia. C			
336.4 kcmil ACSR	Dia. B	Dia. C or Dia D	Dia. C		Dia. A	Dia. A
653.9 kcmil ACSR	Dia. B	Dia. B or Dia C	Dia. B		Dia. C	Dia. C
No. 6 Copper	Double Arm	Double Arm	Single Arm	Single Arm	Single a/ Arm	Single a/ Arm
No. 4 Copper	Double Arm	Double Arm	Double Arm	Single Arm	Single a/ Arm	Single a/ Arm
No. 2 Copper	Double Arm	Double Arm	Double Arm	Single Arm	Double Arm	Double Arm
2/0 Copper	Dia. B or Dia. C	Dia. A	Dia. A		Double Arm	Double Arm
4/0 Copper	Dia. B	Dia. B, C, D	Dia. B		Dia. A	Dia. A

a/ Not approved for heavy loading

b/ Not approved for use on new construction.

Note: See Figure 10–11 for special dead-end construction relating to Diagram A, Diagram B, Diagram C, and Diagram D.

Figure 10–11: Dead-End Construction Diagrams



NOTES:

1. Double-arming brackets may be used on poles with diameters of 6-3/4" to 10-1/2". For poles with diameters of 10-1/2" to 17-1/2", use extension plate with double-arming brackets.
2. Arm guys shall be 3/8" backed-up by 3/8" anchor guys per the *DOH Manual,* Section PO.
3. For Diagram A, Diagram C, and Diagram D use anchor guys only.

Limiting Deviation Angles on Crossarms/Insulators

When the deviation angle exceeds the **limiting deviation angle**, then dead-end construction shall be used. Again, the **limiting deviation angle** is the angle above which side tension exceeds the *G.O. 95* Safety Factor for insulators and hardware.

Table 10–23 may be used to determine the limiting deviation angle allowed for 12/16/33 angle construction using single or double crossarms with angle pin-type insulators. Table 10–24 provides the limiting deviation angles for angle construction in heavy-loading areas above 5,000 feet using single or double crossarms with angle pin- or post-type insulators. Table 10–25 provides limiting deviation angles for secondary multiplex construction. Table 10–27 is used to calculate the deviation angle of a pole line based on the span and the "out-of-line" pole distance.

Table 10–23: Limiting Deviation Angle for 12 kV, 16 kV, and 33 kV Angle Pole Construction

Conductor Size		Limiting Deviation Angle	
ACSR	Copper	Single Arm (degrees)	Double Arm (degrees)
No. 4[a/]	No. 6	45	60
No. 2	No. 4	30	60
1/0	No. 2	20	40
4/0[a/]	2/0	10	20
336.4 kcmil	4/0	7	14
653.9 kcmil	—	7	14

[a/] Not approved for use on new construction.

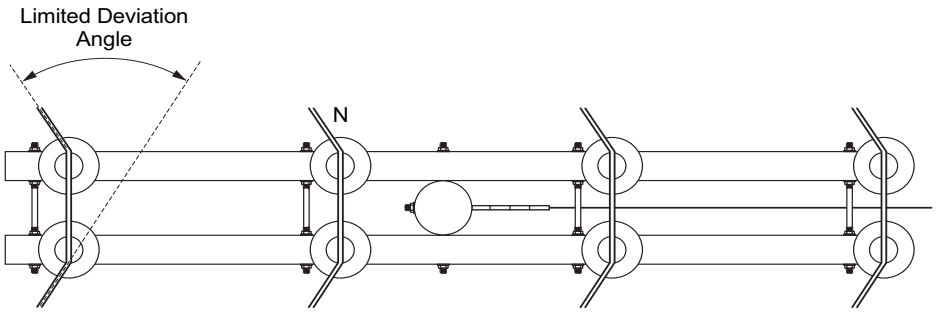


Table 10–24: Limiting Deviation Angle for 12 kV, 16 kV, and 33 kV Angle Pole Construction in Heavy-Loading Areas above 5,000 Feet

Conductor Size ACSR	Limiting Deviation Angle			
	Steel Pin-Type Insulator		Post-Type Insulator	
	Single Arm (degrees)	Double Arm (degrees)	Single Arm (degrees)	Double Arm (degrees)
653.9 (18 × 3) a/	3	6	9	18
1/0 (7 × 1) a/	10	20	25	50
336.4 (30 × 7) a/	3	6	7	14
336.4 (18 × 1) a/	6	12	15	30

a/ Aluminum Strands versus Steel Strands

Table 10–25: Limiting Deviation Angle for Secondary Multiplex Construction

Angle on Spool

Conductor Size		Limiting Deviation Angle	
Al	**Cu**	**Outside (degrees)**	**Inside (degrees)**
1/0	–	40	30
4/0	–	20	20

Angle on Crossarm

Conductor Size		Limiting Deviation Angle	
Al	**Cu**	**Outside (degrees)**	**Inside (degrees)**
1/0	–	15	30
4/0	–	7	15

Note: On double arms use double pins.

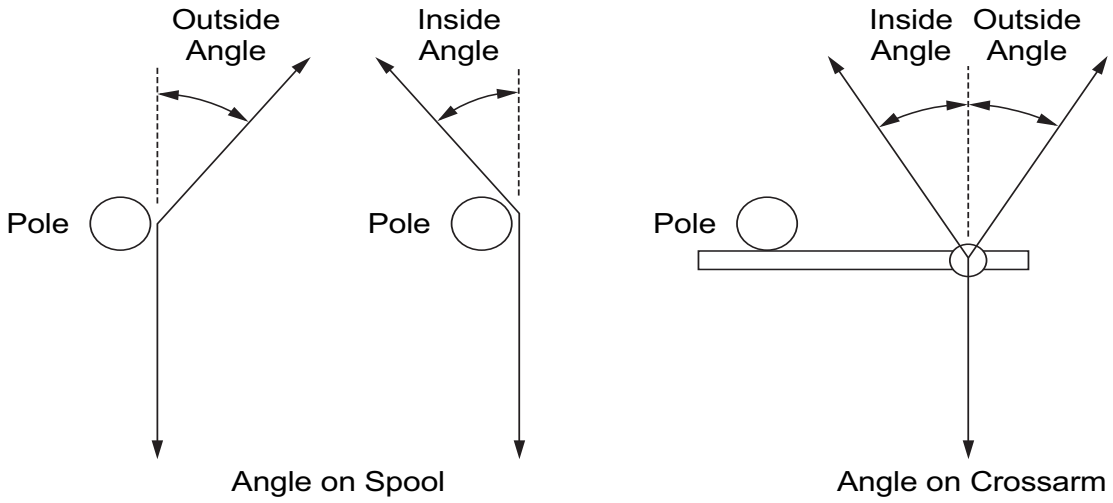


Table for Determining the Maximum Line Deviation or Elevation Angle for Switches

This table should be used to determine the allowable line or elevation angle for each conductor size when using KPF type, single- or double-arm, line-torsion switches. Line-angle switches shall be used where the line or elevation angle is exceeded to a maximum of 45 degrees. Omni-Rupter® switches should be used for installation having a line or elevation angle greater than 45 degrees.

Table 10–26: MAX Line Deviation or Elevation Angle for Switches

Allowable Line Deviation or Elevation Angle for Line-Torsion Type (KPF) Switches											
Circuit Voltage	Copper					ACSR					
	#6	#4	#2	2/0	4/0	#4[a/]	#2	#1/0	4/0[a/]	336	654
	Allowable Line or Elevation Angle										
12 kV	26°	16°	11°	6°	4°	16°	11°	8°	4°	4°	3°
16 kV 34.5 kV	19°	12°	8°	4°	3°	12°	8°	6°	3°	3°	2°

[a/] Not approved for use on new construction.

Line-angle switches shall be used where the allowable angle is exceeded. The maximum angle for these switches is 45 degrees.

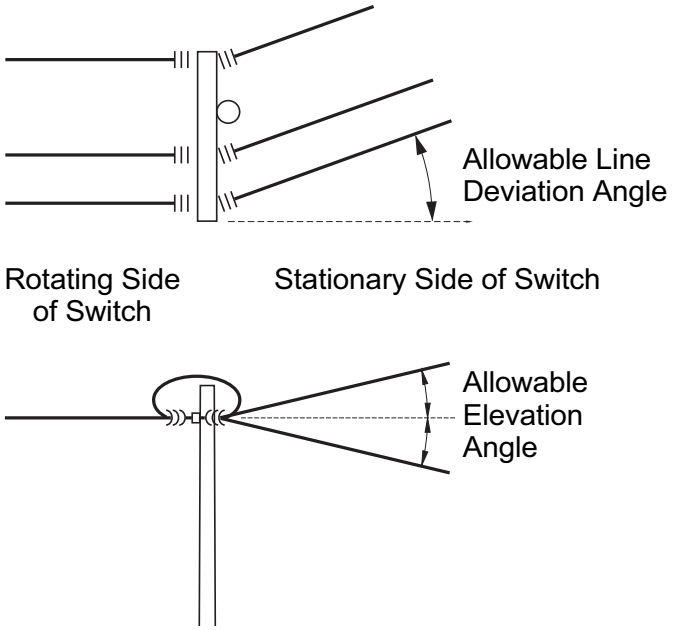
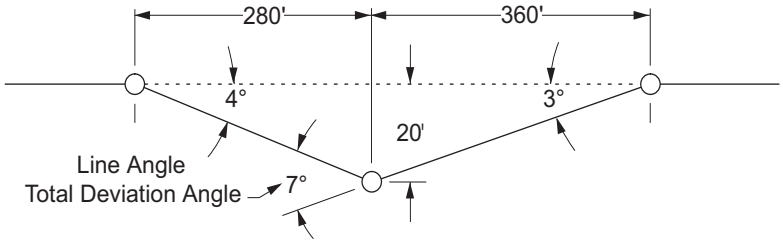


Table 10–27: Determination of Line Deviation Angles

Line Deviation Angle (degrees)	Span (ft)															
	100	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**	**320**	**340**	**360**	**380**	**400**
1°	1.5	2	2.5	2.8	3	3.5	3.8	4	4.5	4.8	5	5.5	6	6.3	6.6	7
2°	3.5	4	5	6	6.5	7	8	8.5	9	10	10.5	11	12	12.5	13	14
3°	5	6	7.5	8	9.5	10	12	13	14	15	16	17	18	19	20	21
4°	7	8	10	11	13	14	15	17	18	20	21	22	24	25	27	28
5°	8.5	10	12	14	16	17	19	21	23	25	26	28	30	31	33	35
6°	10.5	13	15	17	19	21	23	25	27	29	32	34	36	38	40	42
7°	12	15	17	20	22	25	27	29	32	34	37	39	42	44	47	49
8°	14	17	19	22	25	28	31	34	37	39	42	45	48	51	53	56
9°	16	19	22	25	29	32	35	38	41	44	48	51	54	57	60	63
10°	18	21	25	28	32	35	39	42	46	49	53	56	60	63	67	71
11°	19	23	27	31	35	39	43	47	51	54	58	62	66	70	74	78
12°	21	26	30	34	38	43	47	51	55	60	64	68	72	77	81	85
13°	23	28	32	37	42	46	51	55	60	65	69	74	78	83	88	92
14°	25	30	35	40	45	50	55	60	65	70	75	80	85	80	85	100
15°	27	32	38	43	48	54	59	64	70	75	80	86	91	96	102	107
16°	29	34	40	46	52	57	63	69	75	80	86	92	97	103	109	115
17°	31	37	43	49	55	61	67	73	79	86	92	98	104	110	116	122
18°	32	39	45	52	58	65	71	78	84	91	97	104	110	117	123	130
19°	34	41	48	55	62	69	76	83	90	96	103	110	117	124	131	138
20°	36	44	51	58	66	73	80	87	95	102	109	116	124	131	138	146
21°	38	46	54	61	69	77	84	92	100	107	115	123	131	138	146	154
22°	40	48	57	65	73	81	89	97	105	113	121	129	137	145	154	162
23°	42	51	59	68	76	85	93	102	110	119	127	136	144	153	161	170
24*	45	53	62	71	80	89	98	107	116	125	134	142	151	160	169	178
25°	47	56	65	75	84	93	103	112	121	131	140	149	159	169	177	187
26°	49	59	68	78	88	98	107	117	127	137	146	156	166	176	185	195
27°	51	61	71	82	92	102	112	122	132	143	153	163	173	183	194	204
28°	53	64	74	85	96	106	117	128	138	149	160	170	181	191	202	213
29°	55	67	78	89	100	111	122	133	144	155	166	177	188	200	211	222
30°	58	69	81	92	104	115	127	139	150	162	173	185	196	208	219	231

Out-of-Line Distance (ft)

Example



Problem: For span lengths of 280 feet and 360 feet and an *out-of-line* distance of 20 feet, determine the **line angle** and the **total deviation angle**.

Solution:

1. Look in the table under a span of 360 feet for an *out-of-line* distance **closest** to 20 feet; (in this case, it is 19 feet) (shaded area).
2. Look to the left of 19 feet, the line angle is 3°(shaded).
3. Look in the table under a span of 280 feet for an *out-of-line* distance of 20 feet (shaded).

Appendix 10–3: Guying Tables and Examples *(Sheet 1 of 12)*

The tables in this appendix provide the data necessary to determine proper guying requirements. Included is information addressing downguys, side guys, span guys, and sidewalk guys. See the examples following the tables.

Determination of Conductor Dead-end Tension

Table 10–28 lists the dead-end tension of conductors for California light- or heavy-loading conditions. The dead-end tension must be multiplied by the number of conductors to determine the total dead-end tension for guying.

Table 10–28: Conductor Dead-End Tension

Conductor Size/Type (Solid or Stranded)	Wire Size (kcmil or AWG)	Wire Tension at Dead-End (lb)
		Distribution
ACSR	#4[a/]	604
	1/0	1,415
	336.4 kcmil	2,846
	653.9 kcmil	3,267
Copper Triplex	#4	484
	#2	761
Aluminum Triplex or Quadruplex	1/0	1,415
	4/0	2,780
Weather-Resistant Copper	#6	375
	#4	540
	#2	830
	2/0	1,590
	4/0	2,455
Bare Copper	#6	320
	#4	484
	#2	761
	2/0	1,482
	4/0	2,288

[a/] Not approved for use on new construction.

Determination of Conductor Side Tensions

Table 10–29 is used to calculate the resultant-side tension per conductor when the deviation angle of the conductors is known. When this table is used with Table 10–33 and Table 10–34, the proper guy wire size may be determined. To determine the deviation angle, use Table 10–30. Example 3 (Page 10–120) illustrates the use of side guys.

Table 10–29: Conductor Tension for Side Guying Angle Poles

Conductor Size/Type (kcmil or AWG)		Deviation Angles (degrees)						
		10	20	30	40	50	60	70
		Tension (lb)						
ACSR	#4[a/]	105	210	313	413	510	604	693
	1/0	247	491	732	968	1,196	1,415	1,623
	336.4	496	988	1,473	1,947	2,406	2,846	3,265
	653.9	569	1,134	1,691	2,234	2,761	3,267	3,747
Copper Triplex	#4	85	168	250	331	409	484	555
	#2	133	265	394	521	643	671	873
Water-Resistant or Bare Copper	#6	56	111	166	219	271	320	367
	#4	85	168	250	331	409	484	555
	#2	133	265	394	521	643	761	873
	2/0	259	515	767	1,015	1,254	1,483	1,700
	4/0	400	796	1,187	1,568	1,938	2,290	2,630
Aluminum Triplex and Quadruplex	1/0	247	491	732	968	1,196	1,415	1,623
	4/0	484	965	1,439	1,901	2,349	2,780	3,189

[a/] Not approved for use on new construction.

EXAMPLE:

See shaded areas—one 1/0 ACSR conductor at a deviation angle of 30 degrees has a side tension of 732 pounds (see shaded areas).

Determination of Deviation Angle

To determine the deviation angle, use Table 10–30 as follows. Measure any convenient distance from 20 to 60 feet as a continuation of the line in one direction. This distance will correspond to "A" in Table 10–30. Next, measure the distance at right angles to this extension until the line in the new direction is encountered. This will correspond to "B" in Table 10–30 below. The deviation angle is used with Table 10–29 to determine the resultant conductor tension on an angle pole.

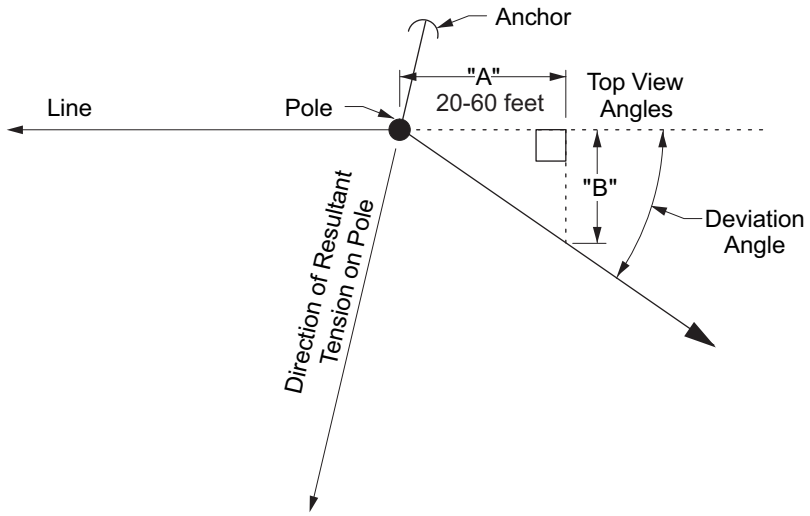


Table 10–30: Deviation Angles

Distance "A" (ft)	Distance "B" (ft)									
60	11	22	28	35	42	50	60	71	86	104
55	10	20	26	32	38	46	55	65	78	95
50	9	18	23	29	35	42	50	60	71	86
45	8	16	21	26	31	38	45	54	64	78
40	7	15	19	23	28	34	40	48	57	69
35	6	13	16	20	25	29	35	42	50	61
30	5	11	14	17	21	25	30	36	43	52
25	4	9	12	14	17	21	25	30	36	42
20	4	7	9	12	14	17	20	24	29	35
Deviation Angle	10°	20°	25°	30°	35°	40°	45°	50°	55°	60°

EXAMPLE:

If Distance "A" = 50 feet and Distance "B" = 29 feet, the Deviation Angle is 30 degrees

Determination of Angle From Guy to Pole

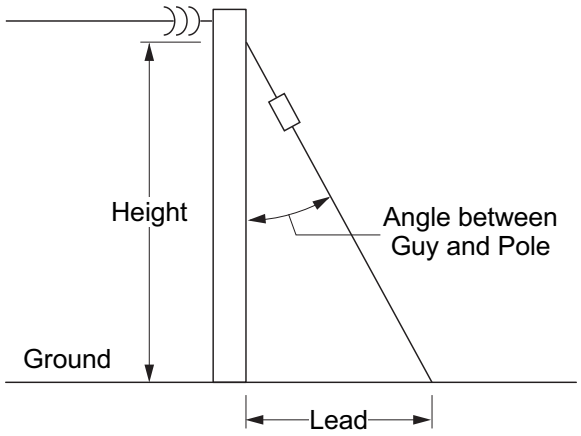
Table 10–31 is used to determine the angle created by the guy wire and the pole. When used with Table 10–33 and Table 10–34, the guying tensions for dead-ended conductors and side guying may be determined.

Table 10–31: Angle between Guy and Pole

Height (Guy-to-Ground)	Lead (Pole-to-Anchor [ft])									
90'	16	33	42	52	63	76	90	107	129	156
85'	15	31	40	49	60	71	85	101	121	147
80'	14	29	37	46	56	67	80	95	114	139
75'	13	27	35	43	53	63	75	89	107	130
70'	12	25	33	40	49	59	70	83	100	121
65'	11	24	30	38	46	55	65	77	93	113
60'	11	22	28	35	42	50	60	71	86	104
55'	10	20	26	32	38	46	55	65	78	95
50'	9	18	23	29	35	42	50	60	71	86
45'	8	16	21	26	31	38	45	54	64	78
40'	7	15	19	23	28	34	40	48	57	69
35'	6	13	16	20	25	29	35	42	50	61
30'	5	11	14	17	21	25	30	36	43	52
25'	4	9	12	14	17	21	25	30	36	43
20'	4	7	9	12	14	17	20	24	29	35
Angle (Guy-to-Pole)	10°	20°	25°	30°	35°	40°	45°	50°	55°	60°

EXAMPLE:

A guy wire is attached to a pole 45 feet above the ground and the lead is 38 feet. The angle between the guy and the pole is 40 degrees.



Determination of Angle From Guy-to-Pole for Sidewalk Anchors

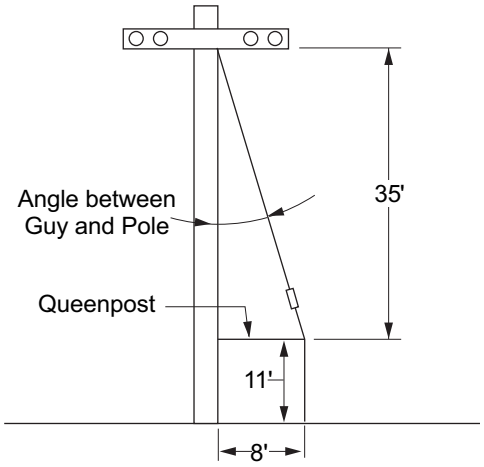
Table 10–32 is used to determine the angle from the guy to the pole created by a sidewalk anchor. When used with Table 10–33 and Table 10–34, the guying tensions for sidewalk anchoring may be determined.

Table 10–32: Angle between Guy and Pole for Sidewalk Anchor

Height (Guy Attachment-to-Queenpost) (ft)	Length of Queenpost (ft)							
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**
10	17	22	27	31	35	39	42	45
15	11	15	18	22	25	28	31	34
20	9	11	14	17	19	22	24	27
25	7	9	11	13	16	18	20	22
30	6	8	9	11	13	15	17	18
35	5	7	8	10	11	13	14	16
40	4	6	7	9	10	11	13	14
45	4	5	6	8	9	19	11	13
50	3	5	6	7	8	9	10	11
55	3	4	5	6	7	8	9	10
60	3	4	5	6	7	8	9	9
65	3	4	4	5	6	7	8	9

EXAMPLE:

A sidewalk anchor is installed with the guy wire attached 35 feet above an 8-foot queenpost. The angle between the guy and pole is 13 degrees.



Determination Guy Wire Size

Table 10–32 list the types, sizes, and safety factors of guy wires purchased by Edison. When the maximum conductor tensions are known, these tables can be used to determine the guy wire size and number of guy wires required. The maximum number of guys for a sidewalk anchor is two.

Table 10–33: MAX Conductor Tension for Guy Wires — Grade A or B Construction

(Safety Factor = 2)

MAX Safe Conductor Tension (lb) for One Guy Wire[b/]							
Angle (Guy-to-Pole) (Degrees)	**Guy Size**						
	1/4	**7/32[a/]**	**5/16**	**9/32[a/]**	**3/8[a/]**	**7/16**	**7/16 (EHS)**
3	—	—	209	234	403	379	544
5	—	—	349	390	671	632	906
7	—	—	487	545	938	884	1,267
9	—	—	626	700	1,205	1,134	1,627
11	—	—	763	854	1,469	1,383	1,984
13	—	—	900	1,007	1,732	1,631	2,339
15	—	—	1,035	1,158	1,993	1,876	2,692
20	—	—	1,368	1,531	2,634	2,480	3,557
25	—	—	1,690	1,891	3,254	3,064	4,395
30	—	—	2,000	2,238	3,850	3,625	5,200
35	—	—	2,294	2,567	4,417	4,158	5,965
40	—	—	2,571	2,876	4,949	4,660	6,685
45	—	—	2,828	3,164	5,445	5,127	7,354
50	—	—	3,064	3,428	5,899	5,554	7,967
55	—	—	3,277	3,666	6,307	5,939	8,519
60	—	—	3,464	3,875	6,668	6,279	9,007
Level (Overhead Guy)	2,375	2,400	4,000	4,475	7,700	7,250	10,400

a/ Standard extra-high-strength steel guy strand sizes

b/ Ultimate conductor tension divided by Safety Factor (from Table 24, *G.O.95*).
1/4", 5/16", and 7/16" entries are listed for reference only. The Maximum number of guys for a sidewalk anchor is two.

EXAMPLE:

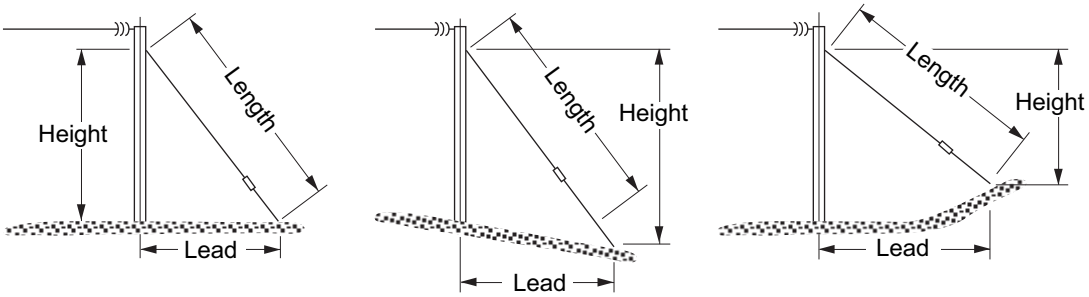
A single 3/8" guy wire installed at a 40 degrees angle, between the pole and guy, is capable of supporting a conductor tension of 4,949 pounds in Grade A construction.

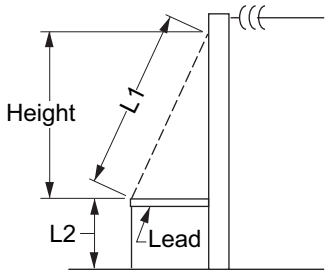
Determination of Downguy Length

Table 10–34 may be used to determine the length of a downguy when the height of the guy is known and the lead (distance from the pole to the anchor) is known.

Table 10–34: Guy Wire Length

Height (ft) \ Lead (ft)	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
10	14	18	23	27	32	37	42	46	51	56	61	66	71	76	81	86	92
15	18	21	25	30	34	39	43	48	53	58	62	67	72	77	82	87	92
20	23	25	28	33	36	41	45	50	54	59	64	68	73	78	83	88	93
25	27	30	33	36	40	43	48	52	57	60	66	71	75	79	84	89	94
30	32	34	36	40	43	47	50	55	59	63	68	72	77	81	86	90	96
35	37	39	41	44	47	50	55	58	62	66	71	75	79	83	88	92	98
40	42	43	45	48	50	54	57	61	65	69	73	77	81	85	90	94	100
45	46	48	51	53	55	58	62	64	69	72	76	80	84	88	92	96	102
50	51	53	54	56	59	61	65	68	71	75	79	82	87	90	95	98	104
55	56	58	59	61	64	66	70	72	76	78	83	86	90	93	97	102	106
60	61	62	64	65	68	70	73	75	79	81	85	89	93	96	100	105	109
65	66	67	68	71	73	75	78	80	83	86	90	93	97	98	103	107	112
70	71	72	73	74	77	78	81	83	87	89	93	97	99	103	107	110	115
75	76	77	78	79	81	83	85	88	90	93	96	98	103	106	110	114	118
80	81	82	83	84	86	88	90	92	95	97	100	103	107	110	114	117	121
85	86	87	88	89	90	92	94	96	98	102	105	107	110	114	117	120	124
90	92	92	93	94	96	98	100	102	104	106	109	112	115	118	121	124	128



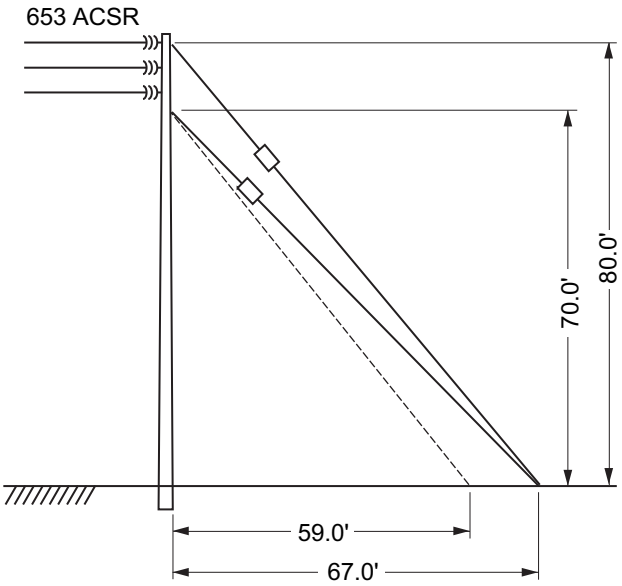


NOTE: L1 is the length from the table.
L1 and L2 = Total length of guy wire for a sidewalk anchor

The following examples illustrate the use of Tables 10–28 (Page 10–111) through 10–34 (Page 10–117) to determine guying requirements.

Example 1: Minimum Anchor Guy Lead

Given three 653.9 kcmil ACSR conductors sagged at 3,267 lb in vertical configuration and supported by a 90-foot pole set 9 feet in the ground, find the minimum lead (distance from pole-to-anchor) required when two 3/8" anchor guys are to support the line in Grade A construction. Each guy wire will support one-half of the total conductor pull.



a. From Table 10–28, determine the conductor tension on each guy wire. Multiply 3,267 pounds by three and divide by two. **Answer**: 4,900 pounds.

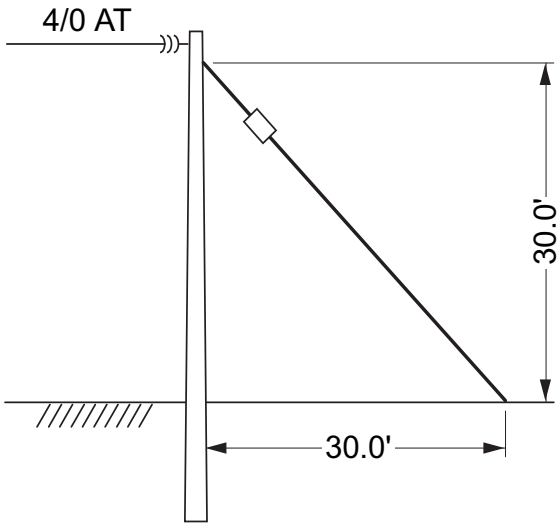
b. Find in Table 10–33, under 3/8-inch guy, a conductor pull safe for one guy that exceeds 4,900 pounds. **Answer**: 4,949 pounds. Determine that the angle of guy-to-pole is 40 degrees.

c. Find in Table 10–31, the value under the Height (Guy-to-Ground) of 80 feet. Read across row to the 40 degrees column (Angle Guy-to-Pole) and see that the lead distance is 67 feet.

d. This 67 feet is the minimum lead required for the top guy. If the lower guy is attached at 70 feet on the pole, find in Table 10–31, that the minimum lead required for a second anchor is 59 feet.

Example 2: Size of Anchor Guy Wire

Given 4/0 aluminum triplex secondary at dead-end, to be anchor guyed, with a lead of 30 feet the guy attached to the pole 30 feet above the ground (height), find the size of guy required. Spans are 150 feet in urban areas.



a. Find in Table 10–28, the tension for 4/0 aluminum triplex conductor.

Answer: 2,780 pounds

b. Next find in Table 10–31, the guy angle most nearly corresponding to a height of 30 feet and a lead of 30 feet.

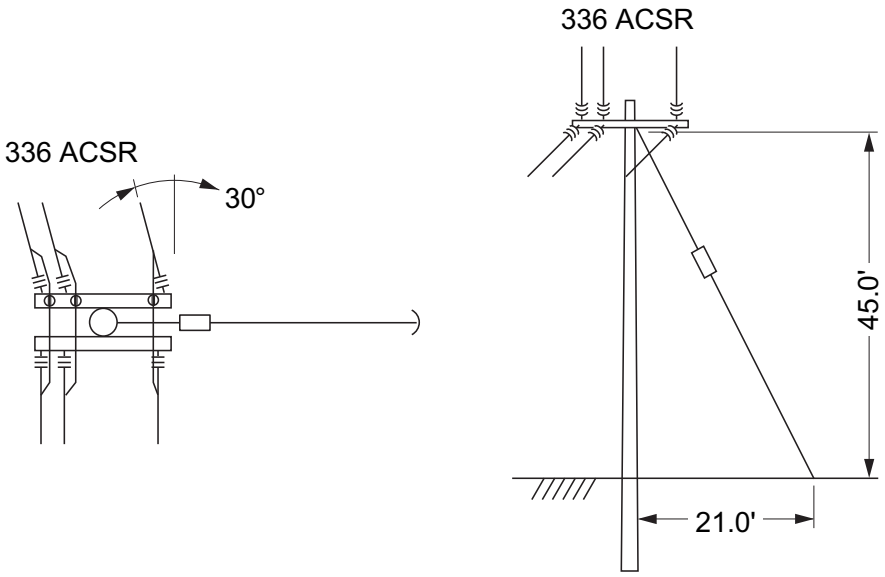
Answer: 45 degrees

c. Then find in Table 10–33, the required size for guy to hold a conductor tension of (a) 2,780 pounds at a guy angle of (b) 45 degrees using the next larger figure above 2,780 pounds. In this case the next larger figure in the column for a 45-degree angle is 2,828.

Answer: Since 5/16" is no longer a standard guy size, one 9/32" guy with a maximum conductor tension of 3,164 pounds should be used.

Example 3: Size of Side Anchor Guy Wire

Given three 336.4 kcmil ACSR distribution conductors with a deviation angle of 30 degrees in the line, find the size of guy to hold the angle pole with a height of 45 feet and a lead of 21 feet, for both Grade A and B construction.



a. Find in Table 10–29, the resultant side pull for three 336.4 kcmil ACSR conductors at a deviation angle of 30 degrees. 3 × 1,473 = 4,419 lb

Answer: 4,419

b. Next, find in Table 10–31, the guy angle most nearly corresponding to a height of 45 feet and a lead of 21 feet.

Answer: 25 degrees

c. For a Grade A construction, find in Table 10–33, the required size of guy for a resultant pull of (a) 4,419 pounds and a guy angle of (b) 25 degrees, using the next larger tension above 4,419 pounds. In this case, the next tension or combination of tensions in the 25 degree column is 1,891 + 3,254 pounds.

Answer: Use one 9/32-inch guy and one 3/8-inch guy (standard guy sizes).

d. For Grade B construction find in Table 10–34, the required size guy for a resultant pull of (a) 4,419 pounds. and a guy angle of (b) 25 degrees using the next larger tension above 4,419 pounds. In this case, the next larger tension or combination of tensions in the 25-degree column is 2,521 + 2,521 pounds.

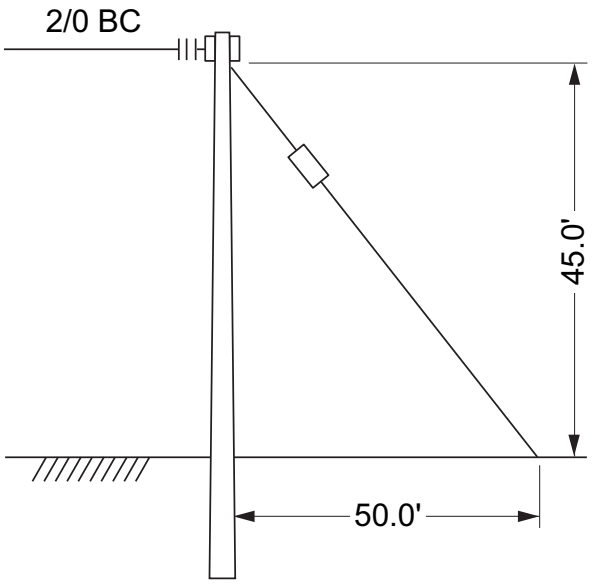
Answer: Use two 9/32-inch guys (standard guy sizes).

Example 4: Size of Anchor Guy Wire

NOTICE:

This example is for use in rural areas only, where Grade A construction is not required, as set forth in the Public Utilities Commission *General Order No. 95*, Rule 42.

Given three 2/0 bare copper distribution conductors at dead-end, to be anchor guyed 45 feet above the ground (height), with a 50-foot lead, find the size of guy required.



a. Find in Table 10–28, the tension for one 2/0 bare copper conductor (1,482 pounds) Multiply 1,482 × 3 = 4,446 pounds.

Answer: 4,446 pounds

b. Next, find in Table 10–31, the guy angle most nearly corresponding to a height of 45 feet and a lead of 50 feet.

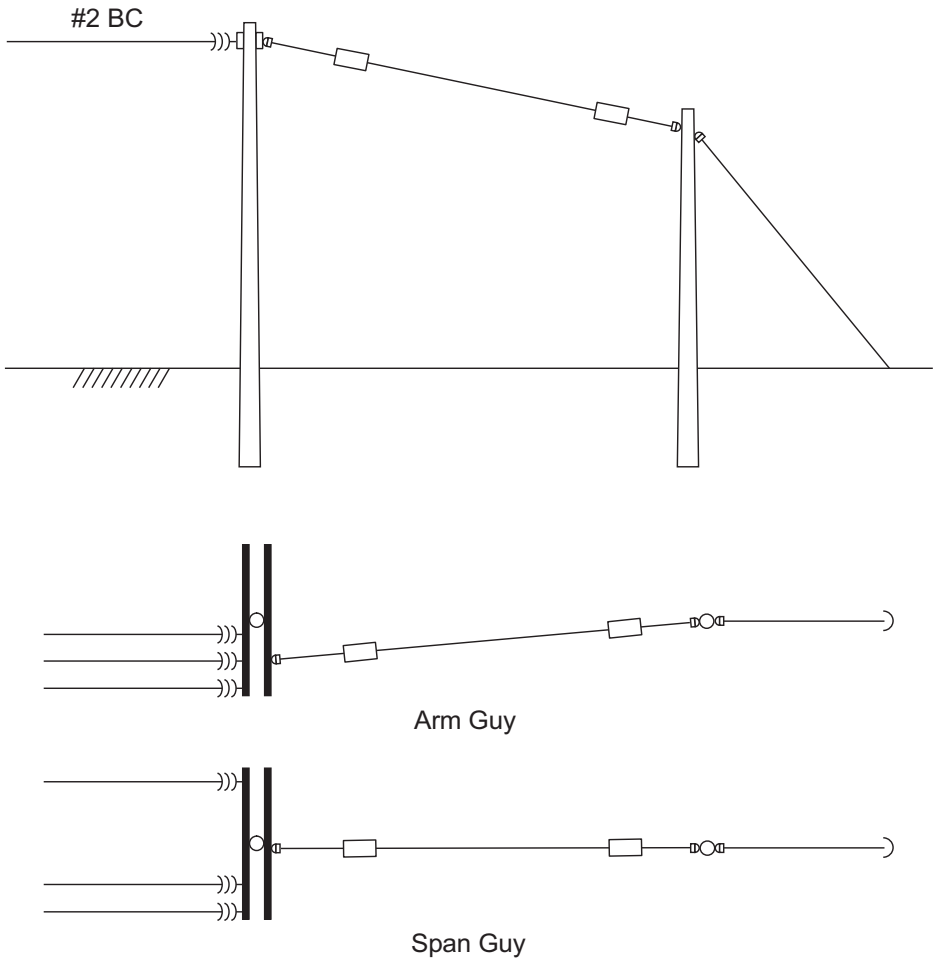
Answer: 50 degrees

c. Then, find in Table 10–34, the required size of guy for conductor tension of (a) 4,446 pounds at a guy angle of (b) 50 degrees, using the next larger tension above 4,446 pounds. In this case, the next larger figure in the column for a 50-degree angle is 4,570 pounds.

Answer: Use one 9/32-inch guy (standard guy size).

Example 5: Overhead Span/Arm Guy

Given three No. 2 bare copper conductors at dead-end on a crossarm, find the size of guy to hold the total load.



a. Find in Table 10–28, the tension for one No. 2 bare copper conductor. Multiply this tension by three. 761 × 3 = 2,283 pounds.

Answer: 2,283 lb

b. Next, find in Table 10–33, the row labeled "Level-Overhead Guys" the required size of guy for a conductor tension of (a) 2,283 pounds, using the next larger figure above 2,283 pounds. In this case, the next larger figure in the column for "level guys" is 2,400 pounds.

Answer: Use one 7/32-inch guy. The downguy may then be calculated using conductor tension of 2,283 pounds.

Appendix 10–4: Anchors and Rods Tables and Examples *(Sheet 1 of 2)*

Table 10–35 lists the holding strength for standard anchors and rods used by Edison. The anchor and rod shall have an allowable holding strength equal to or greater than the working strength of the guy or guys attached to it. The working strength of a guy wire shall be that of the guy wire in a level position shown on Table 10–33 and Table 10–34.

The actual holding strength of a power-installed crew anchor is determined by the number of shear pins used when the anchor is installed. Soft soil conditions may limit the holding strength of a single-helix anchor and require the installation of a double-helix anchor. Refer to the *DOH Manual*, Section PO.

Table 10–35: Allowable Holding Strength for Guy Anchors

Types of Anchors	Torque No. of Loading Pins Sheared	8-Inch Single	8-Inch Double	10-Inch Double	4-Inch Single	4-Inch Double	MAX Guys by Anchor Types (in)
Power Installed Screw Anchors	1	3,000	5,000	6,000			1-9/32 and 2-3/8
	2	8,000	10,000	11,000			1-9/32 and 2-3/8
	3	12,000	13,000	14,000			1-9/32 and 2-3/8
1-3/8" or 1-1/2" anchor hub. 1" × 7' Triple Eye	4	14,000	15,000	20,000			1-9/3 and 2-3/8
	5	17,000	20,000	24,000			1-9/32 and 2-3/8
	6	18,000	24,000	26,000			1-9/32 and 2-3/8
	7	21,000	28,000	30,000			1-9/32 and 2-3/8
	8	27,000	30,000	34,000			1-9/32 and 2-3/8
1-1/2" anchor hub only. 1" × 7' Triple Eye	9	30,000	32,000	36,000			1-9/32 and 2-3/8
	10	33,000	36,000				1-9/32 and 2-3/8
	11	35,000					1-9/32 and 2-3/8
	12	36,000					1-9/32 and 2-3/8
	13	MAX rating of 1" rod.					1-9/32 and 2-3/8
	14						1-9/32 and 2-3/8
4-Inch Granite Anchors 1" × 7' Triple Eye	9				24,000		1-9/32 and 2-3/8
	10				30,000	28,000	1-9/32 and 2-3/8
	12				24,000	36,000	1-9/32 and 2-3/8
Anchor Rod and Plate 5/8" × 6'/Single Eye[a/] 3/4" × 8'/Double Eye a/ 1" × 10'/Triple Eye[a/]	Holding Strength (lb) 10,000 15,000 24,000						1-3/8 1-9/32 and 1-3/8 1-9/32 and 2-3/8
Expanding Rock 3/4" ×15"/Double Eye	Holding Strength (lb) 15,000						2-9/32 or 1-3/8

[a/] Where a backhoe is used to dig holes for plate anchors, each anchor shall be limited to a working load of 11,500 pounds.

The following examples illustrate the selection of the proper screw anchor or anchor and plate.

Example 1: Selection of Guy Anchor

One 3/8" and one 9/32" Extra-High Strength (EHS) guys are to be attached to an anchor in an urban area, Grade A construction. What size guy anchor should be selected?

ANSWER:

See Table 10–33. The total conductor pull at a level angle is the rated guy strength with a safety factor of two (working tension); therefore, 1-3/8" EHS guy has a working tension of 7,700 pounds, and 1-9/32" guy has a working tension of 4,475 pounds. The total holding strength for the anchor should be the sum of the rated working tensions of both guys, or 7,700 pounds + 4,475 pounds = 12,175 pounds. Referring to Table 10–35, it can be determined that an 8" single helix screw anchor with four loading pins sheared will meet the required holding strength. If an anchor rod and plate is required, a 3/4" x 8'/double eye should be selected.

Example 2: Selection of Guy Anchor

Two 3/8" and one 9/32" EHS guys are to be installed on an anchor in an urban area, Grade A construction. (The maximum amount allowed on a triple-eye rod per Table 10–35). What size guy anchor should be selected?

ANSWER:

According to Table 10–33, the full rated working tension for guys with a safety factor of two can be found under **level** angle. 2-3/8" EHS, with a working tension of 7,700 pounds × 2 and one 9/32" EHS of 4,475 pounds. The total pull will be 15,400 pounds + 4,475 pounds = 19,875 pounds.

In accordance with Table 10–35, an anchor with a holding strength above 19,875 pounds should be used. Therefore, a single 8" PISA should be selected to shear seven loading pins. If an anchor rod and plate are to be installed, a 1" x 10'/triple eye having a holding strength of 24,000 pounds should be selected.

Appendix 10–5: Unguyed Spans — Light-Loading and Heavy-Loading Tables and Examples *(Sheet 1 of 7)*

Based on typical unguyed span measurements, Tables 10–37 (Page 10–126) through 10–40 (Page 10–129) provide a means to determine dead-end tension. These dead-end tensions are multiplied by the number of conductors and the height of the conductors to determine the resultant moment on the pole supporting the unguyed span. The resultant moment must be checked against the usable pole strength shown in Table 10–19. A breast block and pole key must be installed on all unguyed spans. Refer to the *DOH Manual*, Section PO. The pole key resisting moment must be greater than the resultant moment on the pole supporting the unguyed span. If the resultant moment exceeds either the usable pole strength or the pole key resisting moment, the strain should be guyed or the resultant moment reduced. The moment may be reduced by (1) reducing the height of the conductors, or (2) increasing the conductor sag thereby reducing the dead-ending tension. Pole key resisting moments will vary depending on the type of soil. (See Table 10–36 below).

With the conductor tensions from Tables 10–37 (Page 10–126) through 10–40 (Page 10–129), the resultant moment can be calculated using Formulas A or B.

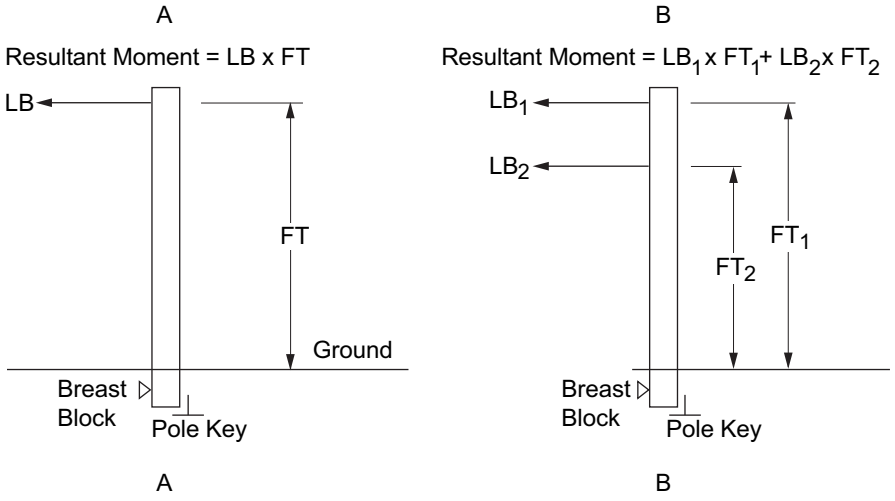


Table 10–36: Types of Soil

Type of Soil		Pole-Key Resisting Moment (ft-lb)
Class	Description	
3	Shale; broken red rock; hardpan; compact clay-gravel mixtures	55,125
4	Gravel; compact gravel and sand; claypan	47,500
5	Medium-firm clay; loose sand and gravel; compact coarse sand	36,750
6	Soft-plastic clay; loose coarse sand; clay silt, compact fine sand	28,875

Table 10–37: Unguyed Span Tensions — Secondary Conductors Light Loading

	Span Length (ft)	Final Sag at 130°F Close-Up				
		1-Foot Sag	2-Foot Sag	3-Foot Sag	4-Foot Sag	5-Foot Sag
		Unguyed Span Dead-End Tension per Conductor (lb)				
#6 Al Duplex	60	198	79	50	37	29
	80	292	149	91	66	52
	100	363	233	147	105	82
	120	436	314	213	154	120
#4 Al Duplex	60	286	102	63	47	38
	80	432	199	118	85	67
	100	545	328	193	136	106
	120	660	449	290	202	155
#4 Al Triplex	60	338	122	75	55	44
	80	500	242	140	100	79
	100	—	391	232	161	125
	120	—	525	344	241	185
#2 Al Triplex	60	480	152	93	68	55
	80	733	314	175	124	98
	100	965	535	295	202	155
	120	—	741	452	306	231
1/0 Al Triplex	60	660	206	127	93	75
	80	1,135	421	237	169	133
	100	—	748	399	274	211
	120	—	1,113	626	414	313
4/0 Al Triplex	60	1,163	318	194	143	114
	80	—	666	364	259	204
	100	—	1,260	621	421	324
	120	—	—	1,004	643	482
1/0 Al Quad	60	783	249	152	112	89
	80	—	512	285	203	159
	100	—	899	484	330	254
	120	—	1,272	753	502	377
4/0 Al Quad	60	—	391	237	174	139
	80	—	827	447	317	248
	100	—	—	768	517	396
	120	—	—	1,242	794	591

Example: A 1/0 Al Triplex unguyed span with a final sag of 3 feet will have a dead-end tension of 399 pounds.

Table 10–38: Unguyed Span Tensions — Primary Conductors Light Loading[a/b/]

	Span (ft)	Final Sag at 130°F				
		1-Foot Sag	2-Foot Sag	3-Foot Sag	4-Foot Sag	5-Foot Sag
		Unguyed Span Dead-End Tension per Conductor (lb)				
#4[c/] ACSR	60	159	46	28	21	17
	80	310	93	53	38	30
	100	385	169	88	61	47
	120	450	265	138	92	70
1/0 ACSR	60	318	79	49	36	29
	80	653	163	91	65	51
	100	—	310	153	105	81
	120	—	524	243	159	120
336.4 ACSR	60	—	158	95	70	56
	80	—	359	180	127	99
	100	—	—	319	208	159
	120	—	—	572	326	239
653.9 ACSR	60	—	276	157	113	90
	80	—	—	305	209	161
	100	—	—	554	347	261
	120	—	—	—	549	394
#6 Copper	60	159	37	22	16	13
	80	284	77	41	29	23
	100	371	146	71	48	37
	120	—	230	112	72	54
#4 Copper	60	248	55	33	24	19
	80	447	117	62	44	34
	100	585	224	106	72	55
	120	—	357	170	109	82
#2 Copper	60	381	78	46	34	27
	80	—	166	88	62	48
	100	—	329	150	101	77
	120	—	543	243	154	115
2/0 Copper	60	—	136	81	59	47
	80	—	295	154	108	85
	100	—	607	265	177	136
	120	—	—	434	271	202
4/0 Copper	60	—	204	122	89	71
	80	—	444	231	162	127
	100	—	—	397	265	203
	120	—	—	—	406	302

a. Use on all 4, 12, 16, and 33 systems.

a. 4 kV is 20" minimum pin spacing.

b. 12, 16, and 33 is 36" minimum pin spacing.

b. 4 kV requires 36" minimum pin spacing.

c. Not approved for use on new construction.

Table 10–39: Unguyed Span Tensions — Secondary Conductors Heavy Loading

	Span (ft)	Final Sag at 130°F				
		1-Foot Sag	2-Foot Sag	3-Foot Sag	4-Foot Sag	5-Foot Sag
		Unguyed Span Dead-End Tension per Conductor (lb)				
#4 Al Duplex	60	521	275	178	132	105
	80	701	463	316	235	187
	100	850	634	474	363	291
	120	990	782	628	505	413
#4 Al Triplex	60	575	303	195	144	115
	80	783	512	348	258	205
	100	—	708	523	400	319
	120	—	870	698	554	454
#2 Al Triplex	60	789	359	224	164	131
	80	1,097	646	409	297	234
	100	—	943	646	470	369
	120	—	1,196	895	679	535
1/0 Triplex	60	1,073	447	274	201	160
	80	—	838	508	364	286
	100	—	1,266	818	584	454
	120	—	—	1,169	855	665
4/- Al Triplex	60	—	620	373	273	217
	80	—	1,256	702	496	388
	100	—	—	1,179	807	619
	120	—	—	—	1,216	916
1/0 Al Quad	60	1,208	507	311	228	182
	80	—	953	578	413	325
	100	—	—	931	664	515
	120	—	—	—	973	756
4/0 Al Quad	60	—	721	432	315	252
	80	—	—	816	575	450
	100	—	—	—	938	719
	120	—	—	—	—	1,069

Table 10–40: Unguyed Span Tensions — Primary Conductors Heavy Loading[a/b/]

	Span (ft)	Final Sag at 130°F				
		1-Foot Sag	2-Foot Sag	3-Foot Sag	4-Foot Sag	5-Foot Sag
		Unguyed Span Dead-End Tension per Conductor (lb)				
#4[c/] ACSR	60	421	206	132	97	78
	80	569	363	238	174	138
	100	—	509	367	274	217
	120	—	627	494	387	311
1/0 ACSR	60	—	265	162	119	95
	80	—	512	301	215	170
	100	—	—	492	346	269
	120	—	—	—	511	394
336.4 ACSR	60	—	396	230	167	133
	80	—	—	442	307	239
	100	—	—	—	507	384
	120	—	—	—	—	578
653.9 ACSR	60	—	596	321	229	181
	80	—	—	642	428	328
	100	—	—	—	—	534
	120	—	—	—	—	—
#4 Copper	60	533	228	140	102	82
	80	—	417	258	185	146
	100	—	611	408	295	230
	120	—	—	570	426	335
#2 Copper	60	—	262	158	115	91
	80	—	510	295	209	164
	100	—	—	482	338	261
	120	—	—	—	499	383
2/0 Copper	60	—	343	201	146	116
	80	—	—	383	268	209
	100	—	—	650	438	334
	120	—	—	—	663	497
4/0 Copper	60	—	429	250	181	144
	80	—	—	479	333	259
	100	—	—	—	547	416
	120	—	—	—	—	621

a. Use on all 4, 12, 16, and 33 systems.

a. 4 kV is 20" minimum pin spacing.

b. 12 kV, 16 kV, 33 kV, and kV is 36" minimum pin spacing.

b. 4 kV requires 36" minimum pin spacing.

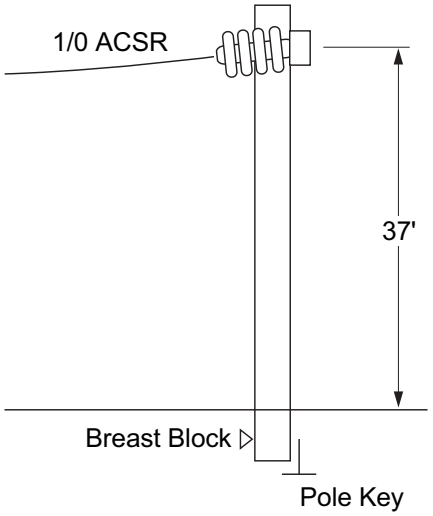
c. No approved for use on new construction.

Appendix 10–5: Unguyed Spans — Light-Loading and Heavy-Loading Tables and Examples *(Sheet 6 of 7)*

The following examples illustrate the method of determining usable pole strength in unguyed spans.

Example 1: Unguyed Span

Given four 1/0 ACSR conductors dead-ended to an unguyed 45-foot pole 37 feet above ground level, determine the proper class of pole and final sag for an unguyed span that meets vertical clearances. The conductor span is 60 feet, in Class 5 soil Table 10–36, and the construction is Grade B in light loading area.



a. Find in Table 10–38 the tension for one 1/0 ACSR conductor with a final sag of 3 feet (49 pounds). Multiply the tension by four. 49 pounds × 4 = 196 pounds.

Answer: 196 pounds

b. Then, multiply the maximum conductor tension by the height from the ground to the point of attachment of the conductors to determine the resultant moment.
196 × 37 = 7,252 ft-lb

Answer: 7,252 ft-lb

c. Next, compare the moment from (b) to the usable pole strengths to select Table 10–18, Table 10–19, or Table 10–20, based on the type of pole) the proper class of pole.

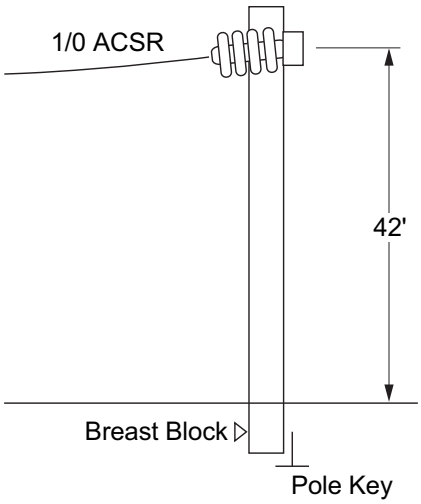
Answer: 45-foot Class 5 pole

d. Compare the moment from (b) to the pole-key resisting moment, which should be used for all unguyed poles.

Answer: The moment applied to the pole does not exceed the pole-key resisting moment of 36,750 ft-lb. See Table 10–36.

Example 2: Unguyed Span

Given four 1/0 ACSR conductors dead-ended to an unguyed 50-foot pole 42 feet above ground level, determine the proper class of pole and final sag for an unguyed span that meets vertical clearances. The conductor span is 90 feet in Class 3 soil, and the construction is Grade B in a heavy-loading area.



a. Find in Table 10–40 the tension for one 1/0 ACSR conductor with a final sag of 4 feet and a 100-foot span (346 pounds). Multiply the tension by four. 346 × 4 = 1,384 pounds

b. Then, multiply the maximum conductor tension by the height from the ground to the point of attachment of the conductors to determine the resultant moment. 1,384 × 42 = 58,128 ft-lb. **Answer** = 58,128 ft-lb

c. Next, compare the moment from (b) to the usable pole strengths Table 10–19 to select the proper class of pole. **Answer**: A 50-foot pole does not provide enough usable pole strength.

d. Assuming there is enough clearance for additional sag, the sag will be extended to five feet for a new tension (269 pounds). 269 × 4 = 1,076 pounds
Answer: 1,076 pounds.

e. Repeat part (b) for the new maximum resultant moment.
1,076 × 42 = 45,192 ft-lb. **Answer**: 45,192 ft-lb

f. Next, compare the answer from (e) to the usable pole strengths Table 10–18, Table 10–19, or Table 10–20, based on the type of pole to select the proper class of pole.
Answer: Select a 50-foot class 1 pole.

4. Compare the answer from (f) to pole-key resisting moment, which should be used for all unguyed poles. Refer to the *DOH Manual*, Section PO. **Answer**: The moment applied to the pole does not exceed the pole-key resisting moment of 55,125 ft-lb. See Table 10–36.

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DDS-11

Southern California Edison
Transmission and Distribution Business Unit

Chapter DDS–11: EMF Management Program

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1.0 Southern California Edison EMF Policy

There are many sources of power frequency electric and magnetic fields, including internal household or building wiring, electrical appliances, and electric power transmission and distribution facilities. There have been numerous scientific studies about the potential health effects of Electromagnetic Fields (EMF). Interest in a potential link between long-term exposures to EMF and certain diseases is based on the combination of this scientific research and public concern.

After many years of research, a health hazard has not been established to exist. Many of the questions about specific diseases have been successfully resolved due to an aggressive International Research Program. Potentially important public health questions remain about whether there is a link between EMF exposures in homes or work and some diseases, including childhood leukemia and a variety of adult diseases, for example, adult cancers and miscarriages. Because of this research, some health authorities have identified magnetic field exposures as a possible human carcinogen.

While scientific research is continuing on a wide range of questions relating to exposures at both work and in our communities, a quick resolution of the remaining scientific uncertainties is not expected.

Southern California Edison (SCE) is aware that there is concern about the potential health effects of power-frequency electric and magnetic fields. Notwithstanding the health, safety, and economic benefits of electricity, SCE recognizes and takes seriously its responsibility to help address these EMF concerns. In order to better understand EMF and to respond to the current uncertainty, SCE will continue to perform the following:

- Assist the California Public Utilities Commission (CPUC) and other appropriate local, state, and federal governmental agencies in the development and implementation of reasonable, uniform regulatory guidance.
- Provide balanced, accurate information to our employees, customers, and public agencies, including EMF measurements and consultation to our customers upon request.
- Take appropriate "no-cost and low-cost" steps to minimize field exposures from new facilities, and continue to consult and advise our customers with respect to existing facilities, subject to CPUC guidance.
- Support appropriate research programs to resolve the key scientific questions about EMF.
- Research and evaluate occupational health implications, and provide employees who work near energized facilities with timely, accurate information about field exposures in their work environment.

For additional information (or to direct customers with EMF Concerns), contact the EMF Research and Education Center at:

CTAC
6090 N. Irwindale Avenue
Irwindale, CA 91702
1.800.200.4723

1.1 Implementation

Design and construction of all distribution lines and distribution substations must comply with all federal, state, and local regulations, applicable safety codes, and SCE design standards. Any possible EMF reduction measures, therefore, must meet these requirements. As supplement to this, the California Public Utilities Commission directed all investor-owned utilities in the state to take "no-cost and low-cost" magnetic field reduction measures for new and upgraded electrical facilities (CPUC Decision 93-11-013).

1.2 SCE Definition of "No-Cost and Low-Cost"

- "No-cost" measures include any design changes that reduces the magnetic field in public areas without increasing the overall project cost;
- "Low-cost" measures are those steps taken to reduce magnetic field levels at reasonable cost. The CPUC Decision (93-11-013) states,

"We direct the utilities to use four percent as a benchmark in developing their EMF mitigation guidelines. We will not establish four percent as an absolute cap at this time because we do not want to arbitrarily eliminate a potential measure that might be available, but costs more than the four percent figure. Conversely, the utilities are encouraged to use effective measures that cost less than four percent."

The CPUC agreed that a "low-cost" measure should achieve some noticeable reduction, but declined to specify any numeric value. SCE uses a minimum fifteen percent (15 percent) reduction as the criteria for the application of "low-cost" measures.

"In 2006, the CPUC completed its review and update of its EMF Policy in Decision 06-01-042. This decision reaffirmed the finding that state and federal public health regulatory agencies have not established a direct link between exposure to EMF and human health effects, and the policy direction that (1) use of numeric exposure limits was not appropriate in setting utility design guidelines to address EMF, and (2) existing "no-cost and low-cost" precautionary-based EMF policy should be continued for proposed electrical facilities."

2.0 Recommended Magnetic Field Reduction Measures for Distribution

This chapter offers a description of "no-cost and low-cost" practices and procedures designed to reduce magnetic field exposures from various distribution equipment and facilities. The magnetic fields practices and procedures are categorized into the following sections:

- Section 2.1, Electric Meters and Panels
- Section 2.2, Low-Voltage Services
  - — Overhead Residential
  - — Overhead Commercial/Industrial
  - — Underground Residential
  - — Underground Commercial/Industrial
- Section 2.3, Low-Voltage Secondaries
  - — Overhead
  - — Open-Wire Close to Buildings
  - — Open-Wire above Pedestrian Walkways
  - — Underground
- Section 2.4, Pad-Mounted and Buried Underground Residential Distribution (BURD) Equipment
  - — Pad-mounted Transformers
  - — BURD Transformers
  - — Switches and Capacitor Banks
- Section 2.5, Primary Conductors
  - — Overhead Distribution Circuits with Transmission Overbuilds
  - — Single Overhead Circuits
  - — Double Overhead Circuits
  - — Single Underground Circuits
  - — Multiple Underground Circuits

Table 11–1 provides a summary of the recommended magnetic field reduction measures to evaluate when constructing or repairing the electrical distribution system.

Table 11–1: Recommended Magnetic Field Reduction Measures for Distribution Construction

Category		Reduction Measures
	Electric Meters and Panels	Locate meters, panels and service wires near storage rooms or garages and at least 3' away from living spaces, such as bedrooms
Low-Voltage Service	Overhead Residential	Use triplex services for new construction and rewires
	Overhead Commercial/Industrial	Use multiplex services for new construction and rewires
	Underground Residential	No additional recommendations beyond standard construction
	Underground Commercial/Industrial	Route, where practical, service cables/conducts away from occupied rooms
Low-Voltage Secondaries	Overhead	Use multipelx secondary's for new construction and rewire
	Open-Wire Close to Buildings	Reduce pin-spacing on crossarm; Increase conductor clearance to building; Replace open-wire secondary's with multiplex conductors
	Open-Wire above Pedestrian Walkways	Reduce pin-spacing on crossarm; Use taller poles
	Underground	No additional recommendations beyond standard construction
Apparatus	Pad-mounted Transformers	Position secondary side of transformer away from building where practical; install barriers to discourage approach
	BURD Transformers	No additional recommendations beyond standard construction
	Switches and Capacitor Banks	No additional recommendations beyond standard construction
	Overhead Transformers	No additional recommendations beyond standard construction

Table 11–1: Recommended Magnetic Field Reduction Measures for Distribution Construction

Category		Reduction Measures
Primary Conductors	Overhead Distribution Circuits with Transmission Overbuild	Use taller poles and a compact subtransmission pole head were appropriate
	Single Overhead Circuits	For circuits using 336 kcmil or larger: Use horizontal crossarm construction (DC510) and a 45' pole; Circuits 1/0 or smaller: No change
	Double Overhead Circuits	Use vertical construction (DC540) and a 50' pole
	Single Underground Circuits	Where practical, install away from occupied areas; heavily loaded circuits at the bottom of the duct bank; Avoid installing cable within 25' of homes
	Multiple Underground Circuits	Where practical, install away from occupied areas; heavily loaded circuits at the bottom of the duct bank; Avoid installing cable within 25' of homes

2.1 Electric Meters and Panels

Based on the magnetic fields findings shown in DDS-11, Table 11–2, use the following design recommendations for residential and Commercial/Industrial meter panels will be used:

- When practical, locate meters, panels, and service wires near storage rooms or normally unoccupied spaces such as garages;
- Consider access needs for SCE Field Personnel as specified in the applicable DDS sections.

Table 11–2 shows magnetic field levels measured with the EMDEX meter at distances of one and three feet from residential and commercial/industrial meter panels. High-current values of 100 A for residential and 250 A for Commercial/Industrial customers were chosen as typical peak demands at the panel.

Table 11–2: Measured Magnetic Fields and Meters and Panels

Service Type	Measured Magnetic Fields		% Reductions
	Parameters	Bmax (Unit: mG)	
Residential	at 100 A, 1 ft at 100 A, 3 ft	96 12	87
Commercial/Industrial	at 250 A, 1 ft at 250 A, 3 ft	128 15	88

2.2 Low-Voltage Services

A. Overhead Residential Services

The following design recommendations, Table 11–3, will be used for overhead residential services.

Table 11–3: Design Recommendations for Overhead Residential Services

Design Category	Design Recommendations
New Construction	• Use only triplex services.
Rewire	• Replace residential open-wire services with triplex services in accordance with the ongoing open-wire replacement program. • Replace all open-wire services with triplex services for customers completing rewire.

By replacing residential open-wire services with triplex services, a reduction of 75 percent in magnetic field levels at three feet can be achieved at "low-cost."

B. Overhead Commercial/Industrial Services

The following design recommendations, Table 11–4, for overhead commercial and/or industrial services will be used.

Table 11–4: Design Recommendations for Overhead Commercial/Industrial Services

Design Category	Design Recommendations
New Construction	• Use only multiplex services. • Whenever practical, avoid "high use" areas.
Rewire	• Replace Commercial / Industrial open-wire services with multiplex services for customers completing rewire.

By replacing commercial/industrial open-wire services with multiplex services, a significant in magnetic field levels at three feet can be achieved. Additional magnetic fields level reduction can be achieved by locating the multiplex services further away from occupied areas or structures; for example, move from three to five feet.

C. Underground Residential Services

Magnetic field levels over underground service are expected to be very low; thus, it is recommended that no changes to be made.

D. Underground Commercial and/or Industrial Services

Where practical, parallel service cables and conduits (to the buildings) should be routed away from normally occupied rooms.

2.3 Low-Voltage Secondaries

A. Overhead Secondaries

Multiplex secondaries are recommended for new overhead secondary installations. When rebuilding or rewiring an overhead secondary, change open-wire secondaries to multiplex conductors when existing open wire is not sufficient to meet capacity and voltage-drop standards.

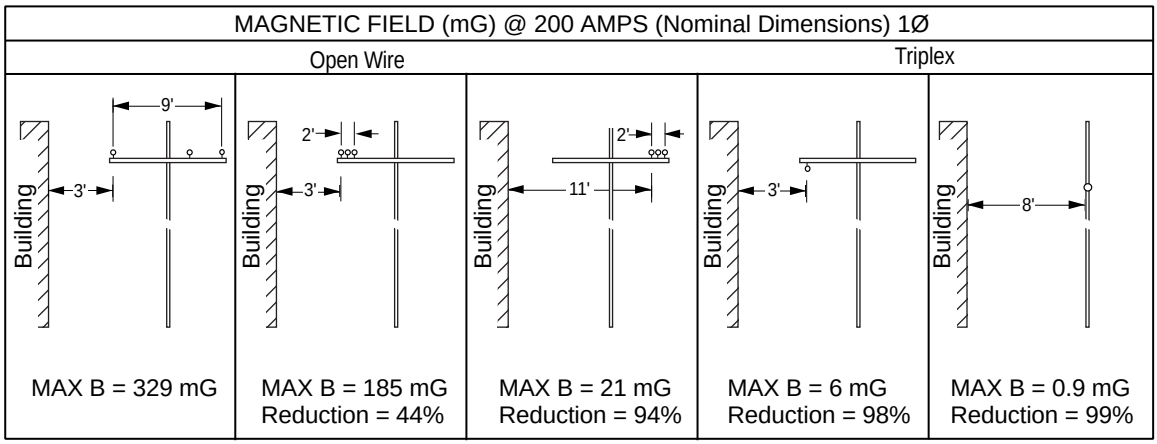
B. Open-Wire Secondaries Close to Buildings

G.O. 95 allows a minimum three-foot horizontal clearance between the overhead secondaries and the building structures. When rebuilding or upgrading open-wire overhead secondaries located close to occupied rooms in buildings, the following "no-cost and low-cost" options may be used to reduce magnetic fields:

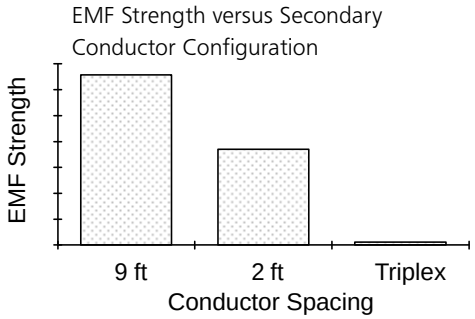
- Reduce the pin-spacing of the open-wire conductors to a minimum.
- Increase the conductor clearance of the open-wire secondaries with respect to the building.
- Replace open-wire secondaries with multiplex conductors.

Figure 11–1, shows an example of how open-wire secondaries can be arranged on a ten-foot crossarms to reduce magnetic fields. It also shows how to convert open wire secondaries to triplex. Depending on the location of the triplex, either at the close end of the crossarm or on the pole itself, the magnetic field levels are reduced accordingly.

Figure 11–1: Proximity to Building — Calculated Magnetic Fields



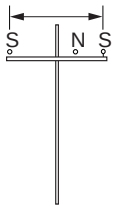
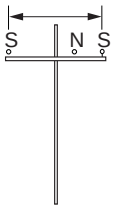
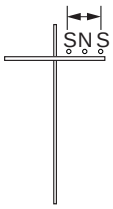
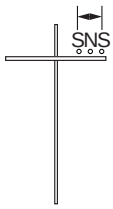
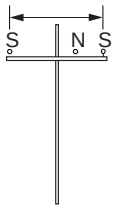
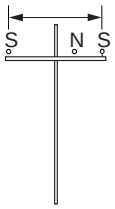
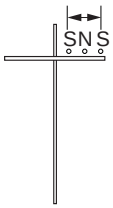
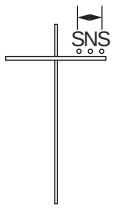
Note: All maximum magnetic field readings (MAX B) are calculated at the edge of the building.



C. Open-Wire Secondaries above Pedestrian Walkways

Figure 11–2 shows the magnetic field levels calculated for 20 feet and 25 feet ground clearance and various open-wire secondary configurations. These calculated values show that installing the open wires closer together or using taller poles will reduce the magnetic field levels.

Figure 11–2: Calculated Magnetic Field — Distance from Secondary Wires

MAGNETIC FIELD (mG) @ 200 AMPS (Nominal Dimensions) 1Ø					
	Open Wire (Nominal Dimensions)				Triplex
Conductor Height	9 ft	7 ft	3 ft	2 ft	
20 ft	 MAX B = 38.6 mG Reduction = N/A	 MAX B = 31.4 mG Reduction = 19%	 MAX B = 15.0 mG Reduction = 61%	 MAX B = 10.0 mG Reduction = 74%	 MAX B = 0.1 mG Reduction = 99%
25 ft	 MAX B = 23.7 mG Reduction = N/A	 MAX B = 19.1 mG Reduction = 19%	 MAX B = 9.0 mG Reduction = 62%	 MAX B = 6.0 mG Reduction = 75%	 MAX B = 0.1 mG Reduction = 99%

Note: All maximum magnetic field readings (MAX B) are calculated at a three-foot above the ground.

D. Underground Secondaries

Since the magnetic field levels over underground secondaries are expected to be relatively low, no further reduction techniques are recommended.

2.4 Apparatus Distribution Equipment

Pad-mounted transformers, switches, and capacitors are common distribution equipment that are installed above ground level and are normally located in open spaces near customers' residences and businesses.

A. Pad-Mounted Transformers

Pad-mounted transformers are installed above ground and located in open yards or parking areas,typically accessible by the public. Magnetic field levels adjacent to the secondary side of the transformer are normally the highest. Levels fall rapidly with greater distance from the transformers. Therefore, when installing a new pad-mounted transformer, position the secondary side of the transformer, when practical away from the building, so barriers such as landscaping, fencing, or block walls will discourage people from approaching the secondary side of the transformer.

B. BURD Transformers

Buried Underground Residential Distribution (BURD) transformers are installed below ground level. The magnetic field levels measured at three feet above ground are relatively low. Thus, changes in existing design practices are not recommended.

C. Switches and Capacitor Banks

The magnetic field levels measured around switches and capacitor banks are relatively low. Thus, changes in existing design practices are not recommended.

D. Overhead and Pole-Mounted Transformers

The magnetic field levels measured at the base of the pole directly below the overhead transformer are relatively low. Magnetic fields from these transformers diminish rapidly with distance. Thus, changes in existing design practices are not recommended

2.5 Primary Conductors

A. Distribution Circuits with Transmission Overbuild

Unlike the transmission or subtransmission lines, distribution line currents are not generally well balanced. When circuits are not well balanced, the magnetic cancellation effect from optimal phasing decreases. In many cases, using taller poles may reduce magnetic fields more than optimal phasing, especially for subtransmission lines with a lateral distribution circuit underbuild. Therefore, consider using taller poles when planning a new or rebuilt overhead distribution circuit with subtransmission overbuild.

B. Single Overhead Circuit

The following guidelines are recommended to reduce magnetic fields for installing single overhead circuits:

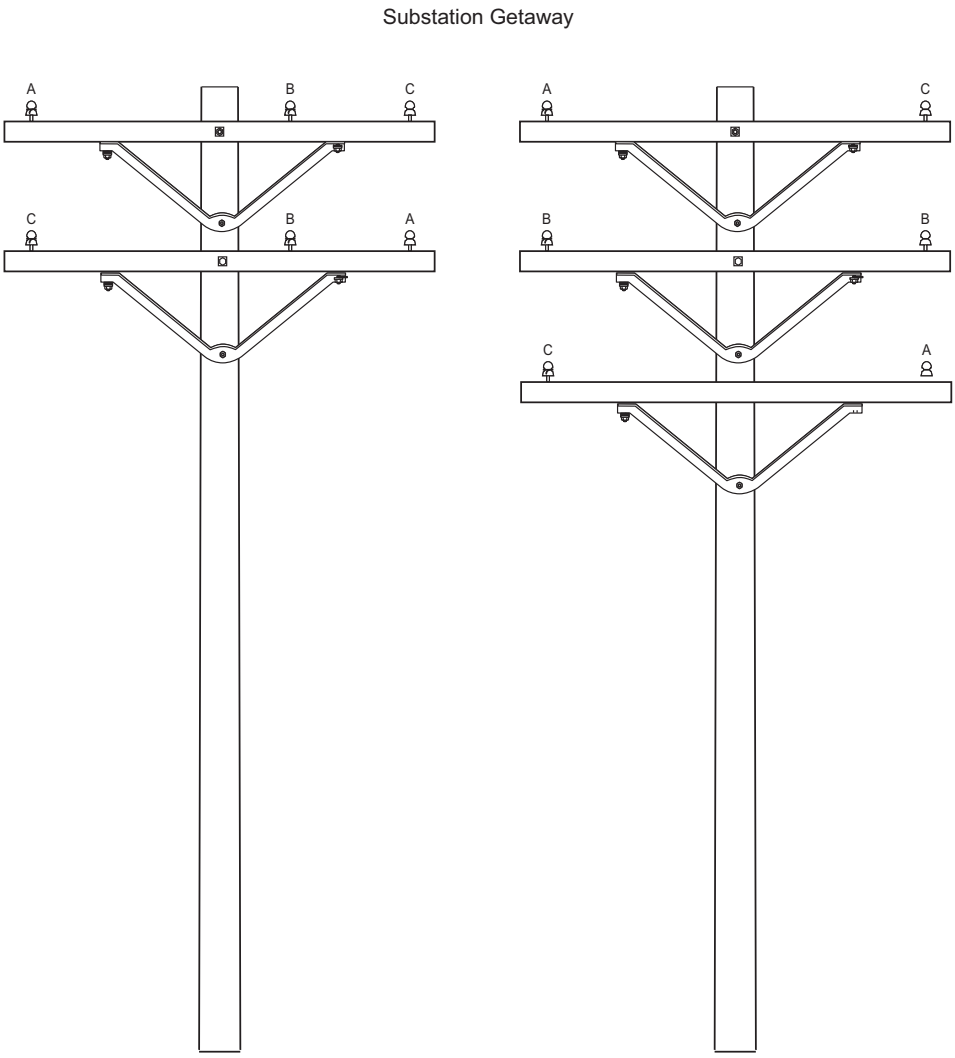
- Whenever practical, use horizontal crossarm design (refer to Distribution Overhead Construction Standard, DC 510) for all new single overhead circuit construction. The single crossarm and the conductors can be positioned higher compared to the vertical design (refer to Distribution Overhead Construction Standard, DC 540); thus, horizontal design reduces magnetic fields levels. Whenever practical, place the neutral wire at the outmost position on the crossarm so that all phase wires are positioned close together.
- For circuits using 1/0 or smaller conductors, no change in existing practices is recommended.
- For circuits using 336 kcmil or larger conductors, a minimum of 45-foot-long poles will be used.

C. Double Overhead Circuits

The following guidelines for double overhead circuits are recommended to reduce magnetic fields and control costs:

- Whenever practical, use vertical design (refer to Distribution Overhead Construction Standard, DC 540) for new double overhead circuit construction because there is more clearance between the two vertical circuits for operation and maintenance.
- Use minimum 50-foot poles for new construction. Using taller poles, in many cases, may reduce magnetic fields more than optimal phasing due to current unbalance.
- At getaways, use opposite phasing, ABC/CBA, if practical, to take advantage of field cancellation from currents in adjacent circuits, for new construction and with other significant work.

Figure 11–3: Optimal Phase Arrangement at Getaways



D. Single Underground Circuit

The magnetic fields directly above the underground circuit can be higher than the magnetic fields directly below an overhead circuit carrying the same currents. The field is stronger because the underground circuit is much closer to ground level than the overhead circuit; however, magnetic fields from underground circuits will drop off more rapidly than comparably loaded overhead circuits due to the closer spacing of the underground cables.

The following guidelines are recommended to reduce magnetic fields for installing a single underground circuit:

- Locate the conduit away from normally occupied areas, where practical.
- Install a heavily loaded circuit in the bottom conduit of a duct bank, where practical.

E. Multiple Underground Circuits

Similar to single underground circuits, the magnetic fields directly above the multiple underground circuits can be higher than the magnetic fields directly below an overhead circuit carrying the same currents. The fields can be reduced by increasing the distance between the more heavily loaded cables to finished grade.

The following guidelines are recommended to reduce magnetic fields for double and multiple underground circuits installed in duct banks:

- Locate the conduits away from normally occupied areas, where practical.
- Install heavily loaded circuits in bottom ducts first, where practical

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Southern California Edison
Transmission and Distribution Business Unit

Chapter DDS–12: Plug-In Electric Vehicles

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DDS—12
Plug-In Electric Vehicles

1.0 Scope

Growing concerns over the environment and rising energy costs are driving auto makers to develop Plug-In Electric Vehicles (PEVs).

This chapter contains items that address providing service to enable customers to charge PEVs, and includes requirements and processes associated with PEV charging equipment.

A new or prospective PEV owner should initiate the process by first contacting the Call Center Offline Support group to discuss rate options and SCE's service requirements by either calling 800-4EV-INFO (800-239-2685) or by submitting a request for a call or information at SCE.com/contactus.

2.0 Design Concept

DDS-12 provides information necessary to serve PEV charging equipment. Specifically, this chapter contains the following:

- 3.0 PEV Charging Service Rates (Page 12–4)
- 4.0 PEV Metering Equipment Requirements (Page 12–4)
- 5.0 PEV Demand Estimating (Page 12–5)
- 6.0 Load and Demand Information (Page 12–5)
- 7.0 Power Quality Issues (Page 12–6)
- 8.0 Updating Service Requests (Page 12–6)
- 9.0 2008 National Electrical Code (NEC)—Article 625 (Page 12–6)
- 10.0 Examples of Residential Methods of PEV Service (Page 12–7)
- 11.0 Examples of Commercial Methods of PEV Service (Page 12–9)

3.0 PEV Charging Service Rates

SCE currently offers the following Time of Use (TOU) EV Rates:

- **Rate Schedule TOU-D-TEV** is a whole house TOU rate designed for residential customers who wish to combine the power to their single family accommodation and electric vehicle(s) charging on the same meter at their residence.
- **Rate Schedule TOU-EV-1** is for residential customers who wish to charge their electric vehicle(s) on a TOU-EV rate separately from their primary residence. This rate requires a second panel and a second dedicated meter for PEV charging.
- **Rate Schedule TOU-EV-3** is available to business customers who own and operate electric vehicles using chargers with a maximum demand of 20 kW or less.
- **Rate Schedule TOU-EV-4** is available to business customers who own and operate electric vehicles using chargers with a maximum demand of 500 kW or less.

4.0 PEV Metering Equipment Requirements

TOU-D-TEV Rate – To qualify for the TOU-D-TEV rate, customers without a SmartConnect™meter will need to have their current meter replaced with a "whole house" TOU demand meter. Customers will still need to proceed with the equipment installations, for example, Electric Vehicle Supply Equipment (EVSE), as needed and obtain final approval for these installations by the local Authority Having Jurisdiction (AHJ).

SCE can proceed to install the new meter once the customer submits the application **and** Service Planning has evaluated SCE's infrastructure and found it capable of supporting the additional load of charging the PEV.

If upgrades to SCE's infrastructure are required, Service Planning must not approve the change to the TOU-D-TEV rate until all upgrades have been completed.

Customers with a SmartConnect™meter will need to call 800-4EV-INFO (800-239-2685) to request a change to the TOU-D-TEV rate. No meter change is required. However, Planning will need to visit every PEV customer's site to determine if SCE's infrastructure is capable of supporting the additional load of charging the PEV.

TOU-EV-1 Rate – To qualify for the TOU-EV-1 rate schedule, customers must first verify with the local authority if a second meter will be allowed, apply for a second meter, and install a dedicated PEV charging circuit. Planning will evaluate the infrastructure and order upgrades as necessary. Customers should consult with a licensed electrical contractor and choose one of the following alternatives:

A. Install a new second service panel or meter socket box and have SCE install a second meter

B. Replace their existing service panel with a dual socket panel and have SCE install a second meter

Once all customer equipment is installed and approved by the local AHJ, SCE will install the second meter and activate the service. All standards and regulations regarding meter heights, clearances, and so forth, must be adhered to (refer to ESR Chapter 1, Section 5 for more specific information).

Note: The EV-1 rate qualifies for a second meter under EV Time of Use (TOU) rates. It is not considered added facilities. The Planner should evaluate each situation for the most cost effective method of service installation.

5.0 PEV Demand Estimating

Three standard levels of EV charging have been defined by the Society of Automotive Engineers (SAE) which consists of utilities, auto manufacturers and EV component manufacturers who have an interest in the future EV market. Those levels are shown in Table 12–1 (Page 12–5).

Table 12–1: Charger Demands[a/]

Level	Voltage	Maximum Demand (kW)[b/]
I	120 V	1.9
II	208 V/240 V	19.2[c/]
III	Three-Phase Commercial Voltage[d/]	300

a/ Demand Factor = 100 percent

b/ Largest size (kW) charger permitted under SAE's J1772 Electric Vehicle Charging Standard. Actual size may vary (but not to exceed these limits) according to manufacturers kW nameplate rating.

c/ Verify with the customer the type of charges being installed to determine the load of the proposed charger.

d/ These chargers include "gas station" type fast chargers in commercial applications.

6.0 Load and Demand Information

Table 12–1 (Page 12–5) shows estimated EV charger demands as summarized below.

6.1 Residential and Small Commercial (Level I & II): 1.9 – 19.2 kW

Residential OEM EV chargers average 7.7 kW. Normally this information is found on the nameplate specifications. Check with the customer to determine actual power requirements.

6.2 Commercial (Level III): 20 kW and Above

Most existing large commercial charger capabilities range from 20 kW and above. Some "fast-chargers" are in the 50 - 300 kW range.

6.3 Transformation Requirements

Each installation will vary depending on hours of operation, load diversity, and power quality of the specific charging equipment being used. Verify with the customer to determine actual power requirements.

Figure 12–1: Typical Electric Vehicle Charge Cycle

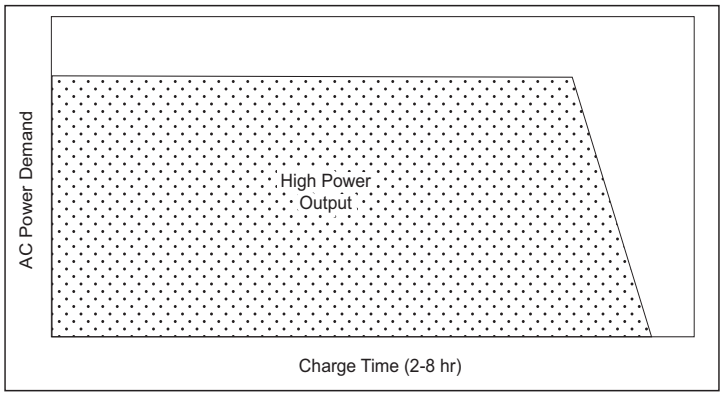


Figure 12–1 (Page 12–6) shows typical EV charging demand profile. Note that EV chargers do not have motor starting in-rush characteristics like those found in air conditioners. Note that EV charging is considered to be a continuous load with the high power output lasting generally over four hours.

7.0 Power Quality Issues

System studies by SCE and others indicate that the use of EV battery chargers could produce adverse effects to the system mainly attributed to harmonic distortion and lower power factor.

The latest generations of chargers address some of these issues by achieving power factors approaching unity and total voltage harmonic distortions of less than three percent.

8.0 Updating Service Requests

Currently the Customer Communications Organization (CCO) tracks all EV Service Requests using the EV document library. Planners are required to work with their Planning Supervisors or appointed representative to update the status of every Service Request in the library in effort to facilitate other customer requests and help refine the process.

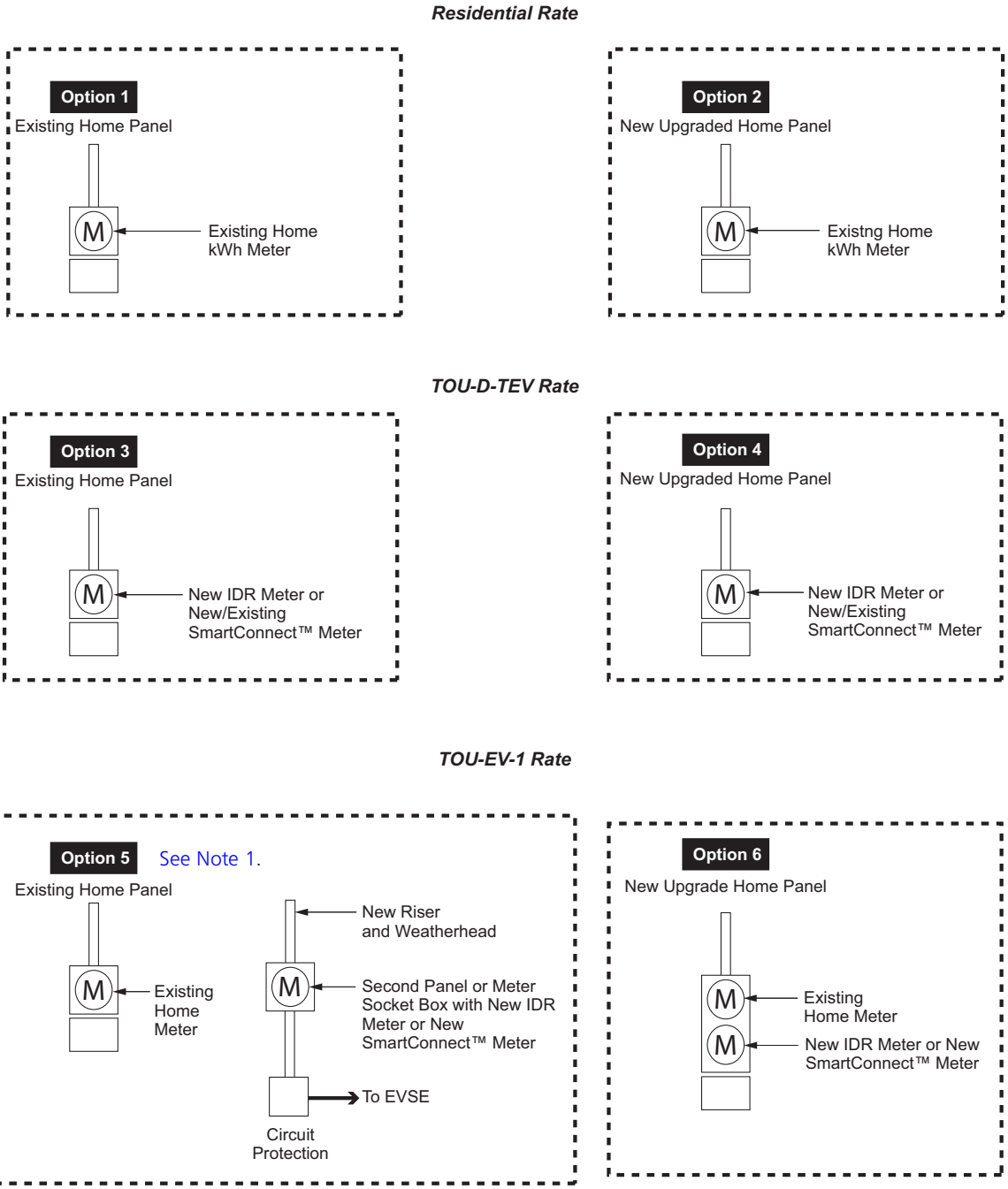
9.0 2008 National Electrical Code (NEC)—Article 625

The 2008 NEC, Article 625 is a dedicated section identifying installation requirements for electric vehicle charging. Specific topics include wiring methods, equipment construction, control and protection, supply equipment locations, and ventilation requirements.

Adoption of the NEC standard varies depending on the local government. Customers are encouraged to contact their city and follow the year code adopted.

10.0 Examples of Residential Methods of PEV Service

Figure 12–2: Residential EV Infrastructure with Overhead Service — Residential Rates

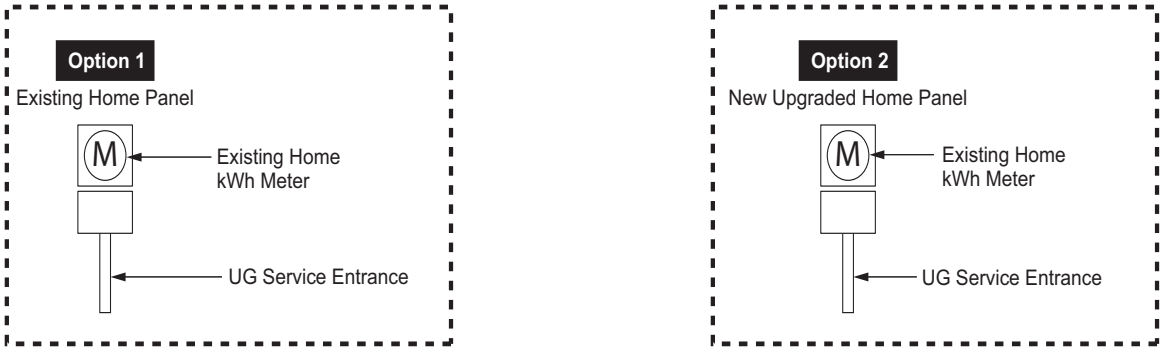


Notes:

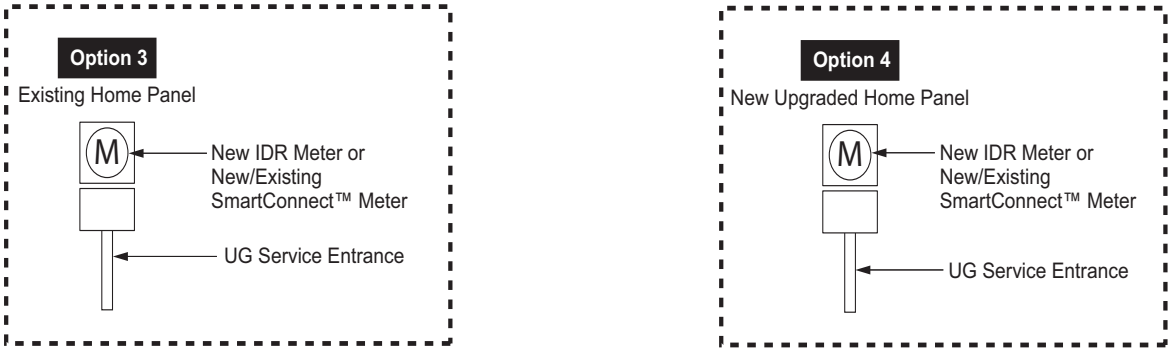
1. Where at all possible, the second panel or meter socket box shall be placed at the same location and directly adjacent to the existing metering.

Figure 12–3: Residential EV Infrastructure with Underground Service — Residential Rates

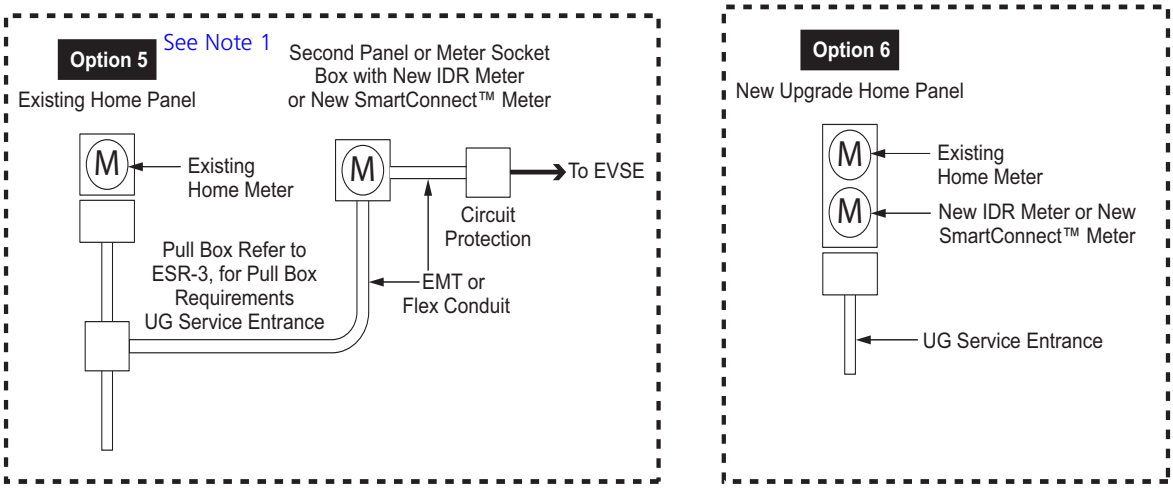
Residential Rate



TOU-D-TEV Rate



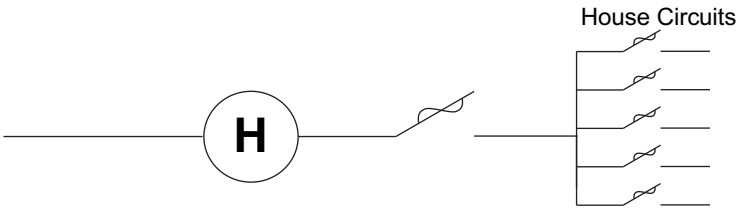
TOU-EV-1 Rate



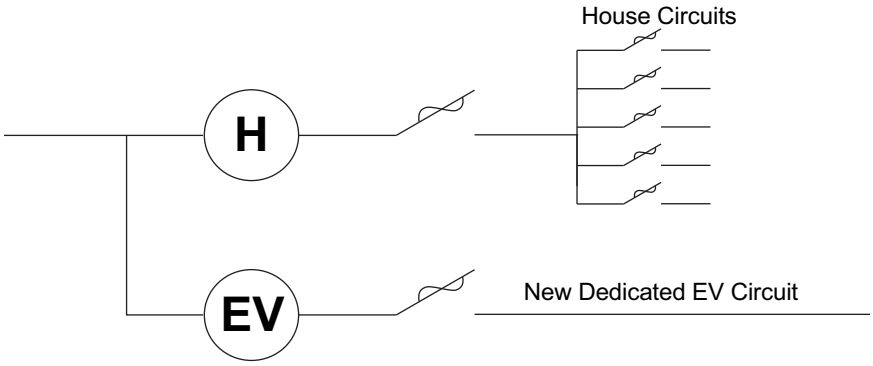
Notes:

1. Where at all possible, the second panel or meter socket box shall be placed at the same location and directly adjacent to the existing metering.

Figure 12–4: Typical Schematic for EV Circuit and Meter



Existing House Meter and Circuit



New EV Meter and Circuit with Existing House Meter and Circuit

11.0 Examples of Commercial Methods of PEV Service

Commercial installations can vary considerably from site to site depending on a variety of factors such as: load and voltage requirements, layout and location of existing electric service, and charging convenience.

Typically, a second meter panel in a commercial application would follow the same equipment requirements as any multi-metering installation. Examples are provided in the next section.

Figure 12–5: Typical Commercial Metering Installation (Example 1)

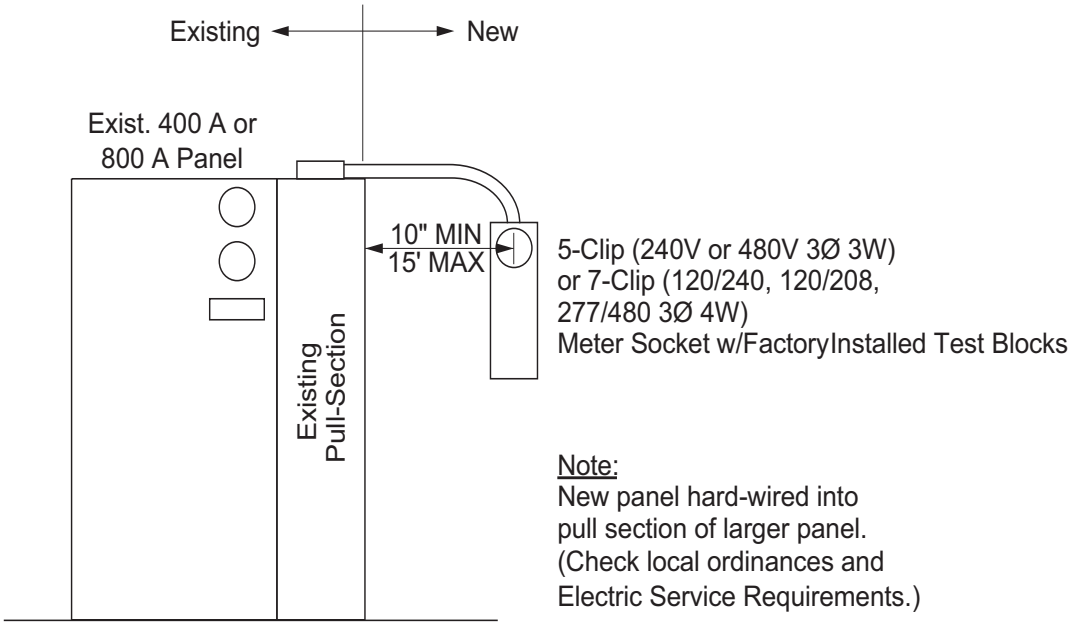
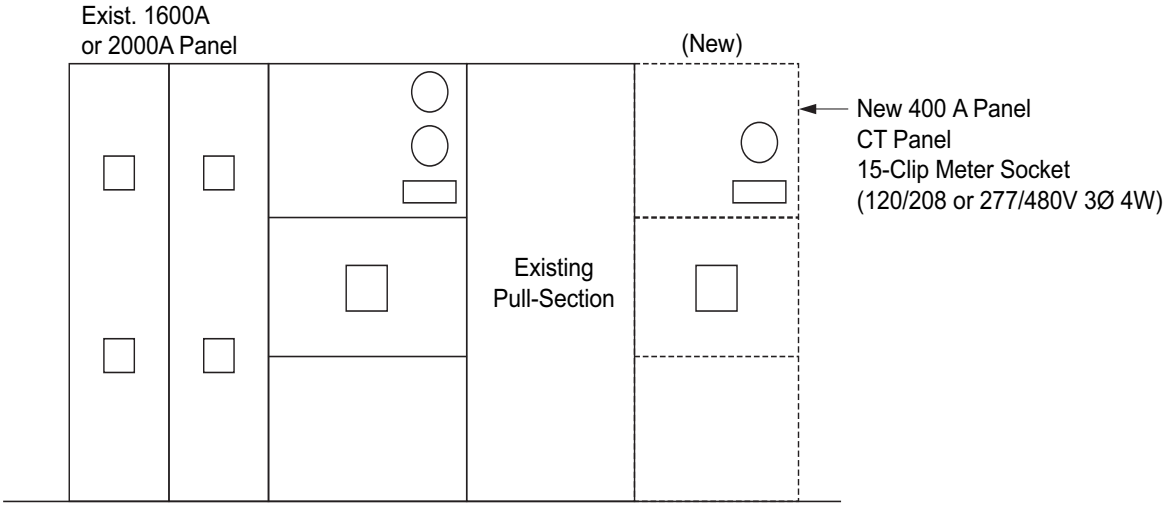


Figure 12–6: Typical Commercial Metering Installation (Example 2)



REBUILD STRATEGY

DDS-13

Southern California Edison
Transmission and Distribution Business Unit

Chapter DDS–13: Rebuild Strategy

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1.0 Scope

This chapter provides criteria for evaluating existing facilities and determining best practices for replacement, rebuilding, and redesigning existing distribution facilities.

Throughout this section, the Planner shall not only consider the immediate customer or system requirements, but the broader, long term system requirements will also be considered. This includes rebuilding the Overhead/Underground systems when new load is added, replacement of cable-in-conduit (CIC) cable, PMH switches, Type "W" KPF switches, automatic reclosers (AR), underground oil switches, primary cable, deteriorated structures, capacitor banks, and non-conforming structures.

Also, this chapter provides the criteria for Worst Circuit Rehabilitation (WCR). WCR involves designing projects to improve the reliability of circuits that experience a high frequency and/or long duration of outages. Circuit performance is measured utilizing System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI). SAIDI refers to the minutes of sustained interruption and SAIFI refers to the number of sustained interruptions experienced by the average customers on that specific circuit. The WCR Program focuses attention on strategies to improve circuit reliability.

2.0 Key Definitions

Chapter DDS-GL contains a glossary which includes the definition of key terms. A review of the glossary will assist in understanding the discussion in this standard.

3.0 Design Concept

The design concepts presented here provide the Planner with the tools to ensure the design concepts are met for:

- Rebuilding and replacing facilities that do not meet current voltage drop/flicker standards for the end-of-line (EOL) customer (the customer furthest electrically from the transformer) when new load is added.
- Replacing primary unjacketed cable (for example, CIC)
- Replacing PMH switches
- Replacing Type "W" KPF switches
- Replacing Overhead/Underground ARs
- Replacing underground feeder oil switches, installing a switch with fewer positions, or rearranging the distribution system to eliminate the switch entirely
- Replacing aged, primary underground cable scoped by AMSR, DSP/PIF, and emergency cable replacement
- Replacing deteriorated structures
- Replacing overhead and underground capacitor banks
- Improving WCR circuits by proactively replacing aging infrastructure in an effort to improve system reliability and increasing the level of reliability to customers
- Evaluating Non-Conforming Structures

4.0 Prerequisite Information

Planning shall incorporate the following specific knowledge and information to determine the design:

A. Existing customer load and future load additions

B. CIC replacement design scope documentation from Asset Management System Reliability (AMSR)

C. AR replacement design scope documentation from AMSR

D. Distribution Overhead Construction Standards (DOH)

E. Distribution Underground Construction Standards (DUG)

F. Distribution Design Standards (DDS)

G. Underground Structures Standards (UGS)

H. Electrical Service Requirements (ESR)

I. Distribution Section of the "*EMF Design Guidelines for New Electrical Facilities: Transmission, Substation, Distribution*"

J. 1,500 kVA Loadblock Criteria

K. Circuit Mapping

L. Facility Inventory Maps (FIM)

M. Base Maps and Utility Look-Ups

N. Worst Circuit Rehabilitation Design Scope Documentation

5.0 Design Criteria

5.1 Residential New Business- Added Load and/or Facility Upgrades for Existing Customers

The Planner will design the existing OH and UG distribution system to accommodate new load added by existing customers. The Planner shall also take into account any known future load additions. If the secondaries, services, or transformers require upgrades due to the new load, the Planner will expand the scope of the project. The Planner will incorporate the EOL customer when calculating voltage drop and flicker.

Where system upgrades are required, the EOL customer shall meet the five percent voltage drop and five percent flicker standards. Refer to DDS-8.

5.2 Cable in Conduit (CIC) or Direct Buried (DB) Cable Replacement

Cable in Conduit (CIC) was installed from the mid 1970s to 2000. Over this period, it is estimated that ten thousand miles of CIC was installed. Over time, the concentric neutrals deteriorate which is contributing to a high rate of cable failures. The CIC Replacement program has been created to replace the primary CIC conductors with a conventional duct system and Jacketed Concentric Neutral (JCN) cable.

For designing a CIC or DB replacement project, the Planner must follow existing design and construction standards when installing transformers, conduits, structures, and conductors. The Planner must also consider site-specific issues: hardscaping, landscaping, rights check, permit requests, easement requests, City rules and regulations, County rules and regulations, HOA rules and regulations, directional drilling (boring), soil conditions, and existing line routes in the area. Planners must also consider City and County public work improvements and moratoriums on streets in the project area.

Notify Districts, Field Engineering, and AMSR of any CIC replacement work orders prior to the start of the design phase.

Design the new system based on the design criteria for CIC or DB replacement per Table 13–1. Evaluate all existing equipment for replacement to ensure current standards and policies are met. For these projects, all live front transformers shall be replaced because live front transformers have reached their life expectancy. The replacement of primary cable and requirement for load break elbows may require structure rearrangement and transformer replacement. Consider converting the existing 12 kV or 16 kV phase-to-phase installation to a 6.9 kV or 9.4 kV if a fourth wire is now available. This would require changing out all of the transformers.

Table 13–1 identifies the various scenarios that may be considered.

Table 13–1: CIC Replacement Design process and Considerations

	Existing Front, Remain in Front	Existing Rear, Relocation from Rear to Front	Existing Rear, Remain in Rear
Option "A" (Primary Only Design, Voltage Drop Five Percent, and Flicker Five Percent)	Preferred Method (based on economic feasibility) 1. Transformer remains in existing location, front property line 2. Handhole remains in existing location 3. Install minimum 1 - 3" primary conduit system to transformer 4. Replace primary XLP cable with JCN per standards 5. Install 1-3" secondary system from source to secondary handhole, wherever primary and secondary share a common trench 6. Replace handholes as needed	1. Transformer remains in existing rear location 2. Source primary cable relocated to front property line 3. Handhole remains in existing rear property line 4. Install minimum 1 - 3" primary conduit system to transformer 5. New primary JCN per standards	1. Transformer remains in existing location rear property line 2. Handhole remains in existing location 3. Install minimum 1 - 3" primary conduit system to transformer 4. Replace primary XLP cable with JCN per standards 5. Install 1-3" secondary system from source to secondary handhole, wherever primary and secondary share a common trench 6. Replace handholes as needed
Option "B" (Primary and Secondary Design, Voltage Drop Five Percent, and Flicker Five Percent)	Includes everything in Option 'A' in addition to: 1. Install 1-3" secondary system and replace handholes as needed in all locations (not limited to common trench) 2. Replace secondary CIC/DB cable	Preferred Method (based on economic feasibility) 1.Transformer and source primary cable relocated to front property line 2. Handhole remains in existing rear property location 3. Install new handholes as needed 4. Install minimum 1 - 3" primary conduit system to transformer 5. New primary JCN per standards 6. Install new 1-3" secondary duct from new transformer location to old transformer location to connect rear secondary system 7. Install new secondary cable from new transformer to old transformer location	Includes everything in Option 'A' in addition to: 1. Install 1-3" secondary system and replace handholes as needed in all locations (not limited to common trench) 2. Replace secondary CIC/DB cable

Notes:

1. If the current project cannot be designed within a particular Design Option(s), then the Planner will utilize portions of other Design Option(s) shown in Table 13–1 as deemed necessary to complete the design.

Documentation as to why the preferred options were not chosen shall be written and included in the work order jacket.

Throughout the design process, the Planner must ensure that the EOL customer will meet the five percent voltage drop and five percent flicker criteria. For designing these projects, the following options are the most cost economical and shall be utilized wherever possible.

A. Existing Front Property CIC and or DB

These systems were originally built on the front property lines, with the primary and secondary conductors located in a common trench.

1. Primary Only CIC or DB — Existing Front Remain in Front
   a. The preferred method is Option A as shown in Table 13–1.
2. Primary and Secondary CIC or DB — Existing Front Remain in Front
   a. The preferred method is Option B as shown in Table 13–1.

B. Existing Rear Property CIC and or DB

These systems were originally built on the rear property line with the primary, secondary, and service conduits sharing a joint trench with phone and CATV. Replacing these systems on the rear property line is not recommended due to the high cost. Construct the replacement system in the front franchise area and adhere to the appropriate standards. The existing handholes, secondary, and services will remain in their current locations.

1. Primary and Secondary CIC or DB — Existing, Relocation from Rear to Front
   a. The preferred method is Option B as shown in Table 13–1.

C. Relocating Existing Transformers

If easements cannot be obtained for front property line pad mount transformers, then the transformers shall remain in the rear property line location. The primary system shall be relocated to the front property line location. Easements for primary and secondary laterals to existing rear facilities shall be secured.

Do not consider BURD transformers for typical use. Install BURD transformers for SCE operating convenience only. When existing field conditions prohibit SCE's ability to inspect, maintain, and operate rear property line transformers, attempt to secure an easement to move the transformer to the front property line. If that is unsuccessful, attempt to secure an easement for a front property line BURD transformer. A standards deviation is required for this option.

Evaluate placing the BURD transformer in the franchise area if the attempt to secure an easement is unsuccessful.

Obtaining easements for every transformer location may not be possible. Systems can consist of front property pad mount transformers, BURD transformers, and rear property line pad mount transformers.

Do not consider designs using vaults and structures for BURD transformers in the street.

5.3 PMH-4 to PME Switchgear Replacement

This design standard covers the planning required to replace existing Pad-Mounted PMH-4 switchgear with either Pad-Mounted Elbow-Connected PME-1 or PME-4 switchgear. The PME dead-front switchgear is the standard replacement for all PMH live-front switchgear. PME switchgear must be fused with current-limiting fuses, unless the installation requires fusing of more than 80 A (two 40 A fuses in parallel). For applications greater than 80 A with fault duty above 10 kA, see exceptions in DUG PD 337.

PMH-4 replacements do not have to be an equivalent PME. The Planner must evaluate if other replacements are appropriate for the current and future applications. Primary Fuse Cabinets (PFC) and PMH-4 switches shall be replaced with PME-1 and PME-4 type switchgears, respectively. In some applications, such as non-fused power transformers and commercial applications, PME-5 switchgears may be used as replacements. When replacing with a PME-5, a larger pad opening is needed. See UGS SS 591 for the appropriate pad when replacing a PMH-4 with a PME-5. PMH-4 switchgears manufactured by Scott Engineering shall have a higher replacement priority than PMH-4 switchgears of other manufacturers.

A. Residential/Commercial Applications

The existing PMH-4s are currently being used to provide fuse protection for multiple 6.9/9.4 kV and 12/16 kV radial systems that feed the downstream single-phase and three-phase transformers.

In some existing installations, the working clearances are no longer adequate. During this retrofit process, the Planner must ensure that proper operating clearances are available. The PME-4 switchgear requires eight feet of clearance on both operating sides and a minimum of three feet of clearance on the sides. Where existing obstructions do not allow for three feet of clearance on the non-operating sides of the switchgear, this distance may be reduced to 18".

In situations where existing clearances are inadequate, the Planner must consider an alternate location.

The **existing** PMH-4 had the ability to be oriented in either position of the pad. However, the new PME-4 replacement switchgear is restricted to one orientation (the doors being parallel to the splice box). In some instances, this may require rotating the replacement PME-4 switchgear 90 degrees from the existing PMH-4 orientation. Where a rotation is required, the Planner shall ensure that the eight feet working clearance requirement is met.

The replacement pad for the replacement PME-4 switchgear must be oriented **parallel and in-line with the long axis** of the existing splice box. The replacement pad is 4' x 6' and the existing splice box is 2' x 3'. The six-foot length of the replacement pad must be oriented in-line and parallel to the three-foot length of the existing splice box.

In all cases, the existing PMH-4 switchgear must be opened by qualified electrical workers to determine the orientation of the existing splice box.

Note: The existing PMH-4 could sit in either position on the pad. However, the replacement PME-4 switchgear must be aligned parallel to the three-foot axis of the splice box. Refer to UGS SS 593 for replacement of the pad.

Figure 13–1: Photo of an Existing PMH-4 Installation



Consult with Field Engineering for other fusing options.

B. Replacement of PMH with a PME in Commercial Applications

Typically, commercial power transformers require switching and fusing capabilities which could be provided by a PMH/PME. In situations where a dedicated switch is available, fusing may be provided by a PME-4.

When replacing a PMH-4 with a PME-5 in commercial applications, the Planner must design the installation based on the standards in DDS-3, Section 5.3.C. A PME-5 can be used when one transformer is feeding a single customer. Refer to DDS-3, Table 3–1 for details.

For pad-mounted equipment structures, refer to DDS-6, Table 6–3.

For the installation of a PME-4, PME-5, and any associated cable upgrades, the unidirectional pulling limitation of the installations shall satisfy the equivalent pulling length. Refer to DDS-9, Table 9–13 for details.

5.4 Type "W" KPF Air Break Disconnect Switch Replacement

Type "W" KPF Switches are no longer approved for operation and will be removed from service.

The Planner shall evaluate the application to determine if a replacement switch is still required. This evaluation will be based on the need to provide an isolation point for each load block of 1,500 kVA of transformation.

If a switch is not required, the Planner shall contact Field Engineering prior to designing the work order to remove the existing switch. Contact Distribution Project Management Organization (DPMO) when a Type W KPF switch is identified in the field which has not been identified on the Switch Replacement Program list.

If a switch is required and the Planner determines the replacement switch should remain in a vertical position, or if the circuitry can be rolled flat to a horizontal configuration, install an approved load break switch. Refer to DOH AP 300 and DOH AP 336 for details.

An avian-safe switch must be utilized.

5.5 Automatic Recloser (AR) Replacement

Existing ARs and associated equipment replacements may require upgrades. The existing AR and its associated equipment may be obsolete and the clearances may be different than the new installation requirements.

ARs are replaced based on the age, design, circuit configuration, and field inspection results to prioritize replacements under the Infrastructure Replacement Projects.

This section details design guidelines for AR replacements. Field Engineering shall be consulted to determine if an AR is still required. Refer to DOH, AP 505 and DUG, AP 210 for approved ARs for new overhead and underground installations.

ARs are used in the distribution system to automatically sectionalize portions of circuits where fault duties on that section are not large enough to cause the circuit breaker at the substation to operate and where there is a need to protect the upstream section from circuit operations. Following an interruption, the AR can be configured to automatically reclose. SCE typically configures ARs with a single reclose attempt 30-seconds after the interruption, although ARs have the capability for multiple reclose attempts and various timer durations. The reclose attempt may result in either restoration of power or again sectionalizing the line section depending on the type of fault. The AR is configured to open before the substation circuit breaker, thereby keeping the section of the circuit upstream from the AR energized. In high fire hazard areas, regulations require circuits to be patrolled before they can be re-energized after a fault and the AR serves to isolate that section of the circuit from the rest of the customers on the upstream circuit until the patrol can be completed. Thus, ARs perform an important function to system reliability and preserving public safety.

ARs have undergone extensive changes since SCE began installing them. The latest ARs have a vacuum breaker and electronic control arrangement. Many of the oldest ARs cannot be repaired cost-effectively, as they are no longer manufactured or are of an obsolete design. ARs are designed for a 30-year service life.

The AR replacement scope submittal from the Distribution Project Management Organization (DPMO) Project Manager must include the following information: District, Substation, Circuit, Field Engineer, Project Manager, Project Analyst, Circuit Map or other means of identifying the general area of the AR installation, and Identification of any required automation. The Planner shall ensure that the completed documents are included in the work order package, such as the NetComm Form, Environmental Screening Form, OD-43 Form, and the CSD-111 Form. Please refer to the last Design Support Update for more detailed information (for example, DSU 1B-09).

Field Engineering shall be consulted in order to determine if an AR is still required. If field conditions prevent an installation of an AR and its associated equipment at the scoped location, the Planner shall contact the Project Sponsor and Project Manager who originally submitted the scope. Consider location requirements such as truck access and crew operability. The pole must pass current pole loading standards, and the existing clearances must adhere to current standards.

A. Digital Photos

At a minimum, the Planner shall include the following digital photos in the work order:

1. The proposed source structure and its general surroundings.
2. Digital photos of the pole or underground structure. If taking a digital photo of a pole, then take digital photos of the top level, communication level, and ground level (base of pole).
3. Any other digital photos needed to help the line crew understand any unusual conditions.
4. Panoramic digital photo for Environmental review.

B. Clearances and Pole Loading

Clearly identify the clearances from the top of the pole to the mounting height of the AR mechanism on the work order map.

Any necessary rearrangement shall be completed on the work order. On the work order map, the clearances from the top of the pole to the mounting height of the AR mechanism must be clearly identified. For an AR installation, the weight of the unit and the mounting elevation will be used to determine the minimum grade of the pole.

If the pole does not meet minimum diameter at the mounting height per Table 10–1 in DDS-10, the Planner may attempt mounting the unit lower on the pole within requirement. If an acceptable diameter cannot be obtained, the pole must be replaced based on both Table 10–1 in DDS-10 and a passing pole load safety factor. See DDS-10 for safety factors for wood, light weight steel, and composite poles.

- Refer to DOH, DC 100 for climbing space requirements.
- Refer to DOH, DC 200 for pole head clearances.
- Refer to DOH, DC 220 for conductor clearances.
- Refer to DOH, AP 335 for clearances for line and load disconnect switches.
- Refer to DOH, DC 520 for heavy loading areas above five thousand (5,000) feet.
- Refer to DOH, DC 530 for suspension construction.
- Refer to DOH, DC 540 for vertical construction requirements.

C. Truck Access

Review the scoped location and determine if there are pullouts or adequate shoulder areas for truck and crew access. Avoid narrow roads with blind corners and no shoulders. Also, assess potential environmental issues and rough terrain. If issues exist at the scoped location that prevent an AR installation, then identify alternate locations and contact the Project Manager and Program Sponsor who originally submitted the scope.

D. Overhead Bypass Switches

Use an Omni-Rupter switch for new installations as the bypass switch. Use Alduti-Rupter switches for 33 kV applications.

Use an inverted switch for Avian-Safe Construction. Refer to DOH, AP 300, for pole-top gang operated switches. Refer to DOH, AP 336, for 17 kV Omni-Rupter and 38 kV Alduti-Rupter switches.

E. Environmental and Avian Protection

An Environmental Screening Form is required to be completed in the field for every work order and for each pole location within the work order. While visiting the site, carefully consider all environmental issues that may be relevant to the project.

If an Environmental Review is required as indicated on the Environmental Screening Form, submit the form for review immediately. The Planner shall attach all relevant photos of the site with the Form. From the photos, the Environmental Specialist may review and possibly release the project. On the work order check sheet, record the submittal date and retain a copy of the Environmental Screening Form in the work order package. The Environmental Screening Form can be found at:

https://portal.edisonintl.com/irj/go/km/docs/sce/Operations%20Support/My%20Company/Safety%20%26%20Environment/Corporate%20Health%20and%20Safety/Topics/F%20-%20J/Ground%20Distrubing%20Activities/Environmental%20Screening%20Form.doc

For Avian-Safe Construction, refer to DDS-10, Section 5.6, N., and DOH, DC 535.

F. Automation

All new ARs shall be automated (remote automatic recloser). It is necessary to obtain latitude and longitude of the proposed location. Use a handheld GPS unit provided by the Planning Organization to obtain these coordinates. Do not use other tools such as Google Earth, as they do not provide the required level of accuracy.

G. Pad-Mounted Remote Automatic Reclosers (RAR)

- All Pad-Mounted RARs require a bypass switch.
- Review structure applications in DDS-6, Section 4.0.
- Refer to UGS, SS 530, for slab box requirements.
- Refer to DUG, AP 500, for bypass switch requirements.
- Refer to DUG, AP 210, for RAR requirements.
- Refer to DUG, AP 200, for bypass switch construction standards.

The Planner shall consider the appropriate operating clearance in front of the control cabinet which houses the automation and controller. Four foot clearance is recommended between the edge of the pad of the control cabinet and the adjacent aboveground structure.

5.6 Underground Feeder Oil Switch Replacement

Gas switches and above ground, pad-mounted switches are Edison's standard installation per the Above Ground Equipment (AGE) initiative. Infrastructure Replacement Programs replace underground oil switches through maintenance inspections or during the course of switching. The strategy for replacing underground oil switches is applicable for the replacement of gas switches.

Underground feeder oil switches are installed for many purposes, including to sectionalize customer load, isolate loadblocks (1,500 kVA), isolate equipment and/or cable for planned or emergency replacement, to balance load from one circuit to another, and to provide customers with immediate access to another circuit for preferred/emergency switching.

Many underground feeder oil switches were installed before the "Design of the 90s" was created, and these installations may exceed the current DDS criteria. In many situations, the underground oil switch can be eliminated entirely; in other cases, the number of positions can be reduced.

Before proceeding with the switch replacement, the Planner shall become familiar with the circuitry in the surrounding area and identify the impact the switch has on the circuitry. The Planner shall review every circuit within the structure of the scoped oil switch. Contact Field Engineering if Planning proposes to remove the switch.

Pad-mounted switches should be considered as replacement for below ground switches per the AGE initiative. If the switch was identified through the Switch Replacement Program and the Planner proposes a change to the original scope, the Planner shall contact the Project Sponsor to discuss the proposed scope change.

For Capital Hand-Offs, the Planner shall contact Asset Management and System Reliability (AMSR) in order to determine if the oil switch has been identified for replacement as part of the Underground Oil Switch Replacement Program.

During the review, the following conditions shall be evaluated:

- Redundant switches or switch positions
- Unnecessary "looped feeders" or paralleling points within the system
- Size and number of loadblocks being served
- T-taps served from the feeder system
- Paper Insulated Lead Covered (PILC) cable connected to the switch

A. Redundant Switches or Switch Positions

If the switch(es) cannot be eliminated, the Planner shall determine the appropriate number of switch positions that are required based on DDS criteria.

A circuit may have a redundant amount of switches and/or switch positions that are not compliant with the DDS. Upon review of the circuitry connected to the switch and the associated loadblocks, there may be an opportunity to eliminate the switch(es) entirely. The existing load may be rearranged by utilizing a T-tap and junction bars or utilizing an empty conduit and installing a run of cable to feed the load from an adjacent switch.

The Planner should contact Field Engineering when switches are proposed for removal.

EXAMPLE 1:

The following example (shown in Figure 13–2) shows a system that was constructed in 1977. This system has an overabundance of switches and switch positions. The total load being served is 4,621 kVA, or three loadblocks. The actual kW of demand on this system is 1,780 kW, which is slightly larger than the 1,500 kVA loadblock criteria. A total of 13 switches were installed, totaling 62 positions (eight of which are empty). Assuming that every switch was replaced as-is (which would not be possible considering the current DDS structures standards), the total approximate replacement cost is $650,000. Compliance with the current DDS criteria ensures a safe and economical approach to the replacement of these switches and reduces the cost of scope for this example.

If a Planner had a project to replace one of these switches, the proper course of action would be to remove the switch and install 3- or 4-way J-bars. In some instances it may be necessary to utilize a 3P, 3W BURD switch to create appropriately-sized loadblocks.

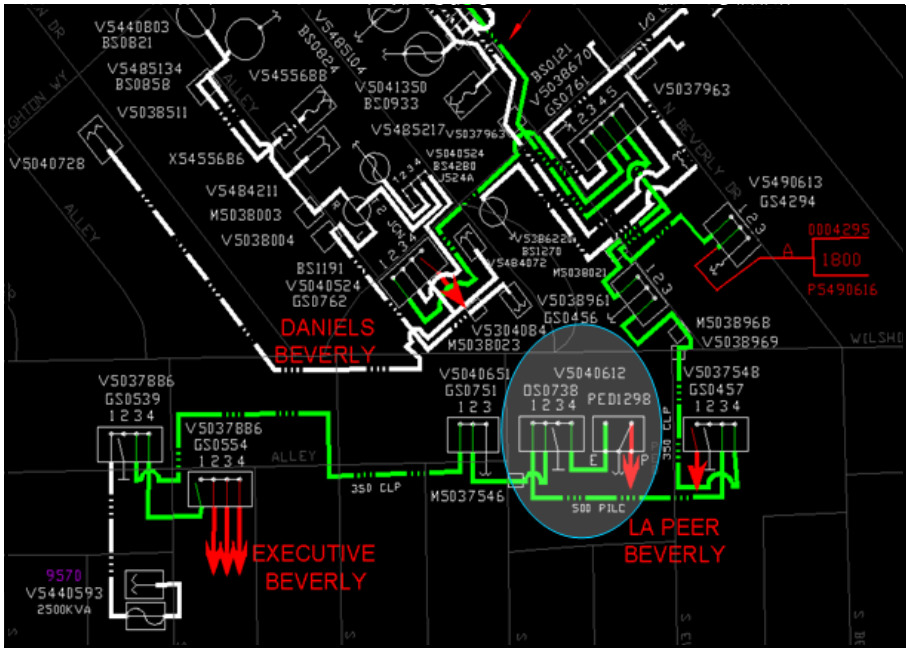
Figure 13–2: Non-Conformant and Unnecessary Practice of Installing Underground Switches



EXAMPLE 2

The following example (shown in Figure 13–3) is a situation where a deteriorated switch can be eliminated. In this situation, OS 0738 is serving no purpose. By replacing the PILC cable with jacketed concentric neutral (JCN) or cross-linked polyethylene (XLPE) cable and a set of 600 A J-bars, the switch can be eliminated. Elimination of this switch saves years of related maintenance expenses and additional replacement costs in the future. When the switch requires replacement. Removal of this switch also eliminates a potentially overcrowded structure issue.

Figure 13–3: Possible Underground Switch Elimination



B. Unnecessary Looped Feeders

Looped Feeders provide a looped system on the same circuit. Reducing unnecessary circuit ties and looped feeders may bring an overcrowded structure back into compliance. The Planner shall evaluate if a parallel run of cable between adjacent switches can be eliminated.

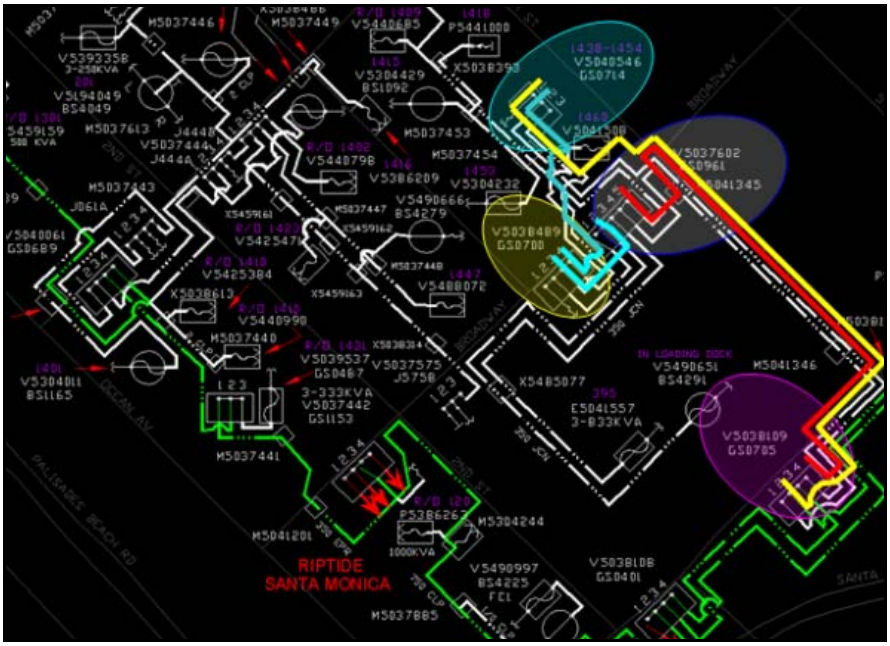
If a switch has more than two attached circuits, the Planner shall also review the overall circuitry to determine if circuit ties can be eliminated. The Planner should contact Field Engineering when circuit ties or looped feeders are proposed for removal.

EXAMPLE 1:

On the Suntower 16 kV (shown in Figure 13–4), there is a loop from GS 0705 to V7602 to GS 0714 (yellow line). The loop continues from GS 0714 to GS 0700 and finally to Open Position 1 of GS 0961 (cyan line). This loop is supporting the load fed from GS 0714, which is a bank of 3-75 kVA transformers.

This system can be brought into compliance with DDS by eliminating GS 0714, GS 0700, and the redundant loop (yellow line).

Figure 13–4: Suntower 16 kV



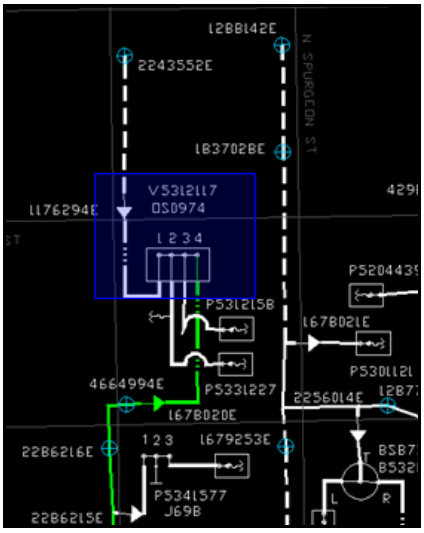
C. Loadblocks

Upon review and evaluation of the switch and associated circuitry, the Planner shall determine if the load being served off the switch is in compliance with the DDS loadblock criteria. In calculating the load for fully developed areas, the Planner shall consider the actual load based on Transformer Load Management (TLM) or billing information after consulting with the customer(s) on their operations. It may be appropriate to use the demand of actual load versus kVA of transformation to determine the size of the loadblock. The Planner shall also consider the need to serve future load in the area, such as adjacent vacant parcels and future capacitor pads.

EXAMPLE 1:

Examining the situation below (shown in Figure 13–5) we find 350 CLP feeding 4-Way OS 0974, a 600 A RAM switch. The switch feeds P5331227 (75 kVA transformer), P5312158 (150 kVA transformer), and an open delta bank on pole 2243552E (65 kVA) for a total transformation of 365 kVA. This system was built in 1985, which was prior to the implementation of the DDS. This switch is not feeding a 1,500 KVA loadblock and it should be eliminated.

Figure 13–5: Suntower 16 kV



D. T-Taps and Feeder System

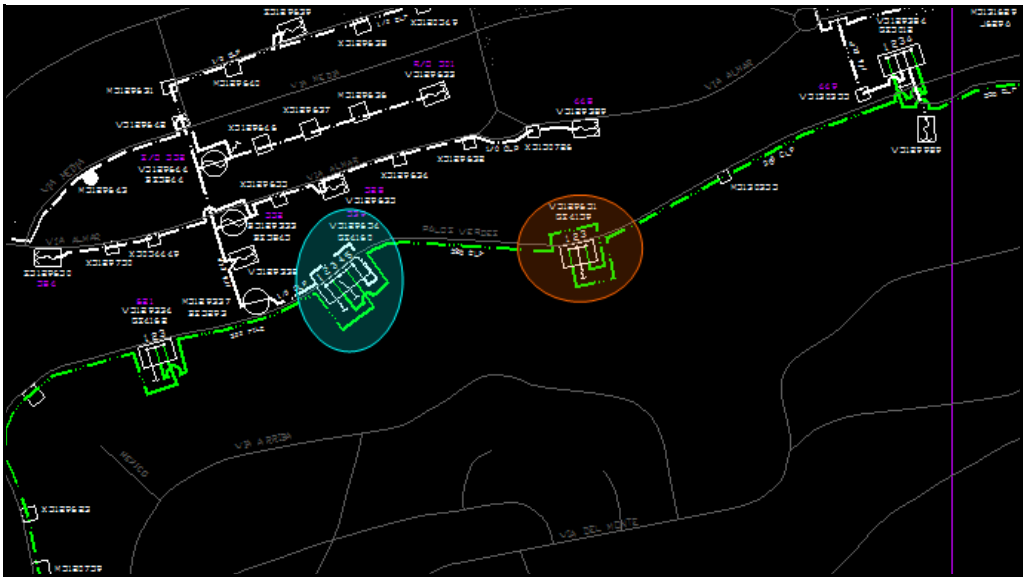
If it is determined that less than 1,500 kVA loadblock is being served by the switch and a review of the entire circuit determines that there is no operational need for the switch, the Planner shall take into consideration the number of T-taps currently fed between switch positions.

A maximum of three T-Taps are allowed between switch positions. Two of the T-taps must be at a switch position and the third must be dedicated to a 25 kVA transformer or less. Refer to DDS-2, Section 3.0 for further details.

EXAMPLE 1:

Within V 129654 on the Chino 16 KV (shown in Figure 13–6, we find GS 4160 which is a 5-Way RAM switch (blue circle) serving a single loadblock. This switch can be eliminated and replaced with J-bars. The adjacent switch, GS 4159 (orange circle), serves a single 50 kVA BURD transformer. This system consists of four, five-inch conduits with two of those ducts empty. By installing 600 feet of 1/0 cable, the Planner can eliminate both of these switches.

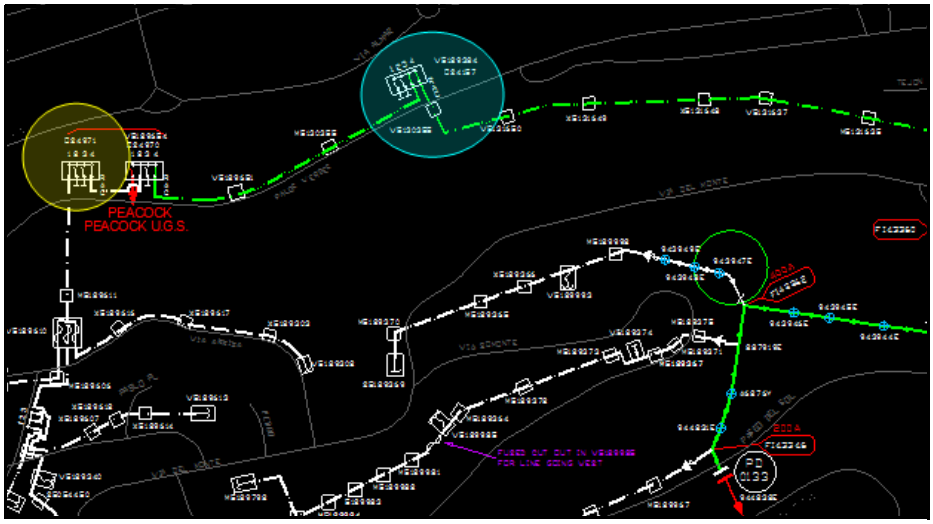
Figure 13–6: Chico 16 kV



EXAMPLE 2

These switches can also be replaced with T-taps or 600 A J-bars.

Figure 13–7: Malaga Cove 4 kV



E. Determining the Appropriate Replacement Switch to Install

DDS-2, Section 5.3 establishes a priority for the installation of switches. This priority listing starts with overhead switches, proceeds through surface operable switches, and ends with switches installed in underground structures. The Planner shall consider the safest, most operationally and economically feasible replacement option. This option may be to use an overhead, pad-mounted underground, or switch. Weigh these options with Local Operations Supervisors, Field Engineering, and Local Planning Supervision.

1. Replacing RAC Switch with RAG or RAM Switch

Contact the Project Sponsor and Field Engineering when rearranging the circuitry. In the past, underground switches had different types such as RAM and RAC switches. When RAC switches were first introduced, their intent was to provide greater switching flexibility. However, their continued use is no longer available. Per today's accepted operational practice, do not permit more than two circuits on an underground switch. To replace a RAC switch, the circuitry will need to be modified to accommodate a RAG or RAM switch replacement. In situations where multiple circuits are attached to a switch, it may be necessary to rearrange and to express one circuit straight through the structure.

Figure 13–8 and Figure 13–9 depict a RAC switch replaced with a single RAM switch.

Figure 13–8: Existing RAC Switch

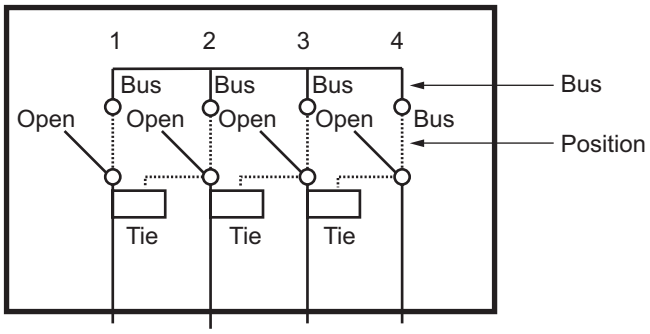
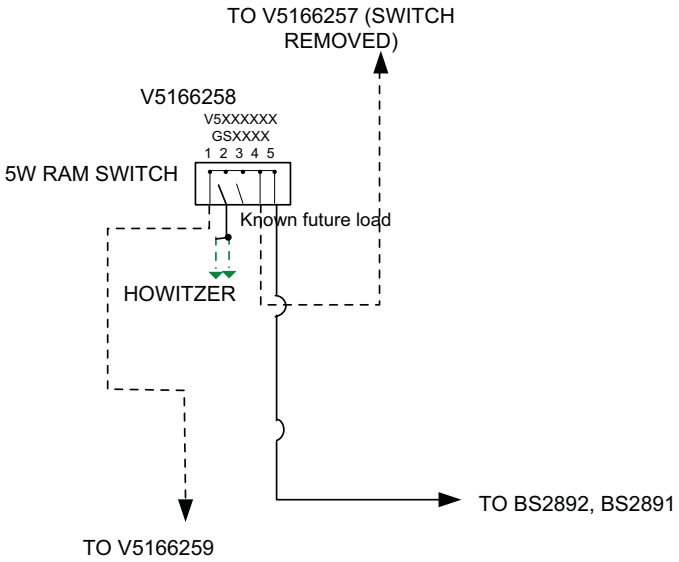


Figure 13–9: Proposed RAM Switch Replacement

PROPOSED BATTALION 12KV
(PARTIAL SINGLE LINE)



2. Replacing RAC or RAM Switch with RAG Switch

   In 2010, the RAG switch was introduced as a new alternative to RAM switches. DDS-2 identifies the RAG switch as the preferred switch in underground installations in specific locations. The new RAG switches were developed to simplify the grounding procedures that must be utilized when crews work on underground conductors. In the past, temporary grounds would be installed through the 200 A or 600 A components on a switch. Grounding in this manner added to the length of the customer's outage. The RAG switch now allows grounds to be applied within the switching mechanism. This switch has three possible positions: 1) closed-to-the-bus; 2) open to the bus and ground; or, 3) closed-to the-ground.

   Due to the cost of a RAG switch, install RAG switches on Infrastructure Replacement Programs, New Business, DSP, Plant Betterment, and Rule 20 Projects. Refer to DDS-2, Section 5.3, to review the alternating combinations of RAG and RAM switches.

   Verify that the existing structure meets the current DDS-6 standards for installation of the RAG or RAM switch.

   Refer to DUG, SE 259, for construction details on RAG switches.

F. RAM Switches

   RAM switches shall be utilized per DDS-2, Section 5.3.

G. Above Ground Switches

   Consider using an above ground switch when replacing a switch and the existing structure is overcrowded.

   PME switches are the preferred option for above ground switches, but the structure size and required clearances may make them impractical and unfeasible. When evaluating the use of PME switches, the Planner shall also consider aboveground equipment (AGE) and local requirements (city, county, and residential).

H. Underground Structure Selection

   Verify the existing structure meets current DDS-6 standards when replacing a switch with a RAG or RAM switch. If the structure does not meet the current DDS-6 standards, prepare a Standards Deviation to use the existing structure. If the Standards Deviation is not approved, then the Planner shall design the work order utilizing a replacement, bypass structure, or other alternate design.

I. PILC Cable Connected to Underground Feeder Oil Switches

   Feeder oil switches connected with PILC cable must be replaced as part of the switch replacement scope. The Planner shall design for the replacement of the connected whole segments (one run in each direction to the next adjacent structure).

   The following considerations shall be made:

   - If existing PILC cable can be landed on the new switch by utilizing lead-poly elbows. Refer to DUG, JJ 450. If there is enough PILC cable so that it can be landed on the new switch, then the PILC cable may not have to be replaced.

- Available ducts, duct sizes, and if existing ducts will support jacketed concentric neutral (JCN) cable or ethylene propylene rubber (EPR) cable.
- Adequate structure sizes.

Based upon the above considerations, the Planner may include in the design of the underground feeder oil switch replacement a design to also replace one run in each direction of PILC cable instead of splicing. If more runs are desired for replacement, contact the Project Manager and Project Sponsor. Refer to Example 2 in Section 5.6, A.

5.7 Primary Cable Replacement

This section provides direction for primary cable replacement which may be replaced through Planned Programs or emergency situations. Types of cable considered under the Primary Cable Replacement Program include PILC and XLPE cable.

To improve the reliability of the underground system, use JCN or EPR cable as the replacement cable.

Evaluate and determine the most cost effective means for replacing the conduit. JCN is the preferred economical cable replacement for PILC. Installing EPR as the replacement cable requires a thorough analysis to confirm EPR is the lowest cost solution (refer to DDS-9, Section 7.0).

In all situations, Planners shall thoroughly evaluate and determine the most cost effective means of replacement before proceeding with the design by utilizing existing duct system(s).

The preferred technical and economical replacement cable for PILC is JCN if the conduit and structures allow for pulling and the replacement cable size meets loading requirements. The alternative cable for replacing PILC is EPR cable, which shall only be installed after performing a thorough analysis showing that no viable lower cost option is available other than using EPR (Refer to DDS-9, Section 7.0). EPR cable is approximately ten times more expensive than JCN cable.

A. AMSR Cable Replacement Program

Cable failures directly impact the circuit reliability indices: System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI). These indices are the focus of the Cable Replacement Program. The requirements for replacing cable within the Cable Replacement Program are feeders with conductors that are at or beyond their service life, or feeders that have a history of reliability issues. Other examples of cable being replaced today include PILC and XLPE unjacketed cable.

AMSR will identify and scope cable replacement based on an analysis of several factors including, but not limited to, failure rates affecting circuit interruption and age of cable.

Consult Substation Engineering, Field Engineering, and the Project Sponsor if cables within substations are identified for replacement and require civil work on substation property:

- Confirm the age of cable that has been scoped for replacement.
- Evaluate undersized cable (chokers) that do not meet load requirements.

- Consult with Field Engineering for load requirements.
- Evaluate circuitry for redundant circuit ties and unnecessary looped feeders.
- Ensure existing structure and conduits meet standards for the JCN cable size to be installed.
- Consider an alternative route where existing conduit and structures do not meet standards.
- If the existing conduit meets standards but the existing structure does not, consider intercepting the existing conduit by means of bypassing the structure thereby avoiding costly replacement. Adding a bypass structure is the preferred economical alternative compared to replacing an existing structure to a larger structure. Refer to DDS-13, Section 5.8.
- Evaluate if the equivalent pull length (EPL) calculations (including multiple point pulling tensions (MPPT)) meet standards for the replacement cable size. (MPPT has replaced EPL).
- Consider duct bank loading for the proposed scope line route. Contact
- Field Engineering for assistance in evaluation.
- Consider the number and location of existing T-Taps.
- Consider minimizing or eliminating CLP-to-PILC terminations where appropriate.
- Any scope changes shall be consulted with the Project Sponsor, Project Manager, and Engineering.

Cables may also be identified for replacement within substations. It is critical to adhere to duct bank and cable loading requirements as shown in DDS-9 and structure requirements as shown in DDS-6. Consult Substation Engineering, Field Engineering, and the Project Sponsor if cables within substations are identified for replacement and require civil work on substation property. This communication is essential to the coordination of work between multiple work groups.

If any civil work is required on substation property, the Distribution, as well as Substation Underground Civil Construction Groups, must participate in the design process. An onsite meeting is mandatory with all parties (Field Engineering, Substation Engineering, Project Sponsor, Underground Civil Construction, Technical Planning, and SC&M) prior to proceeding with the formal design. All associated work order numbers shall be listed on the construction drawings and work order jacket(s).

B. DSP/PIF Cable Replacement

During substation and circuitry review, primary XLPE unjacketed cable and PILC may be identified to be upgraded to larger sizes to meet current and future loading requirements. The cable upgrade projects identified through the Engineering Organization are scoped to provide the Planner with direction on proposed line sections/routes and cable size requirements. The Planner shall take into consideration the points mentioned in Section 5.7, A., during the design and preparation of the work order.

C. Emergency/Failed Cable Replacement

Primary cable failures often occur due to the age of the cable, deterioration, excessive loading, and 3rd party dig-ins. When a cable failure occurs, the main concern is to facilitate the replacement in a timely manner for restoration of service.

Replace failed cable after performing an evaluation for future loading requirements. A like-for-like replacement may not be appropriate. This evaluation is to ascertain that the replacement cable is in compliance with current standards and meets the present and future loading.

Other items to consider:

- Required or unnecessary cable run(s)
- Loading on the failed run(s)
- Evaluate whether the failed cable was a choker
- Number and location of existing T-Taps
- If the cable failure occurs during normal business or is deferred to be replaced at a later time (no immediate replacement is necessary), contact Engineering to determine if future plans are identified for replacement to a larger cable
- Cable failures due to dig-ins and car hit riser runs will be replaced like-for-like due to billing through Claims
- If increasing the cable size, consider if the existing structure(s) and conduit(s) meet existing standards

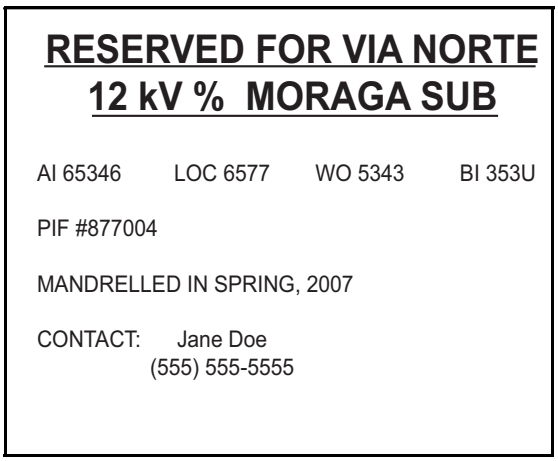
D. Equipment and Structures

Verify that structures involved in the scope of the cable replacement project meet existing standards requirements. Equipment, structures, and cable included in the scope shall meet all requirements of DDS-6 and DDS-9. Communicate any changes to the scope of the project to AMSR.

Mandrelling shall occur during the planning stage of the project. Conduit to be used will be proven clear and tagged appropriately (an example of a tag is shown in Figure 13–10). This tag contains all of the necessary information. If none of the spare conduit passes mandrelling, the Planner shall prepare a work order package for civil repairs.

The conduit which does not pass mandrelling shall be plugged and tagged. In addition, the conduit shall be marked as damaged on FIMs and submitted to the District Field Accounting Organization to be processed for mapping changes

Figure 13–10: Mandrelling Tag



5.8 Underground Structure Replacement

Identifying underground structures requiring replacement based on deterioration can happen through the UDI Program or installations of new or replacement equipment.

The replacement of deteriorated underground structures is complex and expensive. Since many deteriorated structures are 50 years or older and are reaching the end of their life cycle, a significant number require replacement. Consideration should be given to the requirements of the AGE initiative and above ground alternatives evaluated. The Planner shall take the necessary steps to evaluate all aspects identified per the standards for these projects for safe and cost effective means of replacement before proceeding with the design.

The Civil Contractor will excavate and demolish the existing structure and install the new structure working alongside energized cable and equipment. Address safety hazards during the design phase of the project.

A. AMSR Structure Replacement Program

The AMSR Structure Replacement Program manages projects for the replacement of deteriorated structures identified through the UDI inspection process. Structures will be submitted to Distribution Apparatus Engineering for an evaluation. The evaluation will recommend whether the structure will be repaired or replaced. The final decision to actually repair or replace will be determined by Regional and District Management.

B. DSP, PIFs, New Business, Rebuild, and Other Infrastructure Replacement Programs

When designing these projects, if the Planner identifies structures that exhibit signs of deterioration (refer to UGS, MS 860), the Planner shall verify if an inspection has already been performed. This can be done by contacting UDI Management. If no inspection record is found, the Planner shall submit a request for an inspection. If the structure is deteriorated, the SCE employee (for example, General Foreman, General Supervisor, or Service Planner) shall submit a request to Distribution Apparatus Engineering for further evaluation.

The request shall include the following items:

- Location(s)
- Size of structure(s)
- Type and extent of deterioration
- Type and quantity of any contained equipment
- Digital photos including:
  - The deteriorated portion(s) of the structure
  - All four walls of the structure
  - The entire ceiling including details of the opening
  - Digital photo of the opening above the surface
  - Overview digital photos showing the relative location of the structure to sidewalks, streets, greenbelts, and street intersections

The evaluation will be returned to the Planner with a recommendation.

C. Evaluation

When a structure is identified as requiring replacement, the replacement structure shall meet existing and future requirements. In addition, the Planner shall assemble a Project Team (refer to DDS-13, Section 5.8, D. 1.) for a list of mandatory invitees), as required to provide assistance with the design. The process shall include a sequence of events to include:

- Initial Project Meeting
- Red Line Review Meeting
- Civil Job Walk Meeting
- Final Civil Design Approval
- Permitting
- Final Work Order

During the process, the Team shall agree that prior steps have been completed before proceeding to the next step.

DDS-13, Section 5.8, covers the project management aspect of structure replacement projects.

DDS-13, Sections 5.8, D. through 5.8, G., cover the design and design considerations that shall be incorporated into the work order.

D. Project Management

Considering the complexity and expense of facilitating the replacement of deteriorated structures, the Planner shall follow the sequence of events listed below for timely and efficient completion of the replacement. The initial, up-front work performed is expected to reduce the high cost associated with these projects.

1. Initial Project Meeting

In preparation of the meeting, the Planner shall assemble and facilitate the following information:

- FIM maps
- All circuit maps detailing circuits within the structure
- Process the request for utility look-ups and base map

Note: Do this immediately, as the process may require up to eight weeks to complete.

— Look-ups shall be requested for the area a minimum of 250 feet in each direction from the existing structure

— The base map shall include all adjacent structures where work will be performed

— Request a site survey including the installation of "tins and nail" at 50 foot increments

- Request a crew to take pictures within the structure

In addition, the Planner shall consider the following options to present a conceptual proposal to the Team:

- Investigate city street moratoriums and/or city projects
- Elimination of the structure
- Conversion to an aboveground installation
- Relocation of equipment to adjacent structures
- Elimination of unnecessary, redundant, or idle equipment
- Consideration of future requirements per DDS-6
- Consider economical alternatives of installing a new structure in proximity to the old structure (versus replacing in place)
- Consider truck access, easements, and environmental constraints

The Planner shall present the conceptual design detailing safety to crews, civil construction, general public, and the most economical alternative. Additionally, the Planner shall identify a temporary means of service (shoo-fly) to allow de-energizing cable and equipment. Refer to DDS-13, Section 5.8, G., for Temporary Shoo-Fly Construction.

During the design evaluation and process, the Planner shall make every attempt to eliminate any possible safety issues, in addition to minimizing congestion by removing (where possible) cable and equipment associated with the structure being replaced.

The Planner shall assemble a Team and assume the role of Project Lead. This role will include the tasks of scheduling the initial meeting along with subsequent meetings. The involvement of subject matter experts will assist the Planner in understanding and anticipating many activities that may contribute to the overall effectiveness and final design of the project.

Examples may include:

- The need for temporary (shoo-fly) construction
- The need for generation
- Switching procedures
- A thorough knowledge of circuit design and circuit loading
- Experience with complex civil construction projects

The Team shall include the following members:

- Planner
- Distribution Engineer
- Technical Planner
- Project Manager
- Civil Construction Manager (or Inspector)
- Planning Supervisor
- Field Construction General Supervisor/Foreman
- Local Public Affairs (LPA)
- Local Government Affairs (LGA)

After evaluating the existing situation, the Team shall identify the proposed method for replacement. During this process, various Team Members may be tasked with action items to complete and communicate to the Team in a pre-defined time frame.

Once all outstanding issues have been addressed, the Planner may develop the strategy for replacing the structure. Subsequent meetings may be scheduled as needed to review the proposed design.

At the conclusion of this phase, the Planner shall communicate to the Project Sponsor and the Project Manager.

Any changes to the original scope shall be approved and documented.

Once all team members agree with the proposal, the Planner shall proceed with the Red Line design.

2. Red Line Review Meeting

   After considering all options and selecting an appropriate replacement option for the structure, the Planner shall prepare a Red Line civil drawing that incorporates any civil work required for shoo-fly construction. The Planner shall facilitate a Red Line approval meeting or e-mail the Red Line drawing to each team member for review and approval.

The Planner shall submit the approved Red Line to Drafting to obtain the preliminary civil drawing. Upon receipt of the preliminary civil drawing, the Planner shall schedule the civil job walk.

3. Civil Job Walk

   The civil job walk shall be held in the field and include the following team members:

   - Planner
   - Civil Construction Manager/Inspector
   - Field Construction GS (as necessary)
   - Permit Coordinator (as necessary)

   The Project Manager shall be made aware of the civil job walk and attend as necessary. The civil job walk allows the Civil Construction Manager/Inspector to thoroughly evaluate the design and make any changes they feel are necessary.

4. Final Civil Design

   After the civil job walk, any changes required will be incorporated into the design and a final civil drawing will be reviewed and approved by the Civil Construction Manager/Inspector. A copy will be sent to the Permit Coordinator.

5. Permitting

   Once the civil drawing has been completed, the Permit Coordinator will then proceed with acquiring the necessary permits. The Planner shall continue with the work order preparation in parallel with the permitting process.

   The Planner shall identify all permits required:

   - Traffic Control
   - Pedestrian Traffic Control
   - Encroachment
   - Excavation
   - Flood Control District
   - CalTrans
   - Waste Water Engineer Plans (eight week lead time)
   - Railroad Permit (Real Properties Agent)
   - Federal Permits
     - US Forestry
     - Bureau of Land Management (BLM)
     - Bureau of Indian Affairs (BIA)
     - Army Corps of Engineers

6. Final Work Order

   The work order package shall be completed and delivered to the Project Manager. The Project Manager will deliver the work order package to the Resource Planning and Performance Manager (RPPM) to coordinate and schedule all phases of construction including shoo-fly work, civil construction, and the installation of the electrical system.

E. Design Process

The Planner shall take the following items into consideration when designing the replacement.

1. Safety

   The Planner's goal is to design a project that will be constructed in a safe and efficient manner meeting all requirements.The Planner shall make every attempt to de-energize the cable and equipment within the structure to eliminate any potential hazards.

2. Evaluation of the Existing Structure

   Before proceeding with the design, the Planner must first perform a detailed inventory and review of the equipment and cable in the structure. The intent is to eliminate, rather than replace, as much of the equipment and cable as possible while still complying with all DDS requirements.

3. Primary Cable

   In reviewing the circuitry, the Planner shall evaluate cable passing through that may have ties with other circuits that are redundant. In the process of examining the circuitry, the Team must determine if the primary cable remaining is sized properly per DDS-9.

   Where PILC cable is present, the Planner shall evaluate replacement with JCN or EPR cable. If the adjacent structures contain CLP/JCN, then replacement of the PILC may be warranted to improve the reliability and reduce the cost of multiple PILC to JCN/CLP splices. This issue must be discussed with Field Engineering and the Sponsor/Project Manager to determine the appropriate course of action.

4. Secondary and Service Conductors

   If secondary and service conductors originate or pass through the structure the Planner shall consider if they can be rerouted to serve the load from another source. For example, some older systems have splice boxes that are fed or have spare conduits from multiple directions, thereby making it possible to rearrange existing load and feed load from an adjacent structure.

5. Equipment

   Each piece of equipment shall be evaluated to determine if it is still required and conforms to current DDS requirements.

   Examples may include:

- Switches
  - Planner shall determine if the number of switch positions is warranted
  - RAC type switches shall not be reinstalled and must be replaced with a RAM/RAG switch
  - Consider converting the switch to a surface operable equivalent

F. Structure Sizing

The Planner shall determine future growth, equipment requirements, and utilize DDS-6 to determine the appropriate structure size for the installation.

1. Structure Location

   Installing the new structure in the same location can be extremely difficult and complex. While this approach may preserve the existing cable and components, it complicates the civil portion of the work. The Planner, along with the Project Team, shall choose one of the following three options after evaluating site-specific conditions:

   a. Replacing at the Same Location

      Utilizing this option for replacement of the structure in the same location may be the most feasible, but can be the most intricate and expensive. The Planner shall consider and identify within their design several key items that will ensure a safe and effective design. The following items shall be included:

      - Identify all circuitry and equipment that must be de-energized while civil construction replaces the structure
      - Remove cable and equipment to alleviate any congestion
      - Identify the means of providing service to existing customers while maintaining circuitry (for example, temporary shoo-flys, and generators)
      - Evaluate all existing cable and equipment to determine if they comply with standards
      - Ensure the replacement structure can be installed without creating clearance issues to adjacent utilities
      - Consider the need for necessary space to accommodate for shoring
      - The preferred structure shall be a tub type. Contact Distribution Apparatus Civil Structural Engineering for guidance.

      Potholing:

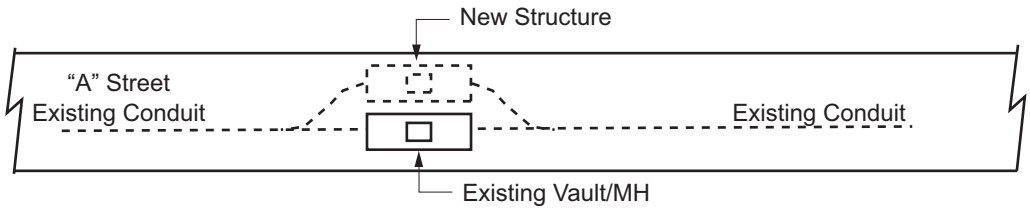
      - Is required to determine the location of SCE and other utilities during the planning stage and to ensure no conflicts when installing the new structure(s)

- The opening dimensions allowing for the intercept of the existing duct bank(s) must be determined during the planning phase
- Identify all permits required:
  - Traffic Control
  - Pedestrian Traffic Control
  - Encroachment
  - Excavation
  - Flood Control District
  - CalTrans
    - Waste Water Engineer Plans (8-week lead time)
- Railroad Permit (Real Properties Agent)
- Federal Permits
  - US Forestry
  - BLM
  - BIA
  - Army Corps of Engineers

2. Intercept Structures

   Intercepting a duct bank with a new structure can be a much less complicated project compared to Replacing at the Same Location.

Figure 13–11: Intercept in Line



The positive aspects of utilizing an intercept structure include:

- The actual intercept can be performed with all of the circuits energized
- The cables in one direction may be reused
- The new structure may be located in an area that provides improved clearances from other utilities
- The new structure may be placed in a location that provides improved access for construction and future maintenance
- The new structure may be surface operable

Other issues to consider before utilizing an intercept structure include:

- Conduits from the existing structure must be rerouted to the new intercept structure
- Joint trenches and relocation of foreign utilities
- Where possible, the new structure should be a tub type. Refer to UGS, VA 400 and UGS, VA 410 for vault and excavation details.In situations where the vault size is greater than 7' × 18', a tunnel vault must be considered. Refer to UGS, VA 411, for tunnel vaults. Contact Distribution Apparatus Civil Structural Engineering for guidance.
- Intercept structures are custom manufactured with openings sized to accommodate the dimensions of the existing duct banks. Before the structure can be ordered, the duct bank must be potholed to determine these dimensions. Potholing may require additional permits, lane closures, and road repairs.

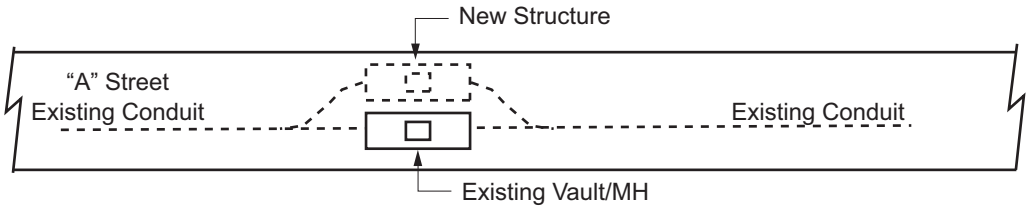
The use of an intercept structure will be dictated by the variables of the site. In some situations, the use of two intercept structures may be a viable consideration. The Team must consider the site specific variables and determine the appropriate structure.

Refer to UGS VA 400 for intercept vaults.

3. Installing a New Structure that is Adjacent to the Existing Structure

   In situations where space is available adjacent to the current structure, it may be prudent to install a new structure and systematically reroute the conduits and cable to this adjacent structure. Once all of the equipment has been rerouted, the existing structure can be demolished in a safe and efficient manner.

Figure 13–12: Adjacent Intercept



The positive aspects of installing a new structure adjacent to the existing structure include:

- Installation of the new structure and rerouting of the conduits can be accomplished within a defined area. This may minimize road repairs and traffic control.
- Where empty conduits exist, they may be easily intercepted and rerouted. Depending on the expected growth in the area, the empty conduits may serve the present and future needs, which will allow the remaining occupied conduits to be abandoned in place.

- The new structure may be installed at the edge of pavement or in the sidewalk, thereby improving access for future maintenance activities.
- The new structure may be surface operable.
- For new structure and structure replacements, if space permits or can be provided at no cost or with low cost minor work, maintain a minimum clearance of 36 inches for pedestrian right-of-way access. Avoid structure (including vents, meter pedestals, etc.) placement in wheelchair ramp locations.
- The new structure may be located in an area that provides improved clearances from other utilities
- Where possible, the new structure should be a tub type. Refer to UGS, VA 400, and UGS, VA 410, for vault and excavation details. In situations where the vault size is greater than 7' × 18', a tunnel vault must be considered. Refer to UGS, VA 411, for tunnel vaults. Contact Distribution Apparatus Civil Structural Engineering for guidance.

Before utilizing a new structure adjacent to the existing structure, consider the conduits from the existing structure that must be rerouted to the new intercept structure. The sweeps required to reroute these conduits may impact MPPT (old EPLs). In this situation, all of the existing cable must be replaced.

G. Utilizing Temporary Construction (Shoo-Fly) or Generation

A temporary system (shoo fly) may be necessary in situations where de-energizing the existing equipment and circuitry is not an option. This shoo fly will provide circuit continuity and/or service to the customers.

Whether a shoo-fly or a generator is used, detailed drawings such as a work order drawing and single line schematic shall be prepared by the Planner.

When shoo-fly construction or a generator is used, Field Engineering shall be consulted to ensure adequate system protection during the temporary arrangement.

1. Underground Shoo-Fly

   By installing new cable, or temporarily changing cable configurations, it may be possible to configure the circuitry in a manner that allows for load pickup. This allows the facilities within the replacement structure to be de-energized. Since this system is considered temporary, it may be acceptable to deviate from various DDS standards, in which case a Deviation must be submitted and approved.

   The Distribution Engineer will be responsible for ensuring the proposed shoo-fly meets expected circuit loading requirements. For example, 5 circuits may be allowed in an adjacent structure if the structure is not overcrowded and the duct bank loadings are not exceeded.

2. Overhead Shoo-Fly

   Consider an overhead shoo fly only if this option is safe and a less costly alternative to other options. Ensure clear access for the crane is available for removal and installation of the structure.

3. On-the-Ground Shoo-Fly

   In emergency situations, cables may be temporarily placed on the ground in order to restore service in a timely manner. In some instances, protective cable ramps may be installed over the conductors to provide temporary protection (in front of driveways). If cable is laid on the ground, physical barriers (cones and protective ramps) will be provided to protect the cable. Depending on the site-specific requirements, the on-the-ground shoo-fly solution may be an applicable alternative. This option may also require the need for closing streets and driveways as well as rerouting pedestrian traffic. Consideration shall be given for the length of time the temporary cable will be in place. Throughout this time frame, adequate site supervision must be provided to ensure a safe environment to the general public.

4. Generators

   Generators are provided only at Edison discretion for Edison operating requirements and not for customer convenience.

   Consider a generator to provide service to an individual or multiple customers. This option depends on the size of the load and how long the customer will be on the generator. Generators may be more cost effective for outages of a short duration (24 hours or less).

   Consider the use of generators based on specific business needs.

   If the team determines that a shoo-fly and/or combination with generators are appropriate, the final proposal shall be reviewed and approved with the Team Members before proceeding. The chronology of events, or phases of the project, must be documented and placed in the work order.

5.9 Capacitor Banks

Overhead and underground capacitor banks are used on distribution systems to provide local voltage support. In an inductive loaded system, capacitor banks reduce the amount of reactive current carried by the system, thus resulting in a local voltage rise. This helps to maintain the voltage supplied to customers over the minimum acceptable levels. Distribution capacitor banks are designed to turn automatically ON or OFF capacitor switches depending on specific control settings such as voltage, temperature, time or a combination of these in order to meet specific circuit VAR demands. Fixed capacitors are permanently connected to the circuit.

There are two types of capacitor banks installed: switched and fixed. Switched capacitor banks turn on and off to accommodate changes in customer load. Fixed capacitor banks are permanently connected to the circuit.

Note: Switched capacitor banks shall not be installed on poles with overhead switches.

For Program generated work, the submittal from the requesting organization shall include the following items:

- Overhead or Underground
- Size and Type of Capacitor (Fixed or Switched)
- Location (Region /District /Physical Location)

- Equipment Number / Structure Number
- Circuit / Substation
- Automation Needed
- Field Engineer
- Project Manager
- Requested Planning Completion Date

In conjunction with the replacement, Engineering may request an upgrade in size or type of installation. The recommendation may be for a fixed bank to be replaced with a switched bank, which would require automation. The Planner shall approach each replacement as if it were a new installation. Each location will be reviewed for accessibility and safety. The Planner shall check the pole for deterioration, adherence to pole loading standards, and adherence to clearance requirements for new equipment.

The Planner shall verify that the work at the identified structure is not already in design and shall search for any pending notifications for the specific capacitor bank or function location (FLOC) in question.

The Planner shall field verify the work identified for the capacitor bank in question and determine if the work has already been performed.

A. Overhead Capacitor Banks

For construction requirements of 2.4 kV and 4.8 kV, switched banks refer to DOH, AP 221.

For construction requirements for 4 kV, 12 kV and 16 kV switched banks, refer to DOH, AP 222.

Figure 13–13: Typical Overhead Switched Capacitor Bank Installation



Fuseholders are open and capacitor is de-energized. For pole loading calculations, the minimum mounting height for a switched capacitor is six feet from the line arm to the upper mounting bolt.

Refer to DOH, AP 210, for specific installation requirements concerning fixed capacitors.

Figure 13–14: Typical Overhead Fixed Capacitor Bank Installation



For pole loading calculations, the minimum mounting height for a fixed capacitor bank is 5'-6" from the line arm to the upper mounting bolt.

1. Digital photos

   The following digital photos shall be included in the work order:

- The pole and its general surroundings
- A close-up identifying the construction at the top of the pole
- A close-up identifying the construction at the communications level
- Base of pole
- Any other digital photos needed to help the line crew understand any unusual conditions

2. Location

   The Planner shall evaluate the existing location and consider needs for periodic and routine maintenance activities including line truck access and minimal exposure to traffic in comparison to nearby locations. The existing location may or may not be adequate. Choose the location that provides line truck access and minimal exposure to traffic. Avoid any possible environmental issues.

   Switched capacitor banks shall not be installed on poles with overhead switches of the same primary voltage as the source circuit. For replacements, the replacement switched capacitor bank shall be relocated to a pole without an overhead switch of the same primary voltage as the source circuit; otherwise, the overhead switch must be relocated. Consult Field Engineering for switch relocations or alternate proposed capacitor bank locations.

   Do not install capacitor banks on steel poles (tubular or light weight steel). Identify a wood pole alternative. Consider reconductoring an existing tap line to 1/0 ACSR (minimum) and ensuring three-phase construction on the tap line. Consider installing a new wood pole interset no more than 1/3 of the distance from the steel pole and as low as possible where no wood pole exists. This distance requirement accommodates conductor sag. Consider installing a pad-mounted capacitor bank with a riser after exhausting all other options.

   Consider alternate locations if the existing pole does not meet standards (pole loading, location, and clearances).

3. Installing Capacitors on Transmission Poles

   Do not install switched capacitors on a transmission pole until all other options are exhausted. Replacement of an existing switched capacitor on a transmission pole is acceptable and does not require a new Transmission Attachment Form. To proceed with this installation, the existing pole must adhere to all existing standards and the capacitor bank must be modified with a 12-foot crossarm.

   Fixed capacitor banks shall not be installed on transmission poles. If the scope calls for a fixed bank to be replaced/installed, either a scope change will have to be processed to install a switched bank or the new bank will have to be relocated to a distribution pole. Current standards do not allow for the re-installation of a fixed capacitor on a transmission pole.

Figure 13–15: Capacitor Bank Installation on a Transmission Pole



Figure 13–16: Capacitor Bank (on Breakoff) Installation on a Transmission Pole



4. Environmental and Avian Protection

   An Environmental Screening Form is required for every work order and for each pole location within the work order. While visiting the site, carefully consider all environmental issues that may be relevant to the project.

   If an Environmental Review is required, the Environmental Screening Form shall be submitted for review immediately. The Planner shall attach all relevant pictures of the site with the form. From the pictures, it is possible that the Environmental Specialist may review and release your project without a field visit. On the work order check sheet, record the date of submittal and keep a copy of the submittal with the work order package.

   For Avian-Safe Construction, refer to DDS-10, Section 5.6, N., and DOH, DC 535.

5. Branch Line Fusing

   Capacitor Banks shall not be installed beyond branch line fusing (BLF). If alternate locations are not available, consult with Engineering to consider removal of the BLFs. For further details, refer to DDS-2, Section 5.10.E.7.

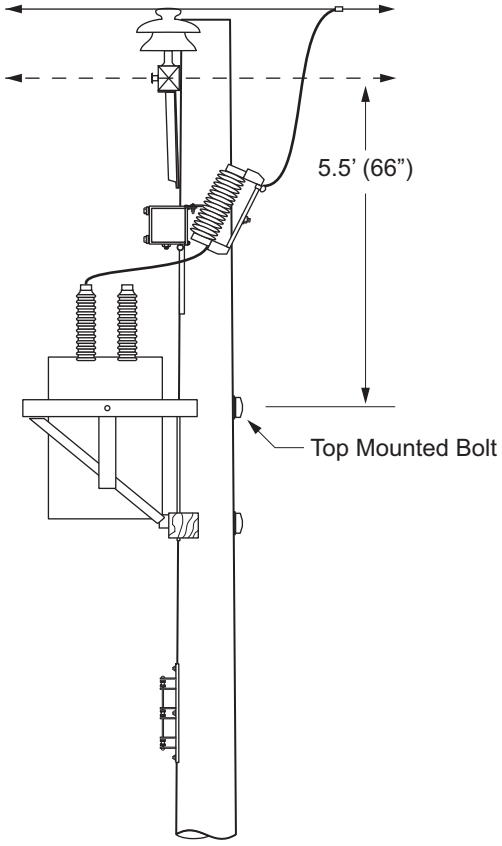
6. Capacitor Mounting Height

   In order to avoid unnecessary pole replacements, the proposed mounting height must be determined. Pole loading shall be calculated based on the elevation of the top hanger bolt on the capacitor bank. Figure 13–17 and Figure 13–18 and Table 13–2 identify the minimum distance that is required between an existing primary line arm and the top hanger bolt of a capacitor rack.

Table 13–2: Capacitor Mounting Heights

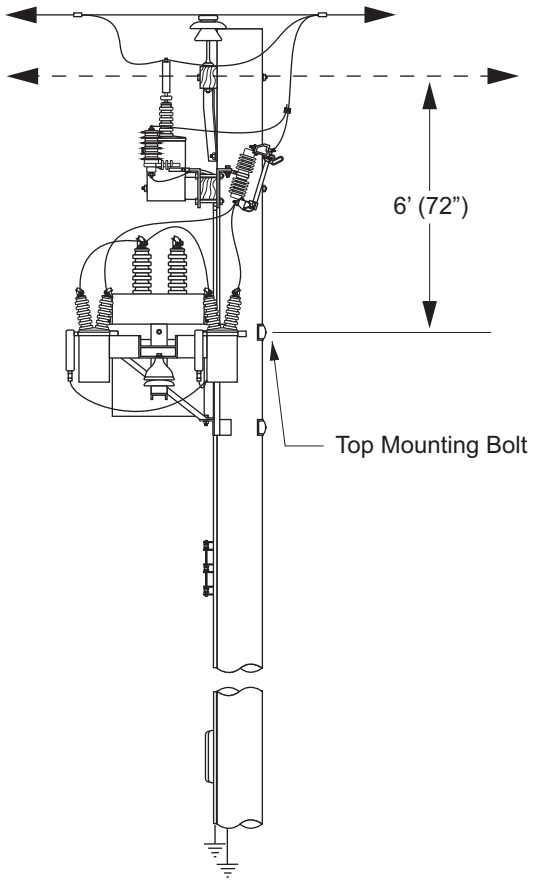
Capacitor Type	Voltage	Vertical Clearance from the Top Hanger Bolt
Fixed	All	66 inches below existing primary line arm (enter 5.5 feet)
Switched	All	72 inches below existing primary line arm (enter six feet)

Figure 13–17: Mounting Height for a Fixed Capacitor Bank



Side Elevation

Figure 13–18: Mounting Height for a Switched Capacitor Bank



Side Elevation

EXAMPLE 1:

If the existing primary line arm is located at 42', and the installation calls for a switched capacitor, then the capacitor mounting height will be at 36'.

(42' - 6' = 36')

Enter the calculated elevation (36') into the Pole Loading program as the equipment mounting height.

If the pole does not meet the minimum diameter at the mounting height, try mounting the bank lower on the pole. Replace the pole if an acceptable diameter cannot be obtained.

B. Underground Capacitor Banks

1. Typical Pad-Mounted Installation

   Walls and other obstructions can create unacceptable conditions and require more than a same location replacement.

Figure 13–19: Pad-Mounted Capacitor Bank



Newer capacitor banks are smaller foot print than the older banks, which may help alleviate some of the replacement issues encountered. Refer to DUG, UC 120, for the physical dimensions of the newer units.

2. Digital photos

   The following digital photos shall be included in the work order:

   - The source structure and its general surroundings
   - Panoramic digital photos to identify vehicular and pedestrian traffic
   - The location of the existing capacitor pad
   - Any other digital photos needed to help the line crew understand unusual conditions

3. Capacitor Structures

   If the capacitor structure is found to be deteriorated, install a replacement pad. If the existing pad is 72" × 94" and has impaired clearances, install a smaller 66" × 72" (refer to the UGS, SS 520) pad.

   The 66" × 72" pad was adopted to allow more capacitors to be placed in a franchise area. This pad may be placed in public franchise with as little as six feet of Right-of-Way. By aligning the pad parallel to the sidewalk or road, the required clearance can be obtained on the front and back of the pad. These are the preferred structures and should be used on all new installations.

4. Loadblock Options

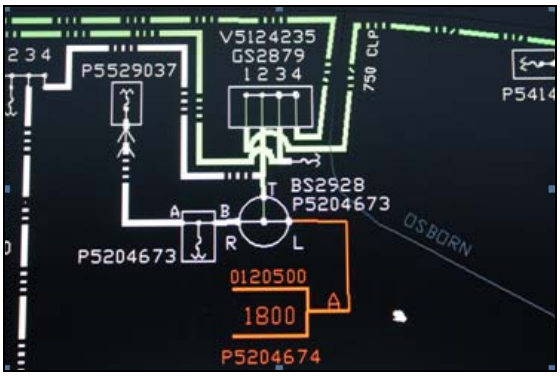
   Capacitors are typically installed on feeder systems, but they can also be fed from a loadblock. There is nothing that precludes the installation from being fed from a loadblock. If the conductor feeding the capacitor bank is #2 Copper CLP, current standards require the conductor to be replaced with a minimum cable size of 1/0 Copper JCN from the capacitor to the feeder system.

The following are some possible loadblock combinations:

BURD Switch

BURD switches are acceptable on existing installations, but are not preferred on new installations.

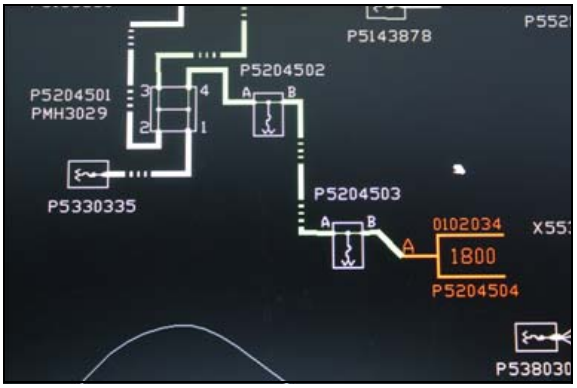
Figure 13–20: BURD Switch



A-B Switched Transformer

In Figure 13-23, 1/0 primary cable would be required from PMH 3029 to the new capacitor installation.

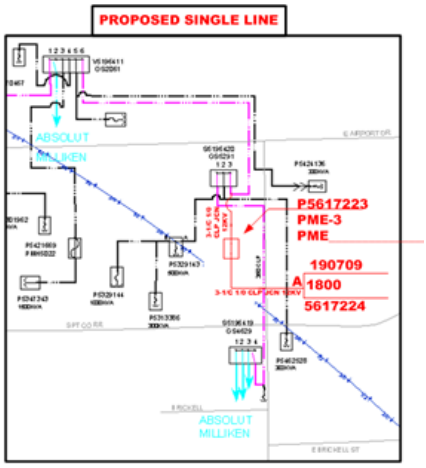
Figure 13–21: A-B Switched Transformer



PME-3 Source Switch

The PME-3 is an acceptable alternative for providing a source side switch on capacitor installations. Table 13–22 is an example of this situation.

Figure 13–22: PME-3 Source Switch



5. Operating Clearances

   Capacitors require 8' clearance in front of the doors on both the front and back of the unit. The most efficient orientation of the 66" × 72" pad is to align the capacitor parallel to the sidewalk as shown in Table 13–23. This approach provides the required clearances and avoids the need for an easement. This strategy may not be possible where the terrain requires the installation of a perimeter wall.

Figure 13–23: Operating Clearances



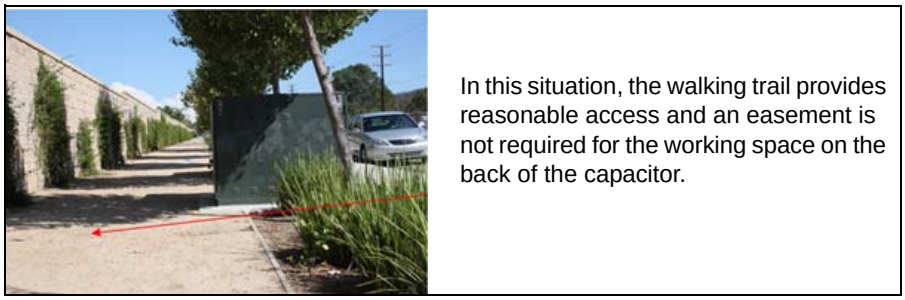
6. Working Clearance and Easements

   In many situations, a capacitor must be placed in a narrow franchise area with the front of the unit facing the street or sidewalk. Oftentimes, the capacitor pad will fit within the franchise area, but accessing the back of the unit requires entering private property. These situations do not necessarily require an easement if all of the following conditions are met:

- The area to the front and back provide 8' of working clearance.
- Both areas are relatively flat and free of obstructions.
- The pad itself is located in an easement or franchise area.
- The area to the rear consists of an open-space area where access can reasonably be assured for the foreseeable future. Acceptable open space areas may include: public parks, HOA green belt areas, horse trails, bike trails, or school playgrounds.

  If all of these conditions are not met, an easement must be obtained.

Figure 13–24: Capacitor Bank with no Required Easement for Back of the Capacitor



7. Line-of-Sight Issues

   When planning a capacitor bank installation or replacement, evaluate each situation, seek out alternative locations if necessary, and weigh risks to public and SCE employee safety.

   At intersections, a capacitor bank can create an obstruction that may restrict a driver's visibility to see oncoming traffic. While the down-traffic side of the intersection may be preferred, it may not be practical. In the up-traffic direction, it may be necessary to move the installation further from the intersection in order to eliminate the potential visibility obstruction. Table 13–25 shows the capacitor as a serious hazard for motorists attempting to make a right hand turn.

Figure 13–25: Capacitor Bank that is a Visibility Obstruction



8. Line-of-Sight Issues

   When planning a capacitor bank installation or replacement, evaluate each situation, seek out alternative locations if necessary, and weigh risks to public and SCE employee safety.

   At intersections, a capacitor bank can create an obstruction that may restrict a driver's visibility to see oncoming traffic. While the down-traffic side of the intersection may be preferred, it may not be practical. In the up-traffic direction, it may be necessary to move the installation further from the intersection in order to eliminate the potential visibility obstruction. Table 13–26 shows the capacitor as a serious hazard for motorists attempting to make a right hand turn.

   While this unit is placed in an undesirable location, it may not constitute a line-of-sight or safety issue. The replacement will be smaller and may greatly improve this situation.

   For new structure and structure replacements, if space permits or can be provided at no cost or with low cost minor work, maintain a minimum clearance of 36 inches for pedestrian right-of-way access. Avoid structure (including vents, meter pedestals, etc.) placement in wheelchair ramp locations.

Figure 13–26: Capacitor Bank on Down-Stream Direction of Traffic



9. Automation

   Most new overhead capacitors are automated and pad-mounted, so it is necessary to obtain the latitude and longitude of the proposed site. These coordinates must be placed on the work order map and also be entered on the NetComm Form. Use a handheld GPS to obtain these coordinates (do not use Google Earth, as it does not provide the accuracy required for these installations).

10. Branch Line Fusing

    Capacitor banks shall not be installed beyond branch line fusing. If the existing bank violates this standard, consider removing the branch line fuses. Refer to DDS-2, Section 5.10.E.7 for details.

11. Environmental Review

    An Environmental Screening Form is required for every work order and for each structure location within the work order. While visiting the site, carefully consider all environmental issues that may be relevant to the project.

    In the effort to improve the quality of the environmental review, the Form must be completed in the field by the Planner.

    If an environmental review is required, the Form shall be submitted for review immediately. The Planner shall attach all relevant pictures of the site with the Form.

    From the pictures, it is possible that the Environmental Specialist may review and release the project without a field visit. On the work order check sheet, record the date of submittal and retain a copy of the submittal with the work order package.

12. Worst Circuit Rehabilitation

    Worst Circuit Rehabilitation (WCR) commodities include but are not limited to:

    - Automatic Reclosers
    - Branch Line Fuses
    - Cable Replacement
    - Underground Cable
    - Cable-In-Conduit
    - Overhead Conductor
    - Fault Indicators
    - Surge Arresters
    - New Poles
    - Remote Control Switches
    - Switch Replacement
    - Underground Oil Switches

- PMH-4
- Type-W KPFs
- Underground Structures

C. Automatic Reclosers

Refer to DDS-2, Section 5.13, and DDS-13, Section 5.5, for details.

D. Branch Line Fuses

Please refer to DDS-2, Section 5.9, for details.

E. Cable Replacement

Refer to DDS-13, Section 5.2, for details on Cable-In-Conduit Replacement.

Refer to DDS-13, Section 5.7, for details on Primary Cable Replacement.

F. Overhead Conductor

Refer to DDS-9 for details.

G. Fault Indicators

When a fault occurs on a circuit, the fault current flows from the substation to the location of the fault. During a fault, the instantaneous fault current may be hundreds of amps greater than the normal loading. Once the fault duty exceeds the trip settings on the circuit breaker, the circuit breaker will open to de-energize the circuit. Install fault indicators (FI) on the circuit at key locations to help facilitate locating the source of the interruption.

FIs are activated when the amperage on the line exceeds specific operating levels. Once activated, the fault indicators "flash" to provide a visual indication that the fault current passed through that location. Since the fault current follows the route from the substation to the fault, all of the FIs along this route will be activated. FIs along unaffected sections of the circuit will not be activated. The operation and placement of FIs is discussed in detail in DDS-2, Section 5.7.

Project Engineers define the type of FI and amperage setting for each project

Figure 13–27: Typical Overhead FIs Installed on Conductor for a Primary Dip Pole



FIs are available as "Fixed Trip" or "Self Adjusting". The type of FI and amperage settings required must be defined by the Field Engineer. Refer to DOH, AP 600, for details of each option.

Since FIs may be installed off-the-pole and on the conductor (typically using a one-man bucket crew), this activity is exempt from:

- Clearing any G.O. 95 infractions on the pole, or
- Installing Avian Protection

A. Underground Fault Indicators

Underground FIs may be installed in a variety of structures and multiple FIs may be installed in a single structure. FIs may be placed on sections of line to provide visual indication for the Troublemen as they investigate circuit interruptions. Similar to overhead FIs, underground FIs sense a fault and provide a visual indication along the faulted line section. The FIs are battery operated.

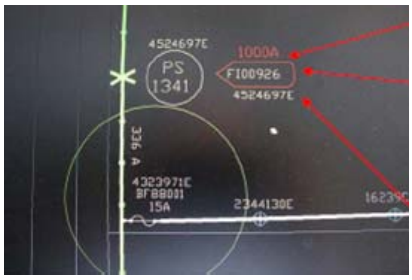
B. Circuit Map Symbology

Overhead and underground FIs have specific circuit mapping symbols. These symbols not only depict the location of the FIs, but also provide the structure and amperage information. For more information, refer to the SCE Distribution Circuit Map Symbols Manual on Portal.

Refer to the latest Design Support Update concerning mapping of fault indicators.

In Table 13–28, "FI00926" is installed on pole "4524697E."

Figure 13–28: Circuit Map Symbology for a Set of Overhead Fault Indicators



"1,000 A" represents the minimum amperage required to activate the FIs.

"FI00961" is the unique number assigned to this set of FIs. A log book is maintained at each district specifically for FIs.

"4524697E" is the pole the FIs are installed on. In this case, they are actually mounted on the switch pole. This location required 1,000 A FIs. Considering that the load on a typical circuit will not normally exceed 720 amps, these 1,000 amps units require a fault significantly above the normal expected loading.

C. Location of Fault Indicators

Fault Indicators may be installed at any of the following locations:

- Pad-Mounted Cabinets (PMEs/PMHs)
- Surface-Operable Enclosure (SOE) (with a modified lid that has a view window)
- Manhole/Vault (with no vent pipes)

Refer to DUG, TD 100, for installation instructions for each location.

Fault Indicators are most effective when they are readily visible. On occasion, the scope of the project will indicate that FIs are to be placed in structures without vent pipes and with no external mounting area.

If no aboveground option is technically feasible, such a situation might include mounting FIs in a manhole. For these locations, a bracket has been created and the FIs can be hung just under the manhole opening. While such an installation is possible, its effectiveness is minimal. To check the FIs, the Troubleman would have to stop his route when patrolling the circuit and open the structure, which is a time consuming task. Where the Engineer requested such an installation, the Planner and the Project Engineer shall find an alternate location.

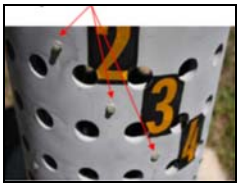
In Table 13–29, the shown location has been equipped with four FIs on the same PME switchgear.

Figure 13–29: FIs on a PME Switchgear

FIs are installed in the vent pipe.



Close-up of FIs.







This PME has been equipped with two sets of FIs.

Figure 13–30: Circuit Map Symbol for PME Switchgear in Figure 13-29



400 A Fault Indicator
Unique FI Number

Mounted on Position #32

400 A units were also mounted on Position #3

When installing FIs in a SOE, the "view window" replacement cover is required. Refer to DUG TD 100 for further details and the appropriate SAP.

D. Surge Arresters

Refer to DDS-10, Section 5.6.L.

E. New Poles

Refer to DDS-10.

F. Remote Controlled Switches (RCS)

A description of the RCS operation scheme can be found in DDS-2.

1. Elastimold Molded Vacuum Switches

Molded vacuum switches are utilized in situations where other forms of automation are not practical. A typical installation requires adequate space for a potential transformer, the vacuum switch, two sets of 600 amp elbows and one set of 200 amp components to serve the potential transformer. The Planner must ensure an overcrowded situation is not created. To determine if the structure is overcrowded, refer to DDS-6. If the structure is overcrowded, the Planner cannot proceed with the installation without an approved Deviation. If equipment cannot be removed from the structure, then an alternate location must be identified.

The switch may be mounted in any position and requires roughly 18" × 34" × 12" of space. The switch is operated by an underground automated When installing FIs in a SOE, the "view window" replacement cover is required. Refer to DUG, TD 100, for further details and the appropriate SAP.

G. Surge Arresters

Refer to DDS-10, Section 5.6.L.

H. New Poles

Refer to DDS-10.

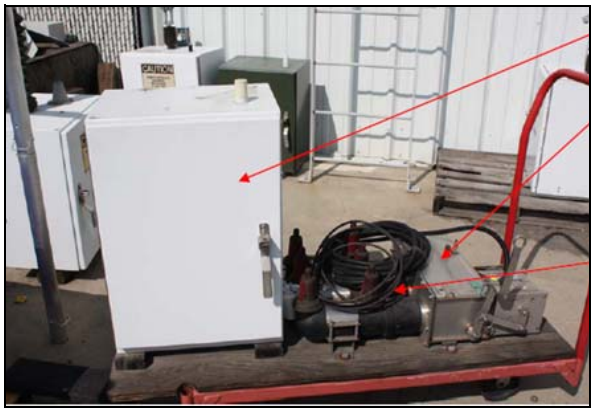
I. Remote Controlled Switches (RCS)

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Figure 13–31: Remote Controlled Switch



UAD Controller

Molded Vacuum Switch

Motor Controller

Control Cable

Circuit Map Symbology for an Automated Molded Vacuum Switch

InTable 13–32, the Project Engineer requested that position 2 be automated to create an RCS tie switch. The existing switch is a RAC switch, which cannot accommodate the G&W motor operator. The only option available is to replace the RAC switch with a G&W SF-6 RAM switch or to install an Automated Molded Vacuum Switch. In this case, the Automated Molded Vacuum Switch was the least cost alternative.

Figure 13–32: Automated Molded Vacuum Switch Symbology



The rectangular box is the symbol for the vacuum switch.

The switch is in the "Open" position.

The switch only has a single position ("Open" or "Closed"), so the label for "POS 1" is not necessary.

The switch is in the non-automatic mode (N).

J. Switch Replacement

Refer to DDS-13, Section 5.6 for Underground Oil Switch Replacements.

Refer to DDS-13, Section for PMH-4 Switchgear Replacements.

Refer to DDS-13, Section 5.4 for Type "W" KPF Switch Replacements.

K. Underground Structures

Refer to DDS-13, Section 5.8

5.10 Non-Conforming Structures

The original DDS created in 1990 provided Tables which identified the quantities of equipment and cable that may be installed in underground structures. Since that time, the tables have been updated in conjunction with changes in equipment types and sizes. Each of these changes has resulted in structures that may not meet the current Standards.

This standard provides guidance in evaluating structures for adherence when performing work and steps to take in facilitating the work. The Planner will determine if the structure meets DDS standards for existing facilities and for the proposed scope of work. The Planner will follow a sequence of steps to determine if the structure(s) conform with the DDS and the appropriate course of action is taken.

A. Safety

The Planner's goal is to design a project that will be constructed in a safe and efficient manner meeting all DDS requirements. In all situations, structure configurations should allow the crew to safely Construct, Operate, Maintain, and Ground.

B. Evaluation

1. Planner Evaluation

When reviewing a new project, the Planner shall determine if the structure meets DDS standards for existing facilities and for the proposed scope of work.

The Planner will review the inventory maps, circuit maps, and structure records to determine if the equipment and cable within the structure meets current DDS standards.

a. If the structure is *in conformance*, the Planner will proceed with their design and work order preparation.

b. If the structure is *not in conformance* but can be brought into conformance by removing idle equipment, or relocating equipment to an adjacent structure, the Planner may proceed with the design. If this effort does not bring the structure into DDS conformance, the Planner will proceed in obtaining additional information for their analysis. Consult Field Engineering whenever mainline circuitry is impacted.

The Planner will submit a request to have a crew gather information and take pictures of the structure(s) where work will be performed. The crew will complete a Structure Inspection Form (see Attachment 1) and verify the following:

- Location(s)
- Size of structure(s)
- Type and quantity of all equipment/cable
- Verify and Identify all Circuitry

Digital photographs will include:

- All four walls of the structure labeled North-South-East-West and including all cable and all duct banks)
- The entire ceiling including details of the opening
- Pictures of the opening standing from the surface
- Overview pictures showing relative location of structure to sidewalks, streets, greenbelts, street intersections

After receiving all of the information, the Planner shall review the pictures, inventory maps, circuit maps, structure records, structure inventory form, and the proposed scope of work. The Planner shall evaluate the alternative options listed below and the costs associated in bringing the structure into conformance. This information will be presented to a Team of experts (see Section 5.10., B.2) for review and concurrence.

The Planner should consider rearranging/removing and relocating equipment as addressed in the following paragraphs.

Switches (requires consultation with Field Engineering)

- Evaluate the 1500 kVA load block criteria standard to possibly eliminate the switch
- Reduction in size (for example, 5-way to 3-way)
- Consider relocation to an adjacent structure
- Replacement with a pad-mounted equivalent
    - Consider space, Above-Ground Equipment (A.G.E)., easements, and local restrictions
- Do not reinstall RAC type switches. Replace the switch with a RAM/RAG switch.

Transformers

- Remove idle transformer(s)
- Eliminate underground transformers from the structure and install as a padmount
    - Consider space, A.G.E., easements, and local restrictions
    - Allow feeding back into the structure with secondaries
    - Voltage drop/flicker will have to conform to standards
- Is it possible to relocate the transformer to an adjacent structure(s) and install secondaries to serve existing load (voltage drop/flicker)
- Consider converting three-phase banks of (3) transformers (240 V 4-wire only) to an open delta bank

Fusing (fuse cabinets not in current tables)

- Consider replacing non-fused transformer(s) with fused transformers to remove the fuse cabinet from the structure
- Consider surface operable (PME-4, PME-5, VFI)

Junction bars

- Can junction bars located on the wall (for example, horizontal in line) be rearranged to stacked or re-installed at a 45 degree angle?
- Do adjacent walls allow for relocation of junction bars to eliminate congestion?

Rearrange Cable

- Will rearranging or reracking cable higher on the wall or to an adjacent wall eliminate congestion?
- If secondary and service conductors originate or pass through the structure, consider re-routing them to serve the load from another source. For example, some older systems have splice boxes that are fed or have spare conduits from multiple directions; making it possible to rearrange existing load and feed load from an adjacent structure.

Re-Route Circuitry

- Relocate new or existing circuitry to an alternative line route where acceptable structures conform with standards

Utilize an Adjacent Structure

- If structure will not allow for work to be performed (for example, switch, transformer replacement/installation), the Planner shall consider relocating the equipment/cable to adjacent structures that will allow for approved installations.
- Consider a different source structure for serving a new business customer
- Where conduits exist between two structures, the Planner shall consider intercepting an empty conduit and connecting the new business load to the most preferable structure.

Reduce Cable Size

- Where existing cable size is excessive and no loading issues exist, consider installing smaller sized cable which may bring the structure into conformance.

Bypass Structure

- Consider intercepting and bypassing congested structure if EPL meets standards

Cable Pulled Straight through Structure

- Eliminate space requirements for 600 A components by pulling cable straight through the congested structure, if standards allow, based on structure spacing and pulling

Circuit Ties (Requires Field Engineering Approval)

- Consider eliminating redundant circuit ties (cable)
- Review other line routes and conformant structures to allow rerouting the existing cable

2. Team Evaluation

The Planner shall schedule a meeting with a Team of experts if removal or rearrangement of cable and equipment does not bring the structure into conformance. The Planner will present the scope of the project, provide all pertinent information, and propose a recommendation to correct the problem.

Team members should be chosen based on their knowledge of the particular situation and their familiarity of overhead and underground field construction.

The Team members will include the following:

- Planner
- Distribution Engineer or Technical Specialist
- District Field Construction General Supervisor and/or Project General Supervisor
- Grid Operations General Supervisor (if equipment is involved)
- Planning Supervisor (Local Planning projects only)
- Project Sponsor/Project Manager (Optional)

The Planner will prepare an agenda and present the following information for the Team.

1. Structure location
2. Existing structure size
3. Circuit and FIM Maps
4. Conformant structure size per DDS-6
5. Inventory of Equipment and Cable (Structure Inspection Form)
6. Scope of Work
7. Detailed photos
8. Planner's recommended strategy

The Planner will present their findings and recommendations to the Team.

(1) Make Structure DDS Conformant

The Planner will proceed with the proposed solution and prepare the work order.

The Team shall review the Planner's recommendations and identify other alternatives. The Team shall evaluate and prioritize all of the alternatives based on operability and cost effectiveness and agree upon the preferred solution.

(2) Non DDS Conforming; Team Recommends Deviation

If the Team members reach a consensus that the scope of work can be performed in a safe and effective manner but the structure is not DDS conforming, the Planner will prepare a deviation form and have all Team members approve and follow the process for final management approval.

- When the *deviation is approved*, the Planner will proceed with the proposed solution and prepare the work order.
- If the *deviation is not approved* the Planner will notify the responsible **Project Manager and Sponsor** of the decision that a structure addition or replacement will be required (refer to Section 5.10.C).

(3) Cannot be brought into Conformance; Structure Upgrade or Addition Required

If the Team determines the structure requires an upgrade or addition, the Planner will document the findings and conclusions. File the document in the work order package for the structure addition or replacement.

The Planner will now proceed with the proposed solution, initiate appropriate notification of scope change, and obtain approval before proceeding with the design.

If the above steps 1, 2, and 3 have been reviewed and no solution has been identified, the Planner may now proceed to Section C below.

C. Structure Addition or Replacement

After exhausting all opportunities for removal/rearrangement of facilities the Planner will reassemble the Team and include the Civil Construction Manager/Inspector. The new Team will determine the appropriate course of action for either adding a structure or replacing the existing structure.

If look-ups or street improvement plans were submitted with the project, the Planner shall begin their preliminary review process. If these documents are not available, the Planner will submit a request to the Underground Drafting and Design Group (UGDDG) for look-ups and a base map. This request should be facilitated immediately as the process may require up to 8 weeks to complete.

- Look-ups should be requested for the area a minimum of 250' in each direction from the existing structure.
- The base map shall include all adjacent structures where work will be performed.

1. Planner Review, Preliminary Conceptual Design, and Project Meeting Preparation

The installation of an additional structure or structure replacement can be very complex and expensive. The Planner will review the base map or street improvement plans to determine if space permits for an adjacent structure (this may include a vault, manhole or a PME), intercept structure, or a larger structure in the same location. The Planner will consider each structure location for accessibility, future requirements, and conformance with the DDS.

The Planner shall consider the civil contractors task with performing the excavation and installation of an additional or new replacement structure while potentially working in close proximity to energized cable and equipment. This situation is not only expensive, but it poses safety issues. Where an existing structure is to be replaced, **the Planner shall make**

every effort to identify a means of de-energizing all facilities within the structure and impacted area of the structural replacement. This requires the Planner to consider switching options and/or the need to install temporary facilities. This will be addressed with the Team and included in the design phase of the project along with material and labor costs incorporated into the final work order package.

PILC Cable

- Where PILC cable is present, the Planner shall evaluate replacement with JCN or EPR cable. If the adjacent structure(s) contain(s) CLP/JCN, then replacement of the PILC may be warranted to improve the reliability and reduce the cost of multiple PILC to JCN/CLP splices. This issue must be discussed with Field Engineering and the Project Manager/Sponsor to determine the appropriate course of action.

4 kV Equipment

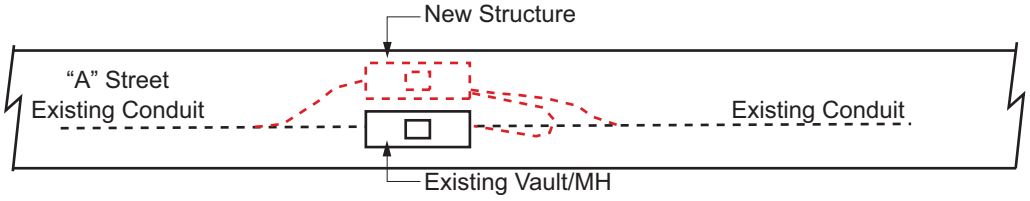
- Consider cutting over 4 kV equipment to the 12/16 kV.
- Consider sizing new structures, conduits, and cables for the ultimate conversion of the 4 kV system.
- Where multiple primary voltages are present in the same structure (4 kV, 12 kV, 16 kV) and an adjacent or intercept structure is to be utilized, the Planner shall attempt to leave the 4 kV circuitry in the existing structure. This allows the obsolete 4 kV conductors, conduit and equipment to remain in service until these facilities are cutover to the 12/16 kV system.

2. Structure Placement Consideration

a. Installing an Adjacent Structure

Where space is available adjacent to the current structure, it may be beneficial to install a new structure adjacent to the existing structure and install the necessary conduits to reroute the existing cable to the new structure. The Planner shall also consider the extent of the corrosion of the structure. If the structure exhibits evidence of severe corrosion, the Planner shall size the adjacent structure to allow for future growth, as well as relocating all existing facilities to the new structure once the existing structure reaches the end of its useful life.

Figure 13–33: Adjacent Intercept (Structure Placement Consideration)



The positive aspects of installing a new structure adjacent to the existing structure include:

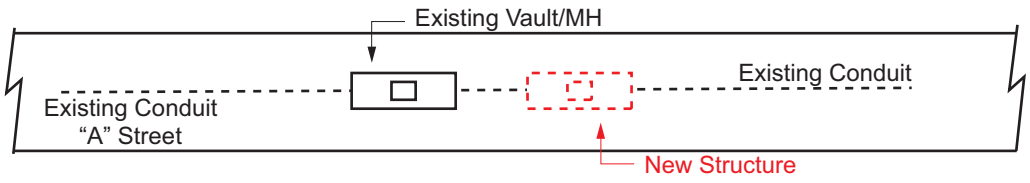
- Installation of the new structure and re-routing or installing conduits tying both structures. This uses a smaller area possibly minimizing road repairs and traffic control.
- Intercept or reroute existing empty conduits. Consider the expected growth in the area and the need for the empty conduits required to serve present and future needs.
- The new structure may be installed at the edge of pavement or in the sidewalk providing improved access for future maintenance activities. (May require city approval).
- Attempt to make the new structure may be above ground per A.G.E. standards.
- When above ground equipment is not possible, new underground structures should be tub type. See UGS, V -400 and UGS, VA 410 for vault and excavation details. In situations where the vault size is greater than 7' × 18', a tunnel vault must be used.

b. Intercept Structure

Intercepting a duct bank with a new structure can be much less complicated compared to replacing the structure at the same location or working around energized equipment.

Where space is available in line to the current structure, it may be beneficial to install a new intercept structure. The Planner shall also consider the extent of the corrosion of the structure. If the structure exhibits evidence of severe corrosion, the Planner shall size the adjacent structure to allow for future growth, as well as relocating all existing facilities to the new structure once the existing structure reaches the end of its useful life. To accommodate this strategy, install the new structure close to the existing structure.

Figure 13–34: Intercept In Line (Structure Placement Consideration)



The positive aspects of utilizing an intercept structure include:

- The actual intercept can be performed with all of the circuits energized.
- The cables in both directions may not be affected.
- If the existing structure becomes deteriorated in the future and requires
- Replacement, the new structure if properly sized initially can facilitate the transferring of facilities.

Other issues to consider before utilizing an intercept structure:

- Where possible, the new structure should be a tub type. See UGS, VA 400 and UGS, VA 410 for vault and excavation details. In situations where the vault size is greater than 7' × 18' a tunnel vault must be used. See UGS, VA 411 for tunnel vault details.
- Intercept structures are custom manufactured with openings sized to accommodate the dimensions of the existing duct banks. Before ordering the structure, determine the duct bank dimensions for the opening.
- Ensure the installation of the new structure does not create clearance issues to adjacent utilities.
- Avoid joint trench and conflict with other utilities

The use of an intercept structure will be dictated by the variables of the site. The Team must consider the site specific variables and choose the appropriate structure.

Refer to UGS, VA 400 for details concerning intercept vaults.

c. Replacing at the Same Location

Utilizing this option and replacing the structure in the same location may be the most feasible, but can be the most intricate and expensive. The Planner shall consider and identify within their design several key items that will ensure a safe and effective design. The following items shall be included:

- Identify all circuitry and equipment that needs to be de-energized while Civil Construction replaces the structure.
- Remove cable and equipment to alleviate any congestion. Provide protection if de-energized cable will remain inside the structure during replacement.
- Identify the means of providing service to existing customers along with maintaining circuitry (temporary shoo-fly's, and generators)
- Evaluate all existing cable and equipment to determine if they conform with current standards.
- Consider the space required to accommodate shoring. A minimum of three feet is required.

- Ensure the replacement structure can be installed without creating clearance issues to adjacent utilities. The preferred structure shall be a tub type.
- The Civil Construction Manager/Inspector may identify a tunnel or special ordered structure manufactured to accommodate specific requirements.

D. Utilizing Temporary Construction (Shoo-Fly)

In situations where the existing circuitry and equipment cannot be de-energized through switching or rearrangement of the circuits, it may be necessary to construct a temporary system. This temporary system, or shoo-fly, will be utilized to provide circuit continuity and/or service to the customers. The use of generators shall also be a consideration based on economic evaluation. Whether using a shoo-fly or a generator, the Planner will provide detailed drawings depicting how to pick up the load.

1. Underground Shoo-Fly

   It may be possible to configure the circuitry in a manner that allows the existing load to remain energized by installing new cable or temporarily changing cable configurations. This allows the facilities within the replacement structure to be de-energized. Since this system is considered temporary, it may be acceptable to deviate from various DDS standards in which case a Deviation must be requested and approved per the existing DDS procedure. For example, 5 circuits may be allowed in an adjacent structure if the structure is not overcrowded and the duct bank loadings are not exceeded. This option will require a thorough knowledge of the circuitry and adjacent underground components. The Distribution Engineer will be responsible for ensuring that the proposed shoo-fly will meet expected circuit loading requirements.

2. Overhead Shoo-Fly

   In many situations, an overhead shoo-fly may be a feasible option. The Planner will consider if preforming this work is safe and less costly alternative to other options. If this option is utilized, the Planner will need to ensure that the overhead facilities are constructed to provide clear access for the crane to install and remove the structures.

3. On the Ground Shoo-Fly

   In some situations, it may be practical to temporarily place the cable on the ground. In these instances, protective cable ramps may be installed over the conductors to provide temporary protection (in front of driveways). If cable is laid on the ground, physical barriers (cones and protective ramps) will be provided to protect the cable. Depending on the site-specific requirements, the on-the-ground shoo-fly solution may be an applicable alternative.

   This option may also require the need for closing streets and driveways as well as re-routing pedestrian traffic. Consideration shall be given for the length of time the temporary cable will be in place. Throughout this timeframe, adequate site supervision must be provided to ensure a safe environment to the general public.

4. Generators

   Depending on the generator size required to serve the load, the Planner may consider this option rather than building a shoo-fly. This method can be utilized to provide service to individual or multiple customers. Generators may be more cost effective for outages of a short duration.

   If the Planner determines that a shoo-fly and/or combination with generators is appropriate, the final design shall be reviewed with the Team members and approved before proceeding.

E. Conceptual Plan

Once the Planner has identified a preliminary conceptual plan for placement of the structure and associated work, the Planner will assemble a Team of subject-matter experts, and working together, accomplish the following project milestones. At each step of the process, the Team will agree that prior steps have been satisfactorily completed. The Planner will follow a sequence of events listed below for timely and efficient completion. The initial up front work performed is expected to minimize the potential high cost associated with these projects.

The Planner shall assemble a Team and assume the role of Project Lead. This role will include the tasks of scheduling the conceptual plan review meeting along with subsequent meetings. The involvement of subject matter experts will assist the Planner in understanding and anticipating many activities that may contribute to the overall effectiveness and final design of the project.

- Conceptual Plan Review (everyone)
- Redline Review and Shoo-Fly Proposal
- Civil Job Walk
- Final Civil Design Approval
- Permitting
- Final Work Order

1. Conceptual Plan Review

   The Planner shall have assembled and facilitated the following information:

   - Previously identified items for consideration in Section 5.10.B.2.
   - Investigate city street moratoriums and/or city projects
   - Identified Engineering and other Planning organization future projects
   - Consideration of existing and future requirements per DDS-6
   - Consider economical alternatives of installing a new structure in proximity to the existing vs. replacing in place
   - Consider truck access, easements, environmental constraints and A.G.E. issues
   - Base maps with lookup information
   - Temporary facilities (Shoo-fly, Generators, and Security)

The Team shall be reassembled and include the following members:

- Planner
- Distribution Engineer
- Civil Construction Manager (or Inspector)
- Planning Supervisor (Local Planning projects only)
- District Field Construction General Supervisor or Project General Supervisor Project Sponsor/Manager (Optional)
- Grid Operations General Supervisor (Equipment Only)
- Local Public / Government Affairs (Optional)

When practical, the Planner may choose to call a formal meeting, use instant meeting, WEBEX, or similar such alternative means for reviewing the conceptual plan. The Planner shall obtain documented concurrence for each aspect of this project from each of the Team members.

After evaluating the existing situation, the Team will identify the proposed method for an additional or replacement structure. During this process, various Team members may be tasked with action items to complete and communicate to the Team in a pre-defined time frame.

Once all outstanding issues have been addressed, the Planner may then develop the strategy for adding or replacing the structure. Subsequent meetings may be scheduled as needed to review the proposed design.

At the conclusion of this phase, the Planner shall communicate the Team's progress to the Project Sponsor and the Project Manager. Any changes to the original scope shall be approved and documented. Once all Team Members agree with the proposal, the Planner shall proceed with the red line design.

2. Red Line Review Meeting

   After considering all options, the Planner will prepare a Red Line civil drawing incorporating any civil work required for shoo-fly construction. The Planner shall facilitate a Red Line review meeting with the Team and obtain approval.

   The Planner shall submit the approved Red Line to Drafting to obtain the preliminary Civil drawing. Upon receipt of the preliminary drawing, the Planner will schedule the Civil job walk.

3. Civil Job Walk Meeting

   The civil job walk will be held in the field and will include the following Team Members:

   - Planner
   - Civil Construction Manager/Inspector
   - Field Construction GS (as necessary)
   - Permit Coordinator (as necessary)

The Project Manager, if applicable, will be made aware of the job walk and attend as necessary. The job walk allows the Civil Manager/Inspector to thoroughly evaluate the design and make any modifications.

4. Final Civil Design

   After the civil job walk, any changes required will be incorporated into the design and a final civil drawing will be reviewed and approved by the Civil Construction Manager/Inspector with a copy sent to the Permit Coordinator.

5. Permitting

   Once the Civil drawing has been completed, the Planner or Permit Coordinator will then proceed with acquiring the necessary permits. The Planner will continue with the Work Order preparation, in parallel with the permitting process.

   Identify ALL permits required:

   - City/County
   - Traffic Control
   - Pedestrian Traffic Control
   - Encroachment
   - Excavation
   - Flood Control District
   - CalTrans
   - Waste Water Engineer Plans (8-week lead time)
   - Railroad Permit (Real Properties Agent)
   - Federal Permits
   - US Forestry
   - Bureau of Land Management
   - Bureau of Indian Affairs
   - Army Corps of Engineers

6. Final Work Order

   Prepare the work order package, include all pertinent information and documentation. Include the chronology of events on the selected design option, shoo-fly design, customer contact/ load, generator(s) size/voltage/phase, location, circuit map(s), and proposed switching.

Appendix 13–1: Structure and Equipment Forms *(Sheet 1 of 2)*

Vault Inspection Form

Planner _____ PAX _____ Date Submitted _____

Requested Completion Date _____ SAP Accounting _____

FIM Map Provided? Yes/No Circuit Map Provided? Yes/No

Structure _____ Size _____ X _____ X _____

Date Fielded _____ Crew Contact _____

Duct? PVC/Other

Structure Deterioration: None Moderate Severe

Digital Pictures Requested:

Digital photographs including: (label walls for reference N-S-E-W)

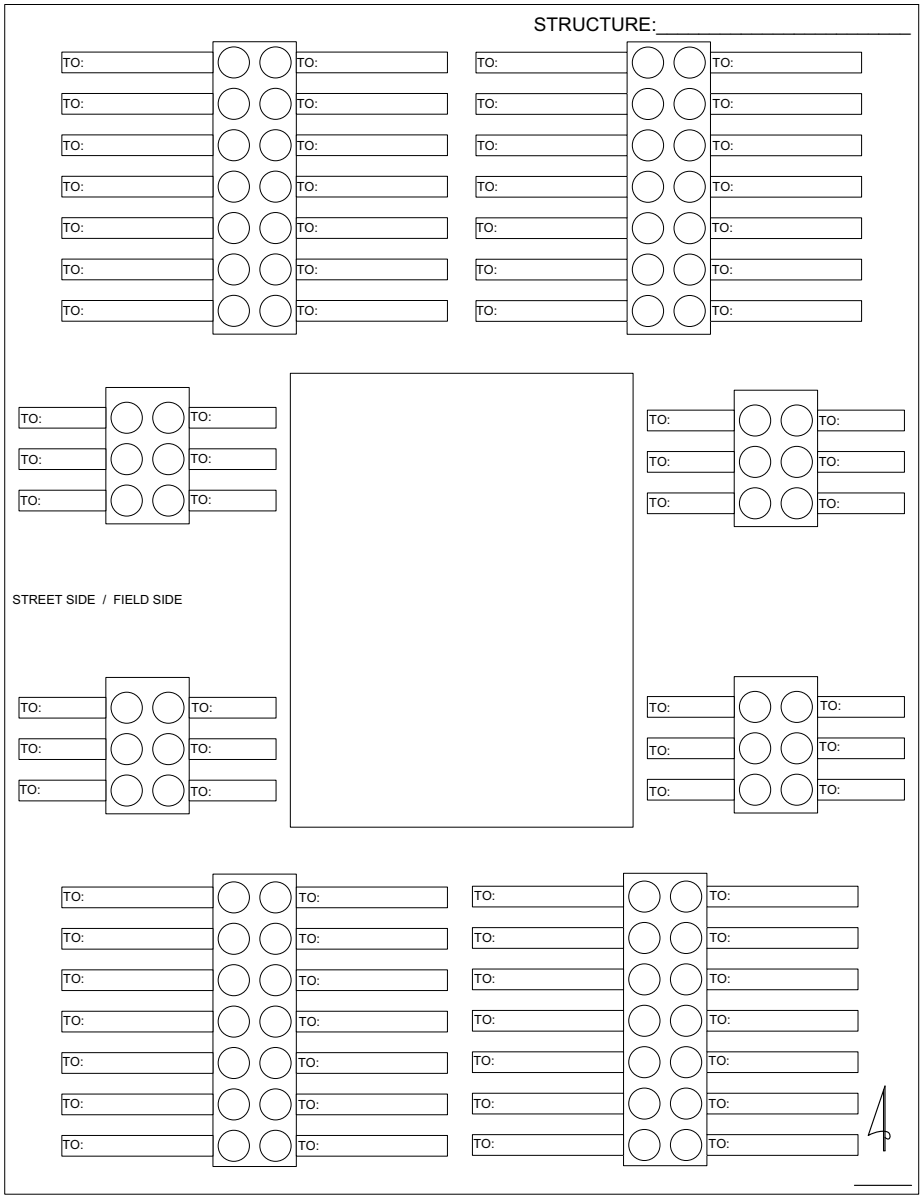
- All 4 walls of the structure
- All equipment
- All cable entering/exiting
- Areas of deterioration
- Overview photographs showing the relative location of the structure to sidewalks, streets, greenbelts, and street intersections

List all Equipment in the structure:

_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Special Instructions for Crew: _____
_____
_____

Appendix 13–1: Structure and Equipment Forms *(Sheet 2 of 2)*



Southern California Edison
Transmission and Distribution Business Unit

Chapter DDS–14: Generation Interconnection

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DDS-14
Generation Interconnection

1.0 Scope

As a result of numerous government sponsored programs, a significant amount of generation is being connected to the SCE distribution system. The purpose of these programs is intended to either offset customer load or to sell power. The common generating technologies employed in these programs are solar, wind, fuel cell, or biogas. This chapter provides an overview of the technical requirements needed to address generation interconnection requests.

The most common uses of generation interconnection are:

A. **Generation with Intent to Sell Entire Production, for example, Wholesale Distribution Access Tariff (WDAT)**

These generation systems are connected to the grid with the purpose of selling generated power.

B. **Generation with no intent to sell, for example, Net Energy Metering (NEM) and Combined Technologies**

These generation systems can be residential or commercial and are typically under the NEM Program. These are usually installed on the customer side of the revenue meter. The Generation is located on an Eligible Customer's premise, operates in parallel with SCE's electric system, and offsets part or all of the Customer's electrical requirements.

C. **Non-Export Generation, for example, Traditional Rule 21 Non-Export**

These generation systems, both residential and commercial, can use any type of generating technology. These generating systems are under the Rule 21 non-export option. The generating facility is located on an Eligible Customer's premise and offsets customer's electrical demand. Protection systems are installed to prevent the generating facility from exporting power to the grid.

2.0 Key Definitions

Refer to DDS-GL, which contains a glossary with the definition of key terms. A review of the glossary will assist in understanding the discussion in this chapter.

3.0 Prerequisite Information

A Service Planner must have the following specific knowledge and information to determine the design to be implemented.

A. *Electrical Service Requirements* (ESR)

B. Rules 15, 16, 20B, 20C, 21

C. *Distribution Overhead Construction Standards* (DOH)

D. *Distribution Underground Construction Standards* (DUG)

E. *Underground Structures Standards* (UGS)

F. *Distribution Design Standards* (DDS), chapters 2, 3, and 4 (1,500 kVA Load-block Criteria)

G. Generation Interconnection Handbook

H. Method of Service from Distribution Field Engineering

I. Customer/Project information sheet

J. Generation size and meter panel drawings

K. Scaled site plot, grading, elevation, and street improvement plans as applicable (both hard copy and digital)

L. Sewer and storm drain drawings as applicable

M. Assessor parcel map and copy of grant deed

4.0 Organizational / Departmental Tasks

4.1 Field Engineering

- Provides technical review, scope, and interconnection requirements
- Coordinates inspections of new primary switchgear as required
- Issues final technical approval of proposed projects
- Installs SCE generation signage on all commercial projects

4.2 Design Organization (Planning)

- If Planning is the Applicant's first point of contact and generation is involved, send Applicants to Customer Solar Group (CSG) or Grid Contracts to start the application process
  - The CSG is responsible for interconnection of generating facilities under the NEM tariff. Contact CSG at customer.generation@sce.com or NEM Hotline at (626) 302-9680.
  - TDBU Grid Contracts is responsible for all other generation projects. Contact WDAT at rule21@sce.com or Grid Contracts Hotline at (626) 302-9597.
- Directs all technical generation inquiries to Field Engineering
  - Assists Field Engineering with data acquisition requests, for example, customer service and transformer data
- Work with Field Engineering when upgrades and interconnection facilities are needed
- Develop work orders and bill customer when required
- Develops and submits MSR(s) upon request
- Coordinates scheduling procedures and outages when necessary
- Assists in addressing construction concerns as needed

4.3 Grid Contracts / CSG

- Initiates all milestones (application, contract, and agreements) to complete the project
- Manages the progress of the project with various stakeholders throughout its life cycle
- CSG issues the Permission to Operate (PTO) for NEMs

4.4 Small Generation Interconnection and Added Facilities

- Manages the design and construction of interconnection facilities in accordance with the Field Engineering requirements

4.5 Applicant

- Fills out interconnection application and submits all the necessary documentation
- Meets all the requirements (from Building and Safety or Local Authority Having Jurisdiction (AHJ)) prior to permission to operate
- Works with Field Engineer and Planning for any upgrades or outages
- Installs plot plan signage (as needed) to identify special circumstances
- Works with Field Engineering for commissioning of generation facility
- Signs interconnection agreement for completed process of interconnection

5.0 Design Concept

Generation Interconnection standards provides the design criteria for facilities needed to interconnect generation systems to the SCE distribution system.

6.0 Circuit Mapping Requirements

This section describes the policy for consistent mapping of generation interconnection facilities on distribution circuit maps.

Generation interconnection facilities shall be mapped under the following conditions:

- All non-inverter based generation shall be mapped regardless of size
- Low voltage interconnection facilities (less than 600 V) with no intent to sell their production
  - 150 kW output or greater on 4 kV circuits
  - 500 kW output or greater on 12 kV, 16 kV, and 33 kV circuits
- All high voltage (600 V or greater) interconnection facilities regardless of generator power output
- All interconnection facilities with intent to sell entire production, for example, WDAT
- Interconnection facilities with special equipment, for example, Ground-banks and Ground Detectors

The required generator information shall be added as text to the maps. The required generator information includes:

- Technology
- Address
- Power output in kW or MW
- Voltage at the Point of Interconnection (POI) (480 V, 4 kV, 12 kV, 16 kV, 33 kV)
- Tariff Device ID (add what is shown in the parenthesis below to the map):
  - Net Energy Metering (N-XXXXX)
  - Wholesale Distribution Access Tariff (W-XXXXX)
  - Grid Facility Identification (G-XXXXX)
  - Qualifying Facilities Identifier (Q-XXXXX)

The symbol for generation interconnection facilities is the CO-GEN (CG) symbol. Low voltage connections will have an SCE owned transformer connected to the CO-GEN (CG) symbol on the primary side of the transformer.

High-voltage connections will have the CO-GEN (CG) symbol connected to the line without the use of a transformer. Remote-Controlled Switches dedicated for connecting the generating facility to the grid are called Remote-Controlled Switches for Generation (RCSG). The line device ID to be used with a Remote-Controlled Switch for Generation is RCSGXXX.

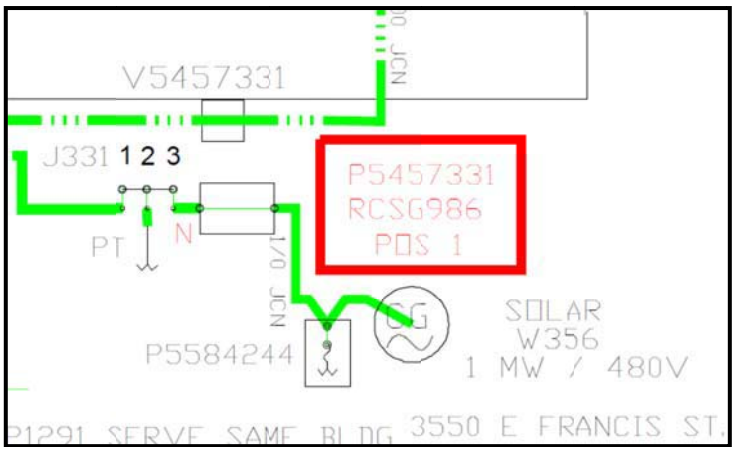
When a generator is connected at a point other than the customer load transformer on the same building, the same text will be used to identify both the customer load transformer and the generation interconnection facility at both points of service.

6.1 Circuit Mapping Examples

Example 1

Generation interconnection facility connected at 480 V (WDAT). All export with intent to sell entire production, for example, WDAT interconnection facilities shall be mapped. Refer to Figure 14–1.

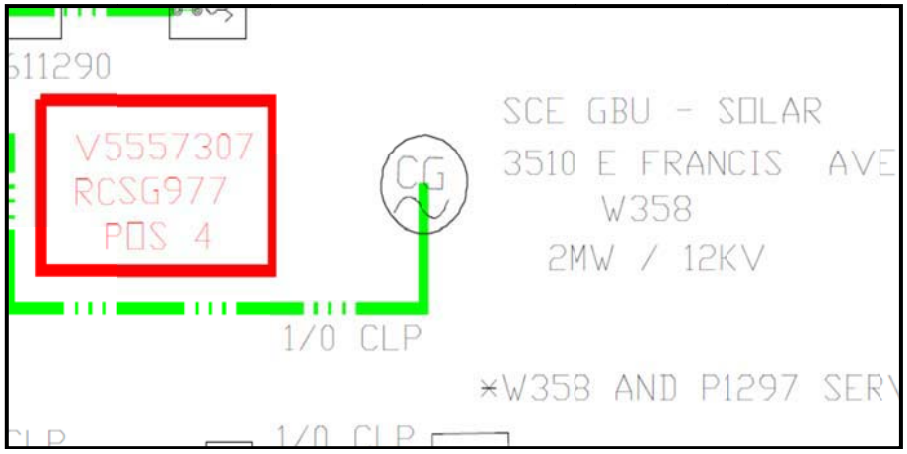
Figure 14–1: Generation Interconnection Facility Connected at 480 V (WDAT)



Example 2

Generation interconnection facility connected at 12 kV (WDAT). All export generating facilities with intent to sell entire production, for example, WDAT shall be mapped. Refer to Figure 14–2.

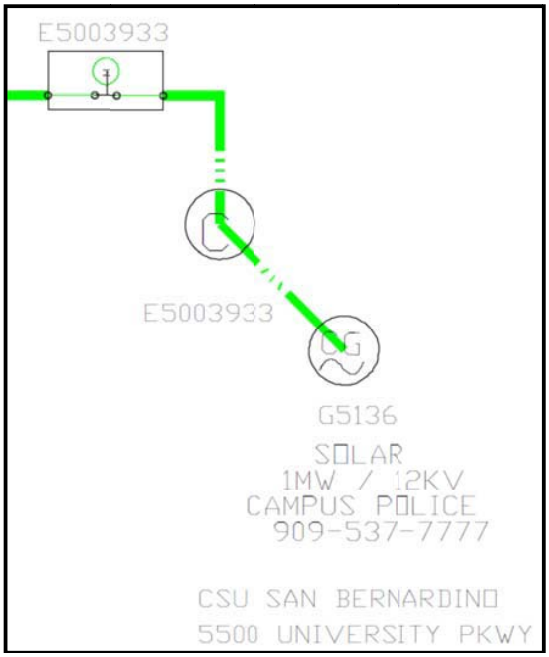
Figure 14–2: Generation Interconnection Facility Connected at 12 kV (WDAT)



Example 3

Primary service with a generation interconnection facility, GFID, export, with no intent to sell, for example, NEM and Combined Technologies. Refer to Figure 14–3.

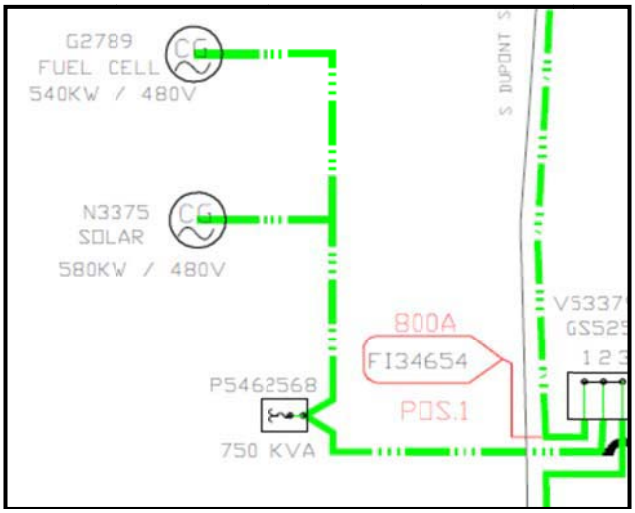
Figure 14–3: Primary Service with a Generation Interconnection Facility, GFID, Export with No Intent to Sell



Example 4

Generation Interconnection Facility connected at 480 V (GFID and NEW and Combined Technologies). Refer to Figure 14–4.

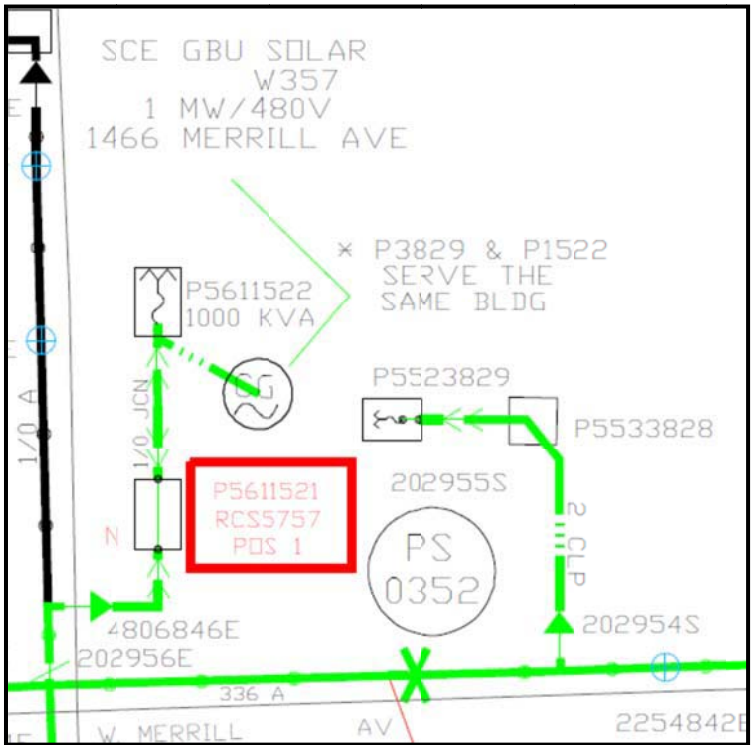
Figure 14–4: Generation Interconnection Facility Connected at 480 V (GFID and NEM and Combined Technologies)



Example 5

The required generator information shall be added as text to the distribution circuit maps. When a generator is connected at a point other than the service transformer on the same facility, text shall be used to identify both the service transformer and the point of generator interconnection. Refer to Figure 14–5.

Figure 14–5: Required Generator Information to be Added as Text



7.0 SCE Requirements for The Applicant

7.1 Visible Disconnect

SCE's CPUC Rule 21, Section D.1.d outlines visible disconnect requirements. Per SCE guidelines, a visible disconnect is required for all of the following aggregate generating facilities:

- All Commercial
- All Residential Non Self-Contained Meters
- All Line-Side Taps (additional overcurrent protection required)
- All Battery Back-up Systems

Refer to SCE's CPUC Rule 21 and Interconnection Handbook for Visible Disconnect requirements.

Disconnects must be reviewed and approved by Field Engineering.

7.2 Protection Requirements

Protection requirements for generation facilities shall comply with SCE's Interconnection Handbook and SCE's CPUC Rule 21.

7.3 Switchgear Requirements

Refer to ESR-7.

7.4 Signage Requirements

Refer to DUG, TX 160 and DOH, T 75.

7.5 Net Generation Output Meter (NGOM) Requirements

Projects requiring NGOM meters shall comply with ESR 1-12.

8.0 Telemetry Requirements

Refer to *SCE's Interconnection Handbook*, Section 7.1 and System Operating Bulletin 510 for telemetry requirements for generation interconnections.

9.0 Ground Bank and Ground Detector Design

As required by the specific generation interconnection requirements, Engineering shall determine the need to install a ground bank (grounding transformer) or a ground detector as part of the interconnection facilities. If such is the requirement, the ground bank is to be designed in accordance with DOH, AP 160, AP 165, AP 166 and DUG, TX 215, TX 220, and TX 240.

10.0 Design Criteria

The following design criteria will provide the SCE Employee working on generation interconnection facilities with the tools needed to correctly plan and design the interconnection to the distribution system.

10.1 Impact to the 1,500 kVA Loadblock Criteria

Limit the amount of generation connected to a loadblock to 1,500 kVA to conform to the 1,500 kVA loadblock limitation criteria. In cases where a single transformer comprises the total loadblock, and that transformer exceeds 1,500 kVA, the amount of generation connected to the loadblock shall be limited to that transformer nameplate rating.

Refer to DDS-2 for more information on loadblock limitation criteria.

- The transformation that is only used to connect the generation system to the grid will not be counted as part of the 1,500 kVA load block criteria.

  Generation systems which are connected to a dead-end feeder can be tapped between switch positions if the tap to the generation system is located on the same customer's facility. It must be a dedicated system exclusive to that Customer. Refer to Figure 14–1.
- Transformers used for the purposes of switch automation shall not be considered a tap for the purposes of feeder design.

The amount of generation allowed on a distribution circuit shall be limited to the amount of load allowed on a circuit.

Individual Generation Projects greater than 1,500 kVA will interface directly with the feeder. A dedicated switch position is the preferred method to connect these generating facilities to the feeder.

10.2 Generation with Intent to Sell Entire Generation Production (WDAT)

A. Service Entrance Requirements

Service entrance requirements shall comply with the ESR.

B. SCE Isolation Switches / Remote-Controlled Switches for Generation

Isolation switches used for the purposes of isolating the generation facility from the distribution system shall be installed as part of SCE's interconnection facilities. (The generation customer is still required to install a visible disconnect as outlined in DDS-14, Section 7.1)

Remote-Controlled Switch for Generation (RCSG) are to be three-phase, gang-operated and automated with dedicated switch positions to serve generating facilities. The G&W RAM-Type SF6 Gas-Filled Switch is the approved switch for RCSG applications.

1. **When the voltage at the POI is greater than 600 V and generator rated power output is less than 1 MVA**:

   The isolation switch shall be a three-phase, gang-operated distribution switch. In addition, the switch is required per ESR-7, Section 19.2.

2. **When the voltage at the POI is greater than 600 V and generator rated power output is greater than or equal to 1 MVA**:

   The isolation switch shall be a Remote-Controlled Switch for Generation.

3. **When the voltage at the POI is less than 600 V and generator rated power output is less than 1 MVA**:

   The isolation switch shall be a three-phase, gang-operated distribution switch. On pad-mounted transformers, the transformer's internal coil switch serves as the isolation switch.

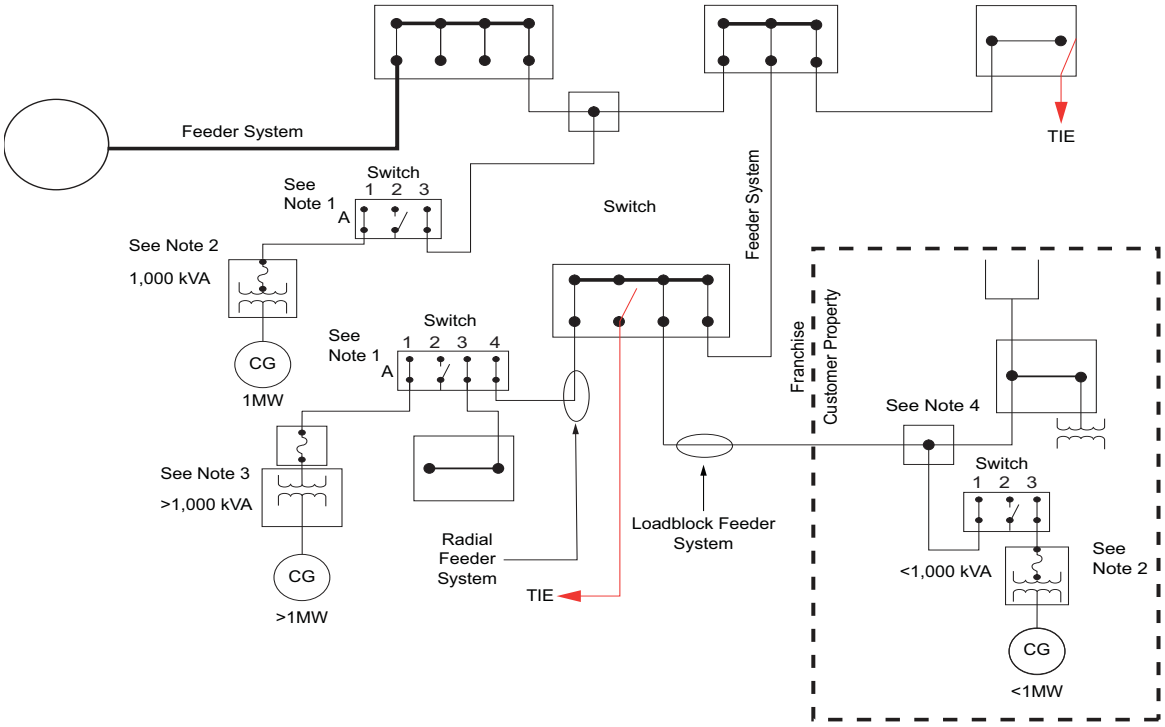
4. **When the voltage at the POI is less than 600 V and generator rated power output is greater than or equal to 1 MVA**:

   The isolation switch shall be a Remote-Controlled Switch for Generation.

Generation connecting to secondary systems shall follow the ESR and DDS Standards.

C. Interconnection Examples

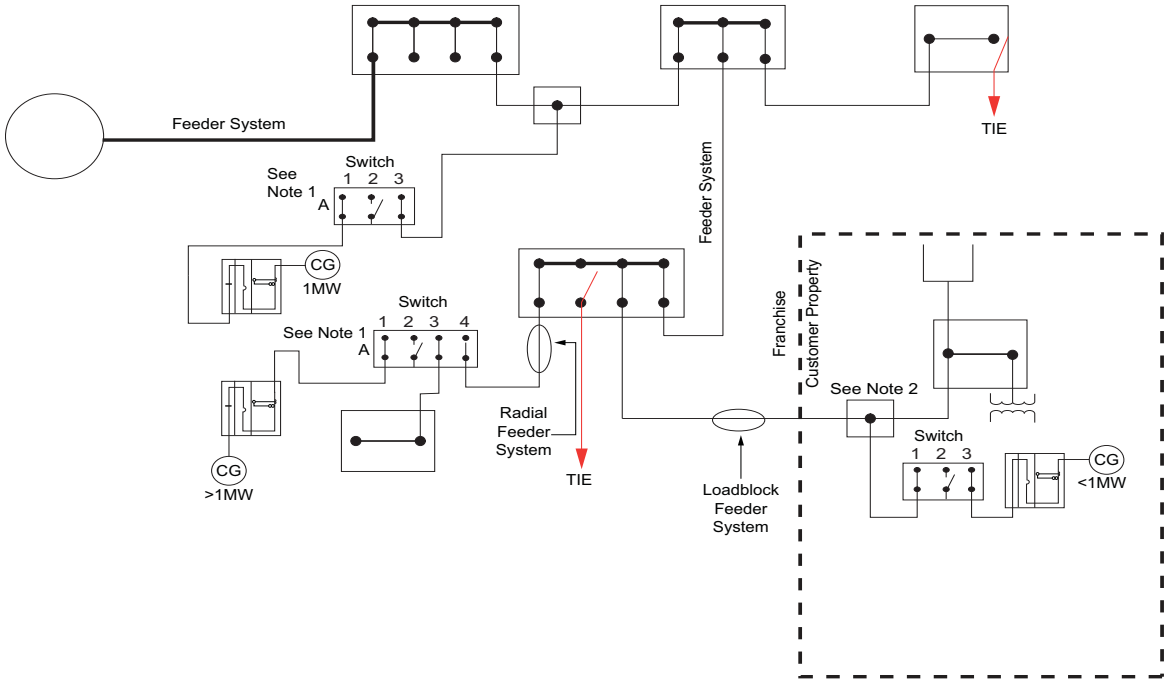
Figure 14–6: Example 1, Generation Projects Connected with Less than 600 V



Notes:

1. Automate switch for generation projects which are larger than or equal to 1MV.
2. For transformers less than or equal to 1,000 kVA, use internal transformer coil switch as the isolation switch.
3. For transformers greater than 1,000 kVA external fusing will be required.
4. Generation systems which are connecting to a loadblock feeder can tap between switch positions if the tap to the generation system is located on the same customer's property. It must be a dedicated system exclusively to that customer.

Figure 14–7: Example 2, Generation Projects Connecting at Primary Voltage



Notes:

1. Automate switch for generation projects which are larger than or equal to 1MV.
2. Generation system switch are connecting to a loadblock feeder can tap between switch positions if the tap to the generation system is located on the same customer's property. It must be a dedicated system exclusively to that customer.

10.3 Generation with No Intent to Sell (NEM and Combined Technologies)

A. Requirements:

1. Validate Existing Facilities

   Upon receipt of an application, Field Engineering shall review and study the proposed generation and existing facility capacity. If verification and/or upgrades are required, the Field Engineer shall contact the appropriate Planning Organization.

2. Meter Panels

   For new panels, relocation of panels, or panel upgrades refer to ESR-3 and ESR-5.

   Typically, these generators will be interconnected to an existing meter panel. The generators are connected either on the customer side of the main circuit breaker or on the utility side of the main circuit breaker (line side tap). In addition, there are generators connected to multiple tenant units. These generators are installed at a single service point with the intent to offset the loading of the entire building and its tenants. The owner allocates the percentage of generation to both house meters and tenants. For examples, refer to the one-line diagrams in Figure 14–8 through Figure 14–13.

3. Services

   Refer to ESR-2 for overhead services for 0-600 V.

   Refer to ESR-3 for underground services for 0-600 V.

   Refer to ESR-6 for switchboards 600 V and below.

   Refer to ESR-7 for switchboards 600 V and above.

   Refer to ESR-3 and ESR-5 for switchboard clearances.

   Refer to Rules 15, 16, and Design Support Updates/Notifications on Portal for additional service requirements. Engineering may determine additional service requirements.

4. Transformers

   Engineering will determine the need for transformer upgrades, modifications, or installation of additional transformation (see DDS-7 for transformer loading requirements). Local planning is responsible for the design, work order creation, and any other steps to needed to implement the facilities.

Generation connecting to the secondary systems shall follow the ESR and DDS Standards.

B. Metering Requirements - NGOM

1. All NEM projects require (per the schedule) that the revenue meter be a bi-directional meter.

2. VNM and Combined Technologies

Engineering shall work with the Applicant to ensure that for MASH-VNM and Combined Technology projects a NGOM is installed to capture the output of the generator ahead of the entire load. Refer to ESR-1, Section 12.0 for NGOM, line and load disconnects, and meter socket requirements. Refer to the MASH-VNM schedule and DSU.

C. Utility side interconnection with respect to the main circuit breaker

1. Additional requirements imposed on the Applicant who chooses to interconnect on the Utility Side of the main circuit breaker, include:

   a. Overcurrent protection (per ESR)

   b. Signed Professional Engineer Stamp

   c. POI shall be reviewed and approved by the Field Engineer and Local AHJ

   d. An outage must be coordinated between the Applicant, Engineer, Planner, and Field Personnel once the application packet has been approved by the Field Engineer

D. Interconnection Examples

Refer to Figures 14-8 through 14-13 for Interconnection Examples.

Tariffs may be found at:
http://www.sce.com/AboutSCE/ReGgulatory/tariffbooks/ratespricing/otherrates.htm

Figure 14–8: Self-Contained Single-Line Diagram, Customer Side Interconnection (0-600 V)

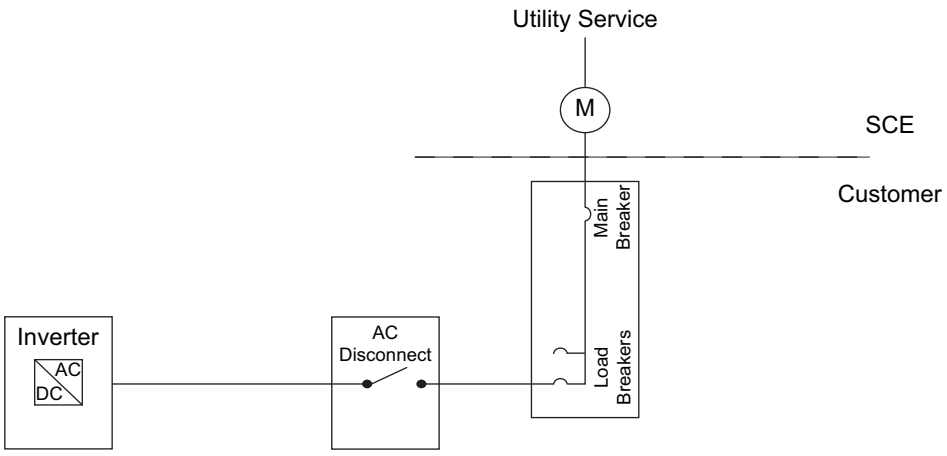
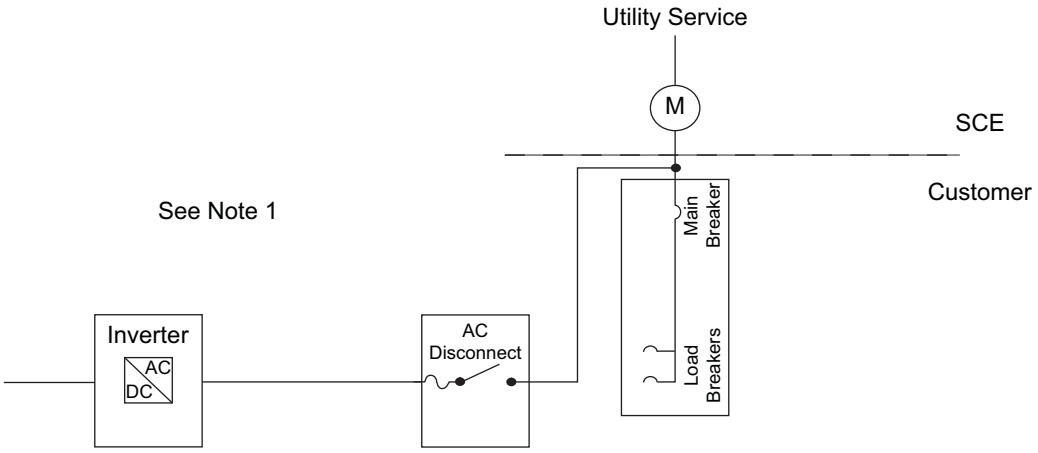


Figure 14–9: Self-Contained Single-Line Diagram, Utility Side Interconnection (0-600 V)



Notes:

1. No connections shall be in SCE sealed compartments. Reference ESR for more information on customer panels.

Figure 14–10: Non-Self Contained Single-Line Diagram, Customer Side Interconnection (600 V and Above)

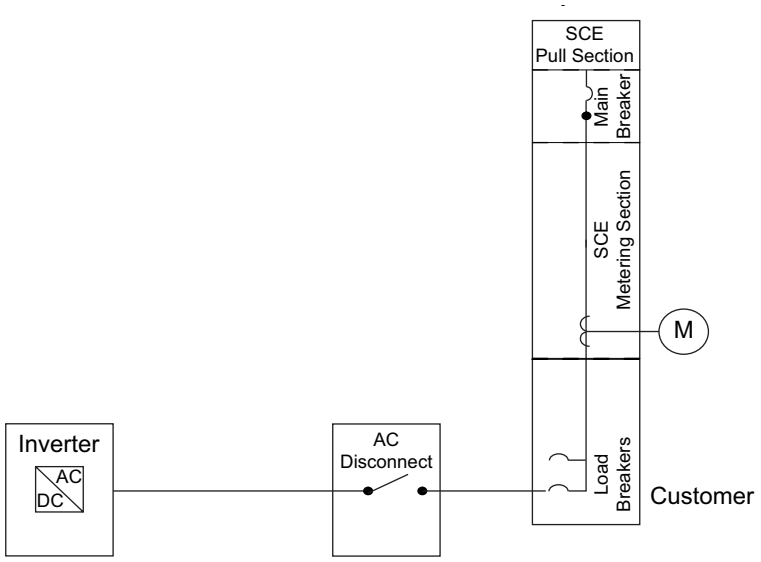
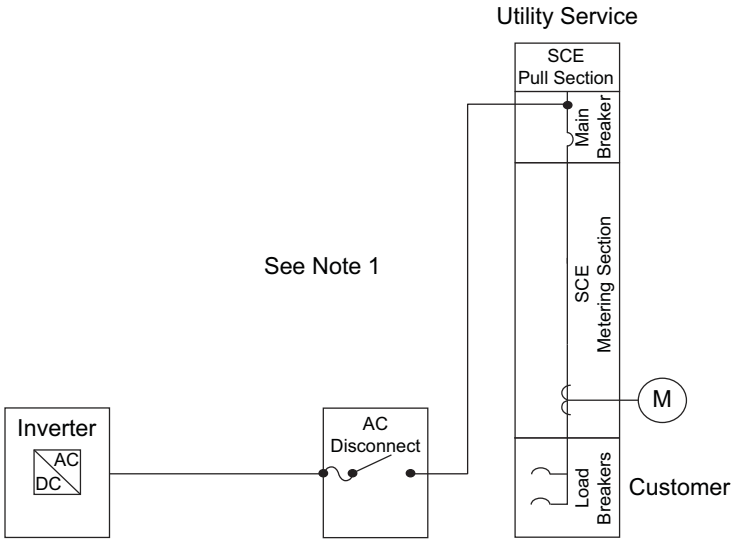


Figure 14–11: Non-Self Contained Single-Line Diagram, Utility Side Interconnection (600 V and Above)



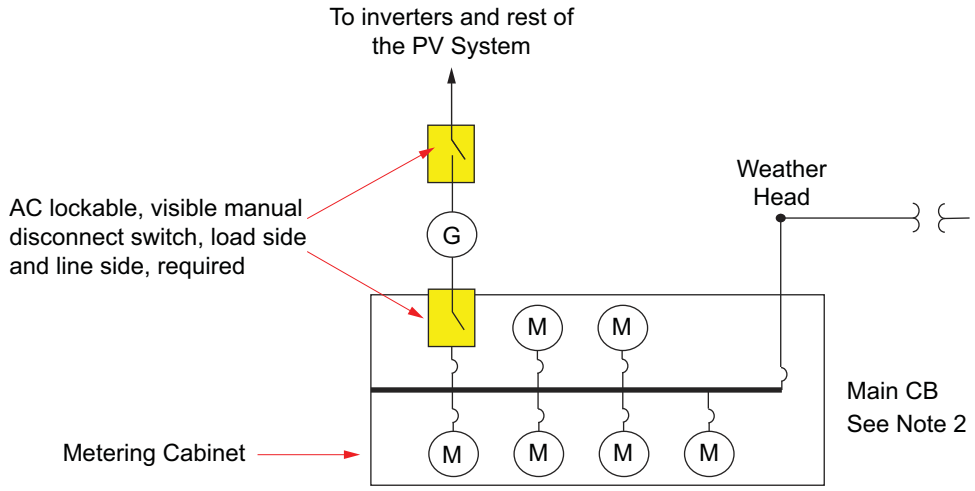
Notes:

1. No connections shall be in SCE sealed compartments. Reference ESR for more information on customer panels.

Note:

1. The illustrations on the following pages are only examples. All panels shall comply with ESR standards, such as:
   - ESR, Section 6, where commercial panels may be required
   - ESR, Section 5, number of meter and or breaker limitations
   - ESR, Sections 1-12, line and load AC disconnects

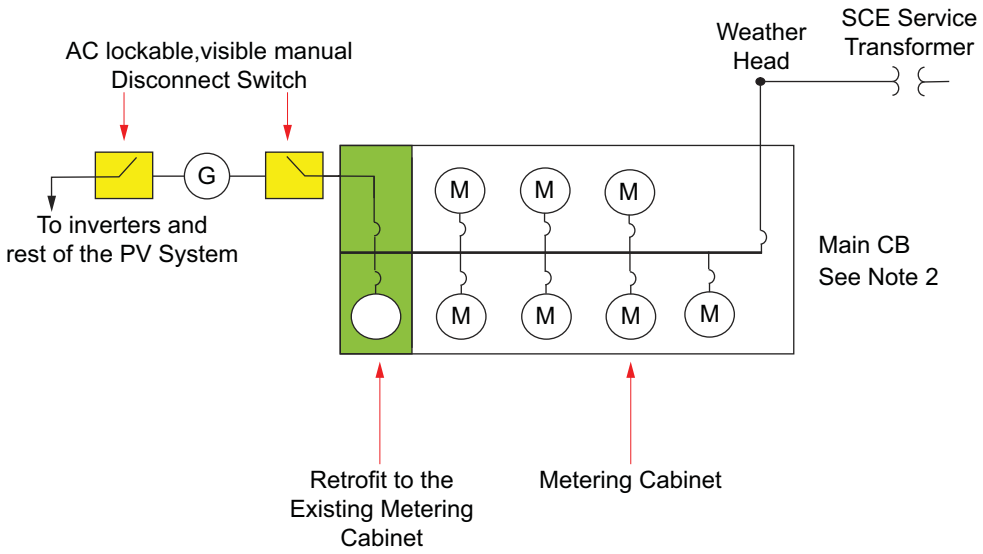
Figure 14–12: Example 1 — Virtual Net Metering Single-Line Diagram



Notes:

1. Example 1,self contained and if a meter spot is available in the metering cabinet.
2. Required if more than six circuit breakers are present.

Figure 14–13: Example 2 — Virtual Net Metering Single-Line Diagram



Notes:

1. Example 2, self contained, if a meter spot is not available in the metering cabinet and existing panel, and if panel can be modified with additional meters.
2. Required if more than six circuit breakers are present

10.4 Non-Export Generation (for example, traditional Rule 21 non-export)

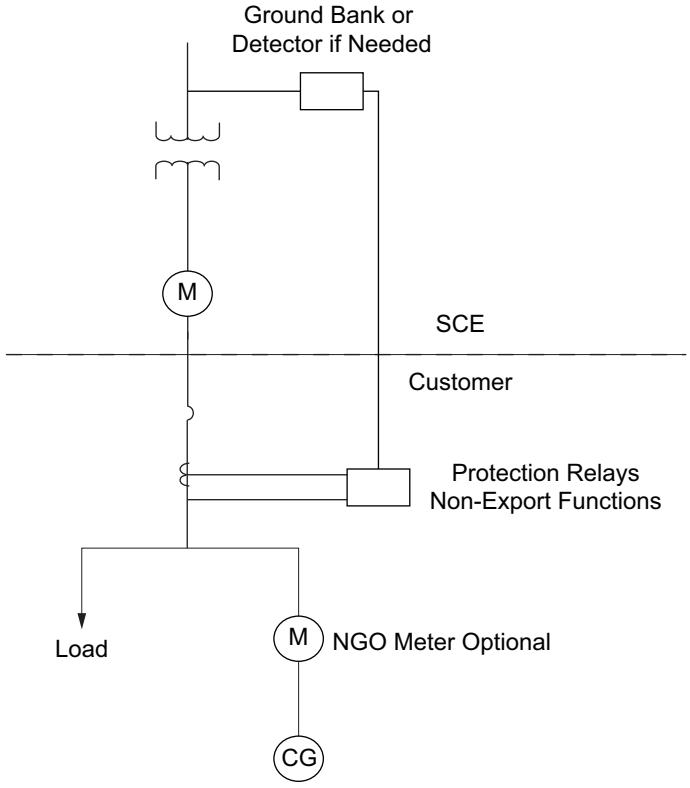
A. Requirements

Generation systems under this category are not allowed to export any power to the SCE distribution system.

In some cases, SCE allows uncompensated power to be exported for a very short period of time ("inadvertent export" which is no longer than 60 seconds) to allow the Customer the flexibility to operate his or her electrical system.

Upon receipt of an application and all related generation information, Field Engineering and Protection Engineering shall review the Customer's proposed system including relay protection settings and diagrams to determine compliance with SCE's Interconnection Standards. If upgrades are required, Field Engineering shall work with Grid Contracts to prepare the required interconnection contracts. Upon receipt of executed contracts, Field Engineering shall contact the Planning Organization for assistance with the Distribution upgrades.

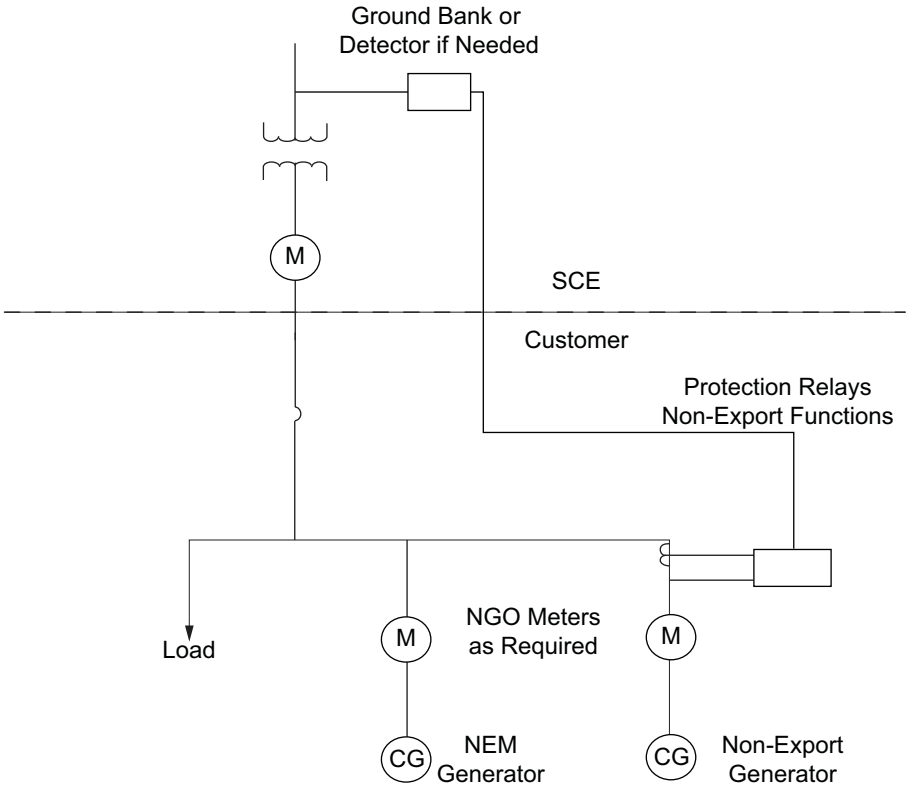
Figure 14–14: Self Contained Single-Line Diagram for Single Non-Export Generation (0-600 V)



B. Combined Technologies

Combined Technologies, where multiple generating types are being utilized, shall only be allowed if the protection systems will adequately protect the SCE distribution system.

Figure 14–15: Self Contained Single-Line Diagram for Combined Technologies with Non-Export Generation (0-600 V)



1. Metering Requirements

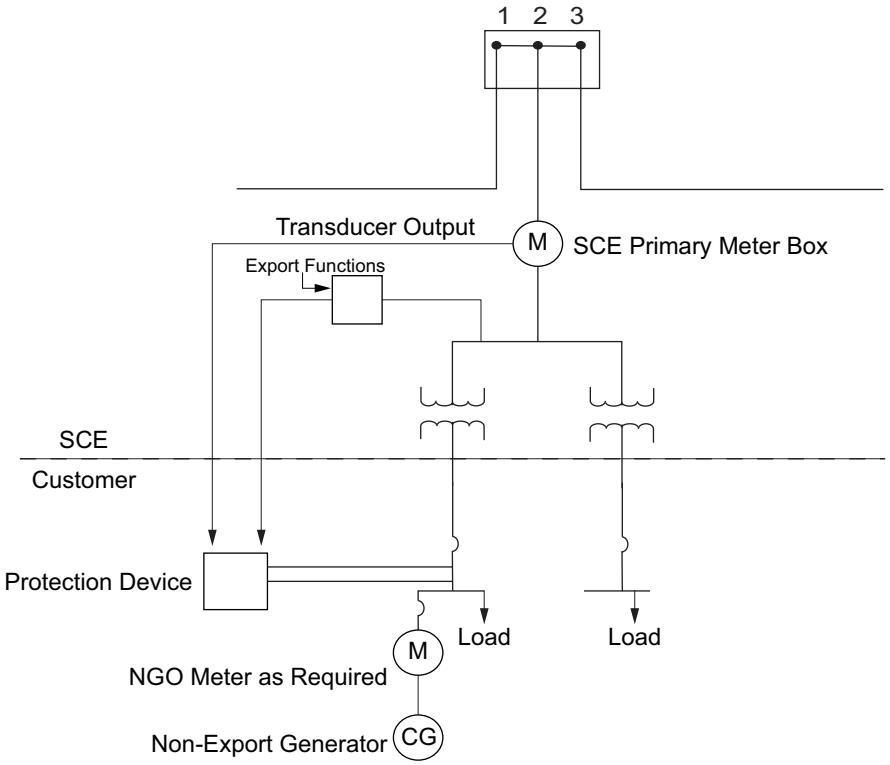
   Install a NGOM meter to capture the output of the generator ahead of the entire load. Refer to ESR-1, Section 12.0 for NGOM, line and load disconnects, and meter socket requirements.

2. Protection Requirements

   Protection systems are required to be installed as part of the generation system to prevent power from being exported to the SCE distribution system.

   For generation projects connected to SCE Added Facilities that utilize a SCE Primary Metering Cabinet, SCE can provide the Applicant the transducer output which can be used by the Applicant for relay power settings.

Figure 14–16: Single-Line Diagram for Non-Export Generation with Primary Voltage (600 V and Above)



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CUSTOMER-OWNED TRANSFORMER ROOM

DDS-15

Southern California Edison
Transmission and Distribution Business Unit

Section DDS–15: Customer-Owned Transformer Room

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DDS—15
Customer-Owned Transformer Room

1.0 Scope

This chapter provides the criteria for designing a new customer-owned transformer room (walk-in vault) located inside a building.

2.0 Key Definition

Chapter DDS-GL contains a glossary that includes the definition of key terms. A review of the glossary will assist in understanding the discussion in this standard.

3.0 Design Concept

Prior to designing an indoor transformer room, refer to ESR-4, Table 4-1, for the preferred transformer locations on customer's premises. The maximum size transformer in a transformer room shall not exceed 2,500 kVA.

Locate the room on the ground level (preferred) or first subterranean level of the building.

For retrofitting existing transformer rooms, contact Field Engineering for guidance.

4.0 Prerequisite Information

A Service Planner must have the following specific knowledge and information to accurately design the transformer room.

A. Building configuration

B. Customer load schedule information with main switch ampacity and location

C. *Electrical Service Requirement Manual* (ESR), Chapter 3 and Chapter 4

D. *Distribution Underground (DUG) Construction Manual*, GR 100

E. Pad-mounted Elbow-Connected (PME) switch construction standard, DUG, PD 337

F. Three-phase pad-mounted transformer dimension and clearances, DUG, TX 180 and DDS-3

G. Three-phase subway transformer dimension and clearances, DUG, TX 400

H. Equipment Clearances in Walk-In Vaults (Transformer Rooms), DUG, AP 300

I. BART pad structure details, DDS-6 and *Underground Structures (UGS) Manual*, SS 508

J. Coil insert installation information, UGS, AC 720

5.0 Design Criteria

5.1 Provisions Required by Applicant and SCE for Transformer Room Applications

The Applicant shall furnish and install the following provisions at their expense. These provisions shall be in compliance with the required specifications met by the Authority Having Jurisdiction and SCE. The Applicant is responsible for providing detailed construction drawings with plan and profile views that incorporate these provisions.

- Transformer room painted white per UGS, VA 400
- Access Doors (personnel door and/or equipment access)
- Space to allow the use of equipment for lifting and equipment installation
- Ventilation louvers/screening and baffles with fire dampers
- Spill mitigation, for example, oil spill catch basin and seal or sump pump well
- Sump pump or other suitable type of equipment (as required)
- Primary cable trays (as required)
- Anchorage/equipment support for seismic resistance
- Grounding scheme (refer to ESR-4 for details)
- Lighting and receptacles
- Coil inserts for pulling eyes (refer to UGS, AC 720)
- Forced ventilation (as required by Local Authority Having Jurisdiction)
- Hasp on door

SCE shall provide and install the following materials per applicable tariffs:

- Primary cables and associated components
- Primary cable racks (as required) and associated components
- Secondary cables for the busway service head to the secondary side of the transformer
- Racking secondary cables from BART pad to the transformer room wall (as required)
- Apparatus Equipment (transformers and/or switches)
- BART pad (as required)
- Padlock for door

5.2 Transformer Room Dimension

Transformer room dimensions vary and rely on the maximum capacity of the main switch, transformer sizes, switch requirements, equipment operating clearances, and room configuration.

The following criteria shall be considered when planning the transformer room dimension:

1. The number and size of transformer(s) and switch(es) (if required) based on the customer's load schedule
2. The maximum transformer size based on the total panel load and transformer selection criteria in Section 5.3
3. Transformer and switch (if required) dimension and clearance requirements in the *Distribution Underground Construction Standard Manual*

5.3 Transformer Selection Criteria

- 500 kVA - 1,000 kVA - Three-phase Bay-O-Net fused pad-mounted transformer on a 71" x 114" x 22" BART pad structure (preferred) or three-phase subway transformer (optional, where space is limited).
- 1,500 kVA or 2,500 kVA - Three-phase pad-mounted transformer on a 71" x 114" x 22" or 71" x 114" x 30" BART pad structure. A PME-5 with SME-20 fuseholder and very slow SMU-20 fuses shall be used. A PME-5 will be installed on a BART pad structure. Contact Distribution Civil/Structural Group for details.

5.4 Planning Considerations

Refer to ESR-4 for wall, ceiling and floor requirements, transformer room equipment and personnel access, grounding requirements, and equipment lifting requirements.

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Southern California Edison
Transmission and Distribution

Chapter DDS–16: Metering and Applications Types

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1.0 Scope

This chapter provides application and design criteria for metering and associated equipment (for example, meters, current transformers, and voltage transformers).

This standard addresses the following metering types:

- Self-contained
- Instrument rated (current transformer (CT) metering)
- Time-of-use (TOU)
- Totalized
- Generation
- Primary metering

2.0 Key Definition

DDS–GL contains a glossary that includes the definition of key terms. A review of the glossary will assist in understanding the discussion in this standard.

3.0 Design Concept

This chapter discusses meter installations for new business, and addresses changes to existing services.

The preferred meter for new and existing installations is the "Edison Smart-Connect" meter. Legacy meters (for example, electro-mechanical, analog, remote-read) shall only be installed when an Edison Smart-Connect meter does not exist or apply (that is, no direct replacement or when a customer enrolls in the Edison Smart Meter "Opt Out" Program).

Self-contained meters do not require additional equipment to capture an accurate reading. Instrument-rated meters require installation of current transformers (CTs) in conjunction with the meter. Primary metering applications also require installation of voltage transformers (VTs).

In order to select the proper meter and associated equipment, the Planner must determine the following:

- Phase and voltage of the service
- Panel (switchboard) size and type
- Estimated customer demand
- Tariff rate

Additional items that should be taken into consideration when designing a meter installation are as follows:

- Application for service

  SCE must receive an Application for Service prior to setting a meter.

- Electrical inspection release

  All new meter installations and meter upgrade/changes require an electrical inspection release from the local authority having jurisdiction prior to energizing the panel.

- Potential outages

  Self-contained meters can be installed on energized panels and therefore do not require an outage. However, the CTs associated with instrument-rated meters should **only** be installed on a de-energized panel. If an outage is required, allow an appropriate amount of time to schedule and execute the outage.

- Metering Services Organization (MSO)

  Pre-engineered meters require MSO Engineering to prepare the meter. Allow an appropriate amount of time for MSO to program the meter and EMS to install the meter and its associated equipment on-site.

- Preset meter

  A *preset meter* describes the process of installing an instrument-rated meter and associated equipment prior to receiving electrical inspection. This is done to incorporate MSO's lead times and to ensure the meter is on-site and installed prior to energizing the panel. When presetting a meter, follow the established preset meter process. Install preset meters only after the panel has been bolted into its final location.

4.0 Prerequisite Information

A Service Planner must have the following specific knowledge and information to properly select the appropriate metering:

- SCE Electrical Service Requirements (ESR) manual standard
- SCE tariff rules and rates
- Distribution Overhead Construction Standards (DOH), Section T: Testing and Metering

5.0 Design Criteria

5.1 Qualify Customer and Secure Customer Information

A Service Planner must qualify a customer(s) service type by identifying the following information to select the correct type of meter and associated equipment.

- Phase and voltage

  Example: 120/240 V, 3 W, 1Ø versus 120/240 V, 4 W, 3Ø; 480 V, 3 W, 3Ø versus 277/480 V, 4 W, 3Ø

  The number of service wires directly relates to phase and voltage and affects (1) meter equipment selection, such as meter clip configuration, and (2) the number of CTs and VTs.

- Panel (switchboard) size and type

  Example: Self-contained versus instrument rated; window versus bar CTs; window CT 4-inch versus 5-inch

  For multimeter switchboards, it is important to identify each individual meter requirement for each meter section. Refer to ESR for approved panels.

- Demand estimating and tariff rate selection

  Customer's operational need, intended use, and actual demand are required to select the tariff rate (for example, PA, AL, TOU, GS.), and instrument-rated equipment.

  For demand estimating information, see DDS–3, Section 5.1.

5.2 Meter Selection

Using the information gathered in Section 5.1, refer to the appropriate section below.

A. Self-Contained Meters

A self-contained meter is a standalone device that is able to meter customer usage with no associated equipment. Use this type of meter for residential applications where the panel size is 400 A or less, or in commercial applications where the panel size is 200 A or less. Refer to Electrical Services Requirement (ESR) manual for self-contained panel specifications.

Note: For application of self-contained meters on TOU, totalized, and generation metering, see Section 5.2, C (page 16–9), Section 5.2, D (page 16–9), and Section 5.2, E (page 16–10) respectively.

See Table 16–1 (page 16–6) to determine the meter SAP material number. Use the SAP material number to search for the compatible unit (CU) in the respective design tools.

Note: Table 16–1 (page 16–6) lists additional meter information (that is, meter socket clip configuration and exhibit type). This will assist the Planner in confirming the relationship of meter stabs to meter socket clips during the panel approval process. For more detail on full panel approvals, refer to the appropriate section in the ESR manual.

Table 16–1: Self-Contained Meter Selection Table

Type of Service			Self-Contained Terminals				
Phase	**Voltage**	**Wire**	**Meter Type[a/]**	**Clip**	**Exhibit**	**SAP**	**DOH Section**
Single	120 V	2-wire	1S ESC	4-clip	Exhibit A	10158735	T-126, 127, 128
	120 V[b/]	2-wire	1S Legacy	4-clip	Exhibit A	10105255	T-126, 127, 128
	120/240 V	3-wire	2S ESC	4-clip	Exhibit A	10168079	T-126, 127, 128
	120/240 V[b/]	3-wire	2S Legacy	4-clip	Exhibit A	10105402	T-126, 127, 128
	120/240 V	3-wire[c/]	2S ESC	4-clip	Exhibit A	10158782	T-126
	120/240 V[b/]	3-wire[c/]	2S Legacy	4-clip	Exhibit A	10105238	T-126
	120/208 V	3-wire	12S ESC (Network)	5-clip	Exhibit B or C[d/]	10158737	T-225
	120/208 V[b/]	3-wire	12S Legacy (Network)	5-clip	Exhibit B or C[d/]	10105526	T-225
	240/480 V	3-wire	2S Legacy	4-clip	Exhibit A	10105522	T-138
	480 V[e/]	2-wire	2S Legacy	4-clip	Exhibit A	10105522	T-135.3
	277/480 V	3-wire	12S ESC	5-clip	Exhibit B or C	10158741	T-135.2
Three	240 V	3-wire	12S ESC	5-clip	Exhibit C	10158741	T-326
	480 V[e/]	3-wire	12S ESC	5-clip	Exhibit C	10158741	T-326
	120/208 V	4-wire	16S ESC	7-clip	Exhibit D	10158742	T-425
	120/208 V[b/]	4-wire	16S Legacy	7-clip	Exhibit D	10105527	—
	120/240 V	4-wire delta	16S ESC	7-clip	Exhibit D	10158742	T-431
	277/480 V	4-wire	16S ESC	7-clip	Exhibit D	10158742	T-425
Totalizing	Select meter from table above and contact MSO Engineering.						—
NEM and NGOM Metering	Select meter from table above and contact MSO Engineering. See DDS–14, Section 10.3 (page 14–14). Contact Field Engineering (refer to ESR manual, ESR-1).						—

[a/] ESC = Edison Smart Connect; Legacy = Non-Smart Connect

[b/] This SAP material number shall only be used for Residential SCE Smart-Connect "Opt-Out" customers ***only***.

[c/] Class 320 – 300/400 A panel

[d/] Exhibit B is the preferred socket configuration.

[e/] Existing installations may exist in the field. Not for new installations. For Reference Only.

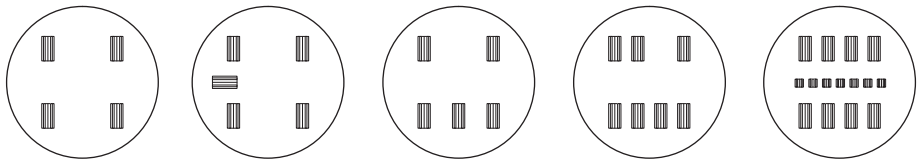


Exhibit A **Exhibit B** **Exhibit C** **Exhibit D** **Exhibit E**

Note: For an example of how to apply Table 16–1 (page 16–6), see Appendix 16–1 (page 16–16).

B. Instrument-Rated Meters

Instrument-rated meters are designed to meter customer usage using auxiliary devices called *instrument transformers*. The two types of instrument transformers are *current transformers* (CTs) and *voltage transformers* (VTs). When used with these devices, the instrument-rated meter is capable of metering high currents and high voltages.

Note: Install CTs on **de-energized** panels ***only***.

Current transformers are used to step down the customer's load current to a usable meter value (~5 A or less), allowing instrument-rated meters to register customer usage. Current transformer sizes are expressed in ampacity ratios, such as 200:5 and 400:5. Each CT also has a rating factor (RF) which increases the ampacity of the CT. Rating factors are identified in the CT tables below. Current transformers shall be used in conjunction with instrument-rated meters for residential applications, where the panel size is 600 A, and commercial applications, where the panel size is 400 A and larger.

Note: For application of instrument-rated meters on TOU, totalized, and generation metering, see Section 5.2, C (page 16–9), Section 5.2, D (page 16–9), and Section 5.2, E (page 16–10).

Voltage transformers, also referred to as potential transformers, are used to step down the customer's service voltage to a usable meter value (120 V), allowing instrument-rated meters to register customer usage. Voltage transformers shall be used in conjunction with instrument-rated meters and CTs for primary metering ***only***.

Note: For application of instrument-rated meters on primary metering, see Section 5.2, F (page 16–11).

Refer to Table 16–2 (page 16–8) to determine the meter SAP material number. Use the SAP material number to search for the CU in the respective design tools. This search will yield multiple CU results with the same meter and differing CT ratios. To identify the correct CU, use Table 16–3 (page 16–9) to properly size the CT. It is important to choose the correct type of CT (for example, window or bar) before sizing the CT. Once identified, the Planner can select the correct CU from the search results.

Note: Table 16–2 (page 16–8) lists additional meter information (that is, meter socket clip configuration and exhibit type) to assist the Planner in being able to confirm the relationship of meter stabs to meter socket clips during the panel approval process. For more detail on full panel approvals, refer to the appropriate section in the ESR.

Table 16–2: Instrument-Rated Meter Selection Type

Type of Service			Current Transformer Terminals				
Phase	**Voltage**	**Wire**	**Meter Type[a/]**	**Clip**	**Exhibit**	**SAP**	**DOH Section**
Single	120 V	2-wire	–	–	–	–	–
	120/240 V	3-wire	3S ESC	5-clip	Exhibit B or C[b/]	10158738	T-155
	120/240 V[c/]	3-wire	3S Legacy	5-clip	Exhibit B or C[b/]	10105523	T-155
	120/208 V	3-wire	45S/5S ESC	15-clip	Exhibit E	10175800	T-250
	240/480 V[d/]	3-wire	3S Legacy	5-clip	Exhibit B or C[b/]	10105523	T-155
	277/480 V	3-wire	–	–	–	–	–
	2.4 kV, 12 kV, 16 kV[e/]	2-wire	3S ESC	5-clip	Exhibit B or C[b/]	10158738	T-199
Three	240 V	3-wire	45S/5S ESC	15-clip	Exhibit E	10175800	T-356
	480 V	3-wire	45S/5S ESC	15-clip	Exhibit E	10175800	T-356
	120/208 V	4-wire	9S ESC	15-clip	Exhibit E	10175799	T-451
	120/240 V	4-wire delta	9S ESC	15-clip	Exhibit E	10175799	T-455
	277/480 V	4-wire	9S ESC	15-clip	Exhibit E	10175799	T-451
	2.4 kV–33 kV[f/]	3-wire	45S/5S ESC	15-clip	Exhibit E	10175800	T-376
	4.1 kV–16.5 kV[f/]	4-wire	9S ESC	15-clip	Exhibit E	10175799	T-478
Totalizing	Select meter from table above and contact MSO Engineering.						–
NEM and NGOM Metering	Select meter from table above and contact MSO Engineering. See DDS–14, Section 10.3 (page 14–14). Contact Field Engineering (per ESR-1).						–

[a/] ESC = Edison Smart Connect; Legacy = Non-Smart Connect

[b/] Exhibit B is the preferred socket configuration.

[c/] This SAP material number shall only be used for Residential SCE Smart-Connect "Opt-Out" customers ***only***.

[d/] Not for new installations. Replacement only.

[e/] Meter installations require VTs. Note that 1-phase, 2-wire service requires 1 VT.

[f/] Meter installations require VTs. Note that 3-phase, 3-wire service requires 2 VTs and 3-phase, 4-wire. Service requires 3 VTs.

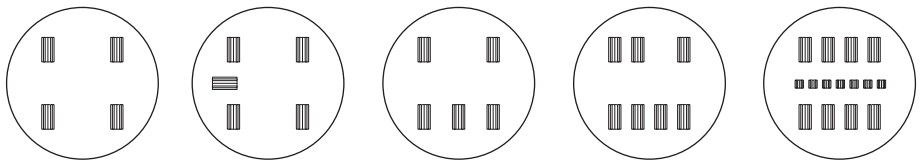


Exhibit A **Exhibit B** **Exhibit C** **Exhibit D** **Exhibit E**

Note: For an example of how to apply Table 16–2 (page 16–8), see Appendix 16–2 (page 16–17).

Table 16–3: Instrument-Rated Meter Selection Type

Voltage Class	CT Ratio (X:5)	Construction	Application	Rating Factor	Installation Range (Amp)	MAX Current Rating[a/] (Amp)	SAP
600 V	200	Bars	Indoor	2	0–300	400	10105854
	400	Bars	Indoor	2	301–600	800	10105855
	600	Bars	Indoor	2	601–900	1200	10105856
	400	Windows 4-inch	Indoor	2	0–600	800	10105859
	800	Windows 4-inch	Indoor	2	601–1200	1600	10105860
	1200	Windows 4-inch	Indoor	2	1201–1800	2400	10105862
	2000	Windows 4-inch	Indoor	2	1801–3000	4000[b/]	10105863
	3000	Windows 4-inch	Indoor	1.33	1801–3000	4000[b/]	10105865
	800	Windows 5-inch	Indoor	2	0–1200	1600	10105861
	2000	Windows 5-inch	Indoor	2	1201–3000	4000[b/]	10105864
	3000	Windows 5-inch	Indoor	2	3001–4500	6000[b/]	10105866
	4000	Windows 5-inch	Indoor	1.5	3001–4500	6000[b/]	10105867

[a/] Maximum loads are based on 30°C ambient temperature.

[b/] Refer to ESR–6 for panel limitations.

C. Time-of-Use (TOU) Rate Metering

All customers on a time-of-use rate require an Interval Data Recorder (IDR) to meter this type of service. Examples of TOU rates are TOU-D1, TOU-D2, TOU-AL, TOU-PA, TOU-EV, and TOU-GS3.

For more information, see SCE tariff rules rates and pricing.

Less than 200 kW

Smart-Connect meters should be installed on TOU accounts less than 200 kW. Smart-Connect meters have the ability to read and store interval data and are therefore considered to be IDR meters. Special tariff rates (that is, TOU-EV and TOU-NEM) may need to be engineered through MSO Engineering. For clarification, contact MSO Engineering.

For meter selection, see Section 5.2, A (page 16–5) and Section 5.2, B (page 16–7). Select the CU related to the TOU rate only.

200 kW and Greater

Legacy Real Time Energy Meter (RTEM) should be installed on TOU accounts 200 kW and larger. These Meter Service Requests (MSRs) **must** route through MSO engineering. Select the CU related to the TOU rate only.

D. Totalized Metering

Totalized metering is a concept using IDR meter(s) to combine the power consumption of multiple switchboards on the same customer premises.

Totalized metering is allowed for installations requiring two or more switchboards when a single switch exceeds ESR requirements and/or per Rule 9, Section B.

New Installations

New installations are *software totalized*. Software totalizing refers to combining multiple meter reads off-site by a computer program within SCE's billing organization. Each panel shall be metered independently.

For software totalized meter selection, follow the process detailed in Section 5.2, A (page 16–5) for self-contained and Section 5.2, B (page 16–7) for instrument-rated meter selection.

Existing Installations

Existing installations may be *current totalized* or *software totalized*. Current totalized refers to combining the load from a maximum of three sets of CTs to a single meter through a physical hardwire connection.

If the existing current totalized meter panel(s) need to be replaced, it shall be considered a new installation. However, if performing a minimal replacement/upgrade (for example, like-for-like CT replacement or CT upgrade with a panel still within ESR requirements) the current totalized scheme can remain.

Note: For more information on totalized metering, refer to ESR manual.

E. Generation Metering

There are several types of *distributed generation* (DG) that can be interconnected onto the SCE system (for example, solar, wind, biomass, geothermal). Metering for DG will utilize one of the two metering schemes detailed below.

Note: For additional information regarding generation metering installations, see DDS–14 and refer to ESR manual.

Net Energy Metering (NEM)

An NEM meter is a meter pre-programmed to read and measure the bi-directional flow of power for customers connecting DG onto the SCE system under the NEM CPUC Tariff. To replace or upgrade/change an existing NEM meter 10 kW and below, follow the process detailed in Section 5.2, A (page 16–5) for self-contained and Section 5.2, B (page 16–7) for instrument-rated meter selection. All NEM meters must route through MSO Engineering for programming.

Net Generation Output Meter (NGOM)

An NGOM meter is a meter pre-programmed to capture the customer's generator output. For all projects involving NGOM, Field Engineering must be contacted for direction and approval. The four main NGOM metering schemes used by SCE are defined as follows:

- Combined technologies/multiple tariffs

  Multiple types of generation and multiple tariffs apply at a single location.

- Non-export distributed generation

  Generation interconnection designed to offset customer load without crediting power export onto the SCE system.

- Export distributed generation

  Generation interconnection designed to credit power export onto the SCE system.

- Virtual net metering

  Generation interconnection designed to credit captured power export across one or more specified customer account(s).

An NGOM meter is utilized for these installations to capture each type of generation output independently at each separate generation location. Each of these meters are located at the generator before the load and are generally used in conjunction with revenue meters. All of the above scenarios are governed under Rule 21. Metering scenarios may vary, subject to terms of the generation contracts.

F. Primary Metering

Primary metering should be used to measure power consumption for customers served by a primary voltage (2.4 kV and above). Instrument-rated meters shall be installed in conjunction with CTs and VTs for all primary metering installations.

Primary metering is not widely used. For that reason, comprehensive CUs for each meter combination (meter, CTs, and VT) were not created. Planners will need to order two CUs, one with the meter and VT and one containing the CTs. To select the CU for the primary meter and VT, input the SAP material number of the VT listed in Table 16–4 (page 16–12) into the planner design tool(s) and find the CU with the correct meter listed (from Table 16–2 (page 16–8)). This kit will order the meter and the appropriate number of VTs.

To select the appropriate CT, use Table 16–5 (page 16–13) (5,000 V Class), Table 16–6 (page 16–14) (15,000 V Class), or Table 16–7 (page 16–15) (34,500 V Class). To order the correct CU for the CTs only, input the CT SAP material number into the planner design tool(s) and find the CU. Be sure to order the correct number of CTs for the installation.

Additional items that should be considered when installing primary metering are as follows:

- A customer-owned primary meter cabinet could require a self-contained meter for control power.
- Contact a Field Engineering Technical Specialist immediately upon learning of a primary metering request.
- Consider ferroresonance and ensure that proper methods for eliminating ferroresonance have been designed into the system, see DDS–2, Section 5.13 (page 2–32).
- Contact EMS, Small Generation Interconnection & Added Facilities (SGI&AF), and MSO groups when required.

Note: For more information on primary metering, refer to the ESR manual.

Table 16–4: Primary Metering Voltage Transformer Selection

Voltage Rating	Voltage Ratio (X:1)	Application	SAP
2400/120	20	Indoor	10105889
2400/120	20	Outdoor	10105896
4160/120	35	Indoor	10105891
7200/120	60	Indoor/Outdoor	10106084
12000/120	100	Indoor/Outdoor	10106089
12000/120	100	Indoor/Outdoor	10106089
12000/120	100	Indoor	10105838[a/]
14400/120	120	Indoor/Outdoor	10106090
16500/120	150	Indoor/Outdoor	10106091
34500/120	300	Outdoor	10106087

[a/] Two 0.5 A fuses in primary winding.

Note(s):

1. 1-phase, 2-wire service requires 1 VT; 3-phase, 3-wire service requires 2 VTs; and 3-phase, 4-wire service requires 3 VTs.

Table 16–5: Current Transformers (5000 V Class)

Voltage Class	Current Transformer Ratio (X:5)	Construction	Application	Rating Factor	Installation Range (Amp)	MAX Current Rating[a/] (Amp)	SAP
5000 V	1200	Bars	Indoor	1.33	0–1200	1600	10105879
	1500	Bars	Indoor	1.33	1201–1500	2000	10105880
	4000	Bars	Indoor	1	1501–3000	4000	10105881
	1200	Bars	Outdoor	1.33	0–1200	1600	10106060
	1500	Bars	Outdoor	1.33	1201–1500	2000	10106061
	2000	Bars	Outdoor	1.33	1501–2000	2667	10106062
	10	Wound	Indoor	1.5	0–11	15	10105870
	25	Wound	Indoor	1.5	12–28	37.5	10105871
	50	Wound	Indoor	1.5	29–56	75	10105872
	100	Wound	Indoor	1.5	57–112	150	10105873
	200	Wound	Indoor	1.5	113–225	300	10105875
	400	Wound	Indoor	1.5	226–450	600	10105876
	800	Wound	Indoor	1.33	451–800	1067	10105877
	10	Wound	Outdoor	1.5	0–11	15	10106054
	100	Wound	Outdoor	1.5	12–112	150	10106056
	200	Wound	Outdoor	1.5	113–225	300	10106057
	400	Wound	Outdoor	1.5	226–450	600	10106058
	600	Wound	Outdoor	1.5	451–675	900	10106059

[a/] Maximum loads are based at 30°C ambient temperature.

Note(s):

1. 3-phase, 3-wire service requires 2 CTs; 3-phase, 4-wire service requires 3 CTs.

Table 16–6: Current Transformers (15000 V Class)

Voltage Class	Current Transformer Ratio (X:5)	Construction	Application	Rating Factor	Installation Range (Amp)	MAX Current Rating[a/] (Amp)	SAP
15000 V[b/]	1200	Bars	Indoor	1.33	0–1200	1600	10105895
	2000	Bars	Indoor	1.33	1201–2000	2667	10105894
	3000	Bars	Indoor	1.33	2001–3000	4000	10105831
	1200	Bars	Outdoor	1.33	0–1200	1600	10106073
	1500	Bars	Outdoor	1.33	1201–1500	2000	10106074
	2000	Bars	Outdoor	1.33	1501–2000	2667	10106075
	3000	Bars	Outdoor	1.33	2001–3000	4000	10106076
	4000	Bars	Outdoor	1	2001–3000	4000	10106077
	10	Wound	Indoor	1.5	0–11	15	10105882
	25	Wound	Indoor	1.5	12–28	37.5	10105883
	50	Wound	Indoor	1.5	29–56	75	10105884
	100	Wound	Indoor	1.5	57–112	150	10105885
	200	Wound	Indoor	1.5	113–225	300	10105886
	400	Wound	Indoor	1.5	226–450	600	10105887
	10	Wound	Outdoor	1.5	0–11	15	10106063
	25	Wound	Outdoor	1.5	12–28	37.5	10106065
	50	Wound	Outdoor	1.5	29–56	75	10106066
	100	Wound	Outdoor	1.5	57–112	150	10106067
	200	Wound	Outdoor	1.5	113–225	300	10106068
	400	Wound	Outdoor	1.5	226–450	600	10106070
	800	Wound	Outdoor	1.2	451–720	960	10106072

[a/] Maximum loads are based at 30°C ambient temperature.

[b/] 3-phase, 3-wire service requires 2 CTs; 3-phase, 4-wire service requires 3 CTs.

Table 16–7: Current Transformers (34500 V Class)

Voltage Class	Current Transformer Ratio (X:5)	Construction	Application	Rating Factor	Installation Range (Amp)	MAX Current Rating[a/] (Amp)	SAP
34500 V[b/]	100 x 220:5	Wound	Outdoor	1.5	0–112/0–225	150/300	10105960
	200 x 400:5	Wound	Outdoor	1.5	113–225/226–450	300/600	10105957
	300 x 600:5	Wound	Outdoor	1.5	226–337/451–675	450/900	10105956
	400 x 800:5	Wound	Outdoor	1.5	338–450/676–900	600/1200	10105955
	600 x 1200:5	Wound	Outdoor	—	—	—	10105954

[a/] Maximum loads are based at 30°C ambient temperature.

[b/] 3-phase, 3-wire service requires 2 CTs.

Appendix 16–1: Self-Contained Meter Selection Example

Example 1

A customer is requesting residential, 1-phase, 120/240 V, 3-wire service with a 200 A panel. The estimated customer demand is at 5 kW.

Answer

Based on this information, the D-rate will apply and the meter equipment will be *self-contained*. To select a meter, use Table 16–1 (page 16–6).

Type of Service			Self-Contained Terminals				
Phase	**Voltage**	**Wire**	**Meter Type**	**Clip**	**Exhibit**	**SAP**	**DOH Section**
Single	120 V	2-wire	1S ESC	4-clip	Exhibit A	10158735	T-126, 127, 128
	120 V	2-wire	1S Legacy	4-clip	Exhibit A	10105255	T-126, 127, 128
	120/240 V	3-wire	2S ESC	4-clip	Exhibit A	10168097	T-126, 127, 128
	120/240 V	3-wire	2S Legacy	4-clip	Exhibit A	10105402	T-126, 127, 128
	120/240 V	3-wire	2S ESC	4-clip	Exhibit A	10158782	T-126
	120/240 V	3-wire	2S Legacy	4-clip	Exhibit A	10105238	T-126
	120/208 V	3-wire	12S ESC (Network)	5-clip	Exhibit B or C	10158737	T-225
	120/208 V	3-wire	12S Legacy (Network)	5-clip	Exhibit B or C	10105526	T-225
	120/208 V	3-wire	2S Legacy	4-clip	Exhibit A	10105522	T-138
	240/480 V	2-wire	2S Legacy	4-clip	Exhibit A	10105522	T-135.3
	277/480 V	3-wire	12S ESC	5-clip	Exhibit B or C	10158741	T-135.2

From the table above, the SAP material number for the meter is “10168079.” When this SAP number is inputted into a Planner’s respective design tool(s), it yields multiple CU results. Using information from the short and long descriptions of the CUs will help the Planner determine the correct CU for this application. In this case, the correct CU is “M-1P/3W-240-DM- 900.”

Appendix 16–2: Instrument-Rated Meter Selection Example

Example 2

A customer is requesting commercial, 3-phase, 277/480 V, 4-wire service with a 1200 A panel utilizing 4-inch window CTs. The estimated customer demand is at 65 kW, ~87 A.

Answer

Based on this information, the GS-2 rate will apply and the meter equipment will be instrument rated. To select a meter, use Table 16–2 (page 16–8).

Type of Service			Current Transformer Terminals				
Phase	**Voltage**	**Wire**	**Meter Type**	**Clip**	**Exhibit**	**SAP**	**DOH Section**
Three	240 V	3-wire	45S/5S ESC	15-clip	Exhibit E	10175800	T-356
	480 V	3-wire	45S/5S ESC	15-clip	Exhibit E	10175800	T-356
	120/208 V	4-wire	9S ESC	15-clip	Exhibit E	10175799	T-451
	120/ 240 V	4-wire delta	9S ESC	15-clip	Exhibit E	10175799	T-455
	277/480 V	4-wire	9S ESC	15-clip	Exhibit E	10175799	T-451
	2.4–33 kV	3-wire	45S/5S ESC	15-clip	Exhibit E	10175800	T-376
	4.1–16.5 kV	4-wire	9S ESC	15-clip	Exhibit E	10175799	T-478

From the table above, the SAP material number for the meter is “10175799.” When this SAP material number is inputted into a Planner’s respective design tool(s), the tool yields multiple compatible units results with various CT sizes. To determine the correct CT size for the application, the estimated demand amperes (~87A) and CT type (4-inch window) need to be cross-referenced in Table 16–3 (page 16–9).

Voltage Class	Current Transformer Ratio (X:5)	Construction	Application	Rating Factor	Installation Range (Amp)	MAX Current Rating[a/] (Amp)	SAP
600 V	400	Windows 4-inch	Indoor	2	0–600	800	10105859
	800	Windows 4-inch	Indoor	2	601–1200	1600	10105860
	1200	Windows 4-inch	Indoor	2	1201–1800	2400	10105862
	2000	Windows 4-inch	Indoor	2	1801–3000	4000[b/]	10105863
	3000	Windows 4-inch	Indoor	1.33	1801–3000	4000	10105865

[a/] Maximum loads are based at 30°C ambient temperature.

[b/] Refer to ESR-6 for panel limitations.

The correct CTs for this example are 4-inch windows 400:5 CTs, and therefore the correct CU would be “M-3P/4W-480-DM-507.”

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Southern California Edison
Transmission and Distribution

Chapter DDS–17: Formulas

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1.0 Scope

The formulas presented in this chapter are approximations that yield results accurate enough for planning purposes. These approximations are made to avoid the use of the more complex vector formulas.

2.0 Formula Legend

atan	=	arc tangent
cos	=	cosine
I	=	Amperes
V	=	Volts
PF	=	Power Factor
W	=	Watts
kVAR	=	kiloVAR
kW	=	Kilowatts
VA	=	Volt Amperes
kVA	=	Kilovolt Amperes
hp	=	Horsepower
eff.	=	Efficiency
$\sqrt{3}$	=	1.73
CT	=	Current Transformer
PT	=	Potential Transformer
Rev.	=	Number of Meter Disc Revolutions

3.0 Single-Phase Formulas

$$I = \frac{W}{V \times PF} = \frac{kW \times 1{,}000}{V \times PF} = \frac{kVA \times 1{,}000}{V} = \frac{hp \times 746}{V \times PF \times eff.}$$

$$V = \frac{W}{I \times PF} = \frac{kW \times 1{,}000}{I \times PF} = \frac{kVA \times 1{,}000}{I} = \frac{hp \times 746}{I \times PF \times eff.}$$

$$W = V \times I \times PF$$

$$kW = \frac{V \times I \times PF}{1{,}000} = kVA \times PF = \frac{hp \times 746}{1{,}000 \times eff.}$$

$$VA = I\mathbf{XV}$$

$$kVA = \frac{V \times I}{1{,}000} = \frac{kW}{PF} = \frac{hp \times 746}{1{,}000 \times PF \times eff.}$$

$$PF = \frac{W}{VA} = \frac{kW}{kVA}$$

$$hp = \frac{V \times I \times PF \times eff.}{746}$$

To determine kW demand by timing the meter disc:

$$kW = \frac{Rev. \times Disc\ Constant \times 3{,}600 \times CTRatio}{Time\ Required\ for\ Rev. \times 1{,}000}$$

Note: Eff. = Efficiency. Assume 90 percent, if actual value is not known.

4.0 Three-Phase Formulas

$$I = \frac{W}{V \times PF \times \sqrt{3}} = \frac{kW \times 1{,}000}{V \times PF \times \sqrt{3}} = \frac{kVA \times 1{,}000}{V \times \sqrt{3}} = \frac{hp \times 746}{V \times PF \times eff. \times \sqrt{3}}$$

$$V = \frac{W}{I \times PF \times \sqrt{3}} = \frac{kW \times 1{,}000}{I \times PF \times \sqrt{3}} = \frac{kVA \times 1{,}000}{I \times \sqrt{3}} = \frac{hp \times 746}{I \times PF \times eff. \times \sqrt{3}}$$

$$W = V \times I \times PF \times \sqrt{3}$$

$$kW = \frac{V \times I \times PF \times \sqrt{3}}{1{,}000} = kVA \times PF = \frac{hp \times 746}{1{,}000 \times eff.}$$

$$VA = V \times I \times \sqrt{3}$$

$$kVA = \frac{V \times I \times \sqrt{3}}{1{,}000} = \frac{kW}{PF} = \frac{hp \times 746}{1{,}000 \times PF \times eff.}$$

$$PF = \frac{W}{VA} = \frac{kW}{kVA}$$

$$hp = \frac{V \times I \times PF \times eff. \times \sqrt{3}}{746}$$

To determine kW demand by timing the meter disc:

$$kW = \frac{Rev. \times Disc\ Constant \times 3{,}600 \times CT\ Ratio \times PT\ Ratio}{Time\ Required\ for\ Rev. \times 1{,}000}$$

Note: Eff. = Efficiency. Assume 90% if actual value is not known.

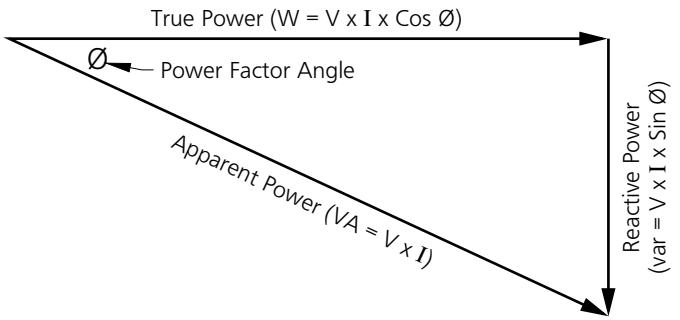
5.0 Power Factor

Power Factor (PF) must be considered in the determination of transformer and cable size.

In the broadest sense, the term "power factor" is intended to represent the ratio of power applied (true power) to the amount that would actually be available for application if voltage and current were ideally related as to phase (apparent power).

Graphically the relationships between true power, apparent power, and reactive power are as follows:

A. Lagging Power Factor



B. Leading Power Factor

$$P.F. = \frac{W}{VA} = \frac{kW}{kVA}$$

$$kVA = \frac{V \times I \times (1.73)}{1,000}$$

The angle Ø is the angle of lag or lead between the current and voltage. A lagging current is produced by serving loads involving magnetizing of motor fields, and so on. A leading current is produced by serving loads which have capacitance, such as capacitors or cable. Loads which are of a resistive nature, that is heating and incandescent lighting, have currents which are in phase with the voltage and will not produce a lagging current. True power and apparent power will be the same when the load is all resistive.

Refer to the formula pages for application of Power Factor.

$$PF\% = \cos = \frac{\text{True Power}}{\text{Apparent Power}} \times 100 = \frac{kW}{kVA} = \times 100$$

6.0 Monthly Load Factor

A customer's monthly load factor can be determined using Table 3–1 or by calculation as follows:

$$\text{monthly load factor} = \frac{\text{monthly kWh usage} \times 100}{\text{kW demand} \times \text{no. of days/months} \times 24 \text{ hours}}$$

7.0 Factors

The following is a list of factors that can be used to compute amperage of kVA or MVA.

Table 17–1: Factors for Secondary Voltages

Voltage	Factor
120 V 1Ø	8.4 A Per kVA
240 V 1Ø	4.2 A Per kVA
277 V 1Ø	3.6 A Per kVA
208 V 3Ø	2.8 A Per kVA
240 V 3Ø	2.4 A Per kVA
480 V 3Ø	1.2 A Per kVA

Table 17–2: Factors for Single-Phase Primary Voltages

Nominal Voltage (kv)	Typical System Voltage	Factor
2.4 kV	2,400 V 1Ø	416 A per MVA
4 kV	4,160 V 1Ø	240 A per MVA
6.9 kV	7,200 V 1Ø	139 A per MVA
9.5 kV	9,800 V 1Ø	102 A per MVA
12 kV	12,000 V 1Ø	80 A per MVA
16 kV	17,000 V 1Ø	59 A per MVA
33 kV	34,500 V 1Ø	29 A per MVA

Table 17–3: Factors for Three-Phase Primary Voltages

Nominal Voltage (kv)	Typical System Voltage	Factor
4 kV	4,160 V	139 A per MVA
12 kV	12,000 V	46 A per MVA
16 kV	17,000 V	34 A per MVA
33 kV	34,500 V	17 A per MVA

The following factors can be used to determine the secondary voltage at a 6.6 amp Constant Current Transformer:

Table 17–4: Factors for Constant Current Transformers

Voltage	Factor
Full load secondary voltage	150 V per kVA
Open circuit secondary voltage	200 V per kVA

Appendix 17–1: Examples *(Sheet 1 of 3)*

SINGLE PHASE

1. Determine full load secondary amps for 75 kVA 120/240V 1Ø transformer:

   Using **Formula**: $I = \frac{kVA \times 1,000}{V} = \frac{75 \times 1,000}{240} = 312$ amps

   Using **Factor**: $I = kVA \times Factor = 75 \times 4.2 = 312$ amps

2. Determine kVA for 160 amps at 240V, 1Ø:

   Using **Formula**: $kVA = \frac{I \times V}{1,000} = \frac{160 \times 240}{1,000} = 38.4$ kVA

   Using **Factor**: $kVA = \frac{I}{Factor} = \frac{160}{4.2} = 38.1$ kVA

3. Determine full load primary amps for a 6.9 kV single-phase radial with 225 kVA of transformation:

   Using **Formula**: $I = \frac{kVA \times 1,000}{V} = \frac{225 \times 1,000}{7,200} = 31.3$ amps

   Using **Factor**: $I = MVA \times Factor = \frac{225}{1,000} \times 139 = 31.3$ amps

THREE-PHASE

1. Determine full load secondary amps for a 225 kVA 120/208V three-phase transformer:

   Using **Formula**: $I = \frac{kVA \times 1,000}{V \times \sqrt{3}} = \frac{225 \times 1,000}{208 \times 1.73} = 625$ amps

   Using **Factor**: $I = kVA \times Factor = 225 \times 2.8 = 630$ amps

2. Determine full load primary amps for a 2,500 kVA 16 kV three-phase transformer:

   Using **Formula**: $I = \frac{kVA \times 1,000}{V \times \sqrt{3}} = \frac{2,500 \times 1,000}{17,000 \times 1.73} = 85$ amps

   Using **Factor**: $I = MVA \times Factor = \frac{2,500}{1,000} \times 34 = 85$ amps

3. Determine kVA for 60 amps at 12 kV, three-phase:

   Using **Formula**: $kVA = \frac{IXVX\sqrt{3}}{1,000} = \frac{60 \times 12,470 \times 1.73}{1,000} = 1,294$ kVA

   Using **Factor**: $kVA = \frac{I1,000}{Factor} = \frac{60 \times 1,000}{46} = 1,304$ kVA

Note: I = Current; kVA = kilovoltampere

R.O. TRANSFORMERS

1. Determine the full load secondary voltage for a 10 kVA 6.6 amp R.O.:

   Using **Formula**: $V = \frac{kVA \times 1{,}000}{I} = \frac{10 \times 1{,}000}{6.6} = 1{,}515$ volts

   Using **Factor**: $V = kVA \times Factor = 10 \times 150 = 1{,}500$ volts

2. Determine the open circuit secondary voltage for a 20 kVA 6.6 amp R.O.:

   Using **Factor**: $V = kVA \times Factor = 20 \times 200 = 4{,}000$ volts

   From the Street Lighting chapter, Table 5–8 "Performance Data for Constant-Current Regulators (RO Transformers)": $V = 4,090$ volts

HORSEPOWER TO KVA

1. Determine the kVA and amps for a 200 hp motor served at 480 V, three-phase:

   Given: Power Factor = 92%

   Assume: Efficiency = 90%

   $$kVA = \frac{hp \times 746}{1{,}000 \times PF \times eff} = \frac{200 \times 746}{1{,}000 \times .92 \times .9} = 180 \text{ kVA}$$

   $$I = \frac{hp \times 746}{V \times PF \times eff. \times \sqrt{3}} = \frac{200 \times 746}{480 \times .92 \times .9 \times 1.73} = 216 \text{ amps}$$

8.0 Joint Trench Formulas

When the cost of trenching or paving is included in the relocation advance of a work-order, the percent allocations for joint trench occupants can be calculated using the cross-sectional formulas below. The following formulas are applicable to construction of all joint trench in feeders and subsystems:

$$\text{Telephone - (T) Share \%} = \frac{T \times 100}{E + T + CATV + Other}$$

$$\text{Cable TV - (CATV) Share \%} = \frac{CATV \times 100}{E + T + CATV + Other}$$

$$\text{Edison - (E) Share \%} = \frac{E \times 100}{E + T + CATV + Other}$$

$$\text{Other - (Other) Share \%} = \frac{Other \times 100}{E + T + CATV + Other}$$

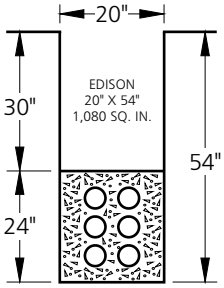
"E," "CATV," "T," and "Other" is the cross-sectional area of trench or surface area of paving per lineal foot of solely-owned trench. The following examples demonstrate the use of the joint trench formulas:

JOINT TRENCH COST ALLOCATION EXAMPLE

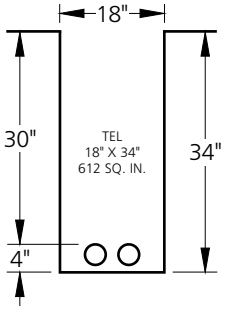
EXAMPLE 1:

Determine the percentage allocation of costs for joint trench and paving for the facilities described below. This trench cross-section and paving measurements are based on each facility being installed separately.

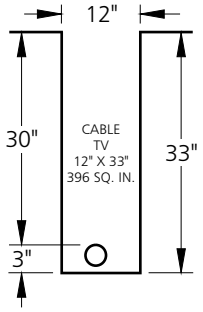
Edison — 6-5" Ducts
Substation getaway



Telephone — 2-4" Ducts



Cable TV — 1-3" Duct



NOTES:

1. Required cover over conduits will vary based on permit agency requirements.
2. Trench widths and depths will vary based on conduit diameter, number of conduits, conduit bank configuration, and permit agency cover requirements.
3. All measurements shown are examples **only**. When calculating the formula for a specific project, use the actual dimensions needed to install each facility for that specific project.
4. Generally the number of duct varies significantly along the trench line. To simplify the joint trench calculation, use only the structure to structure duct configuration for each joint participant. If the structure to structure duct quantity varies, utilize the most predominant configuration.

Utilizing the joint trench formulas, the percentage allocations can be calculated:

JOINT TRENCH:

$$\text{Edison \%} = \frac{E \times 100}{E + T + CATV} = \frac{1{,}080" \times 100}{1{,}080" + 612" + 396"} = 52\%$$

$$\text{Telephone \%} = \frac{612" \times 100}{1{,}080" + 612" + 396"} = 29\%$$

$$\text{CATV \%} = \frac{396" \times 100}{1{,}080" + 612" + 396"} = 19\%$$

PAVING/FEET:

$$\text{Edison \%} = \frac{E \times 100}{E + T + CATV} = \frac{20'' \times 100}{20" + 18" + 12"} = 40\%$$

$$\text{Telephone \%} = \frac{18" \times 100}{20" + 18" + 12"} = 36\%$$

$$\text{CATV \%} = \frac{12" \times 100}{20" + 18" + 12"} = 24\%$$

GLOSSARY

DDS-GL

Southern California Edison
Transmission and Distribution

Chapter DDS–GL: Glossary

Access Right	The right of an owner to have ingress and egress to and from his property.
Accessible	The device is accessible to SCE Maintenance Personnel at all times. Personnel must be able to gain access without a ladder or other special equipment.
ACSR	Aluminum Cable Steel Reinforced
Added Facilities	Added Facilities also take account of differential costs of transmission and distribution systems which exceed the requirements of Edison's standard serving systems (Rule 2). Added Facilities may include a variety of equipment normally installed by the company in developing its electrical transmission and distribution systems and facilities.
Alternating Current (AC)	A current with a magnitude that oscillates above and below zero that is, reverses direction, in a periodic manner.
Ampere (A)	The standard unit for measuring electric current. One ampere represents a charge flow of one coulomb per second.
AR	Automatic Recloser
Arterial Roadway	Typically a high capacity urban road with four or more lanes; two in each direction.
AWG	American Wire Gage
B	Magnetic flux density, measured in Gauss (G) or milliGauss (mG).
Balance	Refers to the degree with which each circuit phase carries equal amounts of current.
Balanced Current	A circuit in which there are substantially equal current, either AC or DC, in all main wires.
Balanced Voltage	A circuit in which there is substantially equal voltages, either AC or DC, between main wires and between each main wire and neutral, if one exists.

Bundle	A circuit phase consisting of more than one conductor. Each conductor of the phase is referred to as a subconductor. For example, a two-conductor bundle has two subconductors per phase.
BURD	Buried Underground Residential Distribution: Equipment and conductors located entirely below ground.
Cable Run	All cables contained in one conduit.
Catenary	The curve theoretically assumed by a perfectly flexible and in extensible cord of uniform density and cross section hanging freely from two fixed points.
Charge	The quantity of electrons or ions that is stored on a conductor, analogous to a quantity of water stored in a vessel. Also, to store electrical charges in a device.
CIC	Conductor in Conduit. Flexible underground conduit containing current-carrying conductor.
Circuit	A circuit refers to any set of primary cables passing through the structure, and is the same as two primary cable runs. A circuit may be pulled straight through or connected with permanent straight splices, T-splices, or a switch.
Circuit Ties	Circuit ties are those points on the feeder where an adjacent feeder can be paralleled through a switch position. These ties enable load transfers during routine and emergency operating conditions.
Climate Zones	The SCE service territory has been divided into five climate zones based on information from the U.S. Weather Bureau. There is a separate residential transformer application standard for each climate zone.
Climbing Space	The space reserved along the surface of a climbable pole or structure to permit linemen ready access to equipment and conductors on the pole or structure. Climbing space shall be maintained from the ground level.
CLP	Cross Link Polyethylene
Combined Technologies	Technology that provides operation for the parallel of a Generating Facility that utilizes generators eligible for service under NEM or other applicable NEM tariffs, for example, NEM, BG-NEM and FC-NEM, that are electrically connected behind the same Point of Common Coupling (PCC) with generators not eligible to receive service under a NEM tariff.
Commercial/Industrial (C/I)	Commercial/Industrial, refers to a customer classification.

Concentric	A series of small wires at ground potential designed to carry neutral current, helically wound over the surface of underground insulated phase conductors.
Condemnation	The exercise of the power of eminent domain; *that is,* taking of private property for public use.
Conductor	A substance capable of passing electric current. Good conductors are generally made of metal, although other substances, such as the earth or the human body, can be relatively good conductors.
Constant Current Transformer	Often referred to as a Regulated Output (RO) transformer. This transformer is used to supply series streetlight circuits at 6.6 amps.
Contiguous	In actual or close contact; touching; adjacent; near.
Coulomb (C)	The standard unit for measuring electric charge. One coulomb contains 6.24×10^{18} *elemental* charges.
CST	Completely Submersible Transformer, commonly used to refer to an obsolete structure that has been replaced by the SOE.
Current	The flow of electric charge. Measured in rms amps for magnetic field calculations.
Current Totalized	Current totalized refers to combining the load from a maximum of three sets of CTs to a single meter through a physical hardwire connection. This is a legacy setup and not for new construction.
Current Transformer (CT) Meter	See instrument-rated meter.
Customer Demand	The peak demand that a customer is expected to reach during a 12-month period.
Custom Home	Homes larger than 5,000 square feet, or homes that include features including, but not limited to, shop facilities, extensive home office space, home business facilities, non-air conditioning motor loads of greater than 1.5 hp, custom yard features that use significant non-renewable energy, air conditioned outbuildings such as stables, or any other load(s) normally associated with commercial buildings or industrial facilities rather than residential tracts.
CVR	Conservation Voltage Regulation.
DCAP	Distribution Capacitor Automation Project.

DCMS	Distribution Control and Monitoring System
DCSM	*Distribution Construction Standards Manual*.
Dead-Break Elbow (DBE)	A premolded 25 kV class 200 A-rated separable connector for #2 STR or 1/0 AWG primary cable. Dead-break elbows are secured to a bushing with a bail assembly and **must be de-energized** before disconnecting or connecting.
Dead-Break Junction	Dead-break junctions are the 600 Amp two-, three- or four-way dead-break junctions, or 200 Amp three- or four-way dead-break junctions that can be disconnected/operated while de-energized only.
Dead-End Feeder	A Dead-End Feeder is a section of cable that originates from a switched position on the System Feeder and extends to another switch with no intent to create a paralleling point. The combined total of all the loadblocks on the Dead-End Feeder will not exceed 4,500 kVA. On Dead-End Feeders, T-taps are not allowed. This will prevent outages impacting multiple loadblocks. This system is intended for situations that are typically a few large commercial/industrial loads on a cul-de-sac. Consideration must be taken of this load as it increases since this limits the ability to switch load between circuits. Planners must work with Field Engineering to make appropriate provisions for capacitors as needed.
Demand Factor	The ratio of peak demand to connected load, expressed as a percentage.
Distributed Generation	Distributed generation is small scale, local generation connected to the distribution system (for example, solar, wind, geothermal, fuel cell).
Distribution	Power delivery system below 50,000 V (50 kV).
DOC	Distribution Operation Center.
DO&M	*Distribution Operation and Maintenance Policy and Procedures Manual*.
Duty (Also: Short-Circuit Duty)	The amount of electric energy at a particular location under a short-circuit condition.
Easement	A right-of-interest in the land of another which entitles the easement holder of some land use such as placement of pole lines, roads, or travel over the land.
ECS	Electrical Construction Standards

Edison SmartConnect "Opt Out" Program	The Edison Smart-Connect "Opt-Out" program is a CPUC board decision allowing residential consumers to request a non-communicating (for example, solid state, electro-mechanical, ERT) meter in place of the existing installed "Smart Meter."
Electric Field	Field resulting from presence of voltage. Measured in volts-per-meter (V/m). Electric fields can be shielded by conducting material. Electric fields are not the primary focus of the design guidelines.
Electrolier	An ornamental lamppost with the necessary internal channels and openings for wiring and external attachments for bracket and luminaire.
Electromagnetic Field	A condition of space containing both *electric* and *magnetic* fields.
Eligible Customer	A Residential, Small Commercial (as defined in SCE's Rule 1), Commercial, Industrial, or Agricultural Customer who uses a solar or wind turbine electrical generating facility (or hybrid system of both) with a total capacity not exceeding 1,000 kVA and wind turbine electrical generating nameplate capacity not exceeding 50 kVA, that is located on the eligible customer's premises and is interconnected and operates in parallel with SCE's electric system intended primarily to offset part or all of the customer's own electrical requirements, which meets all applicable safety and performance standards established by the National Electrical Code, the Institute of Electrical and Electronics Engineers, and Accredited Testing Laboratories, for example, Underwriters Laboratories and rules set forth from the Public Utilities Commission regarding safety and reliability.
EMF	Electric and Magnetic Fields. For purposes of this guide, **only** power frequency (60 Hz) fields are discussed.
Eminent Domain	The right or power of the government to take **private** property for **public** use in exchange for fair compensation.
Encroachment	Trespass; the building of a structure or improvements, partly or wholly on the property of another.
Energy	The capacity for doing work or producing heat.
Enterprise	A separate business or other individual activity carried on by a customer. The term does **not** apply to associations or combinations of customers *(Rule 1)*.

EPPC	Edison Policy & Procedures Central (EPPC) is the central official repository for both Edison International and Southern California Edison. The EPPC database enables version control, electronic signatures, and allows for employees to access published Edison International and SCE governance and implementation documents via the Policies page of Portal.
EPR	Ethylene Propylene Rubber
Feeder	The arterial portion of circuitry which forms the 12 kV, 16 kV, and 33 kV network interconnecting circuits and substations.
Feeder Interface	The interconnection of a subsystem to the feeder. Typically, this is a switch position or T-connection between switch positions.
Ferroresonance	An electrical condition that sometimes occurs when the capacitive reactance of the underground cables is approximately equal to the inductive reactance of the transformer. Due to single-phase switching or a fuse operation, these reactances can become connected in series. Since they tend to cancel each other, large amounts of current, along with extremely high voltages, develop across the cable and transformer.
FI	Fault Indicator, a device that indicates the passage of a fault current. FIs are used to quickly identify and locate a fault in the distribution system.
Fiberglass Reinforced Plastic	Used in the construction of handholes.
Field	A space within which *magnetic* or *electric* forces are active.
Final Customer of Record	Typically a governmental agency. For example, a city or county lighting maintenance district.
Franchise	Permission granted to install electrical facilities along public streets or thoroughfares.
FRC	Fault Return Conductor
Frequency	The number of cycles per second (Hertz) of an alternating current or voltage. The frequency of power equipment in the United Stated is 60 Hertz. In many other countries, a frequency of 50 Hertz is used.
FRP	See Fiberglass Reinforced Plastic

Future System Feeder	A Future System Feeder uses 600 A components and switches without a paralleling point. It consists of 600 A cable between two switches and has the potential to expand. Eventually, these systems may expand and make a paralleling point to create a system feeder. Therefore, the conduit and structures are to be designed as a System Feeder.
G.O. 128	CPUC *General Order 128*, states the State of California Rules for Underground Electric Line Construction.
G.O. 95	CPUC *General Order 95*, provide the State of California Rules for Overhead Electric Line Construction.
Galloping Conductor	Type of conductor movement in which the conductors in one span achieve an inverted sag as they reach their maximum upward excursion while adjacent spans retain their original catenaries. Moments later, the spans alternate their movement as conductors swing in the opposite direction. At any time the line looks like a sine wave as it achieves a full double-amplitude gallop.
Gauss (G)	A common unit for measuring magnetic fields.
Generation Metering	Generation metering is used to meter the several types of Distributed Generation (DG) that can be interconnected onto the SCE system (for example, solar, wind, biomass, geothermal). There are two types of generation metering: NEM and NGOM.
Getaway	That portion of a feeder beginning at the substation and continuing to the first overhead structure or the first underground switch position. **No** load should be connected to the feeder in the getaway.
Guy	A tension member (solid wire or stranded wires) used to withstand an otherwise imbalanced force on a pole, crossarm, or other overhead line structure.
Heavy Loading	The strength requirements specified in *G.O.95* for poles and conductors as affected by wind, ice, and temperature, in areas where the elevation exceeds 3,000 feet above sea level.
Hertz (Hz)	Measurement of frequency of an alternating electric source in cycles-per-second.
High-Rise, Multiple-Occupancy, Residential Building	A multiple occupancy, residential building with seven floors or more above ground level. The Company may, at its option, establish more than one meter room location for groups of individual metering facilities.
HPSV	High Pressure Sodium Vapor

Impedance	The quality of a substance or device to resist the flow of current. Even good conductors have a certain amount of impedance. For the non-specialist, impedance and resistance may be thought to express a similar phenomenon, but there are technical differences between these two terms.
Inductive Coordination	The transpositions in power and communication circuits involved in a parallel efficiently located with respect to each other, and to discontinuities, reducing the inductive effects on communication circuits.
Instrument-Rated Meter	Instrument-rated meters are designed to meter customer usage using auxiliary devices called instrument transformers. The two types of instrument transformers are current transformers (CTs) and voltage transformers (VTs). When used with these devices, the instrument-rated meter is capable of metering high currents and high voltages. This type of meter is used for (1) residential applications where the panel size is 600 A and (2) commercial applications where the panel size is 400 A and larger.
Insulation	A substance that conducts current poorly.
Interconnection Facilities	Consists of protective devices (including circuit breakers, ground fault detection systems, and automatic transfer trip communications systems), transformers (new and upgrades), and metering equipment required solely as a result of a new generator connected to the utility system that cannot be used to serve the utility's general customer population. This may also extend to the utility side of the meter; for example, automatic transfer trip communications systems provide a link between the generator and a circuit breaker on the utility grid.
Interval Data Recorder (IDR)	An Interval Data Recorder (IDR) is the type of meter needed to meter TOU rate and totalized metering accounts. An IDR meter captures customer power usage at a preset interval (that is, every 15 or 60 minutes) and records the data for billing purposes. Edison Smart-Connect Meters are IDR meters.
kcmil	1,000 circular mills, size of conductors, cross-sectional area.
Kilo (k)	Prefix indicating 1,000.
kVA	KiloVolt amps, a measure of electrical power.
LBFC	Load-Break Fuse Cabinet
License	Formal or legal permission to initiate a specific act.

Light Loading	The strength requirements specified in *G.O.95* for poles and conductors as affected by wind, ice, and temperature, in areas where the elevation above sea level is 3,000 feet or less.
Load Factor	The ratio of the average monthly demand divided by the monthly peak demand expressed as a percentage.
Loadblock	Balanced three-phase and/or single-phase load, comprised of one or more subsystems, that can be switched and isolated from the feeder without affecting service to any other loadblock. A loadblock on underground circuits may be connected to the feeder by a dedicated switch position or by utilizing T-taps between two switch positions. On overhead circuits, loadblocks are connected to the feeder between two switches.
Load-Break Elbow (LBE)	A premolded 200-amp-rated primary cable termination for #2 or 1/0 cable that can be operated energized.
Load-Break Junction	Load-break junctions are three- or four-way junctions that may be used to connect/disconnect from the source while energized as long as all the design conditions are met.
Lockable	The visible disconnect must have provisions for a common 3/8-inch padlock, used as part of normal SCE maintenance lockout procedure.
Loss Factor (LF)	The load carried by a cable varies according to a daily-load cycle, that is, load factor. Hence, the losses in cable will vary according to the daily-load cycle. LF = 0.3* lf +0.7* lf^2, where lf is the daily-load factor.
LPSV	Low-Pressure Sodium Vapor
Luminaire	An illumination device containing a light source.
Magnetic Field	A region of influence around a moving charge or current. The intensity is measured by the magnetic flux density B, in milliGauss (mG). Magnetic fields are **not** readily shielded by the ground, buildings, and so on.
Mainline	Also known as Feeder. The arterial portion of the primary distribution network that interconnects circuits and substations.
Master Duct Plan	An SCE plan created and maintained by Field Engineering which identifies required infrastructure within a defined geographical area based on ultimate or forecast land use.

Master Plan	The **master plan** identifies, within a defined geographical area, the required plans for circuitry and substations, based on ultimate or forecast land use.
Maximum B	The range of magnetic flux density, B, varies through a minimum and maximum over a period of 1 cycle. Magnetic fields calculated in this guide will show the maximum magnetic field.
Mega (M)	Prefix meaning one million.
MH	Metal Halide
Micro (μ)	Prefix indicating one one-millionth.
Milli (m)	Prefix indicating one one-thousandth.
Minimum Trip	The minimum current (amperes) that will cause the feeder circuit breaker at the substation to open.
Multi-Family Dwellings	A multi-family dwelling is defined as a structure consisting of two or more individually metered residential dwelling units that share continuous outer wall construction or common walls, floors, and/or ceilings.
Multiplex	A section of conductors consisting of two (duplex), three (triplex), or four (quadraplex) individual conductors twisted around each other. These are generally used as service or secondary wiring.
Net Energy	The difference between the electricity supplied/delivered through SCE and the electricity generated by the customer and feedback into SCE's electric system, measured over the Relevant Period. Thus, where E_S is the energy supplied/delivered by SCE and E_F is the energy generated by the customer and feedback into SCE's system: Net Energy = E_S - E_F.
Net Energy Metering	An NEM meter is preprogrammed to read and measure the bidirectional flow of power for customers connecting distributed generation onto the SCE system under the NEM CPUC Tariff. An NEM meter can be self-contained, instrument rated, and/or an IDR meter, depending on the load, tariff, and location (based on whether a specified area has been deployed with SmartConnect meters).

Net Generation Output Meter (NGOM)	An NGOM meter is a meter that is preprogrammed to read and measure the output of the generator connected within the customer system. NGOM meters are generally used when there are multiple tariffs and/or multiple types of generation at the same premises.
Neutral	Current or conductor carrying current returning to the source. Neutrals are at ground potential and not considered a "phase" of the circuit. Earth may be a neutral path back to the source.
Non-Arterial Roadway	Typically a small residential only road with two lanes; one in each direction.
Normal Operating Conditions	The state of system operation when all components of the system are energized and operating properly, and no temporary or emergency conditions exist.
Occupied Space	Rooms, buildings, playgrounds, and other areas where people may spend extended periods of time.
Open Wire (open-wire)	Secondary voltage conductors on separate insulators and **not** twisted together.
Operating Convenience	This means the utilization, under certain circumstances, of facilities or practices not normally employed, which contribute to the overall efficiency of Edison's operation. The term does not refer to customer convenience nor to the use of facilities or practices required to comply with applicable laws, ordinances, rules or regulations, or similar requirements of public authorities (Rule 1).
Overhead (DOH)	Overhead refers to electrical overhead conductors and equipment mounted on poles. The abbreviation DOH is sometimes used to refer to the *Distribution Overhead Construction Standards Manual*.
Pad Mount	Equipment (transformers, switches, and so on) which sits on the ground on concrete-like "pads" fed by underground conductors.
Peak Load	The maximum load expected on the circuit or subsystem being considered.
Phase	Electric current, voltage, or conductors carrying electricity greater than ground potential. Each "phase" of a circuit will have unique electrical values at any point in time, compared with other "phases" of the same circuit.

Perimeter Wall	A structure designed to restrict the uncontrolled transport of soil or other undesirable materials into the working areas around pad-mounted equipment, BURD enclosures, vaults and manholes. It differs from a retaining wall in that a perimeter wall is limited in height and does not resist any significant lateral soil/other pressures.
Phase Conductors	One of the three sets of current-carrying wires in a three-phase AC power line.
Phased/Phasing	The physical positioning of each phase of the circuit(s) on a pole line with respect to each other to minimize EMF or net-through unbalances.
Photocontroller	A small device containing a light-sensitive cell and a switch to turn the lights on when light decreases to a predetermined level, turning them off in the morning when the light increases to a certain level.
PILC	Paper-Insulated Lead-Covered Cable
PME	Pad-Mounted, Elbow-Connected. Designates a dead-front (elbow-connected) air-insulated switch.
PMH	Pad-mounted Housing; or, Pad-mounted, Heavy Duty. Designates a live-front air-insulated switch.
Point of Interconnection (POI)	Electrical transfer point between a generating facility and SCE's distribution system. This may or may not be coincident with the point of common coupling,
Pole Spotting	Selecting a specific location where a utility pole will be set.
Power Factor (PF)	The ratio of true power (kW) divided by apparent power (kVA) expressed as a percentage.
Pre-Engineered Meter	A pre-engineered meter is a meter that has been configured by MSO Engineering, prior to installation, based on load, tariff, and/or customer requirements.
Primary	Signifies voltage or conductors carrying voltage greater than 600 V on the distribution system. Also refers to the "high side" voltage on a transformer.
Primary Metering	Primary metering is used to measure power consumption for customers served by a primary voltage (2.4 kV and above). This type of metering utilizes instrument-rated meters in conjunction with CTs and VTs.
RA	Rocker/Rotary Arm, signifies the type of operating mechanism for a switch, Rocker/Rotary Arm.

RAC	An RA-type switch. The RAC switch will have four or more positions. The switch may be manually operated or spring operated. The far left position has only two attitudes (Open - Bus); while the remaining positions have three attitudes (Tie - Open - Bus). This creates the capability of electrically tying two adjacent positions together without utilizing the Bus.
RAD	This is an RA-type switch. RAD is a load transfer mechanism normally controlled automatically by a control mechanism. Operated automatically, it has the capability of transferring a load from a Preferred circuit to an Emergency circuit when potential on the Preferred circuit is lost.
RAJ	This is an RA-type switch. The RAJ switch is a 4-way switch. The No. 1 way is connected Solid to the Bus. The No. 3 way is connected Solid to a Tie. The No. 2 and No. 4 ways are switched positions that may be in one of 3 attitudes. One attitude connects these ways to the Bus, one attitude connects them to the No. 3 way, and one attitude is **off**. This switch will normally be applied to a 4 kV system. It is a 7.5 kV voltage class switch.
RAK	This is an RA-type switch. The RAK switch is a 4-way position switch with operating characteristics similar to the RAC. The difference is that the No. 1 way is connected Solid to the Bus. There are only 3 switched positions. The No. 2 position has only two attitudes (Open - Bus), while the remaining positions have three attitudes (Tie - Open - Bus).
RAM	This is an RA-type switch. The RAM switch may be a 2, 3, 4, 5, or 6-way switch. It can be manually operated or spring operated.
Raptor	Bird of prey
Resistance	The quality of a substance or device that resists the flow of current. Even good conductors have a certain amount of resistance.
Right-of-Way (ROW)	In its strict meaning, ROW is the right of passage over another man's ground and is an easement. Through usage at Edison, the term has come to mean any right (fee, license or easement) secured to permit the construction, maintenance, reconstruction or removal of Company facilities.
RO	Short for Regulated Output, commonly used to designate a constant current transformer used to supply series streetlight circuits.

Rules	The rules promulgated by the California Public Utility Commission (CPUC) which are applicable to design and installation of a distribution system being considered.
Run	A run refers to any set of primary or secondary cables that enters the structure from any direction. A run may be one to four conductors (for example: 1-1/0 AWG 6.9 kV or 3-700 kcmil and 1-350 kcmil Al CLP 120/208V).
Safety Factor	The minimum allowable ratio of ultimate strength of materials to the maximum working stresses as defined in *G.O.95*.
Secondary	Voltage, or conductors carrying voltage, less than 600 V on the distribution system. Also refers to the “low side” voltage on a transformer.
Self-Contained Meter	A self-contained meter is a standalone device that is able to meter customer usage with no associated equipment. This type of meter is used for residential applications where the panel size is 400 A or less or in commercial applications where the panel size is 200 A or less.
Service Point	The Point of Service is the location where the utility’s conductors attach to the terminals of the customer’s service equipment or splice to the customer’s service-entrance conductors, regardless of the location of the Company’s meters or transformers.
Services	Conductors carrying power to customer meter panel, generally at secondary voltages of 0-600 V.
SF_6	SF_6 (*sulfur hexafluoride*) is an excellent gaseous dielectric for high-voltage power switches. It is a gas that is nontoxic, nonflammable, colorless, and odorless. The gas will cause suffocation if inhaled directly from a cylinder or if concentrated in an enclosed area with out proper ventilation.
Shielding	A substance or device that possibly reduces electric or magnetic fields.
Short Circuit	An abnormal connection (including an arc), of relatively low impedance, between two points of different potentials.
Short-Time Cable Load	The amount of load at which the feeder cable may operate for a specified short length of time without damaging the cable and associated equipment.
Single-Family Residences	Dwelling units such as single-family homes, condominiums, and townhomes, with no more than two walls (floors and ceilings included) in common with other dwelling units.
SLS Pole	Light-Duty Steel Pole

SOE	Surface-Operable Enclosure
Software Totalized	Software totalizing refers to combining multiple meter reads off-site by a computer program within SCE's billing organization. Each panel shall be metered independently.
SOLO	Street and Outdoor Lighting Organization
Subsystems	Three-phase and/or single-phase components serving C/I developments and/or residential developments. Subsystems will generally be 200 A systems utilizing 1/0 CLP cable, and 200-amp-rated equipment. Subsystems are combined together to form loadblocks.
Subtransmission	Power delivery system at voltages between 50,000 and 161,000 V (50 kV – 161 kV).
Swing	The movement of conductor, or amount of movement, due to the source of wind on the conductor.
System Feeder	The System Feeder uses 600 A components and switches, and contains paralleling points to other circuits and/or itself. The Underground System Feeder is designed with cables ranging in size from 350 to 1,000 kcmil for 12 kV to 16 kV, and 4/0 to 1,500 kcmil for 33 kV. The Overhead System Feeder is designed with 336 to 653 Aluminum Conductor Steel Reinforced (ACSR). In some cases, it may be appropriate to use 1/0 CLP and 1/0 ACSR for the System Feeder in accordance with planned future system requirements.
T-Body Separable Connector	A "T-shaped" dead-break elbow used to connect equipment/apparatus and cable on primary feeder and network circuits. Designed to accommodate large conductor, and has bolted connections. These are also known as hammers, 600 A elbows, and basic elbow receptacles. When two (2) or three (3) T-Body separable connectors are stacked, they function as a splice.
T-Body Splice	A single dead-break cable component that provides an alternate method of splicing and joining cables using standard T-Body Separable Connectors. It is designed to perform the task of two (2) in-line stacked T-body Separable Connectors. These are also known as vault stretcher, and co-molded T-Body Separable Connector.
TC-1	Designates metered traffic signals.

Totalized Metering	Totalized metering is a metering concept used to combine the power consumption of multiple panels on the same customer premises. An IDR meter is required to meter a totalized metering account. There are two types of totalized metering: software totalized and current totalized.
Transmission	Power delivery system above 161,000 V (161 kV).
Transmission System	An interconnected group of electric transmission lines and associated equipment which transfer electric energy, in bulk, between points of supply and points of delivery.
Transposed Line	The phase conductors of the circuit have interchanged positions on the structure between successive lengths of line, minimizing electrical unbalances.
T-Tap	A 200 A splice into the feeder system which serves subsystems/loadblocks.
Unbalance	Different amounts of current carried on each phase of the circuit.
Uncorrected Power Factor	The power factor of the load on a circuit if there were no capacitors on line.
Underbuild	The lower voltage circuit(s) constructed beneath a higher voltage circuit on the same pole line.
Underground (DUG)	Underground refers to electrical underground conductors and surface and below ground equipment. The abbreviation DUG is sometimes used to refer to the *Distribution Underground Construction Standards Manual*.
Usable Pole Strength	The maximum bending moment that may be applied to a pole (due to pole loading and conductor strain) for a given wind area without exceeding the safety factor for the specified grade of construction. Grade “A” construction requires a safety factor of 4:1 and Grade “B” requires a safety factor of 3:1.
Var/Watt Ratio	The ratio of vars to watts represents the uncorrected power factor of the customer load on a circuit/substation.
VFI	Vacuum Fault Interrupter. Designates apparatus containing switches and/or vacuum interrupters used for protecting and switching large transformers. The switches and vacuum bottles can be oil insulated or SF_6 insulated.
Volt (V)	The standard unit for measuring voltage.
Voltage	The electrical force which propels current in a conductor, analogous to the pressure in a water hose.

Volts per Meter (V/m)	A standard unit for measuring the strength of an electric field.
WAL	Weather resistant all aluminum cable. This cable is obsolete.
Working Space	The space extending laterally from the climbing space, reserved for working below, above, and between conductor levels.
Zoning	The designated permitted use of land used by local governments, based on mapped zones which separate one set of land uses from another. This information can be found at City/County/Municipality.

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