ADS–10: Overhead Systems

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ADS–10: Overhead Systems

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 (G.O.) No. 95.

The following design criteria for overhead systems are covered in this chapter:

Subsection 5.1: Covered Conductors - General

Subsection 5.2: Poles

Subsection 5.3: Crossarms and Insulators

Subsection 5.4: Guying

Subsection 5.5: Determine the angle created by the guy to the pole from Table 10–41, using the height of the guy attachment above the Grounding and Neutrals

Subsection 5.6: Construction Practices

Subsection 5.7: Design and Implementation of System Hardening for Supporting SCE's Wildfire Mitigation Plan (WMP) in High Fire Risk Area (HFRA)

Subsection 5.8: Special Conditions

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 Construction Standards (DOH) manual are also referred to, providing additional information for consideration when designing overhead systems.

2.0 Key Definitions

See ADS–16.

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, and street-lighting circuits.

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 (FE) 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. 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.

D. 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 described in ADS–2.

In many cases, existing 12 kV or 16 kV, 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.

E. 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; 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 pad-mounted transformer. Consult ADS–2, Subsection 5.8, for methods of mitigating ferroresonance.

A description of SCE secondary systems can be found in the Distribution Overhead Construction Standards (DOH) manual, Section DC.

F. 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

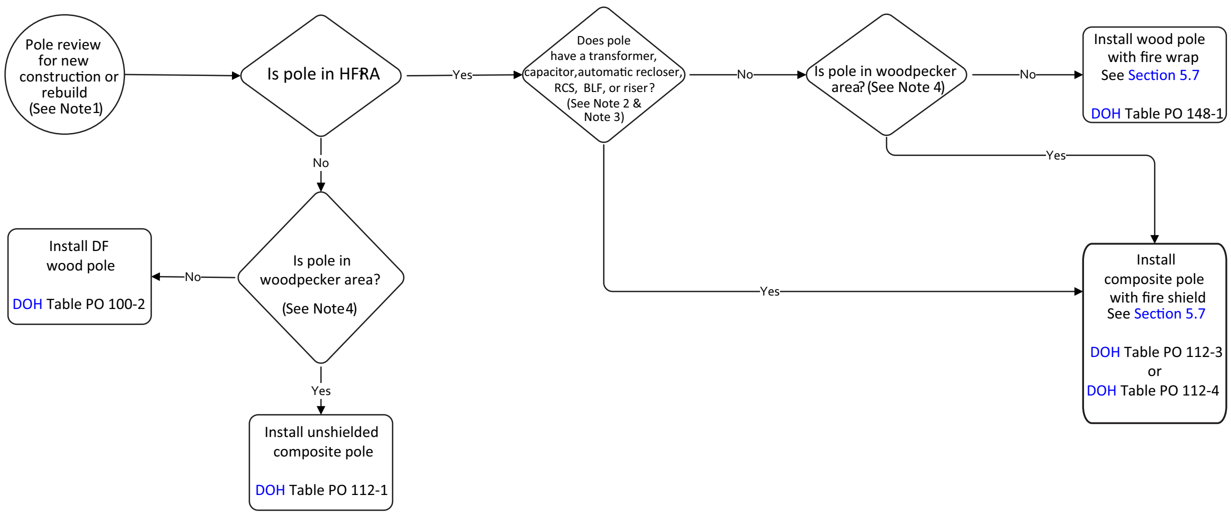
It is a three-wire delta system that has bus regulation. All transformer installations (single-phase or three-phase banks) are connected phase-to-phase.

The 33 kV circuits are mostly used as source lines to small substations and pole tops, and 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

Figure 10–1: Pole Decision Tree for New Construction and Rebuilds in HFRA



Note(s):

1. The decision tree applies to new primary pole lines and pole replacements only.
2. Equipment that do not have ground attachments to the pole will be installed on wood pole with fire wrap.
3. Per ADS–10, Paragraph 5.6 L. 5., branch line fuses (BLFs) installed on covered conductor systems require surge arrestors which require the pole to be grounded. Thus, BLFs installed with covered conductor will be installed on a composite pole with fire shield.
4. This decision tree is also applicable to animals, insects, fungus, moisture, and other severe environmental conditions.

Poles used to support overhead conductors and equipment must be designed to meet the economic and operational needs of the Company.

A. Wood Poles

The following types of wood poles are approved for use in the distribution system:

1. Pacific Coast Douglas-fir (DF) (*Pseudotsuga menziesii*) Wood Pole

   Refer to DOH PO 100 for SAP codes, dimensions, weights and construction details.

2. DF (*Pseudotsuga menziesii*) Wood Pole with Fire Wrap (or Protective Barrier)

   The fire wrap DF wood poles will be used in new construction and rebuilds in High Fire Risk Areas (HFRAs). Refer to Figure 10–1 for application of the fire wrap wood poles in HFRAs. See ADS–10, Paragraph 5.7 C. 2.for fire resistant poles in HFRA.

   Poles shall be delivered from the pole manufacturer with the fire wrap installed. The fire wrap will be positioned to start at 2 feet 10 inches below ground line and extend up to a height of approximately 20 feet above ground line.

   The fire wrap wood poles are available in lengths from 25 feet to 65 feet. For additional heights and classes, contact a Wood Pole Product Specialist. Refer to DOH PO 148 for SAP codes, dimensions, weights and construction details for the fire-wrapped wood pole.

Pole load the fire wrap wood poles using the corresponding pole species, class and height (i.e. if the pole is Douglas Fir through-bored, select from the DF-TB species).

NOTE SCE's Primary Distribution System shall be designed to Grade A and Grade B construction only. All joint pole attachments shall be designed to Grade A construction.

B. Composite Poles

Composite poles are fiberglass-reinforced polymer (FRP) structures. They are non-conductive, corrosion, wildlife, rot and flame resistant. Composite poles are lighter in weight and have the capacity to carry more load when compared to wood poles of the same class and size.

In general, composite poles are preferred in lieu of wood poles when one or more of the following conditions exist:

- Areas of restricted vehicle access (applies to sectional composite poles)
- Areas of severe or accelerated pole degradation due to animals, insects, fungus, moisture, and other severe environmental conditions.
- Areas subject to pole shrinkage and constant winds
- Load weights or distances that exceed helicopter and/or crane capabilities

SCE previously installed single-piece octagonal, non-tapered composite poles manufactured by Creative Pultrusion (previously known as Powertrusion), sectionalized composite poles manufactured by Resin Systems (RS), and round, tapered composite poles manufactured by Shakespeare and Newmark. Consult Linear and Structural Strategies for equipment installation or third party attachments on Creative Pultrusion, Shakespeare, Intelli-Pole, and Newmark poles.

The Resin Systems (RS) composite poles are manufactured using a filament wound process that delivers a sectional, tapered pole that is larger in diameter at the bottom and smaller in diameter at the top. The Creative Pultrusion (CP) composite poles are manufactured using a pultruded process that delivers a single piece with a consistent diameter from top to bottom. In addition to the shape variation, pultruded poles by nature are single piece products as opposed to RS sectional poles. SCE takes the approach to have composite poles designed to, at least, wood equivalent for both class and size. Therefore, even though the poles vary in shape, they provide the same design characteristics. Contact Linear and Structural Strategies for any questions or concerns.

There are presently four (4) types of composite poles that are approved for use on the Edison system:

❶ Resin System (RS) sectional composite poles

❷ Creative Pultrusion (CP) monopole

❸ Resin System (RS) with Fire Shield

❹ Creative Pultrusion (CP) with Fire Shield

1. RS Sectional Composite Poles

   The RS sectional composite poles are available in lengths from 35 feet to 65 feet. The standard color is brown.
   (Contact Structural Asset Engineering for details).

2. CP Monopole Composite Poles

   The CP monopole composite poles are available in lengths from 35 feet to 80 feet. The standard color is brown.

3. RS Sectional Composite Poles with Fire Shield

   The RS sectional composite poles with Fire Shield are available in lengths from 45 feet to 75 feet. The standard color is brown. Composite poles with fire (or protective) shields are intended for use in new construction and rebuilds in HFRAs. Refer to ADS–10, Paragraph 5.7 C. 2. for additional info on composite poles and Figure 10–1 for application of the fire shield composite poles in HFRAs.

4. CP Monopole Composite Poles with Fire Shield

   The CP monopole composite poles with Fire Shield are available in lengths from 35 feet to 80 feet. The standard color is brown. Composite poles with fire (or protective) shields are intended for use in new construction and rebuilds in HFRAs. Refer to ADS–10, Paragraph 5.7 C. 2. for additional info on composite poles and Figure 10–1 for application of the fire shield composite poles in HFRAs.

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 future transmission been taken into consideration
- ☐ Is the route in a heavily vegetated area
- ☐ Is the route within 1 mile of coastal area or area known to have unique accelerated corrosion

The route should be selected so that the total cost of the completed line will be at a minimum, while at the same time consideration is given to (1) accessibility for maintenance, and (2) 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 SCE's 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.

NOTE Covered conductor or aerial cable shall be considered where the possibility of intermittent contact with vegetation is likely.

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 pole-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 pole-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 pole-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.

NOTE Covered conductor or aerial cable shall be considered where the possibility of intermittent contact with vegetation is likely.

4.0 Prerequisite Information

The Service Planner should have a good knowledge of the following:

- California Public Utilities Commission rules
- DOH manual
- General Order (G.O.) 95 and 128
- Electrical Service Requirements (ESR) manual
- Rights-of-way and franchise agreements
- Joint Pole procedures and practices
- Policies, procedures, and restrictions of governmental agencies
- Policies and procedures of the Transmission/Substation Division and Construction Field Forces Region
- The distribution section of the “EMF Design Guidelines for New Electrical Facilities: Transmission, Substation, Distribution”

5.0 Design Criteria

5.1 Covered Conductors - General

Primary conductor sizes are determined by the economic loading limits (ADS–9), and mainline conductor sizes are reviewed by FE. Secondary conductors are sized based on customer demand, voltage drop, flicker, and motor starting load (ADS–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 DOH. General conductor information (for example, use of copper wire in beach areas, weight, amperage, and diameter) may be found in DOH, Section CO.

Covered conductor improves reliability by preventing faults due to contact from objects such as tree branches, palm fronds, metallic balloons, or other conductors. Because of this advantage, covered conductors will be useful in areas that regularly or have a high probability of experiencing faults due to contact from object. In addition, the use of covered conductor can improve public safety in scenarios where the public can inadvertently come into contact with an energized overhead line.

By decreasing the chance of faults due to contact from objects through the use of covered conductors, the chance of ignition can be substantially reduced. Therefore, covered conductors shall be used system-wide.

Reduced tension unguyed (or slack) spans may be considered when the use of downguys or span guys is not feasible. They have lower sags which increase the chance of conductor-to-conductor clashing. Therefore, covered conductor shall be used in reduced-tension unguyed spans.

Additionally, spans shall be constructed with covered conductor either to extend to existing dead-ends or extend to new dead-end locations.

Covered conductor shall be treated and worked on as a bare conductor. Furthermore, covered conductor does not exempt tree trimming requirements.

Refer to DOH, Section CC, for all construction standards for covered conductor.

COVERED CONDUCTOR 1.0

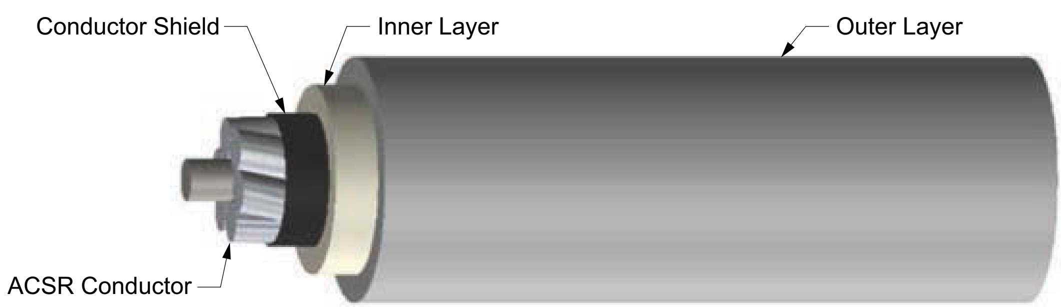
Covered Conductor, also known as tree wire, is a conductor that is protected by layers of insulating material. There are four components in the covered conductor: the conductor, a conductor shield, an inner layer, and an outer layer.

The conductor can be Aluminum Conductor Steel-Reinforced (ACSR) or Hard Drawn Copper (HDCU).

The conductor shield is made out of a semi-conducting thermoset polymer. Its purpose is to reduce stress concentrations caused by flux lines from the individual conductor strands. By encircling the strands, it effectively transforms the strands into a single uniform conducting cylinder. The conductor shield can increase the life of the covered conductor by reducing the electrical stress on the contact area, therefore increasing the time to failure when an object makes contact with the covered conductor.

The inner layer is Crosslinked Low Density Polyethylene (XL-LDPE), which is an insulating material. The insulation contributes to the high impulse strength of the cover and protects the conductor from phase to phase and phase to ground contact.

The outer layer is Crosslinked High Density Polyethylene (XL-HDPE), which is an insulating material as well. It has the same insulating function as the inner layer. However, due to being high density, it is also a tougher layer, making it abrasion and impact resistant. The outer layer is also track resistant, which limits the charging current flowing on its surface. This track resistant property will help maintain the integrity of the insulation surface over time by significantly reducing electrical tracking that could lead to erosion of the insulation. Additionally, the XL-HDPE layer is specified for UV stability, making it less susceptible to UV degradation.



The conductor covering can also protect the conductor from corrosion, especially in coastal environments. Therefore, covered conductors may benefit installations in coastal areas (within one mile of the coast). Because the conductor may be exposed in certain areas, such as dead-ends, copper covered conductor shall be used due to being more resistant to corrosion than aluminum, except for the following:

- For coastal circuitry operated at greater than 17 kV, such as 25 kV and 34.5 kV
- For coastal circuitry where the ampacity requirements exceed 4/0 copper covered conductor [1/]

[1/] Contact Field Engineering to determine if development of higher voltage rating or ampacity for covered conductor can be accommodated for the project, or whether bare copper or greased ACSR may be required until Covered Conductor 2.0 is available for the application.

COVERED CONDUCTOR 2.0

NOTE

CC 2.0 is currently deployed **For Planning Use Only** and is not authorized for construction without engineering approval at this time. New work orders with operational dates in 2027 or beyond shall use the CC 2.0 Standard.

SCE is introducing Covered Conductor 2.0 which will replace the first-generation covered conductor as the main covered conductor option. Additional details and a comparison of the two designs can be found later in this section. Both conductor types will utilize the same 3-layer design, incorporating key design updates from lessons learned from deployment of the first-generation covered conductor.

Covered Conductor 2.0 is designed with similar components as it's predecessor: the conductor, a conductor shield, an inner layer (Crosslinked Low Density Polyethylene or XL-LDPE), and an outer layer (Crosslinked High Density Polyethylene or XL-HDPE).

Where Covered Conductor 2.0 is different is as follows:

- Reduced insulation thicknesses to reduce total weight (lb/ft.) which can aid in reduced pole replacements
- Compact stranding to further reduce weight as compared to the previous generation's equivalent size.
- Moisture block between conductor strands to prevent moisture ingress and the potential for strand corrosion, particularly in coastal environments.
- Embossed printing on the outer layer for easier identification of conductor data as the conductor is exposed to various elements.

Covered Conductor 1.0 will continue to have specific scoping limitations for 34.5 kV coastal circuitry due to copper conductors not existing with the 35 kV covering. However, upon publication of this standard and availability of CC 2.0 sizes, 34.5 kV circuits in coastal applications shall utilize CC 2.0 for scoped work and designs.

Covered Conductor 2.0 will be deployed for planned work such as Overhead Conductor Program (OCP), 4 kV Cutover, Distribution System Planning (DSP) upgrades, and any remaining WCCP work with operational dates in 2027.

First-generation covered conductor will continue to be deployed for maintenance, in-flight work orders and on-going Wildfire Covered Conductor Program (WCCP) work through 2026. Eventually, inventory transition will take place in order to begin utilizing Covered Conductor 2.0. Once first-generation covered conductor is depleted, Covered Conductor 2.0 will be required for all program, planned, and maintenance work moving forward.

CC 2.0 Construction

❶ **Conductor**: Compact stranded short lay ACSR/AW with Water Blocking Tap and/or Yams.
❷ **Strand Shield**: Semi-Conducting cross-linked polymer
❸ **Inner Layer**: Low-Density Crosslinked Polyethylene (LDXLPE)
❹ **Outer Layer**: Track Resistant High-Density Crosslinked Polyethylene (HDTRXLPE)

Important: Covered Conductor 2.0 should not be mixed with first-generation covered conductor and vice versa in a given span. If CC 2.0 is introduced in a circuit with mixed conductor types, it should only be utilized at the nearest dead-end structure where a clean transition can be made. A span shall not contain both conductor types.

The Sentient MM3 RFI (see DAP AP 604) **shall not** be used on Covered Conductor. The gripping teeth in the clamping mechanism of the Sentient MM3 RFI can cause damage to the sheath of Covered Conductor. If there is a Sentient MM3 RFI on a line that will be replaced with Covered Conductor, perform the following:

- **Do not** re-install the Sentient MM3 RFI on the Covered Conductor.
- Send the removed Sentient MM3 RFI's to Wire Engineering, SSID.
- Contact E-Maps, with the structure number that is associated with the Sentient RFI, and arrange for the RFI to removed from E-Maps at that location.
- Contact the Distribution Automation Hotline at 714-285-5325 with the structure number that is associated with the Sentient RFI, and inform the Automation Engineer that the Sentient RFI has been removed and will be sent to Wire Engineering at SSID.
- Arrange for the removed Sentient MM3 RFI to be replaced with a PDP Overhead RFI (see ADS–2: Feeder Systems, DAP AP 635) at or near the same location.

NOTE

For acceptable fault indicators to be used with covered conductor, see Distribution Apparatus Construction Standards Table AP 600-2 and AP 635.

Aerial Bundled Cable

Aerial Bundled Cable (ABC) consists of one, two, or three individual cables, each having an aluminum conductor with cross-linked polyethylene with concentric neutral wires covered by a jacket. The factory-assembled cable comes with pre-spun and pre-wrapped messenger and lashing wires.

ABC is recommended for use in areas with dense vegetation that cannot be trimmed. Because ABC is fully insulated, it can withstand permanent contact with objects, including vegetation.

Multiplex Overhead Conductor

In HFRA, multiplex conductor (See DOH, CO 108) shall be used for new overhead construction and reconstruction work.

For Wildfire Covered Conductor Program (WCCP) work, on structures supporting open wire secondaries (OWS) or weather resistant all-aluminum secondary conductors (WAL) and covered conductor, new multiplex conductor shall be installed. OWS and WAL extending from structures supporting covered conductor shall also be replaced with multiplex conductors to the end of the secondary lead.

INSULATED OVERHEAD WIRE SPACERS

The purpose of insulated overhead wire spacers is to prevent bare wires from coming in contact with each other.

Overhead wire spacers are not applicable for covered conductor or aerial bundled cable.

SCE has approved both standard and lightweight wire spacers and installation, which require bucket truck accessibility. If there is no bucket access, a reconfiguration of the circuit with 3-wire ridge pin (see DOH Manual Figure DC 535–5), two levels of crossarms (box type, see DOH Manual Figure DC 535–3) construction, or "zig-zag" construction (see DOH DC 587) may be considered for design options to the pole top configuration.

Installation requirements for line guards and/or armor rods are detailed in DOH Tables CO 450–2 & 3 based on wire sizes and spacer versions.

The application of the overhead insulated wire spacers for horizontal and vertical configuration are as follows, respectively:

A. Horizontal Configuration:

   Any span for which the sag is equal to or exceeds the minimum conductor separation (either at the crossarm or throughout the span) shall have overhead wire spacers installed. Refer to DOH CO 450 for additional details.

B. Vertical Configuration:

   Any span where conductors are subjected to uplifting wind forces due to any of the following criteria shall have line spacers installed:

   1. Ice formation (heavy loading areas) that can result in traveling waves or line galloping.

   2. Extreme changes in terrain (pole line on apex of ridge) that can result in traveling waves or galloping.

VIBRATION DAMPERS

Use of the Vibration Dampers is intended to reduce Aeolian vibration. Aeolian vibration is high frequency, low amplitude vibration that is caused by low wind velocities (below 15 mph) blowing across overhead conductors. Over time, Aeolian vibration can lead to abrasion or fatigue failures, which are associated with loose connections between conductor and hardware or strand breakage, respectively. Vibration dampers are used on both bare wire and covered conductor.

For bare wire, spiral vibration dampers shall be installed on spans 300 ft or greater for new construction or during planned maintenance activities. They are limited for use up to 336 ACSR and 4/0 Cu and are not placement specific. Spiral vibration dampers are not required in heavy loading areas due to low conductor tensions. Vibration dampers will be installed in heavy loading areas when vibration on the conductor is observed. Refer to DOH, Section CO 460 for bare wire system installation instructions, quantity of dampers per span length, and SAP codes.

For vibration damper requirements on covered conductor, see ADS–10, Section 5.7.

CLAMPSTAR SPLICE SHUNTS

The purpose of ClampStar splice shunts is to increase the electrical and mechanical performance of conductor spans on which automatic splices are present. They shall be installed during planned work at the primary level to bypass any automatic splices found on primary conductors in truck accessible locations within one span in any direction of the pole being planned. For installation instructions and SAP codes, refer to DOH CO 470.

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 **Table 1** and **Table 2** of G.O. 95.

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 10–27 through Table 10–29. Usable pole strengths are listed for 6 pound, 8 pound, 12 pound and 18-pound winds, for Grade A (SF-4), and for Grade B (SF-3) construction. The usable pole strengths for 8-pound winds should be used when determining pole strengths for pole loading in 6-pound heavy-loading areas. See Table 10–27 through Table 10–29. 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. Table 10–30 provides the horizontal wind pressure in pounds-per-square-foot for various conductor types and sizes. Pole loading for heavy-loading areas is calculated using a 6-pound wind (48 mph) and assuming one-half inch of ice on the conductor. Pole loading in light-loading areas is normally based on an 8-pound wind (56 mph); however, a 12-pound wind is used in areas subject to winds up to 68 mph. An 18-pound wind is used in areas subject to winds up to 84 mph and a 24-pound wind is used in areas subject to winds up to

97 mph. The wind zone map (located in the E-World Portal) can be used to determine the area's proper pole load design criteria for their given area. Examples dealing with pole strength and pole loading are included in Appendix 10–1.

C. Extra Heavy-Loading Areas above 5,000 Feet

Special construction requirements have been established for extra heavy-loading areas above 5,000 feet (normal heavy-loading areas between 3,000 feet and 5,000 feet elevation). 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 10–1 and Table 10–2 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 overhead platform rack (2- or 3-pole) may be installed in accordance with Paragraph 5.2 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 10–3 through Table 10–8 will be used to determine dimensions and weights of various types of equipment.

Table 10–1: Minimum Pole Class for New Transformers and Equipment Mounted on Existing or New Wood Poles

Minimum Pole Class for New Transformers and Equipment Mounted on Existing or New Wood Poles		
Equipment Mounting Height Above Ground Line (ft)	**Min. Pole Class**	**Transformer and/or Equipment Weight (lb)**
27.5 or Below	4	Up to 1,500
	3	1,501–1,850
	2	1,851–2,500
	1	2,501–3,350
	H1	3,351–4,250
	H2	4,251–4,850
	H3	over 4,851
	H4	over 4,851

Table 10–1: Minimum Pole Class for New Transformers and Equipment Mounted on Existing or New Wood Poles ***(Continued)***

Minimum Pole Class for New Transformers and Equipment Mounted on Existing or New Wood Poles		
Equipment Mounting Height Above Ground Line (ft)	**Min. Pole Class**	**Transformer and/or Equipment Weight (lb)**
27.6–32.0	4	Up to 1,300
	3	1,301–1,700
	2	1,701–2,200
	1	2,201–3,000
	H1	3,001–3,900
	H2	3,901–4,850
	H3	over 4,851
32.1–36.5	4	Up to 1,300
	3	1,301–1,700
	2	1,701–2,200
	1	2,201–3,000
	H1	3,001–4,000
	H2	4,001–4,850
	H3	over 4,851
36.6–41.0	4	Up to 1,200
	3	1,201–1,500
	2	1,501–2,200
	1	2,201–2,500
	H1	2,501–3,350
	H2	3,351–4,250
	H3	4,250–4,850
	H4	over 4,851
41.1–45.5	4	Up to 1,200
	3	1,201–1,500
	2	1,501–1,850
	1	1,851–2,500
	H1	2,501–3,350
	H2	3,351–4,250
	H3	4,251–4,850
	H4	over 4,851

Table 10–1: Minimum Pole Class for New Transformers and Equipment Mounted on Existing or New Wood Poles *(Continued)*

Minimum Pole Class for New Transformers and Equipment Mounted on Existing or New Wood Poles		
Equipment Mounting Height Above Ground Line (ft)	**Min. Pole Class**	**Transformer and/or Equipment Weight (lb)**
45.6–50.0	2	Up to 1,850
	1	1,851–2,500
	H1	2,501–3,350
	H2	3,351–4,250
	H3	4,251–4,850
	H4	over 4,850

Note(s):

1. For new poles, this table should be used to select pole class prior to pole loading. For existing poles with no existing transformers or equipment that are scheduled to have equipment attached, this table should be used prior to pole loading.
2. Existing poles with existing transformers or equipment installed to the pole do not need to meet this table criteria, however, a visual
3. inspection is required to ensure that there is no excessive bowing due to the installed apparatus as well as a passing pole load calculation.
4. Changing like-for-like transformers or equipment requires a visual inspection and passing pole load calculation,
5. This table shall be used if the existing transformers or equipment are being replaced with heavier ones. A passing pole load calculation isrequired.
6. Refer to PLM–2, Table 7: Equipment Weights and Surface Area for equipment weights.
7. A pole load calculation is required when any equipment weighing 200 lb or more is installed on a wood pole.
8. Choose correct bracket to support the weight of the transformer being mounted. If weight exceeds the mounting bracket capacity, then an overhead platform rack shall be used. Refer to DOH DC 640 for platform rack details. Refer to DAP AP 131 for mounting brackets details.

Table 10–2: Weight Limitation of Three-Phase Transformers — Transformer Bracket Mounted on Wood Pole

Transformer Size (kVA) (See Note 3)	Transformer Individual MAX Weight (lb) (See Note 1)	Transformer Weight (Times 3) (lb) (See Note 1)	Transformers & Mounting Bracket Total Weight (See Note 1)
(a)	(b)	(c)	(d)
10	286	858	1,208
15	313	939	1,289
25	450	1,350	1,700
37.5	500	1,500	1,850
50	650	1,950	2,300
75	1,000	3,000	3,350
100	1,300	3,900	4,250
167	1,500	4,500	4,850

= For Reference Only

Note(s):
1. A pole-load calculation must be performed whenever any equipment 200 lb or greater is installed on a wood pole.
2. 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. Round up to the nearest transformer weight shown in column (d).
3. Transformers (10 kVA and 15 kVA) are not available and not approved for use on new installations or replacements.
4. Choose correct bracket to support the weight of three single-phase transformers. If weight exceeds the mounting bracket capacity, then an overhead platform rack shall be used. See DOH DC for platform rack details.
5. See AP 131 for mounting bracket details.
6. Transformer weights are for 4 kV, 12 kV, and 16 kV, 120/240 and 277/460 V transformers only. For 33 kV primary or above 600 V secondary voltages, contact engineering.

Table 10–3: Single-Phase Overhead Transformer Weight and Dimensions

Transformer Size[a/] (kVA)	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	1,000	2 x 4
100	1,300	2.08 x 4
167	1,500	2.08 x 4.5

Note(s):
1. 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.

[a/] 10 kVA and 15 kVA transformers are not available and not approved for use on new installations or replacements.

Table 10–4: Overhead Capacitor Weight and Dimensions

Overhead 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 10–5: Voltage Regulator Weight and Dimensions

Voltage Regulators		
Size (kVAR)	**MAX Weight (lb)**	**L x W x H Dimensions (ft)**
5	3,050	2.3 x 2.3 x 7.3
14.4	5,000	2.6 x 2.6 x 8.2
19.9	3,950	2.3 x 2.3 x 7.5

Table 10–6: 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 10–7: 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[a/]	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

[a/] 10 kVA oil-type control power transformers are not approved for use on new installations.

Table 10–8: Overhead 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

To calculate the load on a piece of equipment use the following formula:

woe x hoe x qoe x (pld – lb) x hoa = 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. Overhead Platform Racks on Poles

1. Use of 17'-4" Platform Rack

Use only 17'-4" platform racks for new installations requiring equipment racks. Depending on the overall equipment weight, install the 17'-4" platform rack onto a 2- or 3-pole design configuration. Use 17'-4" racks to replace existing 13'-6" and 15'-0" racks unless the conditions described in Paragraph 5.2 E. 2. apply. For proper rack selection, see Paragraph 5.2 E. 1. a. and Paragraph 5.2 E. 1. b. Install the 17'-4" platform rack on **Class H5** poles.

a. Use of 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.

b. Use of 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.

2. Use of 13'-6" Platform Rack (2- and 3-Pole Design) for Retrofit Applications Only

Use of 13'-6" racks are only approved for replacing existing installations when a 17'-4" rack is not practical and one of the following three conditions exists.

❶ Limited space: 17'-4" platform rack installation is not possible.

❷ Gaining access or easement permits is not possible.

❸ Existing circuit and/or line construction will not be constructible with a 17'-4" platform rack without excessive add-on cost.

Install the 13'-6" platform rack on Class H5 poles. The installation and construction for all overhead platform racks will be the same. A minimum clearance of 12 inches from face of pole to tank of transformer or cooling radiators/fins shall be maintained. Refer to DOH, DC 640, for 13'-6" platform rack retrofit 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 FE when considering installation of an H-frame structure. For H-frame construction details, refer to 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 subtransmission. For Smith Corner construction details, refer to DOH, DC 635.

H. Pole Top Extension/Replacement versus Pole Replacement

Wood pole top extension may be used in the Distribution System as described below. Fiberglass and metallic pole top extensions are no longer approved for use. A pole load calculation and an intrusive inspection (performed within the previous 5 years) are required prior to installation. If the existing pole is a Class 4 or Class 5 (19- or 21-inch circumference at top of pole), then an adapter kit must be used in conjunction with the extension.

Pole top extensions may be used to:

- Correct insufficient minimum vertical or radial clearance situations.
- Remedy fire-damaged or deteriorated pole tops.
- Support crossarms with fuseholders/cutouts, surge arresters, and primary or secondary conductor.

- Support unguyed secondary or service conductor on 3-spool or single spool racks (including extended racks/spools).
- Support primary or secondary risers.
- Support non-SCE antennas, provided the requirements in DOH, DC 222, are met.

The following requirements must be met for each installation:

- ☐ Minimum SCE clearance requirements for other conductors, crossarms, equipment, and bolt zones.
- ☐ Top of subject pole is not damaged or deteriorated.
- ☐ Subject pole is climbable to the top portion.
- ☐ Environmental standards, including wildlife.
- ☐ Subject pole is a Class 5 (minimum) and not larger than a Class 2 (maximum).
- ☐ Subject pole meets SCE pole loading requirements.

Extensions shall ***not*** be installed on poles:

- ☐ Greater than 40 years of age.
- ☐ Smaller than Class 5 or larger than Class 2.
- ☐ Used in Grade A and Grade B crossings, dead-end or angle construction (requiring guys).
- ☐ To support apparatus (transformers, capacitors, switches, automatic reclosers)
- ☐ Treated with Cellon, or Dow (gray).
- ☐ Supporting transmission facilities.
- ☐ To support an alley arm.
- ☐ Made of fiberglass, steel, or concrete.

NOTE Existing apparatus supported by a pole top extension shall be removed if the equipment or pole is replaced.

I. Pole Spotting

When spotting a pole location in a franchise area (for example, a parkway or 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 4-foot clearance shall be maintained from top of slope of a commercial driveway, and 2-foot clearance from top of slope of a residential driveway.

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 *wildlife hoods* or constructed using suspension-type build. Refer to DOH, DC 530 and DC 535, for wildlife-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 DOH, PO 100 and GR 111; and Distribution Underground Construction Standards (DUG), CR 141, 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.

    b. All distribution primary and secondary neutrals (except for primary neutrals on circuits with floating neutral protection schemes) shall be connected to the pole.

CAUTION

Primary distribution circuits with isolated 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 isolated neutral shall ***not*** be electrically connected to the LWS pole.

Check with FE 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. See Subsection 5.3 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 wildlife-safe construction on LWS poles.

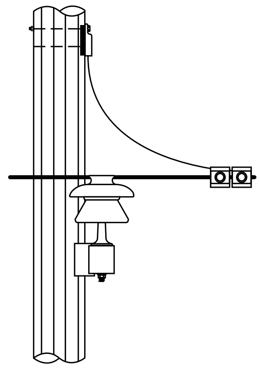
2. Each subtransmission LWS pole with distribution attachment requires an electrical connection through a continuous metallic path to a substation ground grid. This path to the substation ground grid is called the pole *fault return conductor (FRC)*. The Transmission Estimator will consult with the area E&TS Field Engineer and then designate each pole's FRC to be either:

    - 2/0 Cu or 4/0 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).

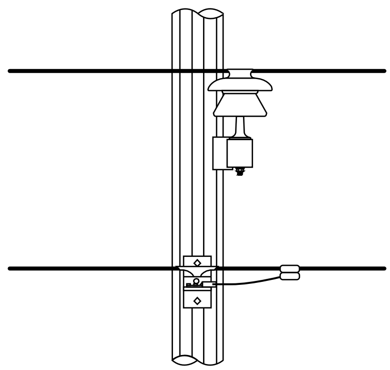
OR

- 4/0 ACSR pole-bond wire (usually installed by subtransmission crews)
  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

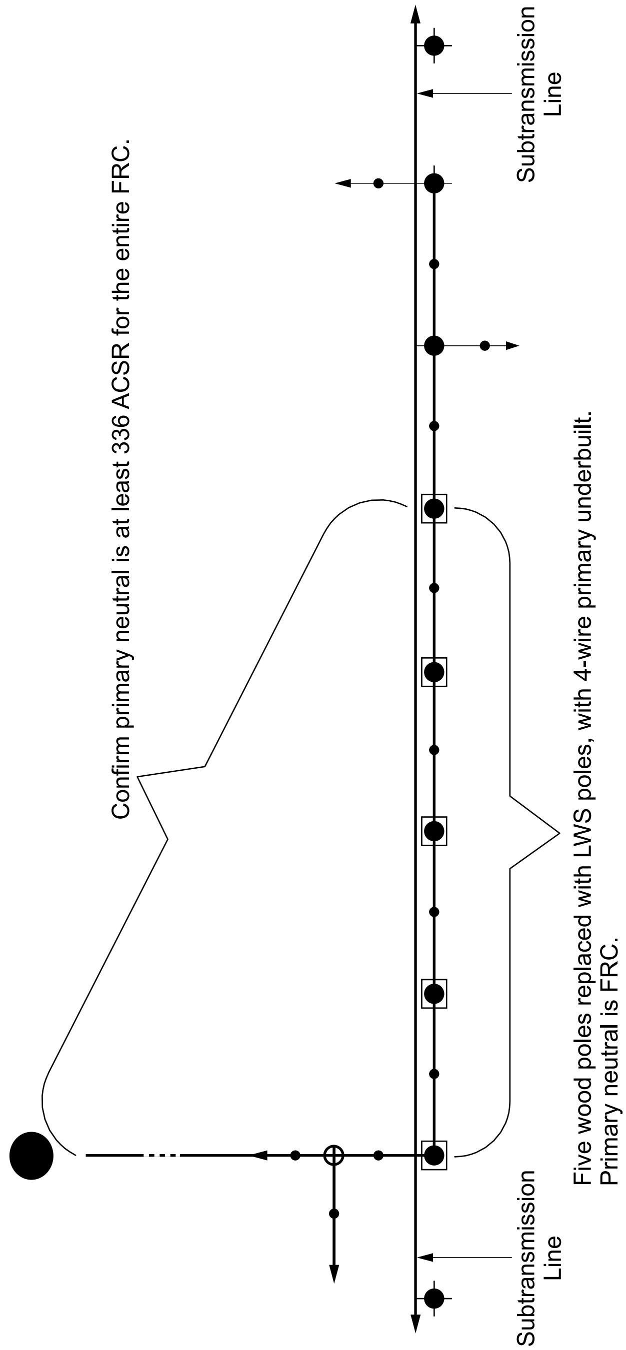
3. Design Considerations

   Field Engineering (FE) must approve each primary neutral FRC design prior to installation.

   Verify the primary neutral size from the LWS pole attachment back to the substation ground grid if the Transmission Estimator designates the primary neutral as the FRC. Install a minimum 2/0 Cu or 4/0 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 must be checked to ensure they 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 must be with #4/0 copper wire. If there is no room in the duct bank for a #4/0 copper to be installed, contact FE 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

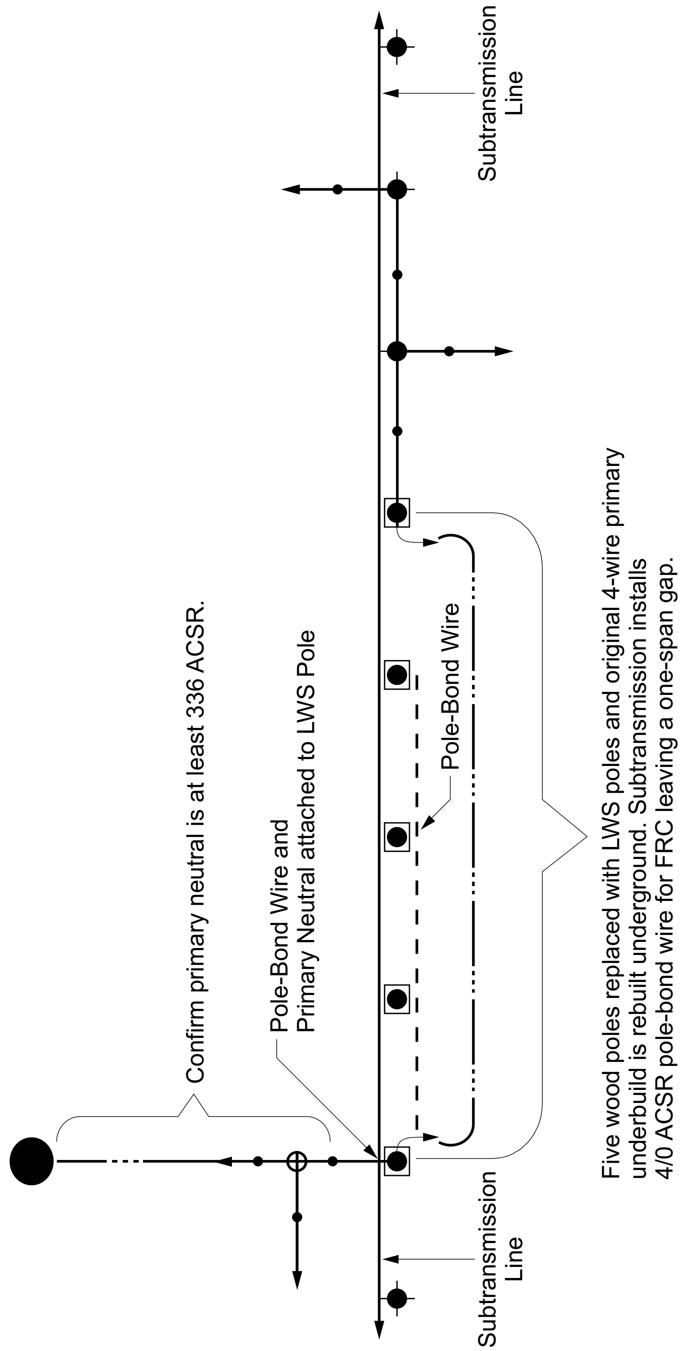
Field Engineering must approve each primary neutral FRC design prior to installation.

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 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 (1) 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, FE 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 Field Engineers and/or Planners shall coordinate with the third party to verify that a parallel path is not created for neutral current under normal operating conditions. This may require isolating the third party's attachments 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 attachments. 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 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 will be marked on the steel pole.

5.3 Crossarms and Insulators

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.

A. Crossarms

Composite crossarms with mounting brackets shall be used on composite, wood, and LWS poles.

For clearance requirements when mounting composite crossarms on wood poles, refer to DOH PO 100 and for pole loading requirements, refer to PLM-2.

If installing wood crossarms, flat braces shall be installed where conductors of #2 str copper or 4-1/0 ACSR or smaller bare conductors are to be installed. V-braces are required on composite crossarms that are installed in elevation areas above 5,000 ft. due to additional mechanical loading. In all other areas V-braces and back braces shall not be used on composite crossarms. Five-foot composite crossarms do not have a center mounting bracket, and therefore can be installed with a thru-bolt and flat-braces when installing as a guard arm or supporting arm for small conductors. The illustrations in DOH, Section DC, specify the maximum span lengths for various types of construction.

Aerial cable applications will present unbalanced loading to the crossarm, therefore, utilize V-braces for composite crossarms, regardless of elevation criteria.

Distribution equipment installed on composite or LWS poles will use the same construction practices as for equipment installed on wood poles with the exceptions provided in Subsection 5.2; DOH, PO 100; DOH, PO 112; DOH GR 111; and DUG, CR 141.

Refer to DOH, GR 111, to determine when COMMON NEUTRAL signs (SAP 10135292) must be installed on primary crossarms.

B. Dead-Ending

Crossarm requirements for dead-ending conductors are illustrated in Table 10–31 for wood crossarms, and Table 10–32 for composite crossarms. Distribution circuits crossing Limited Access Highways as defined in DOH PO 200 shall be considered Grade “A” crossing and 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 10–18 through Table 10–37 in Appendix 10–2 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 DOH, Section CO.

C. Insulators

Insulator requirements are identified in DOH, Section GR, and are designated by the insulation area map, which identifies high, moderate, and light areas of contamination.

Utilize the following type of insulator for each conductor application:

1. Bare Aluminum Conductor

☐ Polymer post-type insulators (universal clamp-top or trunnion-top) for all construction

2. Bare Copper Conductor

☐ Polymer post-type insulators (trunnion-top) with applicable clamp-top (refer to DOH CO 510)

3. Covered Conductor

See Table 10–1 to determine which insulator type shall be installed. For instances where both insulators are acceptable, post insulators are preferred while vise-tops are alternatives.

Table 10–9: Insulator Type Application

Contanmination Area (DOH GR 215)	Application / Construction	Post Insulators (Universal and Trunion-Type)	Pin Insulators (Nylon Inserts Only)
A	HIgh Contamination Areas (DOH GR 215)	✓	
ABC	Angle Deviations (DOH DC 520 or DC 575)	✓	
ABC	Heavy Loading Above 5,000 feet. (DOH DC 520)	✓	
ABC	Incline/Decline Terrain (Trunnion Clamp)	✓	
ABC	Uplift Support	✓	
BC	Over-the-Arm, Vertical, and Other Jumper Supports	✓	✓
BC	Tangent / Straight Through	✓	✓
ABC	Transformer Delta Bracket & Switch Jumpers		✓

When installing, use pin-type polymer insulators with 1–3/8" pins in all construction. For any construction involving angles with polymer pin-type insulators, use an angle pin (refer to DOH, GR 200, for insulator details).

In addition to the applications above, when there is an upward vertical strain in the line, use polymer post-type insulators with appropriately sized insulator studs for bare and covered conductor applications. For any construction involving angles with polymer post-type insulators, use an angle base (refer to DOH, GR 205, for insulator details).

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 or less must be used due to obstacles including but not limited to fences, houses, and flood controls. 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.

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, and flood control channels. 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.

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.

STEP 1. 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 10–38 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 10–40, then locate this deviation angle on Table 10–39 to determine the resultant strain for each conductor size.

5.5 Determine the angle created by the guy to the pole from Table 10–41, using the height of the guy attachment above the Grounding and Neutrals

Grounds are applied on SCE's Distribution System in the following applications:

A. Primary Grounds/Neutrals — (2.4/4.16 kV) Four-Wire Systems

1. The neutral conductor of all four-wire primary circuits (except isolated neutral systems) 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. Refer to DOH, Section GR, for specific construction practices.

2. 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.

3. 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.

4. Primary grounds shall not be located on the same pole with transformer secondary grounds whenever possible. The secondary neutral ground shall be placed on an adjacent pole.

   Where secondary neutral grounds cannot be placed on an adjacent pole place the secondary neutral ground on the same pole as the primary neutral ground. In this situation, place two separate sets of ground rods (one set for the primary neutral and one set for the secondary neutral) not less than 6 feet apart between the different sets.

   Contact Field Engineering for guidance on arrangement of grounds where these requirements cannot be met.

5. The neutral conductor of a 4 kV primary circuit shall not be interconnected with the neutral conductor of a 120/240 V secondary circuit, except on existing “common-neutral” systems. No new “common-neutral” system shall be established without FE approval. Extension from existing “common-neutral” systems shall be reviewed by FE 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.

6. If a four-wire primary distribution circuit is underbuilt on the pole line, the circuit neutral is the preferred choice for the FRC (except for 4 kV isolated neutral systems). A 4 kV isolated neutral may be built on a lightweight steel pole (LWS) but the isolated neutral will not be electrically connected to the pole. Lightweight steel poles with an underbuilt isolated neutral will require installation of an FRC.

7. When circuits or tap lines with an isolated neutral system have sensitive ground protection, the neutral conductor shall not be grounded beyond the neutral current transformer (CT) at the power circuit breaker or automatic recloser. The neutral system will be grounded, but only upstream of this protective device. Refer to DOH, Section GR, for specific construction practices.

8. Isolated neutral systems use sensitive phase and ground fault protection not possible with normal circuit relay settings.

9. Isolated neutral systems always begin at a protective device such as a circuit breaker or AR, which includes a neutral CT. Isolated neutral systems include the entire circuit beyond that point. These systems may be identified by the presence of a neutral disconnect on phase-to-neutral connected load combined with a low ground minimum trip, typically 10 A or less, as opposed to the usual 25 percent or more of phase minimum trip on multi-grounded systems.

   Grounding of isolated neutral systems requires the following:

   - ☐ Do not install primary neutral grounds beyond the initial protective device of the isolated neutral.
   - ☐ The neutral conductor must be switchable at any point in both overhead and underground systems.
   - ☐ The primary neutral must be electrically isolated from steel poles.
   - ☐ Concentric wires cannot be used as a neutral or connected to the neutral conductor on aerial cable or underground cable.
   - ☐ Any primary equipment neutral must be isolated from ground.
   - ☐ The neutral of all underground dips must be fully insulated primary cable.
   - ☐ For transformer selection, see ADS–4, Paragraph 5.3.

   Direct any questions regarding design or implementation specifics to FE. Do not create new isolated neutral systems without approval from FE. Existing isolated neutral systems shall not be reduced or eliminated without approval from FE.

B. Primary Grounds/Neutrals — (12/6.9 kV and 16/9.4 kV) Four-Wire Systems2

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 used 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 Sections GR and T, and DAP, 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 DAP. 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 6-inch minimum clearance.Refer to , 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 **8 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 , Section GR and DAP.

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 risk areas, or environmentally sensitive areas.

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.

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

1. For the purpose of recognizing relative hazards, G.O. 95 segregates lines into classes. Distribution circuits are either Class H (5000 V and above), or Class L (below 5000 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.

2. 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 Class L circuit crosses a major railway. G.O. 95 and , Section PO, should be reviewed for Grade A requirements.

3. Grade A and limited access highway crossings (refer to G.O. 95) require that double crossarms be used. For all Class H and/or Class L distribution conductors, use of double dead ends and dead-end insulators shall be used. (Refer to DOH, Section PO, for illustrations of these requirements along with requirements for guying). 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			

Note(s):

1. The various conductor sizes and configurations will require case-specific guying. The various cases may be reviewed in DOH, Section PO.

[a/] Not approved for use on new construction.

4. Per General Order 95 Rule 49.1-B, when a wood pole is being replaced or installed in Heavy Loading Area and Grade A construction is required, a Class 3 or larger pole shall be utilized.

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 and DUG. Refer to , DC 200 and DC 220, for polehead conductor clearances and grade clearances. Refer to , 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.

For new construction on application of horizontal to vertical span transition:

1. Vertical to horizontal spans can potentially create conductor clashing in high wind conditions. Do not design vertical-to-horizontal transition (and vice versa) or barre corner construction unless a must for right-of-way or clearance limitation. If easement allows:

    a. If the deviation angle is 60 degrees or less, use double dead-end construction. See DOH DC 580

    b. If the deviation angle is greater than 60 degrees, use line and buck (corner pole) construction.

    c. Install Insulated Overhead Wire Spacers per CO 450

2. If vertical-to-horizontal transition must be used in HFRA, use covered conductor;

3. If covered conductor is not in scope, re-design the existing poles to convert two immediate poles from the vertical pole with box configuration or install two new box configuration poles per DC 586. Reconfigure the vertical pole with the above criteria if easement allows to.

For existing construction on application of horizontal to vertical transition for mitigating conductor clashing – the Long Span Initiative (LSI) used LiDAR to identify at-risk transition spans:

1. If a conductor span is in scope for future covered conductor replacement, consider to accelerate the work order to install covered conductor. Reconfigure the vertical pole if easement allows to:

   a. If the deviation angle on the vertical pole is 60 degrees or less, use double dead-end construction. See DC 580

   b. If the deviation angle on the vertical pole is greater than 60 degrees, use line and buck (corner pole) construction.

   c. Install Insulated Overhead Wire Spacers per CO 450

2. If covered conductor is not in scope, re-design the existing poles to convert two immediate poles from the vertical pole with box configuration or install two new box configuration poles per DC 586. Reconfigure the vertical pole with the above criteria if easement allows.

NOTE

Do not use conductor covering (GreyEEL) to mitigate existing transition poles

D. UG Dips and Risers

The first 8 feet above ground level of a 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. Risers are preferred to be installed using unistrut or powerstrut, for climbing purposes. Alternately, one riser of any size or two 4-inch risers may be installed directly on the pole. (Refer to DUG, Section CR, for details.)

Refer to PO 100.4 for pole step requirements. Review DUG, Section CR, for two-stranded conduit sizes and typical construction requirements. Typical pothead termination requirements are found in DUG, 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 may be used to determine the proper riser size for the various sizes of service and primary cable.

A disconnectable device shall be applied for all dip and riser construction applications where standards exist unless exempted per Table 10–14. Disconnectable devices provide methods to sectionalize and energize underground cable from a dip or riser pole. The benefits of this design are as follows:

- Ferroresonance mitigation (when gang-operated switch applied)
- Simplifies procedures for energizing cable
- Improves reliability by reducing switching time associated with planned and unplanned outages

Where ferroresonance is not an issue, fuseholders with appropriate fuses satisfy the disconnectable requirement. See Table 10–12 for details and options for disconnectable means on branch line dip poles when ferrorresonance is not an issue.

Where ferroresonance is an issue, a gang-operated switch is required as the disconnectable means for all two- and three-cable risers. Potentially ferroresonant transformer connections downstream of the riser pole are defined in ADS–2, Paragraph 5.8 A. and DOM TR-8 Attachment 8-1 Section 5. Where space constraints drive costly changes, or construction standards do not allow for a gang-operated switch to be mounted on the riser pole, the gang-operated switch shall be located no further than three spans from the main line riser pole and with less than or equal to 150 KVA between the switch pole and the potheads on the riser pole on the overhead line section (see Figure 10–5). Where relocating the gang-operated switch from the riser pole introduces greater than 150 kVA of overhead load being dropped other than the intended riser load, see Table 10–12 and apply single cable riser disconnectable means. Follow ferroresonant condition marking requirements in DUG PD 100 Section 2.0, DC 620, and ADS–2, Paragraph 5.8 C.

See Table 10–11 for details and options for disconnectable means on branch line dip poles when ferroresonance is an issue.

See Table 10–12 for details and options for disconnectable means on branch line dip poles when ferroresonance is not an issue.

See Table 10–13 for details and options for disconnectable means on mainline dip and riser poles.

Figure 10–5: Example of Relocation of Switch from Riser Pole on Branch Line

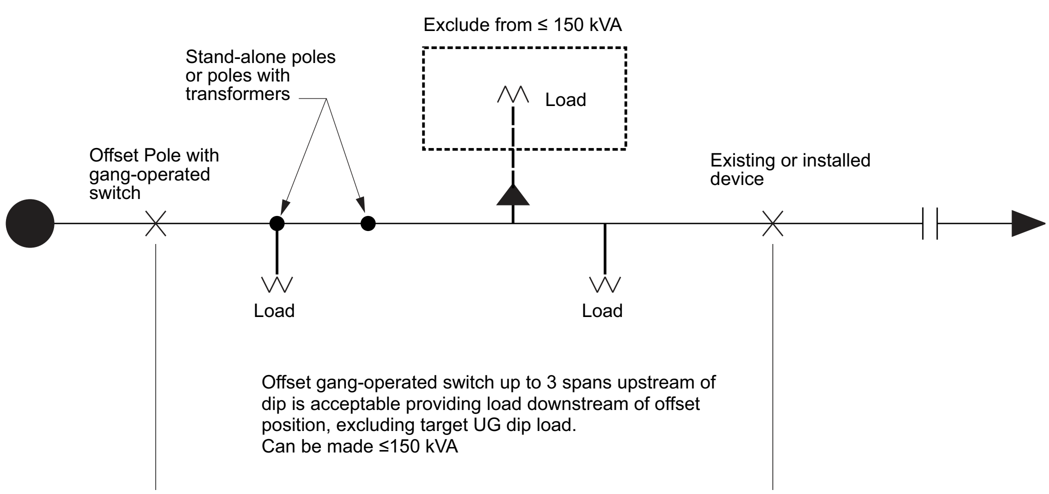
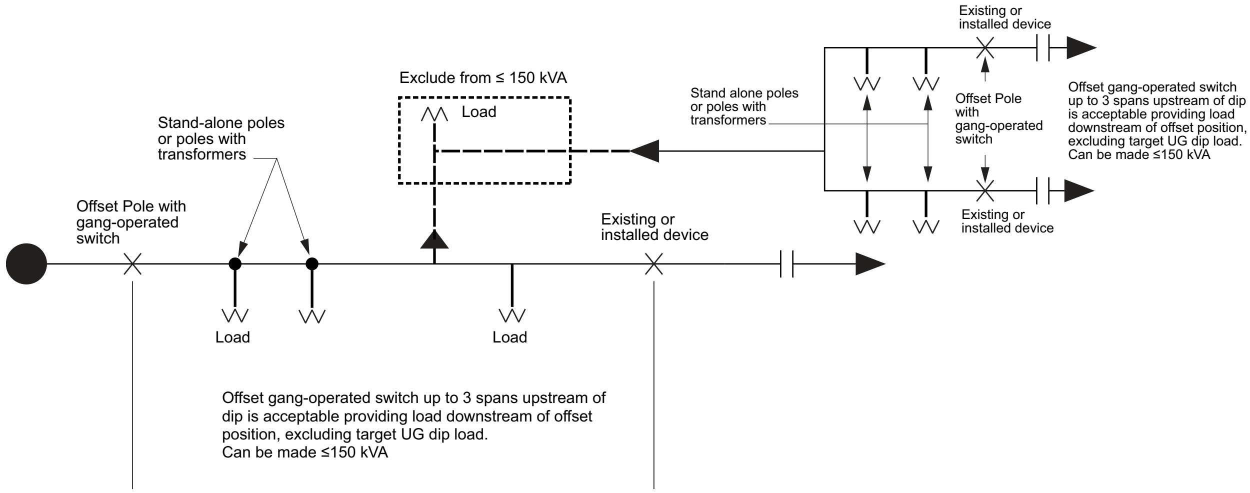


Figure 10–6: Example of Relocation of Switch from Dip or Riser on Main Line



CAUTION

When energizing unfused underground dips, follow DOM TE-2, TE-3 and TE-11 policy statements, for example, gang-operated switches.

When Omni-Rupter® switches are used on mainline riser poles, they shall be installed at a location on the circuit where the mainline Omni-Rupter® switch riser/dip pole is within 10 conductor miles of the nearest underground mainline load-break switch on the circuit.

When Alduti-Rupter® switches are used on mainline riser/dip poles, they shall be installed at a location on the circuit where the mainline Alduti-Rupter® switch riser pole is within one-half conductor mile of the nearest underground mainline load-break switch on the circuit.

Further information is available as follows:

- Details of fusing practices for fused options are found in Paragraph 5.6 K., PR 100, and DUG PD 212
- Construction practices, including cable charging ratings for pole switches, can be found in Paragraph 5.6 L.
- Table 10–11, Table 10–12, Table 10–13 and Table 10–14 (below) provide a summary of disconnectable means on dip and riser poles.

Table 10–11: Disconnectable Means When Ferroresonance Is an Issue

Branch Dip when Ferroresonance is an Issue				
No. of Cables on Dip	**Connections Downstream of Dip**	**Voltage**	**Existing UG**	**Disconnectable Means**
2 or 3	Phase to Phase	4 kV, 12 kV, 16 kV	Load Only	**Alternative 1 (recommended):** Install Gang Operated Omni-Rupter on Dip, See Note 1.
				Alternative 2: Install Gang Operated Omni-Rupter Offset, See Notes 1 & 2.
				Alternative 3: Install Fuses on Dip and Gang Operated Non Fused UG-Switch in UG. Ensure no Phase to Phase load connected between UG Switch and Dip.
				Alternative 4: Install Fuses on Dip and Gang Operated Fused Switch (other than PME5) in UG Providing Coordination Can be Maintained e.g. Fused BURD, Transformers with Coil, Loop, and Coil/Loop Switches. Ensure no Phase to Phase load connected between UG Switch and Dip.
				Alternative 5: Install Fuses on Dip and Gang Operated PME5 in UG Per Note 3. Ensure no Phase to Phase Load connected between UG Switch and Dip.
			Non fused Gang Operated Switch (Non- PME 5) See Note 6.	**Alternative 1 (recommended):** Install Fuses on Dip, See Table 10–12 for fuse recommendations.
				Alternative 2: Install Gang Operated Omni-Rupter on Dip, See Note 1.
				Alternative 3: Install Gang Operated Omni-Rupter Offset, See Notes 1 & 2.
			Fused Gang Operated Switch Including transformers with Coil, Loop, and coil/loop switches (Non-PME 5) See Note 6.	**Alternative 1 (recommended):** Install Fuses on Dip, if coordination can be maintained. See Table 10–12 for fuse recommendations.
				Alternative 2: Install Gang Operated Omni-Rupter on Dip. See Note 1.
				Alternative 3: Install Gang Operated Omni-Rupter Offset. See Notes 1 & 2.
			Fused Gang Operated PME 5 See Note 6.	**Alternative 1 (recommended):** Install Fuses on Dip. See Note 3 and Table 10–12 for fuse recommendations
				Alternative 2: Install Gang Operated Omni-Rupter on Dip. See Note 1.
				Alternative 3: Install Gang Operated Omni-Rupter Offset. See Notes 1 & 2.
		25 kV & 33 kV	Load Only	**Alternative 1 (recommended):** Install Gang Operated Alduti-Rupter.
				Alternative 2: Install Gang Operated Alduti-Rupter Offset. See Notes 1&2.
			Non fused Gang Operated Switch See Note 6.	**Alternative 1 (recommended):** Install Fuses on Dip, See Table 10–12 for fuse recommendations.
				Alternative 2: Install Gang Operated Alduti-Rupter on Dip. See Note 1.
				Alternative 3: Install Gang Operated Alduti-Rupter Offset. See Notes 1 & 2.

Note(s):

1. Fuses may be included as necessary. Gang-operated switch is the disconnectable means for ferroresonance application.
2. Where gang switch on riser cannot be installed, install a gang-operated switch on a nearby pole within 3 spans and overhead load less than or equal to 150 kVA between the gang operated switch and end of line excluding underground beyond subject dip.
3. Where coordination between fusing on the dip and in the PME-5 becomes an issue, see DUG PD 337, Note 8, for information on a solid bar SMU-fuse replacement option for the PME-5.
4. Where alternatives in the table cannot be applied, see Table 10-3. Follow ferroresonant condition marking requirements in DUG PD 100 Section 2.0, DOH DC 620, and ADS–2, Paragraph 5.8 C.
5. See ADS–2, Paragraph 5.8 A. and DOM TR-8 Attachment 8-1 Section 5 for the four conditions that must be present for ferrorresonance to occur, and how to estimate if it is present.
6. No phase to phase load connected between UG switch and dip. Where phase to phase connected load is between existing UG switch and dip, apply "Load Only" solution Alternatives 1 and 2.
7. For voltages other than listed, consult Field Engineering.

Figure 10–7: Branch Dip when Ferroresonance is an Issue — 4 kV 12 kV 16 kV

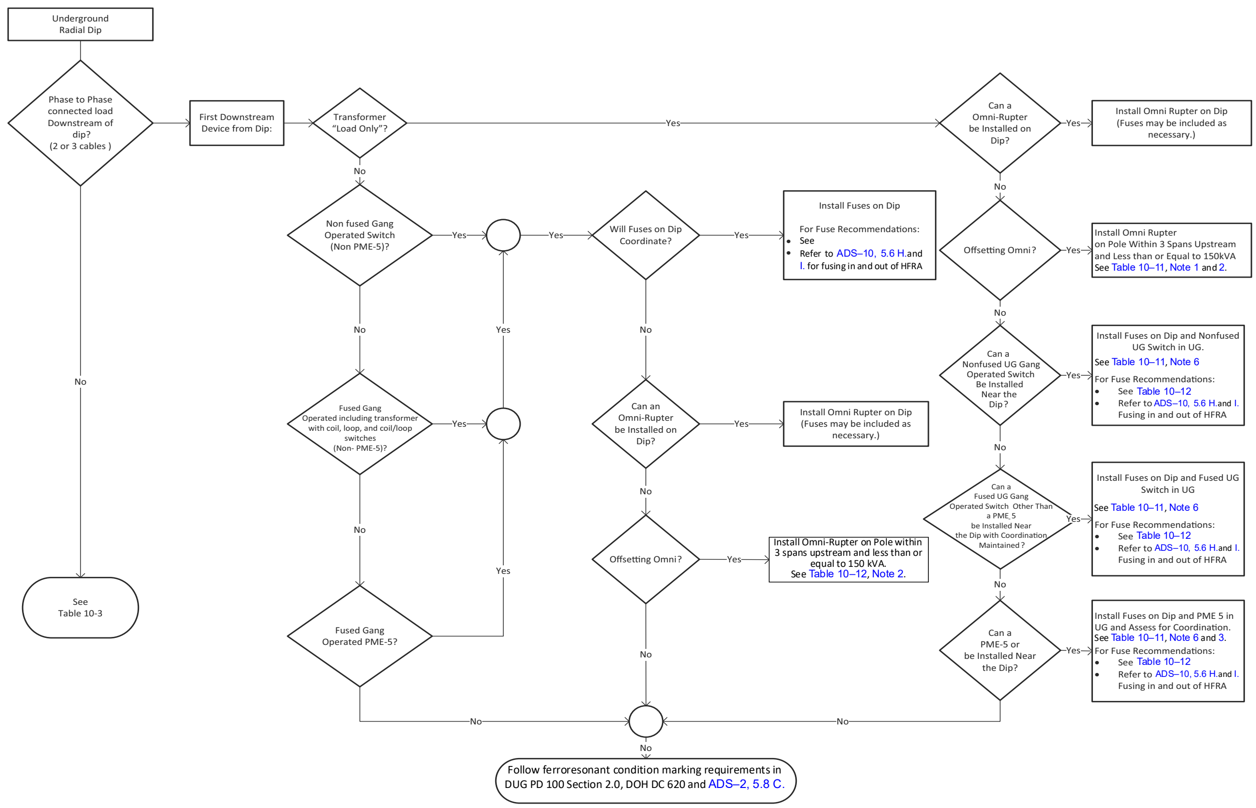


Figure 10–8: Branch Dip when Ferroresonance is an Issue — 25 kV and 33 kV

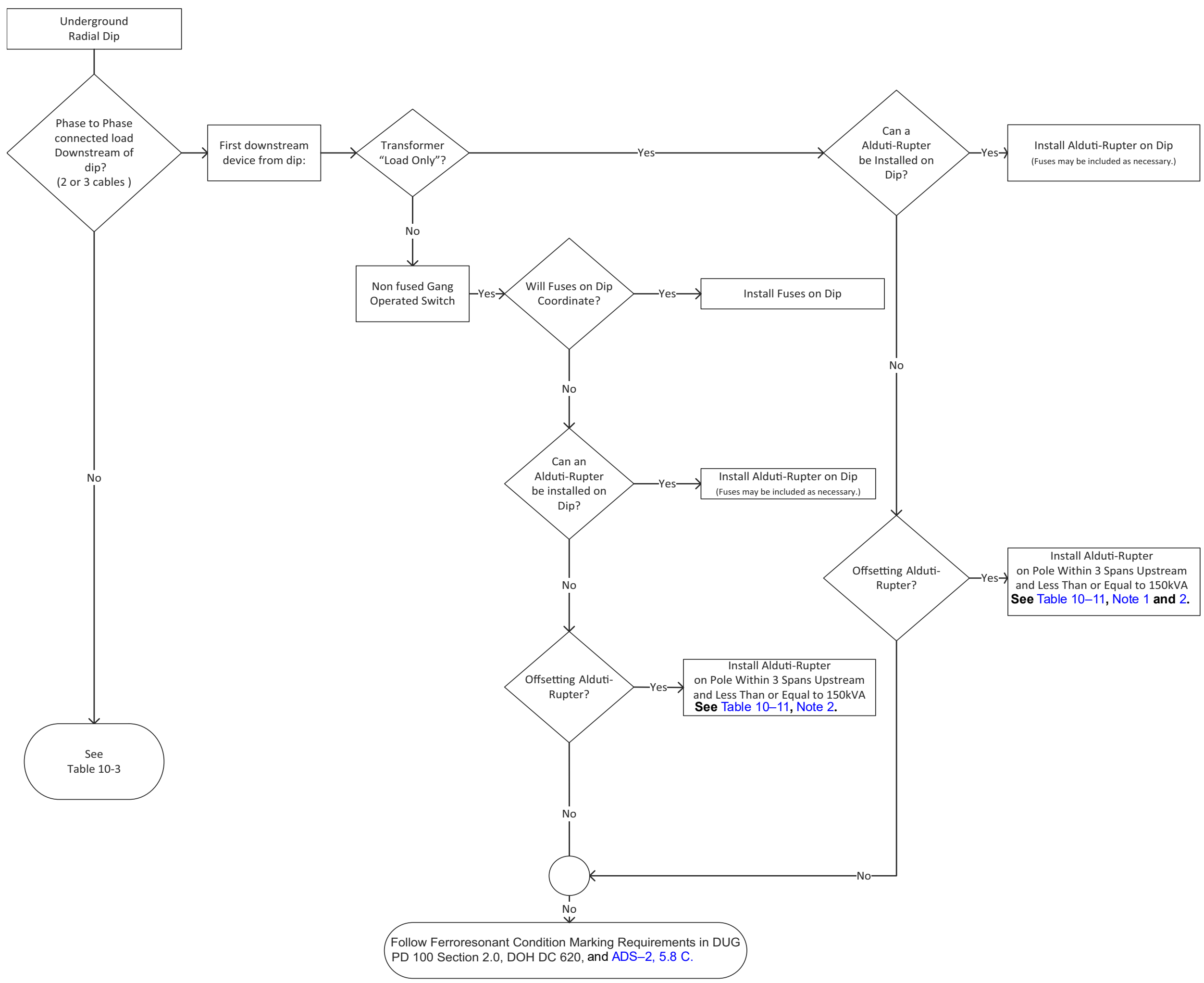


Table 10–12: Disconnectable Means When Ferroresonance Is Not an Issue

Branch Dip when Ferroresonance is not an Issue				
Number of Cables on Dip	**Connections Downstream of Dip**	**Voltage**	**Continuous Current & Short Circuit Duty**	**Disconnectable Means**
1, 2, or 3	Phase-to-Neutral	2.4 kV, 6.9 kV, 9.4 kV, and 14.4 kV	**Alternative 1** **Continuous Current** < 200 A **Short Circuit Duty** < 10 kA	Fuse Holder with Power fuses. See also Note 1. Refer to Paragraph 5.6 H.& Paragraph 5.6 I. for Fusing in and out of HFRA.
			Alternative 2 **Continuous Current** < 80 A **Short Circuit Duty** > 10 kA	Fuse Holder with Current Limiting Fuses. See also Note 1. Refer to Paragraph 5.6 H. & Paragraph 5.6 I. for Fusing in and out of HFRA.
2 or 3	Phase-to-Phase	4 kV, 12 kV, 16 kV	**Alternative 1 (recommended):** Apply Phase-to-Neutral Disconnectable Means from this table.	
			Alternative 2: Install Gang Operated Omni-Rupter on Dip.	
			Alternative 3: Install Gang Operated Omni-Rupter Offset. See Note 2.	
2 or 3	Phase-to-Phase	25 kV & 33 kV	**Alternative 1 (recommended):** Apply Phase-to-Neutral Disconnectable Means From This Table.	
			Alternative 2: Install Gang Operated Alduti-Rupter on Dip.	
			Alternative 3: Install Gang Operated Alduti-Rupter Offset. See Note 2.	

Note(s):
1. Consult Field Engineering where PM/UG phase to phase transformers are fused to ensure proper coordination can be maintained.
2. Where gang switch on riser cannot be installed, install a gang operated switch on a nearby pole within 3 spans and overhead load less than or equal to 150 kVA between the gang operated switch and next switchable device downstream excluding beyond subject dip.
3. For voltages other than listed, consult Field Engineering.

Figure 10–9: Branch Dip when Ferroresonance is Not an Issue — 2.4 kV, 6.9 kV, 9.4 kV, 12 kV, 16 kV, and 14.4 kV

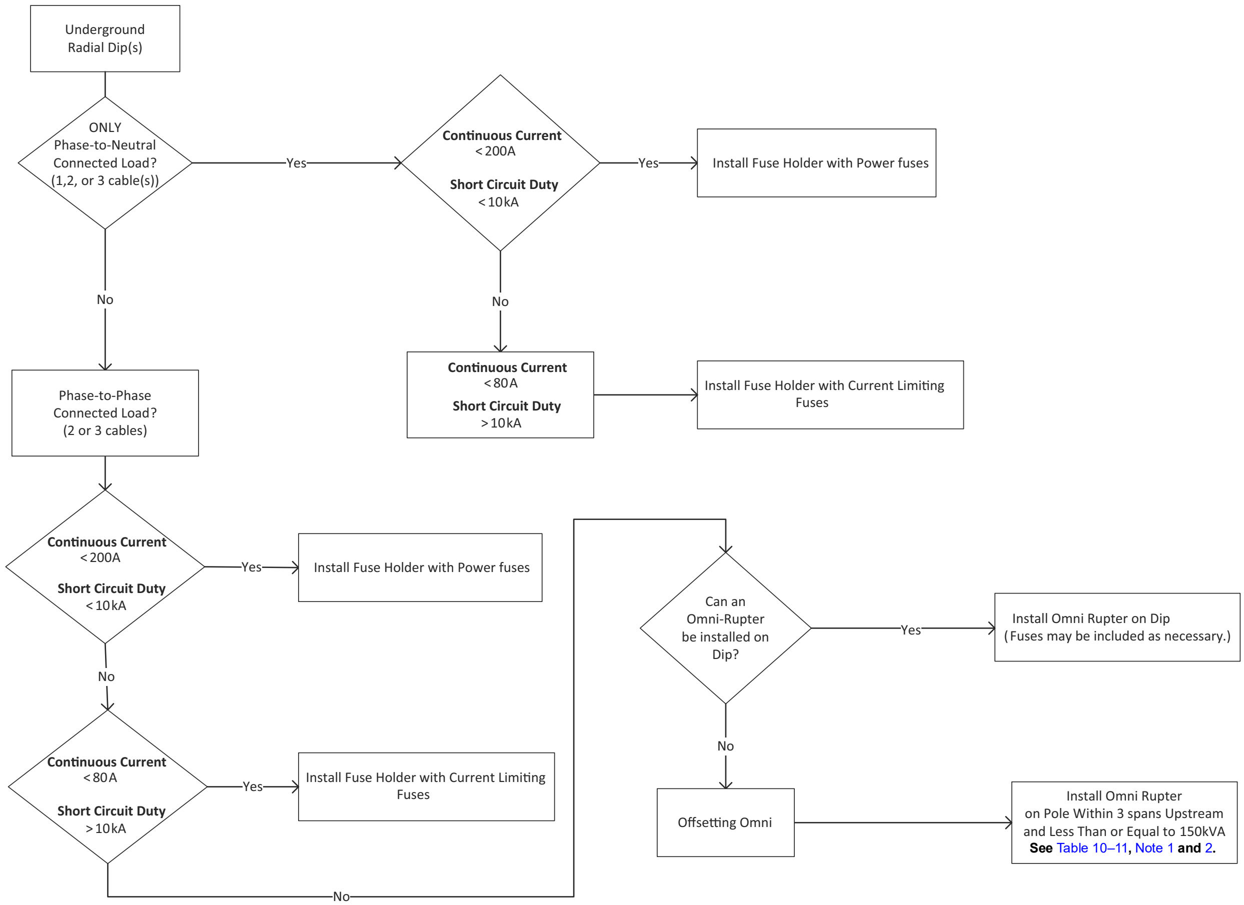


Figure 10–10: Branch Dip when Ferroresonance is Not an Issue — 25 kV and 33 kV

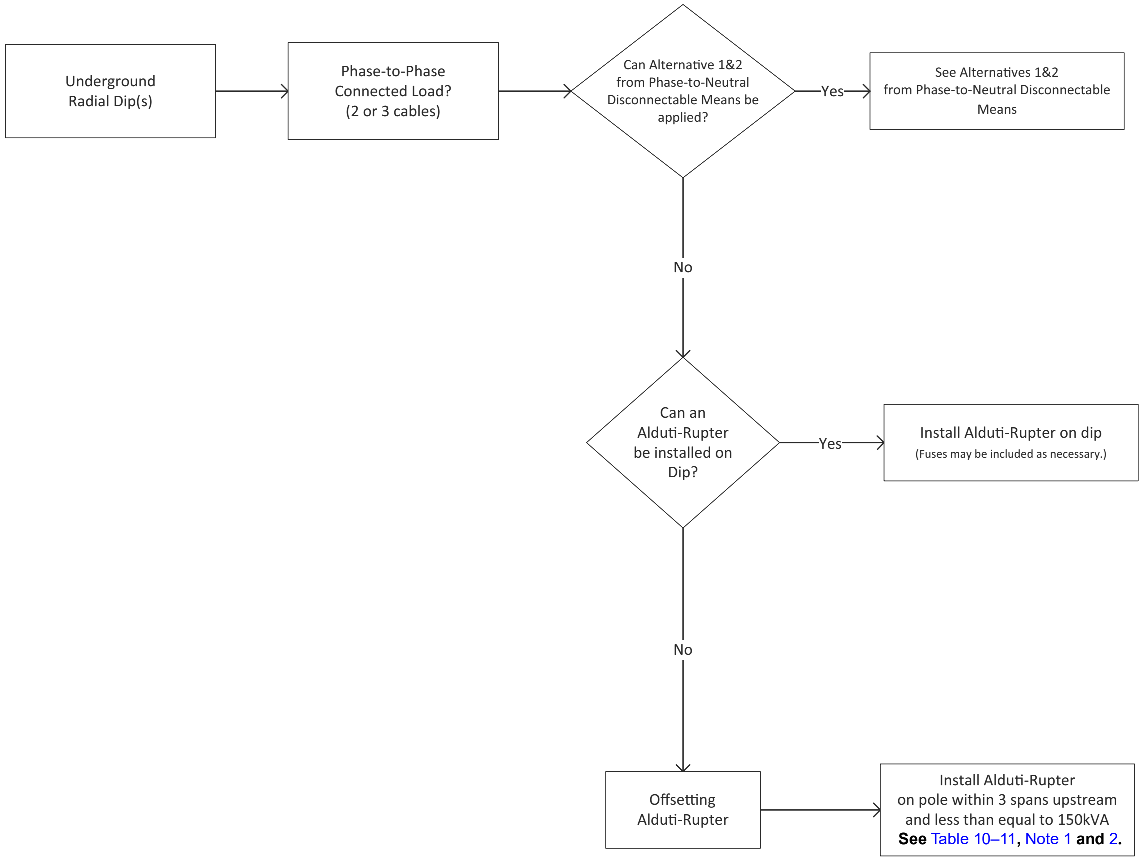


Table 10–13: Disconnectable Means for Mainline Dip or Riser

Number of Cables on Dip/Riser	Voltage	Disconnectable Means
3	4 kV, 12 kV, 16 kV	**Alternative 1 (recommended):** Gang Operated Omni-Rupter
		Alternative 2: Gang Operated Omni-Rupter Offset. See Notes 1, 2, 3
	25 kV, 34,5 kV	**Alternative 1 (recommended):** Gang Operated Alduti-Rupter
		Alternative 2: Gang Operated Alduti-Rupter Offset. See Notes 1, 2, 3

Note(s):

1. Gang operated switch is the disconnectable means for mainline dip or riser application.
2. Where gang switch cannot be installed on dip, install a gang operated switch on a nearby pole within 3 spans line side of dip with overhead load less than or equal to 150 kVA between the gang operated switch and next switchable device downstream excluding underground beyond subject dip. See Figure 10–6.
3. Where gang switch cannot be installed on riser, install a gang operated switch on a nearby pole within 3 spans load side of riser with overhead load less than or equal to 150 kVA between the gang operated switch and the riser. Where branching occurs between the riser and the offset gang operated switch, an existing or new gang operated switch shall support the less than or equal to 150 kVA requirement. See Figure 10–6.

Table 10–14: Exemption Summary for Disconnectable Means

Case	Exemption from Disconnectable Means on Dip/Riser Pole	
1	Disconnectable means is not required when construction standards do not exist to support field conditions.	Where DUG TP and DAP do not provide standard construction methods for disconnectable means. e.g. two vertical three phase circuits transition from OH-UG.
2	Disconnectable means is not required when field conditions do not support disconnectable means on a pole.	Where exceptional cost and/or difficulty is encountered in order to apply disconnectable means e.g. backyard, wilderness, urban congestion.
3	Disconnectable means is not required on risers when branchline or mainline have no tie.	Where branchlines or mainline have no tie, disconnectable means are to be applied to all dips. Risers are not required to have a disconnectable means
4	Disconnectable means is not required if fuses only option when branchline dip/riser coordination issue exists.	When fuses are the only option for disconnectable means and coordination with upstream and downstream protection devices[a/] can not be achieved.

[a/] Fuses, RARs, CBs and so on.

E. 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 detailed below.

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 SCE contract work within national forestlands, 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.

F. 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.

G. 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.

H. 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:

- Expulsion fuses (SMU-20 and fuse links)
- Current-limiting fuses (ELF, Fault Tamer®, Valiant 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 4–10 and Figure 4–11.

The application of overhead branch-line fusing on distribution circuits shall be limited to selected locations, and requires Field Engineering (FE) approval. Contact FE for all branch-line fusing applications and selection.

The types of fuses (by voltage classification) to be installed on overhead distribution systems are shown in Table 10–17. Note that the table differentiates between areas located inside and outside high fire risk areas.

I. Fusing Application in High Fire Risk Areas (HFRA)

Current-limiting fuses are the preferred option for fusing in HFRA.
See Table 10–22: Fuse Prioritization in High Fire Risk Areas (HFRA).

SMU-20 fuses are also approved for use in HFRA. When the loading current exceeds the maximum current-carrying ability of current-limiting fuses, the SMU-20 fuse may be used. SMU-20 fuses are also the only approved fusing option for capacitor banks, regardless of whether they are located in HFRA, or in non-HFRA.

Refer to DOH, DC 605, for overhead construction line requirements in HFRA.

J. Fusing Applications

For information on fusing applications based on economic preferences, see Table 10–15.

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:

   ❶ Fault duty must be below 7500 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 and load rolling.

   ❷ 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.

   ❸ 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.

   ❹ For exceptions, contact FE for certification that fault duty is less than 7500 A.

   Maximum ampere rating is 100 A. (SMU-20 is available for requirements above 100 A.)

   The open-style fuse cutout is **not approved** for use in HFRA.

2. Fault Tamer® (3 A – 20 A) — 12 kV, 16 kV and 14.4/25 kV Systems

   Fault Tamer® combines a fuse cartridge with a 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.

The Fault Tamer® can be installed as follows:

❶ In Non-HFRA, on 12 kV and 16 kV overhead distribution transformers, and on single-phase 25 kV (14.4 kV-to-ground) transformer applications 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®.

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 system voltages of 4.8 kV and lower for overhead distribution circuits, including high fire risk areas, and in fusing applications where current limitation is desired.

The **15 kV ELF fuse** can be installed as follows:

❶ Anywhere on 12 kV and 16 kV overhead distribution circuits, and on single-phase 25 kV (14.4 kV-to-ground) applications, including high fire risk areas.

❷ 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®.

❸ 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 a 14.4 kV nominal/17.2 kV maximum version, a 25 kV version, and a 34.5 kV version. All versions of the SMU-20 can be used in HFRAs. . 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 systems for single phase application (14.4 kV), up to a maximum fault duty of 14,000 A (symmetrical).

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, up to a maximum fault duty of 12,500 A (symmetrical). This is legacy item is only used in a few pad-mounted transformer installations. All new three-phase transformer installations or new three-phase or phase-to-phase branch line installations in the 25 kV system should use the 34.5 kV version of the SMU-20 fuse.

The SMU-20 34.5 kV fuse is used on the 33 kV system, up to a maximum fault duty of 10,000 A (symmetrical). The 34.5 kV SMU-20 is also the only fusing option in the 25 kV system for three-phase transformer fusing, and for three-phase and phase-to- phase branch line fusing.

SMU-20 fuses can be installed as follows:

1. The 14.4 kV version of the SMU-20 fuse can be used anywhere on the 2.4 kV, 4.16 kV, 4.8 kV, 12 kV, 16 kV, and in 14.4 kV single-phase (phase-to-ground connected) applications on the 25 kV system, including HFRA where the maximum fault duty is 14,000 A (symmetrical).
2. The 25 kV version SMU-20 fuse is to be used on 25 kV delta to wye pad-mounted transformer banks. It can be used in HFRAs, and has an interrupting capability of 12.5 kA system.
3. The 34.5 SMU-20 is also the only fusing option in the 25 kV system for new 25 kV three-phase transformer fusing, and for three-phase and phase-to- phase branch line fusing. It has an interrupting capability of 10 kA.

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 DOH, Section PR 134.

5. X-Limiter / Valiant — 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 Valiant is a full-range current limiting fuse and is available in sizes from 10 A to 50 A.

The X-Limiter and Valiant fuses can only be mounted in an SMD-20 fuse holder. The X-Limiter and Valiant fuses are approved for use in HFRAs. This type of installation is the most expensive option.

The X-Limiter and Valiant can be installed as follows:

1. Anywhere on 12 kV and 16 kV overhead distribution circuits and on single-phase 25 kV (14.4 kV-to-ground) applications, including HFRA.
2. 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 & Valiant should be compared with other options; for example, fuse cabinets, PME w/CL fuse compartments, and BURD/pad-mounted fused switches.
3. On underground dips, consult with FE for exceptions.

6. Liquid Replacement Fuses

Cooper Power ELF-LR or the Bushman-type “LRB” fuse (formerly, FDSH-type) is the replacement fuse for Size One (1) 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 DOH, PR 127.

7. Liquid Fuse Size 3 and Size 4

   Size 3 and 4 liquid fuses are no longer available. Replacement of Size 3 or Size 4 liquid fuses and fuseholders must be performed in accordance with this manual.

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 maximum current of the installation will exceed the 80A maximum fuse size of the X-Limiter and Valiant, and 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 7500 A.

Table 10–15: Transformer Fusing Selection in Non-HFRAs Listed in Order of Economic Preference ***(Sheet 1 of 2)***

Voltage Class: 4 kV	Mounting Type	MAX Fault Duty Symm. (Amp)	Current Limiting	Remarks
1. Open-style fuse cutout (1 A–100 A)	15 kV open-style universal cutout	6,250	No	Preferred
2. Enclosed cutout (1 A–100 A)	Enclosed (box-type) cutout	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	31,000	Yes	The only current-limiting fuse that can be used in 4 kV systems.
4. SMU-20 (3 A–200 A)	SMD-20	14,000	No	Non–current-limiting expulsion fuse. Used for 4 kV branch-line fusing and in HFRA.

Voltage Class: 12 kV and 16 kV	Mounting Type	MAX Fault Duty Symm. (Amp)	Current Limiting	Remarks
1. Open-style fuse cutout (1 A–100 A)	27 kV open-style universal cutout	7,500	No	Preferred
2. Fault Tamer® (3 A–20 A)	27 kV open-style universal cutout	14,000	Yes	Used as replacement for liquid and SMD-20 fuses in HFRA, for load requirements up to 20 A.
3. 15 kV ELF fuse (6 A–50 A)	27 kV open-style universal cutout	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	14,000	No	Non–current-limiting expulsion-type.
5. X-Limiter (10 A–100 A) Valiant (10 A–50 A)	SMD-20	43,000	Yes	Used to replace SMU-20 expulsion fuse to current limiting in SMD-20 fuse holder, where fault duty exceeds 10,000 A rating for load-break elbow application.

Table 10–15: Transformer Fusing Selection in Non-HFRAs Listed in Order of Economic Preference *(Sheet 2 of 2)*

Voltage Class: 25 kV	Mounting Type	MAX Fault Duty Symm. (Amp)	Current Limiting	Remarks
1. Open-style fuse cutout (1 A–100 A)	27 kV open-style universal cutout	7,500	No	Preferred
2. Fault Tamer® (3-20A)	27 kV open style universal cutout	14,000	Yes	Single-phase 14.4 kV phase-to-ground applications. Used in HFRA for load requirements up to 20 A.
3. ELF fuse (6 A–50 A)	27 kV open-style universal cutout	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)	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	14,000	No	The 14.4 kV SMU-20 fuse is used for single-phase 14.4 kV phase- to-ground transformers and single-phase (phase-to-ground) branch line fusing applications. The 25 kV SMU-20 fuse is to be used on delta-wye pad-mounted transformer banks. Non–current–limiting expulsion-type. The 34.5 kV SMU-20 fuse is used for fusing new three-phase transformers in the 25 kV system, and for three-phase and phase-to-phase branch lines.
6. X-Limiter (10 A–100 A) Valiant (10 –50 A)	SMD-20	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 fuse holder, where fault duty is in excess of 10,000 A.

Voltage Class: 33 kV	Mounting Type	MAX Fault Duty Symm. (Amp)	Current Limiting	Remarks
1. SMU-20 (3 A–125 A)	38 kV SMD-20	10,000	No	Expulsion-type. Used where fault duty is 10,000 A or less.
2. SMD-1A (3A–200 A)	38 kV SMD-1A	17,500	No	Expulsion-type. Used where fault duty is more than 10,000, but less than 17,500 A.

Table 10–16: Branch Line Fusing Selection for Non-HFRA

System Voltage	Power Fuse and Fuse Holder	Power Fuse Maximum Ampere Rating and Interrupting Rating	Power Fuse Holder	Current Limiting Fuse and Fuse Holder [a/]
4.8 kV and Lower	14.4 kV SMU-20	Available up to 200A. For Fault Duties up to 14 kA.	SMD-20	8 kV ELF, in 15 kV Universal Cutout. Available up to 80A. Use only for Fault Duties > 14 kA. See Note 2.
12/16 kV	14.4 kV SMU-20	Available up to 200A. For Fault Duties up to 14 kA.	SMD-20	X-Limiter/Valiant in SMD-20 Fuse Holder. Available up to 100A. Use only for Fault Duties > 14 kA
14.4/25 kV Single-Phase to Ground Branch	14.4 kV SMU-20	Available up to 200A. For Fault Duties up to 14 kA.	SMD-20	X-Limiter/Valiant in SMD-20 Fuse Holder. Available up to 100A. Use only for Fault Duties > 14 kA
14.4/25 kV Phase-to-Phase and Three-Phase Branch Lines	34.5 kV SMU-20	Available up to 100A. For Fault Duties up to 10 kA.	34.5 kV SMD-20	No Current-Limiting Fuse Options Available
34.5 kV	34.5 kV SMU-20	Available up to 100A. For Fault Duties up to 10 kA.	34.5 kV SMD-20	No Current-Limiting Fuse Options Available

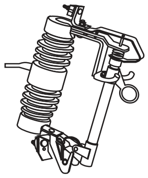
Note(s):

1. This table does not apply to HFRA fuse selection. For HFRA fuse selection, refer to Table 10–22.
2. Refer to DOH PR 107 for SAP numbers.
3. For current-limiting fusing in 4.8 kV and lower voltage systems, use only the 8 kV ELF fuses. Do not use the X-Limiter fuses, Valiant fuses, 15 kV ELF fuses, or the Fault Tamer in 4.8 kV and lower voltage systems.
4. Every SMU-20 fuse listed above can be used both HFRAs and in non-HFRAs.
5. Due to possible coordination issues with downstream transformer fusing, current-limiting fuses should only be used in non-HFRA branches where the fault duty exceeds the interrupting capability of the SMU-20 power fuse.

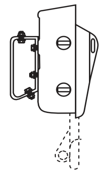
[a/] Use only for areas where fault duties are too high for power fuses.

Figure 10–11: Overhead Distribution Transformer Fuses

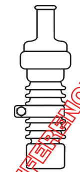
Figure Note: (The footnote references below are clickable. The footnotes themselves are located in Table 10–17.)



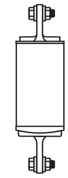
15 kV Open Cutout
See DOH, Table PR 107-1
(See Footnotes [b/], [d/], and [j/].)



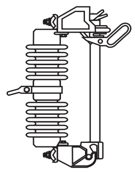
4.8 kV Enclosed Cutout
See DOH, Table PR 107-1
(See Footnotes [b/] and [c/].)



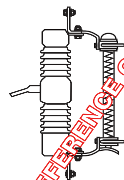
4.8 kV Bayonet Cutout
(Key 06)



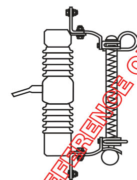
8.3 kV CLD
See DOH, Section PR-126
(See Footnote [e/].)



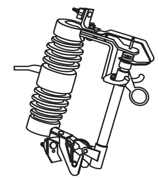
See DOH, Table PR 107-3
14.4–17 kV SMU 20
(See Footnotes [b/] and [h/].)



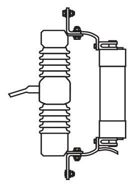
14.4 kV Liquid Fuse (#1)
(KEY 06)



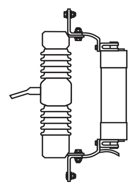
14.4 kV Liquid Fuse
(KEY 06)



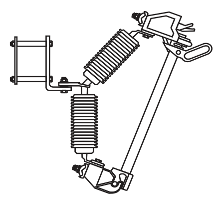
27 kV Open Cutout
for use on 12/16/25 kV
See DOH, Table PR 107-1
(See Footnotes [b/] and [j/].)



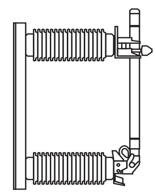
20.5 kV LR Fuse (Kearney)
for use on 12/16/25 kV
(KEY 06)
(See Footnote [i/].)



23 kV LRB Fuse (Bussman)
for use on 12/16/25 kV
See DOH, Section PR 127
(formerly FDSH)
(See Footnote [i/].)



34.5 kV SMU 20
See DOH, Table PR 107-7
(See Footnotes [b/], [n/], and [q/].)



34.5 kV SMD 1A
See DOH, Table PR 107-8
(See Footnote [b/].)

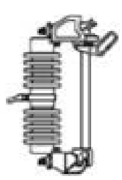
27 kV Cutout with ECD
See DOH, Table PR 107-1
(See Footnote [p/].)

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 Footnotes [b/] and [l/].)

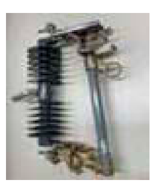
15 kV ELF Fuse
6 A to 50 A
See DOH, Table PR 107-5
(See Footnote [m/].)

8 kV ELF Fuse
6 A to 80 A
See DOH, Table PR 107-2
(See Footnote [f/].)

17 kV X-Limiter Fuse
10 A to 100 A
See DOH, Table PR 107-6
(See Footnote [n/].)



25 kV SMU-20
See DOH, Table PR 107-3
and PR 107-7
(See Footnote [b/].)



Stainless Steel Polymer
27 kV Open Cutout
for use on 12/16/25 kV
See DOH PR 129
(See Footnote [k/])

17 kV Valiant Fuse
10 A to 50 A
See DOH, Table PR 107-6
(See Footnote [n/].)

Table 10–17: Fuse Applications

Fuse Applications by Voltage[a]			
2.4/4.16/4.8 kV	**7/12/16 kV**	**14.4/25 kV**	**33 kV**
• Enclosed cutout[b/,c/] • Bay-O-Net cutout (Key 6) • Open cutout[b/,d/] • CLDs[e/] • 8 kV ELF fuse[f/] • 14.4 kV SMU-20[g/]	• 14.4 kV SMU-20[b/,h/] • CLDs[e/] • LR fuse or LRB fuse[i/] • Open cutout[b/,j/,k/] • Fault Tamer®[b/,l/] • 15 kV ELF[m/] • X–limiter / Valiant [n/] • Liquid fuse (Key 6)[o/]	• 14.4 kV SMU–20 [b/,h/, p/] • 25 kV SMU-20 [b/] • 34.5 kV SMU–20 [b/, p/] • Open cutout [b/, j/, k/] • Cutout with ECD [q/] (Key 6) • 15 kV ELF[m/] • X–limiter / Valiant [n/ , p/] • Liquid fuse (Key 6) [o/] • Fault Tamer®[b/ , l/]	• 34.5 kV SMU–20 Up to 500 MVA duty[b/,r/] • SMD–1A Over 500 MVA duty[b/] • CLD[e/]
Fuse Applications in High Fire Risk Areas (HFRA) Firebreak clearing around poles is not required for poles with all exempt equipment and material. Refer to DOH, Section DC. Exempt fuses include liquid, SMU-20, CLD, LR, FDSH, Fault Tamer®, X-Limiter, Valiant, ELF, and ECD cutout designs. Nonexempt fuses include open cutout, enclosed cutout, Bay-O-Net cutout, and SMD-1A designs.			

Note(s):

1. It is acceptable for both porcelain and polymer cutouts and/or fuse holder holders to be on the same pole.
2. When installing a new cutout or fuse holder, use the new end fittings supplied with the new cutout or fuse holder.
3. Polymer 27 kV Universal Cutouts and Polymer SMD-20 fuse holders functionally equivalent to the porcelain 27 kV Universal Cutouts and porcelain SMD-20 fuse holders, and may be used anywhere that the porcelain cutouts and porcelain SMD-20 fuse holders are used.

a/ Fuse sizes for each type of installation are shown in the fuse tables (DOH, Section PR).

b/ Do not leave fuse hanging in the holder in an open position. Moisture may enter through the exhaust end and damage the fuse.

c/ For use on 4 kV or 4.8 kV on congested poles (limited vertical space).

d/ 4.16 kV through 14.4 kV rated, but limited to use on 4 kV and 4.8 kV systems.

e/ Refer to DOH, Section PR, for CLD application.

f/ 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.

g/ For use in HFRA in 2.4/4.16/4.8 kV systems where current limitation is not required, and in 4.16 kV branch-line fusing.

h/ 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.

i/ Refer to the DOH, Section PR, for LR and FDSH fuse application.

j/ Restricted to non-HFRAs where the available fault current does not exceed 7500 A (sym).

k/ The stainless steel polymer 27 kV Universal Cutout is intended for use in coastal environments (within 1 mile of the ocean), but is also approved for use in non-coastal (inland) environments. This cutout is for use on 12 kV, 16 kV and 25 kV (single-phase, 14.4 kV line-to-ground) overhead systems (SAP 10215071).

l/ Includes open cutout mounting. For 12 kV, 16 kV, and 14.4/25 kV systems where the available fault current is above 7500 A (sym). Refer to DOH, Section PR.

m/ 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.

n/ The X-Limiter & Valiant are current-limiting fuses designed specifically for use in an SMD-20 mounting (SAP 10107506).

o/ 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.

p/ The 14.4 kV SMU-20, Valiant and X-Limiter are not approved for three-phase and phase-to-phase branch-lines or three-phase transformers in the 25 kV system. Use the 34.5 kV SMU-20 fuse for 25 kV three-phase transformers and branch lines that are three-phase and phase-to-phase.

q/ 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. The ECD is no longer manufactured.

r/ Use fuse adapter (SAP 10107599) when using newer type SMU-20 fuses on old 34.5 kV SMD-20 fuseholder (SAP 10107515 – Key 6).

Current-limiting devices shall be used when installing 12 kV 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, Section PR, for details of 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, Section DC.

More detailed information on overhead fusing requirements for 4 kV through 33 kV are described in DOH, Section PR. Bulletin 22 fusing is also included in DOH, 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

Arrowhead	Fullerton	Montebello	Santa Ana	Thousand Oaks
Catalina	Huntington Beach	Ontario	Santa Barbara	Valencia
Compton	Kernville	Redlands	Santa Monica	Ventura
Covina	Long Beach	Saddleback	South Bay	Whittier
Foothill	Monrovia	San Joaquin	Tehachapi	

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 distribution pole tops
- 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	Blythe	Ridgecrest	Wildomar
Barstow	Menifee	Shaver Lake	Yucca Valley
Bishop	Palm Springs	Victorville	

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 reclosers, sectionalizers, remote-controlled switches (RCS), PE gears, capacitor banks, and distribution pole tops
- All overhead transformer 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 FE 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. For details, refer to DOH, Section AC.

   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 DOH, Section GR.

5. Covered Conductor

Surge Arresters shall be installed on all equipment in the following list, regardless of whether the covered conductor is located in Low/Medium Lightning density areas, or in High Lightning-Density areas. The specific equipment that must have arresters when installed in a covered conductor system are:

- Remote Automatic Reclosers (RARs)
- Remote Sectionalizing Reclosers (RSRs)
- Capacitors
- Line Voltage Regulators
- Potential Transformers (PTs) associated with Remote Control Switches (RCS)
- PTs associated with Overhead Preferred Emergency (PE) Equipment
- Overhead Transformers (All installations)
- Branch Line Fusing installations
- All underground dips from overhead lines must have arresters installed.

When installing covered conductor, if an MOV arrester is at the location, it can remain on the pole. If a Silicon Carbide arrester is at the installation, remove it, and replace it with an approved arrester. For identification of Silicon Carbide arresters, See DAP, AP 405 (Surge Arrester Identification).

Cal-Fire Exempt Surge Arresters are to be used in High Fire Risk Areas (HFRA) for covered conductors (DAP AP 415). Refer to ADS–10, Table 10–19: Cal-Fire Exempt MOV-Type Surge Arrester for Distribution Applications in HFRA for applicable SAP codes. Use standard distribution arresters in non-HFRAs. Refer to ADS–10, Table 10–18: MOV-Type Surge Arresters for Distribution Applications for applicable SAP codes.

Table 10–18: MOV-Type Surge Arresters for Distribution Applications

Standard Distribution Arresters			
Circuit Voltage (kV)	**Nominal Arrester Rating (kV)**	**MCOV Rating (kV)[a/]**	**SAP (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

Note(s):
1. Use 18-kV–rated arresters on the 16/9.5 and 16 kV circuits; use 15-kV–rated arresters on 12/6.9 and 12 kV circuits.
2. In animal-problem areas use Wildlife Protector (SAP 10067758.)
3. For overhead and underground (riser pole) installations, refer to DAP; and DUG, Section TP 209.

[a/] MCOV—maximum continuous operating voltage (applied to a MOV arrester)

Table 10–19: Cal-Fire Exempt MOV-Type Surge Arrester for Distribution Applications in HFRA

Circuit Voltage (kV)	Nominal Arrester Rating (kV)	MCOV Rating (kV)[a/]	SAP (Polymer Housing)
2.4 and 4.16 / 2.4	3	2.6	10210904
4.8	6	5.1	10210905
7.2	9	7.7	10210906
12 / 6.9 and 12	15	12.7	10210907
16 / 9.5 and 16 and 24.9 / 14.4	21	17	10210909
33	42	34	10210910

Note(s):

1. This Cal-Fire Exempt Surge Arrester is installed exactly the same way as standard distribution arresters. All individual surge arrester standards apply to these arresters. Refer to specific construction standards in the DOH and DUG manuals.
2. In animal-problem areas use Wildlife Protector (SAP 10067758).
3. For overhead and underground (riser pole) installations, refer to DAP; and DUG, Section TP 209.

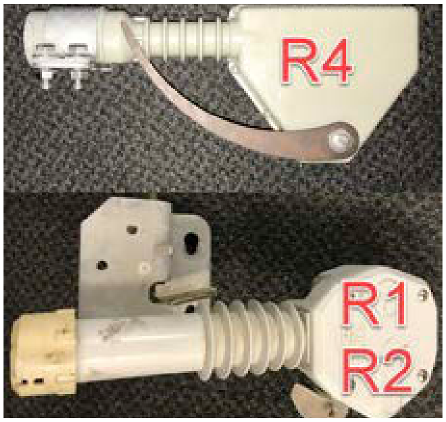
[a/] MCOV—Maximum continuous operating voltage (applied to a MOV arrester).

M. Pole Switches and Disconnects

Eighteen types of overhead line switches are used on the 4 kV, 12 kV, 16 kV, and 33 kV systems. Refer DAP AP 300 Table 300-1 for a complete listing of group operated load break switches and their ratings. Construction practices and switch illustrations may be found in DAP. Refer to DAP AP 336, AP 338, and AP 340 for construction standards applicable to group operated air break switches.

1. The Omni-Rupter® load-break switch can be installed on 4 kV, 12 kV and 16 kV systems. The Omni-Rupter® load-break switch is available in horizontal (single-arm), vertical (three-arm) and DIP configurations. The horizontal arrangement is the most economical configuration to install. The Omni-Rupter® switch is rated 600 A continuous and load interrupting, with a 25 kA momentary symmetrical fault rating (1 second). The R1/R2 Type Omni-Rupter® switch vintages are is considered exempt equipment (refer to Power Line Fire Prevention Field Guide) in regards to high fire risk areas (HFRA). and clearing a firebreak around the pole is not required. R4 Omni-Rupter switch vintages are not considered exempt equipment. R1, R2 and R4 Omni-Rupter vintages can be visually identified by the type of interrupter that is attached to each phase's switch unit. See Figure 10–12. 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 10–38 for conductor tensions.

Figure 10–12: Omni-Rupter Interrupters



Note(s):

1. R4 is non-exempt.
2. R1/R2 is exempt.

The Omni-Rupter® switch has the following applications:

- Ability to switch unloaded underground cable charging current up to 20 A, approximately equivalent to switching 10 miles of unloaded underground 1000 kcmil cable. See ADS–9, Table 9–15: Typical Underground Cable Charging Current per Unit Length for typical cable charging currents.
- Mainline and branch-line riser pole switching applications. (See Paragraph 5.6 D.)
- Ability to switch ferroresonant cable and transformer systems.
- Ability to switch unloaded overhead line charging current up to 10 A.
- Ability to switch at system parallel locations.
- Ability to drop up to 900 A load during emergency conditions such as when SCE is called upon by the ISO to drop load.
- The Omni-Rupter® switch can be automated for RCS applications on 16 kV systems and below.

The Omni-Rupter® switch should not be installed to switch a capacitor bank or function as an RCS-G switch. Refer to Distribution Apparatus Construction Standards (DAP), for Omni-Rupter® load-break switch construction standards.

2. The Altuti-Rupter® load-break switch can be installed on 25 kV and 33 kVsystems. The Alduti-Rupter® load-break switch is available in horizontal (single-arm) and vertical (three-arm) configurations. The horizontal arrangement is the most economical configuration to install. The Alduti-Rupter® switch is rated 600 A continuous and load-interrupting, with 25 kA momentary symmetrical fault rating (3 seconds). The Alduti-Rupter® switch is considered *non-exempt equipment*.

   Therefore, if the switch is to be installed in a HFRA, a firebreak clearing around the pole is required. Refer to DOM, 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.

   The Alduti-Rupter® switch has the following applications:

   - Ability to switch ferroresonant cable and transformer systems

- Ability to switch unloaded cable current up to 17.6 A or approximately up to four miles of unloaded 1500 kcmil cable. See ADS–9, Table 9–15: Typical Underground Cable Charging Current per Unit Length for typical cable charging currents.
- Mainline and branch-line riser pole switching applications. (See Paragraph 5.6 D.)
- Ability to switch at system parallel locations

3. The LineBOSS™ load-break switch can be installed on 12 kV and 16 kV systems. The LineBOSS™ load-break switch is available in a horizontal (single-arm) configuration. The LineBOSS™ switch is rated 600 A continuous and load interrupting, with a 31.5 kA momentary symmetrical fault rating. The LineBOSS™ switch is considered non exempt equipment (refer to Power Line Fire Prevention Field Guide) in regards to high fire risk areas (HFRA) and clearing a firebreak around the pole is required. The LineBOSS™ switch has the following applications:

   - Ability to switch unloaded underground cable charging current up to 26 A, approximately equivalent to switching 14 miles of unloaded underground 1000 kcmil at 16 kV cable. See ADS–9, Table 9–15: Typical Underground Cable Charging Current per Unit Length for typical cable charging currents.
   - Ability to switch ferroresonant cable and transformer systems.
   - Ability to switch unloaded overhead line charging current up to 6.2 A.
   - Ability to switch at system parallel locations.
   - Ability to drop up to 600 A load during emergency conditions such as when SCE is called upon by the ISO to drop load.
   - The LineBOSS™ switch can presently be automated for RCS applications.
   - The LineBOSS™ switch should not be installed to switch a capacitor bank or function as an RCS-G switch.
   - Refer to Distribution Apparatus Construction Standards (DAP), for LineBOSS™ load-break switch construction standards.

4. Single-arm, horizontal group operated switches are to be used wherever possible, as they are the most economical to install. KPF switches are for reference only and shall not be used for new installations. All other types are designed for special applications.

   a. Single-arm horizontal group-operated 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.

      Use the following considerations for installing or retrofitting switches mounted below the line arm:

      1) Dead-end the supply conductors directly to the switch for bypass switch applications with automatic recloser (AR) installations. Refer to DAP AP 502 and AP 510, for overhead RAR construction details.

      2) For switch replacement, it is acceptable to install the switch below the line arm if the existing switch is installed below the line arm.

3) Where a pole and crossarm are being replaced, or in urban areas where existing or future facilities are installed on poles, the preferred construction shall dead-end the line terminations to the switch.

4) In rural areas, below line arm construction is recommended for switch installation, provided the existing line crossarm is not deteriorated nor requires replacement within 5 years of the switch installation. Do not install the switch below the line arm if there is not enough clearance, requiring replacement with a taller pole.

5) Where angled overhead construction is needed, the below line-arm Omni- Rupter® switch construction method should be used. Follow DOH (Section DC) construction standards for wire tensions, sag, and guying requirements.

6) A Hughes adapter must be installed with new construction of an inverted Omni-Rupter® switch mounted below the line arm. The Hughes adapter prevents the taps from contacting the interphase rod. Refer to DAP AP 336, for below line arm construction details of switch.

7) Note, for below-arm construction at 12 kV& 16 kV, the Inertia LineBOSS™ is an approved alternative and provides equal performance the S&C Omni-Rupter®.

b. Applications requiring vertical constructed switches shall use a default single arm or double arm vertical Omni-Rupter® and vertical Alduti-Rupter® switches which are factory assembled onto composite crossarms. See DAP Table AP 300-2 for applicable SAP codes. Wood variants may be used as an exception for special applications.

c. Single-arm LineBOSS™ load-break switches can be installed using two methods; these are:

1) Tangent/sectionalizer, **OR**

2) Under a double or single line arm equipped with sectionalizers. The switch is therefore suitable for Grade A crossings and angled overhead construction. Use the following considerations for installing or retrofitting LineBOSS™ switches mounted below the line arm:

d. Where below arm construction is not suitable, utilize instead an Omni-Rupter® switch

e. A Hughes adapter must be installed with new construction of an inverted LineBOSS™ switch mounted below the line arm. The Hughes adapter prevents the taps from contacting the interphase rod. Refer to DAP AP 340, for below line arm construction details of a LineBOSS™ switch.

Pole switch and single-blade disconnect applications are summarized in Table 10–20 and Table 10–21.

Table 10–20: Gang Operated Pole Switch Applications

Gang Operated Pole Switch Application	4 kV Approved	12 kV & 16 kV Approved	25 kV & 33 kV Approved
Isolating long single phase tap lines where required	✓	✓	✓
Bypass and/or isolating switches within consumer substations	✓	✓	✓
Paralleling and sectionalizing, including applications such as: mid | tie | clearing | 1,500 kVA load block | disconnectable means	✓	✓	✓
Bypass switch on pole top installations for regulators, reclosers, preferred emergency equipment, and sensitive ground installations	✓	✓	✓
Drop Load	✓	✓	✓

Table 10–21: Hookstick Operated Disconnect Applications

Disconnect Switch Application	4 kV Approved	12 kV & 16 kV Approved	25 kV & 33 kV Approved
Isolating long single phase tap lines where required	✓	✓	Not Applicable
Line and load isolating disconnects on pole top installations for regulators, reclosers, and preferred emergency equipment only	✓	✓	✓
Bypasses and/or isolating switches within consumer substations	✓	✓	Not Applicable
Paralleling and sectionalizing	✓	Not Applicable	Not Applicable
Bypass switches on sensitive ground installations and/or reclosers	Not Applicable	Not Applicable	Not Applicable
Drop load	Not Applicable	Not Applicable	Not Applicable
Bypass switches on single phase voltage regulators	✓	✓	✓

f. Obsolete switches: KPF and tilting switches shall be removed or replaced as opportunity and funding permit.

g. Idle switches: Idle energized or de-energized overhead switches, regardless of type, shall be removed as opportunity and funding permit. Idle switches are considered idle when not used for a period of time, generally greater than 10 years, or if not deemed useful as defined by approved applications in this Distribution Design Standards (DDS) manual.

N. Environmental Services Department (ESD)

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 ESD 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, off-roading); vegetation removal; or installation, replacement, or removal of electrical equipment and/or petroleum tanks with a combined storage capacity of equal to or greater than 55 gallons, 500 pounds, or 200 cubic feet of gases 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. Once the Environmental Screening Form (ESF) is completed, the Environmental Services Department (ESD) will review and issue an Environmental Requirements Document (ERD). The ERD must be available in the work order package. Work cannot be completed with the ESF; work must be followed through by completing the ERD. 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:

https://sapportal.edisonintl.com/irj/portal/interop?NavigationTarget=pcd:portal_content/SCE/com.sce.Operations_Support/com.sce.My_Company/com.sce.iViews/com.sce.EnvironmentHealthandSafety/forms/com.sce.ivu.esf&NavMode=3

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 wildlife mortalities on power lines and developed construction standards for wildlife protection. Following an wildlife event, the retrofitting of existing structures may be required.

WILDLIFE PROTECTION REQUIREMENTS

New poles, bare and covered lines, equipment, apparatus, and pole replacements shall be constructed per DOH, DC 535.

❶ Standard Construction

- — 36 inches of horizontal phase-to-phase/ground separation and 36 inches of vertical phase-to-phase/ground separation.
- — Covered conductor systems will be an all-covered system. This includes exposed dead-ends, connectors, and splices. Apparatus terminations shall be covered as they would be in bare wire systems but utilizing appropriate covers listed in DOH Table DC 535-1.
- — In covered conductor systems, wildlife protection shall be used on all phases as well as the neutral. For example, a 4-wire dead-end construction must have dead-end wildlife protection for all four wires.

NOTE

Covered Conductor systems do not require use of wildlife hoods, wildlife hood extenders, and/or protective tubing.

- — Overhead equipment shall have bushing covers.
- — All overhead taps, leads, and jumper wires shall utilize covered conductors (i.e. covered conductor or PGW when applicable). If covered conductors can't be utilized n a bare wire system, split-tubes may be used as an alternative option.
- — All new overhead switches shall be inverted.
- — Areas where secondary or service drop conductors have been damaged (chewed or gnawed) by rodents and damage to the conductor has been observed, copper secondaries shall be utilized in replacement in order to prevent from additional chewing or gnawing.

❷ 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 (United States 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.

— Regardless of sufficient separation, wildlife protection material shall be used in bare wire and covered conductor systems. Spacing and covers shall be constructed per the figures shown in DOH DC 535.

❸ Eagle Zones with Exceptions Rules

Standard Construction:

— Development on both sides of the street or pole line.

— Less than approximately 40 acres of open space on either side of a street or pole line.

— Open space such as groomed parkland or golf courses.

Eagle Construction:

— Greater than approximately 40 acres of open space on either side of a street or pole line.

— In situations that are **not** clearly defined above as **standard construction** (when in doubt).

❹ Exceptions to Wildlife 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. All obsolete switches must be replaced with the appropriate inverted switch.

— Apparatus crews performing maintenance.

— Troublemen performing normal duties.

— When installing necessary wildlife protection creates an unsafe working condition, exception shall require an explanation and documentation submitted to the Environmental Services Department (ESD).
ESD May be contacted via

- email: environmentalrequirements@sce.com
- phone: (833) 723-2362

NOTE

Refer to DOH, DC 535, Section 5.0, to identify which districts or portions of districts have been designated as Eagle Zones. In addition, contact the Manager of Government Lands in Real Properties for further information on public lands.

O. Extra Heavy-Loading Areas above 5,000 Feet

Special construction requirements have been established for extra heavy loading areas above 5,000 feet (normal heavy loading areas are between 3,000 feet and 5,000 feet elevation). 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 DOH, Section DC.

For crossarm and insulator requirements in extra heavy-loading areas above 5,000 feet, refer to ADS–10, Paragraph 5.3 C. 3.,[page 33].

P. Heavy Tree or Heavy Snow/Ice Loading Areas

Aerial cable may be considered for heavy tree concentration areas. Consult FE for application.

Note: Areas where vegetation is above tree trimming capabilities, or intermittent contact with vegetation is likely, covered conductor may also be considered.

Q. 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.

R. Combination Grounds-Power and Communication

Agreements have been made between SCE and the communication companies listed below, and with the governmental agencies that grant the right to attach their facilities to SCE'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.

S. SCE Communication Facilities on Distribution Poles

The following procedure is established for the handling of SCE communication facilities on distribution poles by distribution crews.

1. Scope of Work

   These instructions cover (primarily) those cases where a distribution pole carrying SCE communications facilities is being replaced and, in a relatively few other cases where it may become necessary to relocate SCE 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 SCE 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.

T. Joint Use Applications, Joint Crossing Over and Extensions along Railroad Rights-of-Way

When SCE installs poles in order to cross over 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 Design and Implementation of System Hardening for Supporting SCE's Wildfire Mitigation Plan (WMP) in High Fire Risk Area (HFRA)

A. Purpose and Application

There have been several new standards and updates outlining the design and implementation of SCE wildfire mitigation in High Fire Risk Areas (HFRA) issued in the past few years. In lieu of creating new standards, the purpose of this ADS section is to organize wildfire mitigation standards in an efficient and user-friendly manner. To achieve this objective, this section will consolidate all standards pertinent to wildfire mitigation into a logical flow with relevant links and references. The intent is to provide planners and other stakeholders easy access to design standard requirements and references to all relevant standards to ensure correct design and implementation of critical wildfire mitigation work in HFRA in alignment with SCE’s WMP.

Each mitigation standard is supported with a concise explanation and justification. Examples and companion drawings are used to help explain the applications. A brief description of justification is intended to equip the user with a basic understanding of the mitigation application. This brief description is not intended to cover complete analysis, which is typically provided in the work paper or engineering studies and not included in the standards.

PRIMARY USERS OF THIS ADS STANDARD SECTION

The development of this ADS section is intended to provide clarity and tools for designers, planners, and engineers to apply the appropriate standards for designing lines, structures, and various equipment in HFRA. This Section will also provide construction personnel a central location for construction requirements. To reiterate, the details of design and construction will continue to reside in the appropriate sections of other distribution standard manuals such as this ADS and the Distribution Overhead Construction Standards Manual (DOH), which are referenced in this section.

1. Introduction

Public and worker safety is a top priority for SCE. SCE is committed to creating and maintaining a safe environment for its customers, workforce and the communities it serves. Consistent with SCE's commitment to protect public safety and the requirements of California Public Utilities (PU) Code Section 8386(a) to construct, maintain, and operate its electrical lines and equipment in a manner that will minimize the risk of catastrophic wildfire posed by those electrical lines and equipment, SCE has developed a multi-year Wildfire Mitigation Plan (WMP) to set forth an actionable, measurable, and adaptive plan to reduce the risk of potential wildfire-causing ignitions associated with SCE's electrical infrastructure in HFRA.

SCE's long-term vision is to significantly reduce ignitions that could lead to devastating wildfires, and substantially mitigate impacts related to implementing its wildfire programs including Public Safety Power Shutoff (PSPS). We also strive to safeguard SCE's electric system against wildfires regardless of ignition source and improve system resiliency where operationally feasible.

2. Understanding Ignition

Most wildfires in California are not caused by electrical utilities. According to historical wildfire activity statistics data maintained by CalFire, electrical power is generally associated with up to ten percent of statewide fires. Approximately 90 percent of all the fires associated with electrical equipment in SCE's service area are related to distribution level voltages (33kV and below). There are different failure modes of an electrical system that could cause a fire ignition. This excerpt will briefly explain acceptable failure modes and fire ignition.

Faults on the distribution system primarily occur either due to: contact from foreign objects such as animals, conductor slapping, metallic balloons, or vegetation; or an equipment or facility failure; equipment such as capacitors, conductors, connectors, crossarms, fuses, hardware, insulators, poles, switches or transformers.

Root cause analysis indicate approximately 60% of wildfires initiated by an electrical system anomaly is attributed to contact of electric conductor/equipment from objects while approximately 30% is due to equipment failure. The remaining 10% is due to other undetermined or inconclusive causes. For a fault due to contact with object, the source of fire ignition could be either incandescent particles (sparks from molten metals), falling burning debris (failed parts, animal carcasses), or falling energized wire down.

Although rare, these faults can result in high-energy and high-temperature arcing between two conductors (phase-to-phase) or between one conductor and the ground (phase-to-ground). If arcing contains sufficient energy – given local conditions such as temperature, humidity, and adjacent dry vegetation – ignition could lead to a wildfire.

An ignition source such as those described above could initiate a fire at the base of the pole, on top a pole, or under a mid-span of a conductor. Understanding this basic fire ignition progression would help to design and construct SCE electric system effectively to mitigate the risk of ignition.

SCE's design tenets for wildfire mitigation construction is to reduce the risk, energy, and effect of faults caused by electrical system anomalies that can result in potential wildfire-causing ignitions and significant damage to SCE's infrastructure. For example, installing covered conductor systems and appropriate use of wildfire covers are proactive, effective mitigation measures used by SCE to significantly reduce risk of wildfire by preventing contact-related faults.

B. WMP Objectives and Program Overview

1. WMP Objectives

The primary objective of SCE's WMP is to protect public safety, and includes an actionable, measurable, and adaptive plan for multiple years to reduce the risk of potential wildfire causing ignitions associated with SCE's electrical infrastructure in High Fire Risk Areas (HFRA) through enhanced system hardening, situational awareness, and operational practices.

Additional key objectives include:

- Minimizing PSPS impact to its customers and communities;
- Implementing measures that increase resiliency and safeguard SCE's electric system against wildfires irrespective of ignition source;
- Improving fire agencies' ability to detect and respond to emerging fires;
- Improving coordination with utility emergency management personnel;
- Reducing the impact of wildfires and wildfire mitigation efforts on the public; and
- Educating the public about how to prepare for, prevent, and mitigate wildfires in SCE's HFRA.

2. WMP Program Overview

Detailed wildfire mitigation programs included in the WMP include several initiatives, which are organized by the following categories:

- Risk assessment and mapping
- Situational awareness and forecasting
- Grid design and system hardening
- Asset management and inspections
- Vegetation management and inspections
- Grid operations and protocols
- Data governance
- Resource allocation methodology
- Emergency planning and preparedness
- Stakeholder cooperation and community engagement

The focus of this ADS section is to provide an outline of design requirements for Grid Design and System Hardening, which is one of the initiatives, included in the WMP. SCE's goal is to deploy system-hardening measures that reduce the risk of ignitions associated electrical infrastructure as quickly as possible. The grid hardening measures focus on reducing ignition risk and improve reliability by reducing the frequency and impact of faults resulting from contact from objects. The increased resistance to faults and conductor insulation may also reduce the frequency of wire down, wire-to-wire contact, and wire contact with energized equipment incidents.

SCE has extensive plans to replace bare overhead conductor with covered conductor as part of SCE's WMP Grid and System Hardening initiative. SCE will also continue efforts on resiliency hardening with application of fire-resistant wrap to protect new wood poles, installation of composite poles with fire shield, and further expansion of fusing and sectionalization.

While these collective efforts are designed to mitigate the risk of fire ignition events associated with SCE's electrical infrastructure, the risk of ignition will not be eliminated. Over time and cumulatively, the success of the individual programs and activities in the WMP are expected to result in an overall reduction of controllable fire ignition events associated with SCE's electrical infrastructure.

C. System Hardening Equipment and Materials Design Standards

Design and construction work in HFRA shall be done with utmost care while strictly adhering to the requirements of all existing standards and guidelines. The following sections provide concise explanation of justification for each mitigation equipment with references to relevant standards as well as description of important considerations and application criteria when designing and constructing system hardening equipment in HFRA.

Designs shall use exempt equipment and materials whenever they are available for new construction. Most materials and apparatus have exempt options for HFRA application, though some apparatus may not and still require vegetation management at the base of the pole. Refer to Section 9 below for details on exempt and non-exempt material and equipment. Work at a given pole location shall also take appropriate opportunities to replace existing non-exempt materials. In general, equipment that may be non-exempt but has exempt counterparts are primary voltage connectors, primary voltage fuses, surge arresters, and pole switches. Secondary and grounding connectors (except the connection between the neutral and ground) do not have requirements around exempt and non-exempt material classifications.

Opportunity resiliency work is also an important factor to allow cost effective bundling of activities with programmatic and maintenance work. The list below summarizes opportunity work items; some of these items are included in SAP and notifications to aid in identification and tracking of field conditions. Whether a notification in SAP exists or not, these activities shall be bundled with other work when it is expected to be performed at the same level or below on a given pole.

Opportunity work:

- Application of wildlife cover to bushings, terminals, jumpers
- Replacement of PGW jumpers where covered conductor should be applied (generally for over the arm jumpers on aluminum covered conductor systems)

- Replacement of non-exempt materials or equipment with exempt materials (generally connectors, fuses, arresters)
- Replacement of pole switches which are not inverted designs
- Replacement of non-compression splices
- Replacement of automatic guying attachments
- Replacement of liquid fuses
- Replacement of Hendrix universal insulators
- Replacement of X-limiter / Valiant fuses where notification in SAP is present
- Installation of line spacers for long horizontal bare wire spans per ADS-10 criteria
- Taping of exposed connectors on insulated secondary conductors

1. Covered Conductor

Covered conductor is aluminum or copper wire insulated with a three-layer design, providing robust protection against contact-related faults and the electrical arcing associated with a variety of fault conditions. Covered conductor, unlike bare conductor wire, is specifically designed to withstand incidental contact with vegetation, other debris, and even the ground in a wire down event.

Preventing the occurrence of faults in turn reduces the likelihood of the anomalies that lead to fault-related fire ignitions. As secondary benefit, the thick insulating layer of covered conductor also improves reliability and can reduce the risk associated with human contact with energized conductor, such as a wire down event.

Covered conductor achieves many of the same fire mitigation benefits as converting overhead wire to underground cable, but at a fraction of the time and cost to implement. It also has similar public safety benefits but does not suffer from the troubleshooting and restoration delays associated with underground systems, meaning faster repairs and shorter outage times for customers.

Deployment of covered conductor represents the bulk of SCE's infrastructure-hardening effort in HFRA. SCE targets installation of covered conductor on certain spans of the overhead distribution system in HFRA that are estimated to pose the greatest risk of fire ignition. In addition, SCE considers areas where covered conductor can mitigate the need for PSPS events in the near-term.

To ensure a robust covered conductor system, the following are important considerations when designing and constructing with covered conductors.

a. Lightning Arrester Requirements

For covered conductors, overvoltage events can lead to conductor or insulation damage if the overvoltage initiates an arc. Due to this phenomenon, the standard requires that for covered conductor systems, lightning arresters are to be applied to equipment and risers in accordance with existing standard requirements for High Lightning Density areas, regardless of the lightning density at the installation location. This requirement is outlined in the Distribution Apparatus Construction Standards (DAP), Subsection AP 400 5.2 and ADS–10, Section 5.6 L.

Cal-Fire Exempt Surge Arresters are to be used in High Fire Risk Areas (HFRA) for covered conductors (DAP AP 415). Refer to ADS–10, Table 10–19: Cal-Fire Exempt MOV-Type Surge Arrester for Distribution Applications in HFRA for applicable SAP codes. Use standard distribution arresters in non-HFRAs. Refer to ADS–10, Table 10–18: MOV-Type Surge Arresters for Distribution Applications for applicable SAP codes.

b. Limiting Deviation Angle Requirements

Exceeding the limiting deviation angle may lead to failure from mechanical overloading of the insulators. Covered conductor systems and bare wire systems will follow the same limiting deviation angle crossarm requirements outlined in ADS–10, Appendix 10–2 and DOH, DC 575.

c. Sag and Tension Requirements

Over-tensioning may mechanically overtax the conductor, which may lead to conductor failure. This failure risk is especially high in heavy loading areas when ice is present. Additionally, over-tensioning can also lead to Aeolian vibration, which may cause abrasion or fatigue damage on the conductor over time. To ensure that proper tensions are applied in covered conductor installations sag boards or dynamometers shall be used during construction. Furthermore, the sag charts and tension temperature stringing tables (DOH CC 120) shall be used to determine the appropriate sag or tension values.

d. Insulator Requirements

Polymer post-type insulators or vise-top insulators with nylon inserts may be used for covered conductor. Refer to ADS–10, Paragraph 5.3 C.for application details. For additional construction details, refer to DOH CC 150, DOH GR 200 and DOH GR 205.

e. Jumper/Tap Requirements

When making connections, jumpers shall be covered conductor of equal or greater ampacity. Protective Ground Wire (PGW) may be used to connect to equipment except for terminations/potheads. However, PGW shall not be used for line connections in covered conductor systems due to their limited current carrying capacity. It is not necessary to cover PGW with a split tube. Refer to DOH CC 150.4 for more information.

f. Wildlife Cover Requirements

Covered conductor systems shall be an all-covered system. This means that wildlife covers shall be installed on dead-ends, terminations, connectors, equipment bushings, and any partially covered exposed conductor. Further covering other equipment with wildlife protection covers will increase the covered conductor system's overall effectiveness at preventing contact-with-object faults. Refer to DOH CC 150.4 for more information.

g. Vibration Damper Requirements

Two types of dampers will be used in covered conductor systems: spiral vibration dampers and Stockbridge dampers. Vibration dampers shall be installed on every span in light loading areas. Vibration dampers will be installed in heavy loading areas when vibration on conductor is observed. For the 336 (30/7) ACSR covered conductor, vibration dampers shall be installed on every span in both light loading and heavy loading areas. Vibration dampers are only required on full tension spans and are not required on reduced tension spans. Refer to DOH CC 190 for damper installation requirements and instructions.

h. Secondary and Service Conductors

In HFRA, multiplex conductor (See DOH, CO 108) shall be used for new overhead construction and reconstruction work.

For Wildfire Covered Conductor Program (WCCP) work, on structuressupporting open wire secondaries (OWS) or weather resistant all-aluminum secondary conductors (WAL) and covered conductor, new multiplex conductor shall be installed. OWS and WAL extending from structures supporting covered conductor shall also be replaced with multiplex conductors to the end of the secondary lead.

The replacement of OWS and WAL conductors will mitigate ignition risk at thesecondary or service level.

2. Fire Resistant (FR) Poles

SCE utilizes two types of fire-resistant poles, a composite pole with a fire-resistant sleeve and a wood pole with a fire-resistant wrap. Both types of fire-resistant poles provide a resiliency benefit such that if the pole experiences a fire, the pole will still have structural integrity supporting the equipment and conductors. A fire-resistant composite pole provides the additional benefits of ignition prevention and deterrent from woodpecker damage. Composite poles prevent ignitions due to their high resistivity, reducing electrical tracking that can occur at the pole top and from their inherent fire resistive properties by avoiding catching on fire during an equipment failure event. With these benefits in mind, SCE is targeting poles that support equipment or are in areas prone to woodpecker activity for replacement with fire resistant composite poles. All other locations are targeted for wood poles with fire resistant wrap.

SCE’s FR protective wraps and shields are installed to a minimum of 18’ above ground line. Most of the terrain in SCE’s HFRA was determined to be 6’ chaparral. The 18’ minimum protection is meant to protect poles from a fire that is approximately three times the height of the surrounding vegetation.

a. Fire Resistant Wood Poles

SCE’s FR-wrapped wood pole is created by applying an intumescent wrap shielding the pole in the event of a fire. SCE utilizes wood poles that are pre-wrapped by the pole supplier. The pre-wrapped wood pole is intended for use on new construction and rebuilds in HFRA. Refer to ADS–10, Figure 10–1 for application of FR wrap wood poles in HFRAs.

Pre-wrapped wood poles are available in all size and classes that traditional wood poles are available in. Refer to DOH PO 148.1 for SAP codes, dimensions, weights and installation details of the pre-wrapped wood poles.

Structures identified for the FR Wrap Expanded Deployment Program as defined in the WMP shall have FR Wrap installed on in-service wood poles with existing covered conductor located in Severe Risk Areas (SRAs) where TUG is not an option.

NOTE FR Wrap can also be installed on in-service wood poles to support fire restoration.

Refer to DOH PO 148.2 for installation details of FR wrap on in-service wood poles.

Applying a protective layer to wood poles has proved to be an effective measure to protect them from structural damage and the typical conditions a wood pole may be subjected to during a passing wildfire (after an ignition has occurred). This fire-resistant pole-wrapping technology is a cost-effective alternative to installing fire-resistant composite poles when the probability of an ignition at the pole is low (i.e., no electrical equipment on the pole and/or not a woodpecker area).

b. Fire Resistant Composite Poles (Composite Poles with Fire Shields)

Wildfires are a major threat to the integrity of traditional wooden poles. SCE has evaluated an alternative pole material in addition to fire resistant wraps, FR composite. SCE determined a combination of these pole types provides the most cost-effective way to harden the grid.

Composite poles with fire (or protective) shields are intended for use in new construction and rebuilds in HFRAs. Refer to Figure 10–1 for application of the fire shield composite poles in HFRAs.

Composite poles with fire shields will use the same construction practices as the RS sectional and CP monopole composite poles, except for the fire shield embedment. The shield will be embedded 12 inches below the ground line (refer to DOH Figure PO 112-3 and PO 112-4 for details).

RS Sectional Composite poles with fire shields are available in lengths 45 feet to 75 feet. They can be ordered as partially pre-assembled or fully pre-assembled poles. In partially pre-assembled poles, the manufacturer will pre-assemble the bottom two sections with the fire shield. The remaining section(s) will be assembled in the field. Refer to horizontal assembly of RS sectional composite poles in DOH PO 112 for details. The partially pre-assembled pole with the fire shield is to be used where road access is available or for helicopter sets. In a fully pre-assembled pole, the manufacturer will pre-assemble pole sections and the fire shield. The fully pre-assembled composite poles with fire shields are to be used for helicopter sets when warranted.

CP monopole composite poles with fire shields are available in lengths 35 feet to 80 feet. They can only be ordered fully pre-assembled. Refer to DOH PO 112 for construction standards and material codes of the CP composite pole with fire shield.

Composite poles with fire shield should only be utilized when there is mechanical setting means (i.e. truck access or crane/helicopter set).

Refer to DOH PO 112 for SAP codes, dimensions, weights and installation details of the fire shield composite poles.

For composite pole materials (such as composite crossarms, climbing steps, and guying hardware), refer to DOH PO 370.

Refer to PLM-2 for pole loading requirements on composite poles.

c. FR Pole Selection

Selecting and installing the appropriate type of pole is very important in HFRA. The correct use of fire-resistant poles can reduce the chance of ignition, enhance the resiliency of SCE's infrastructure in HFRA, and help with rapid restoration.

Installation of fire-resistant protective wrap/barrier to wood poles in combination with fire-resistant composite poles will allow SCE to lower costs while meeting the need of hardening its grid. Refer to the decision tree below for installation guidelines.

Refer to Figure 10–1 to determine the appropriate fire resistant pole type for New Construction and Rebuilds.

3. Composite Crossarms

Composite crossarms shall be used to replace traditional wood crossarms that are damaged or are identified for replacement because of other reasons. Composite crossarms are lighter in weight and easier for attachment to poles. Like composite poles, composite crossarms provide two benefits regarding ignition prevention. Composite crossarms provide high impedance path reducing tracking that helps eliminate pole top ignitions. Composite crossarms arms are also inherently fire resistant and will not ignite in the event of equipment failure or conductor contact.

All wood crossarms shall be replaced with composite crossarms and shall be used on all new poles per ADS–10, Paragraph 5.2. Do not damage composite cross arm during transportation and installation. Composite crossarms should be installed per DOH PO 370.

4. Wildlife-Safe Power Line Construction

Wildlife-safe power line construction standards are intended to protect lines from wildlife and vice versa by constructing sufficient phase-to-phase and phase-to-ground clearances as well as installing approved protective materials on high voltages lines and equipment. In addition, installing wildlife covers in the correct application will mitigate other contact-related faults from foreign materials.

While wildlife covers were initially introduced to protect high priority wildlife, additional benefits are procured when discussing wildfire mitigation. By utilizing the correct wildlife covers, electrical events that may result in incandescent particles or other debris will likely be mitigated due to the added fire, track, and arc resistant protection.

Refer to DDS-10 and DOH DC 535 for correct application of wildlife covers in covered conductor systems and applications for high voltage apparatus and hardware.

5. Connectors

Bolted wedge connectors are the preferred primary connector in all areas, including covered conductor systems. They shall be installed per DOH CO 420. If bolted wedge connectors are unavailable or where work methods and proper tooling do not permit safe installation of bolted wedge connectors, parallel groove connectors shall be used for primary connections.

Work methods and tooling refers to working of the pole and/or where bucket access is available. If a hot-stick can be used to install or if the line is de-energized upon installation, then the appropriate wedge connector shall be used. If a hot-stick cannot be used due to the connection being close to the pole, parallel groove may be used.

Refer to DOH CO section for other acceptable connectors for use in HFRA

6. Fuses

Current-limiting fuses are the preferred option for fusing in HFRA due to their ability to clear high-level faults in a timely manner. Clearing faults quickly reduces the magnitude and duration of ignition-causing arcs.

SMU-20 fuses are also approved for use in HFRA (see Table 10–22.). When the loading current exceeds the maximum current-carrying ability of current-limiting fuses, the SMU-20 fuse may be used. SMU-20 fuses are also the only approved fusing option for capacitor banks, regardless of whether they are located in HFRA, or in non-HFRA.

Refer to DOH, DC 605, for overhead construction line requirements in HFRA.

7. Switch Placement

Switches, when installed in strategic locations, enable robust sectionalizing capability which is beneficial to limit the impact of PSPS events in HFRA.

Correct placement of switches in HFRA can be a cost-effective mitigation strategy as an alternative to, or in conjunction with, installation of covered conductor. Switched are typically placed in between two areas where there are significant differences in PSPS risks.

Examples of strategic switch locations for PSPS include:

1. Between an area with high wind and an area with low wind.
2. Between an area that is fully covered conductor and an area with bare conductor.
3. Between an area in HFRA and an area not in HFRA. Install the switch outside of HFRA as some devices have operating restrictions during a warning or threat condition. Refer to SOB322 for Operating Restrictions.

Choosing the appropriate switch type is important in limiting the impact of PSPS events. A remotely operated switch, such as an RAR, RSR or underground RCS can be operated within HFRA. These switches are fully enclosed and reduce the ignition risk. Overhead RCS's can be operated outside of HFRA boundary and allow for SCE to operate remotely. Since these switches can be operated remotely, additional field resources are not required to manually operate the switch, thereby expediting implementation of switching procedures. This shortens the de-energization duration of some customers and can be critical during substantial PSPS events when available field resources may be limited.

8. Wildfire Mitigation Technology Projects

   As part of SCE's Wildfire Mitigation Plan a collection of Alternate Technology options are included to help communicate and bring awareness of potential on-going mitigation options. These technologies can vary greatly, but many times the technologies will be applied to the Distribution system as a pilot project. Some pilot projects may be applied to distribution poles or structures or may influence circuit operations and are listed below with a brief description.

   a. Rapid Earth Fault Current Limiter (REFCL)

      As the name suggests, these pilot technologies rapidly limit fault current or energy associated with ground faults. These systems limit phase-to-ground fault currents so significantly that conventional over-current devices like fuses will not operate for fault events. These systems operate as ungrounded or resonant grounded systems to limit ground fault energy which also provides increased fault detection sensitivity. Research suggests REFCL systems can reduce the potential for ignition for ground faults by 70-90%. There are three technologies as part of the REFCL projects described in the sub bullets below and each will only function on 3-wire systems:

      ❶ Ground Fault Neutralizer (GFN) – System of hardware which is applied at larger substations to help compensate for both real and reactive power during fault conditions. While most system modifications are made within the substation, there are also special Capacitive Balancing Units (CBUs) which are applied on the distribution circuit to balance the line to ground capacitance of the network.

      ❷ Resonant Grounded Substation (RGS) – Similar to the GFN, except these systems focus on installations that are smaller substations or pole tops as they target compensation of reactive power during fault events. The substation equipment is focused on an Arc Suppression Coil (ASC) applied to the substation or pole top neutral connection. These systems may also include CBU installations on the distribution circuit to balance system capacitance.

      ❸ Isolation Transformer - These pilot installations are applied on the distribution circuit typically on circuits that can be segmented into 4-wire and 3-wire portions, where the system downstream of the isolation transformer is entirely 3-wire The isolation bank allows the system to be ungrounded or resonant grounded limiting fault energy and increasing fault detection sensitivity.

Effective 2Q-2022, the ADS was updated to require 3-wire radial construction on circuit segments residing in HFRA. This was done to reduce the cost of re-working existing 4-wire systems during future REFCL implementation. The impacted standards detailing this design philosophy and requirements can be found in ADS–4, Section 5.7 Radial Subsystem Design and ADS–4, Section 5.8 Extension of Fourth Wire for New Developments in non-HFRA for New Development in Non-HFRA respectively.

b. Early Fault Detection (EFD)

The pilot equipment is focused on identifying potential system issues prior to failure. Identification of assets in degraded or undesirable conditions (rather than “faulted” equipment) allows for repair prior to a fault. EFD sensors are placed around 3-miles apart from one another on a circuit and work in pairs to detect system anomalies, such as, vegetation contacting lines, squatting insulators, damaged connectors, and broken conductor strands. The sensors provide a specific location for any detections, identifying whether the potential issue is at a structure or mid-span.

Table 10–22: Fuse Prioritization in High Fire Risk Areas (HFRA)

System Voltage	Application	Fuse Ampere Ratings	Fuse Type	Fuse Holder
2.4 kV, 4.16 kV, 4.8 kV	Transformer	6 through 80	8 kV ELF	15 kV Universal Cutout
2.4 kV, 4.16 kV, 4.8 kV	Transformer	81 through 200	14.4 kV SMU-20	SMD-20
2.4 kV, 4.16 kV, 4.8 kV	BLF	6 through 80	8 kV ELF	15 kV Universal Cutout
2.4 kV, 4.16 kV, 4.8 kV	BLF	81 through 200	14.4 kV SMU-20	SMD-20
12kV, 16 kV	Transformer	6 through 50	15 kV ELF	27 kV Universal Cutout
12kV, 16 kV	Transformer	51 through 100	15 kV X-Limiter	SMD-20
12kV, 16 kV	Transformer	101 through 200	14.4 kV SMU-20	SMD-20
12kV, 16 kV	BLF	10 through 100	X-Limiter	SMD-20
12kV, 16 kV	BLF	10 through 50	Valiant	SMD-20
12kV, 16 kV	BLF	101 through 200	14.4 kV SMU-20	SMD-20
14.4 kV	Single-Phase Transformer	6 through 50	15 kV ELF	27 kV Universal Cutout
14.4 kV	Single-Phase Transformer	51 through 100	15 kV X-Limiter	SMD-20
14.4 kV	Single-Phase Transformer	100 through 200	14.4 kV SMU-20	SMD-20
14.4 kV	Single-Phase (Phase-to-Ground) Branch Line	10 through 100	15 kV X-Limiter	SMD-20
14.4 kV	Single-Phase (Phase-to-Ground) Branch Line	10 through 50	15 kV Valiant	SMD-20
14.4 kV	Single-Phase (Phase-to-Ground) Branch Line	10 through 200	14.4 kV SMU-20	SMD-20

Table 10–22: Fuse Prioritization in High Fire Risk Areas (HFRA)

System Voltage	Application	Fuse Ampere Ratings	Fuse Type	Fuse Holder
25 kV	Three-Phase Transformer	15 through 80	34.5 kV SMU-20	34.5 kV SMU-20
25 kV	Three-Phase or Phase-to-Phase Branch Line	15 through 80	34.5 kV SMU-20	34.5 kV SMU-20
33 kV	Transformer	3 through 100	34.5 kV SMU-20	34.5 kV SMU-20
33 kV	BLF	15 through 100	34.5 kV SMU-20	34.5 kV SMU-20

9. Wildfire Program for Conductor Clashing Mitigation

SCE's Wildfire Program for Conductor Clashing Mitigation, also known as the Long Span Initiative (LSI)[2/], addresses increased risk of conductor clash in high wind conditions associated with bare distribution conductor spans of a certain length, spans with mixed conductor, spans that have a sharp angle and meet certain sag criteria, or spans that transition between vertical and horizontal configuration.

Long spans that are at high risk for conductor clashing are prioritized based on ignition consequence.

SCE began using LiDAR on its distribution long spans to identify locations with potential conductor clash issues and planned to remediate the highest risk locations upon field validation.

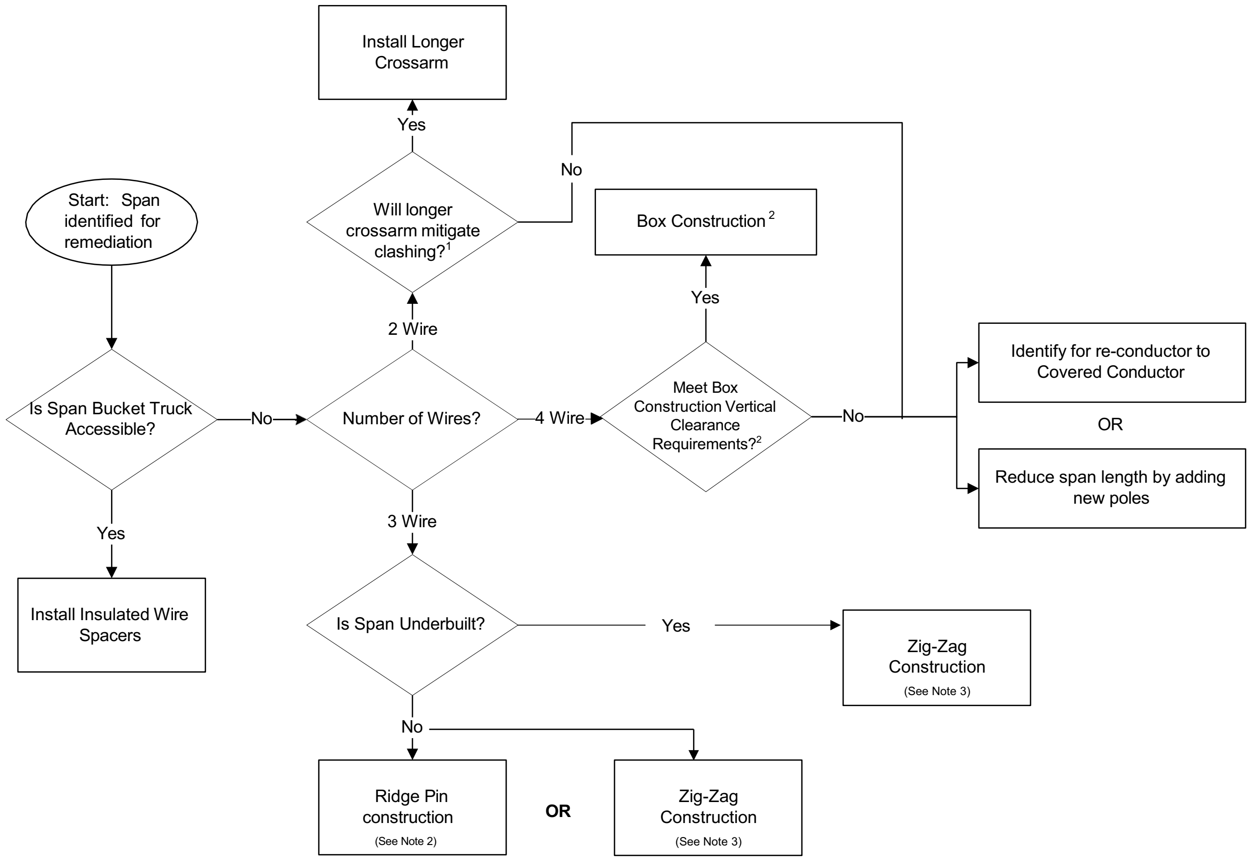
This initiative includes three types of remediations that are carried out with the purpose of reducing conductor clashing risks from long spans:

1. **Insulated Wire Spacers** – Insulated equipment that separates the lines to reduce the possibility of wire-to-wire contact. It is the preferred remediation type due to the speed of deployment and its effectiveness against clashing. They are utilized during instances where there is bucket truck accessibility. The type of insulated wire spacer that is installed is dependent on the size of the conductor as well as the phase spacing, which is specified in DOH CO 450.
2. **Alternate Construction** – This includes ridge pin, two level (box) construction, zig-zag construction, wider crossarms, and interset poles. These construction configurations increase phase spacing or reduce sag, which minimizes the probability of wire-to-wire contact. This type of remediation is typically utilized when there is no bucket truck accessibility for insulated wire spacers.
3. **Covered Conductor** – The wire ensures that the lines are protected if clashing occurs. Covered conductor will be installed in instances where there is no bucket truck access and either a 3-wire span is underbuilt, or a 4-wire span does not have sufficient space for box construction.

The following flowchart demonstrates how SCE makes a determination on the type of remediation appropriate for different scenarios.

[2/] Note that this program is referred to as the Long Span Initiative (LSI) in the Wildfire Mitigation Plan (WMP), General Rate Case (GRC), and in the LSI Field Assessment Playbook.

Figure 10–13: Decision Tree for Conductor Clashing Remediations



Note(s):

1. The conductor spacing must be greater than the sag of the conductors.
2. Refer to DOH DC 535 for Ridge Pin and Two Level (Box) Construction.
3. Refer to DOH DC 587 for Zig-Zag Construction.

10. Resources

- 2020-2022 SCE Wildfire Mitigation Plan
- 2019 SCE Wildfire Mitigation Plan
- 2018 SCE GS&RP

HFRA

High Fire Risk Areas (HFRA) identifies areas with elevated wildfire risk based on operational and environmental factors.

HFRAs are defined by the State of California's Public Resource Code, Section 4292. It includes CPUC's official High Fire-Threat District (HFTD) map plus additional SCE defined polygons for risk mitigation. It is used to apply stricter operational controls, construction standards, and fire prevention measures beyond regulatory minimums.

Maps of HFRAs must be maintained at 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 HFRA. 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.

STATE RESPONSIBILITY AREA (SRA)

State Responsibility Areas (SRA) define boundaries where specific fire-fighting agencies are responsible for leading wildfire suppression efforts. These boundaries are established by CAL FIRE under the California Public Resources Code and represent lands where the State assumes primary responsibility for wildfire prevention and suppression. SRA maps are published and typically reviewed and updated every five years.

In SRA zones, compliance requirements apply to vegetation management and defensible space standards. While a significant portion of SRA overlaps with High Fire Risk Areas (HFRA), the two designations are not identical-SRA is a jurisdictional designation, whereas HFRA is based on operational wildfire risk. HFRA includes many SRA areas but also additional high-risk zones outside SRA.

The SRA mapping layer has been integrated into SCEGeoView to display both HFRA and non-HFRA SRA designations, supporting accurate planning and construction decisions. Planning and Construction teams can use this layer to identify SRA locations and consistently apply exempt material requirements and vegetation management protocols.

All SRA areas will follow HFRA design standards, including required materials and the HFRA decision tree. This approach ensures that design, construction, and clearance requirements comply with SRA regulations while meeting HFRA risk mitigation standards.

NON-EXEMPT EQUIPMENT
(VEGETATION CLEARANCE REQUIRED AROUND POLES IN HFRA)

- Non-exempt fuses with: open cutout fuse link, enclosed cutout fuse link, Bay-O-Net cutout, and SMD-1A designs
- Line disconnect not associated with reclosers, regulators, or similar apparatus
- Surge arresters without an SPU including MOV and porcelain designs

- Split-bolt connector
- Copper vise connectors
- S&C Omni-Rupter® R4[3/]
- Grasshopper/ Tilting Insulator Pole Switches[3/]
- S&C Alduti-Rupter®[3/]
- Vacuum / Solid Dielectric Reclosers (G&W Viper, Cooper Nova)[3/]
- Solid dielectric transformers, typically applied for control power or metering[3/]
- Capacitor banks with vacuum switches[3/]
- Inertia LineBOSS® Switches

[3/] These items are standard materials for new construction in HFRA applications, and exemptions for these materials are in process with Cal Fire and Board of Forestry.

EXEMPT EQUIPMENT (VEGETATION CLEARANCE OPTIONAL)

Below is a list of equipment that is exempt in HFRA. This list exceeds the list of approved exempt equipment in the Power Line Fire Prevention Field Guide (published by the California Department of Forestry and Fire Protection).

- Exempt fuses: SMU-20, CLD, Fault Tamer®, ELF, X-Limiter, Valiant
- Line disconnect associated with recloser, regulator, or similar apparatus
- Oil-filled transformers
- Fixed capacitor banks
- Switched capacitor banks with oil switches
- Oil-filled automatic reclosers
- Bolted wedge connectors
- Parallel groove connectors
- Fargo GA 9000 connectors
- Hot line clamp connectors
- Insulation piercing connectors
- Flat plate connectors with no less than 2 bolts (i.e., NEMA lug)
- Line poles, where conductors are continuous, and any primary ground connections are made with exempt connectors, such as parallel groove or bolted wedge connectors
- Dead-end or angle poles with no taps or connections
- Dead-end or corner poles with taps or connections made with exempt connectors, such as parallel groove or bolted wedge connectors
- Automatic dead-ends
- Automatic or compression line splices
- S&C Omni-Rupter® R1/R2
- KPF
- ABB Lightning Arrester w/Spark Prevention Unit (SPU)

5.8 Special Conditions

A. EMF Reduction

Electromagnetic Fields (EMFs) are an important issue in the area of environmental awareness. SCE 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.

ADS–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.

- Hauling permits
- Digging permits
- Highway permits — state and county
- Flood control permits
- Coastal Zone Commission
- Traffic control permits

C. Joint Pole

The proposed installation, removal, relinquishment, replacement, and maintenance of joint use poles shall be planned with all utilities (Southern California Joint Pole Committee members) and tenants (Cable TV and other non-SCJPC companies) operating in the area. The purpose of joint planning is to allow SCE and the interested third parties to determine the most practical and economical method for accomplishing the desired results, helping ensure that all parties derive the maximum possible service at minimum costs. Participation by SCJPC members shall be in accordance with the SCJPC Joint Pole Routine Handbook. (See Form SCE 14-413).

Agreements are made with CATV or other communication companies, and other public or private entities that are not members of the SCJPC to rent or license space for wireline and wireless facilities when surplus space and strength is available on the pole. These agreements are handled through SCE’s Joint Pole Organization, a subset of the T&D Distribution Business Line.

“Request for Access” applications submitted by non-SCJPC members (described above) seeking to attach facilities to solely-owned SCE distribution and sub-transmission poles and SCE space on jointly owned distribution and sub-transmission poles are subject to the terms and conditions of License or Rental agreements, including applicable T&D standards, policies, and practices. Requests by SCJPC and non-SPJPC companies to attach facilities to transmission structures are considered on a case-by-case basis in coordination with the responsible Transmission Grid estimating manager, however, such attachments are not subject to the CPUC's Rights-of-Way rules governing non-discriminatory access.

Joint used wood and non-wood poles are not required to be stepped. However, and incoming joint owner or licensee may choose to install steps in wood poles, (See DOH, PO 100).

When a joint use wood pole supporting third-party facilities is replaced with a composite pole, a small section of the wood pole (where the third-party facilities are attached) may be temporarily attached to the composite pole, (See DOH, PO 115).

D. Transmission Line Rating Remediation (TLRR) Program

The TLRR program is a compliance program that is a collective effort between Transmission, Distribution and/or Carrier Solutions to rememdiate overhead line clearance issues on the SCE system to comply with NERC Reliability Standards and to comply with G.O. 95. Light Detection and Ranging (LiDAR) technology was used to identify these infractions and a mitigation plan was filed and accepted by WECC. This program has a set amount of scope and many of the subtransmission infractions that were identified are on transmission poles with distribution underbuild. Appropriate clearances can be found in both G.O. 95 and the DOH, Section DC.

TLRR budget is limited to remediating the infractions determined through the LiDAR study that was completed. End-of-line (EOL) voltage drop and flicker calculations will not be required for like-for-like pole, wire, or transformer replacements. Transformers found on poles with identified infractions will be sized properly per ADS-7.

E. 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 (5000 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 V to 50,000 V — 600 feet
- 50,000 V to 75,000 V — 750 feet

F. Crossings and Conflicts

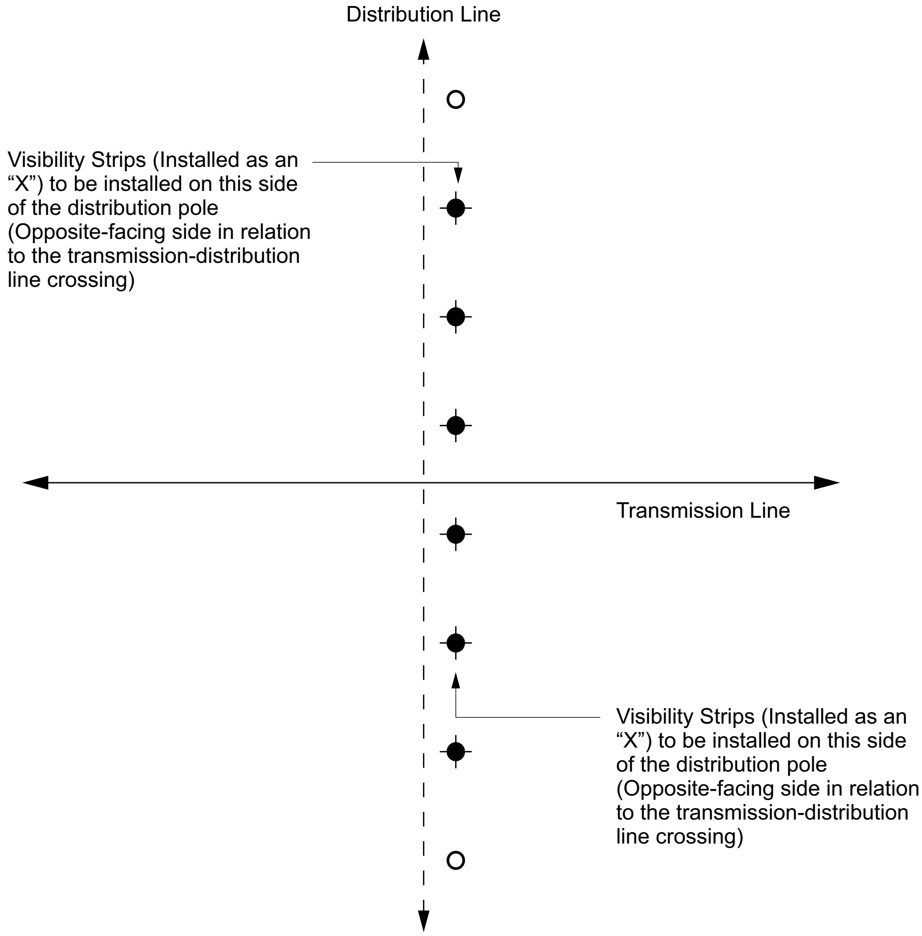
Distribution circuit conductors crossing divided state highways of four lanes or more, or freeways, shall be dead-ended at the crossing poles.

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, *X markers* (visibility strips configured as an “X”; refer to DOH, Figure DC 538-2) shall be installed on the **three** 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.The Air Ops manager can be reached at (909) 974-4676.
See Figure 10–14; and refer to DOH, DC 538, for details.

Figure 10–14: Distribution Poles that Shall Be Marked at an Overhead Transmission-Distribution Line Crossing



G. Construction Near Airports or Structures/Spans 200 feet in Height or Greater

It is the obligation of SCE 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 structures/spans 200 feet in height or greater requires a notice or proposed construction or alteration, contact T&D Aviation Filing and Maintenance (AF&M) Compliance Program at AFM@sce.com. For construction standards of FAA lighting, refer to DOH SL 601.

Any aboveground construction or alteration of existing facilities within 20,000 feet of an airport, or 5,000 feet of a heliport not covered in Table 10–23: Pole Height Construction near Airports, should be referred to AFM@sce.com for an evaluation of its affect on the airspace and determination of necessary Federal Aviation Administration (FAA) filing, except when:[4/]

❶ No lateral or height change to the structure or lines is made.

[4/] Always contact FE when constructing or altering overhead distribution lines spanning rivers, freeways, and canyons, or if in doubt.

2 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-rises and hills), such that the proposed construction/alteration would exist within the shield.

3 If the land around the airport is flat, AFM@sce.com must be contacted only if the pole height exceeds the height shown in Table 10–23: Pole Height Construction near Airports. (If the construction location is in hilly terrain, then contact AFM@sce.com regardless of pole height).

Table 10–23: Pole Height Construction near Airports

Table Note: Contact AFM@sce.com if construction exceeds height shown.

Distance from Airport/Heliport to Construction Site (ft)	Airport Pole Height above Ground (ft) if longest runway is > 3,200 ft.	Airport Pole Height above Ground (ft) if longest runway is 3,200 ft. or less[a/]	Heliport Pole Height above Ground (ft)
Under 500	Contact AFM@sce.com	Contact AFM@sce.com	Contact AFM@sce.com
500	Contact AFM@sce.com	Contact AFM@sce.com	20
1,000	Contact AFM@sce.com	20	40
1,500	Contact AFM@sce.com	30	60
2,000	20	40	80
2,500	25	50	100
3,000	30	60	120
3,500	35	70	140
4,000	40	80	160
4,500	45	90	180
5,000	50	100	200
6,000	60	120	No contact necessary
7,000	70	140	No contact necessary
8,000	80	160	No contact necessary
9,000	90	180	No contact necessary
10,000	100	200	No contact necessary
15,000	150	No contact necessary	No contact necessary
20,000	200	No contact necessary	No contact necessary
Over 20,000	No contact necessary	No contact necessary	No contact necessary

Note(s):

1. Always contact AFM@sce.com when constructing or altering overhead distribution lines spanning rivers, freeways, and canyons, or if in doubt.

[a/] Airports include: Baker, Catalina, Compton/Woodley, Corona Muni, Eckert Field, Exeter, Fallbrook Community Airpark, Flabob, Fullerton Muni, Furnace Creek, Santa Paula, Sequoia Field, Sierra Sky Park, and Woodlake.

H. Aerial Obstruction Marker Balls

Aerial marker balls are aviation orange, white, and yellow spherical markers typically attached to overhead powerlines and shield wires where it could impair aviation safety.

Transmission/Distribution lines where the height above ground level exceeds 200-feet or are located near airports, heliports, across rivers, canyons, lakes, or freeways where an aircraft is likely to approach would require aviation marking.

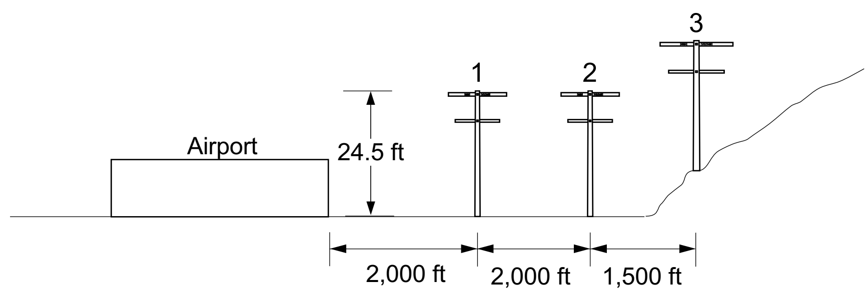
AirOps or the FAA may also designate other locations besides overhead powerline crossing like glide slopes into airports where aerial obstruction marker balls shall be installed.

Aerial Obstruction Marker Balls can be installed on Distribution lines where it is the highest conductor on the circuit.

EXAMPLE 10–1: DETERMINING POLE NUMBER FOR OVERHEAD LINE CONSTRUCTION NEAR AIRPORTS

SCENARIO: Thirty-foot poles are being placed as shown in Figure 10–15. According to Appendix 10–1, 24.5 feet of the pole will be aboveground.

Figure 10–15: Overhead Line Construction near Airports



PROBLEM: Per the usable pole strength tables shown in ANSI 05.1.2008, 24.5 feet of the pole will be aboveground. Airport's longest runway is greater than 3,200 ft.

SOLUTION: Pole number is determined by the following factors:

1. Pole height 24.5 feet — Table 10–23: Pole Height Construction near Airports indicates to contact AFM@sce.com 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 AFM@sce.com as the pole is less than 40 feet aboveground. Table 10–23: Pole Height Construction near Airports indicates to contact AFM@sce.com 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, FE must be contacted since pole is not at same level as airport.

I. 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* mean 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 lightweight 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 T&D poles.

3. Joint Owners seeking to install antennas below SCE facilities (for example, lines, equipment, guys) must seek access in accordance with the Southern California Joint Pole Committee Agreement and Routine Handbook.

4. Licensees seeking to install antennas below SCE facilities (for example, lines, equipment, guys) must seek access in accordance with SCE's Pole License Agreement and Request for Access process.

5. All entities seeking to install antennas above or between SCE equipment (for example, lines or guys) must seek access in accordance with the provisions of SCE's Pole License Agreement for Commercial Mobile Radio Service (CMRS) or Competitive Local Exchange Carrier (CLEC) Antenna Attachments and the Request for Access process. CLECs that are not party to the Southern California Joint Pole Committee and wish to install antenna(s) located below SCE equipment (for example, lines or guys) in space owned by SCE, will abide by the requirements established in a fully executed "Pole Competitive Local Exchange Carrier (CLEC) Antenna Attachments."

6. 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 G.O. 95 requirements.

   b. Entities failing to correct unsafe conditions in a timely manner, may be reported to the California Public Utilities Commission's Consumer Safety and Enforcement Division; and/or billed for necessary remedial action undertaken by SCE.

7. Refer to the Pole Loading Manual (PLM) for approved non-SCE antennas.

J. Edison SmartConnect® Communication Devices

Edison SmartConnect® communication devices provide a solution to capture and transfer meter data information from Edison SmartConnect® meters located in RF Isolated locations. SCE's Grid Services Advanced Metering Operations (AMO) 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.

NOTE

Grid Services Advanced Metering Operations (AMO) was formerly known as the SmartConnect® Operations Center (SOC).

Edison SmartConnect® has developed the following communication device options:

1. Edison 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 DAP, AP 720.

2. Edison 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 (preferred) or Powertrusion multi-sided composite poles at the secondary voltage level. Maintain all minimum construction and clearance requirements as specified in DAP, AP 715.

K. NetComm over Satellite (NetCOS) Assembly

The NetCOS assembly provides NetComm RF coverage for equipment located in isolated areas. The NetCOS assembly uses NetComm radios to communicate with equipment, but the "back haul" communication takes place through the iDirect Satellite system, which is transparent to the operators. All communication electronics are housed in a NEMA 4 enclosure that is mounted to a wood pole along with the satellite dish and radio antennas. Construction details are located in DAP, AP 705.

NetComm Engineering is responsible for providing and coordinating NetCOS installation request.

L. Weather Monitoring System

In an effort to integrate meteorological data with infrastructure asset information, SCE is installing weather stations throughout the distribution system. Powered by 65-watt solar panels, SCE's weather stations can track and log humidity, temperature, irradiance and wind speed. This data is used for supporting Public Safety Power Shutoff criteria. This data is communicated via satellite. However, cellular-based weather stations still exist in the field.

Weather stations are installed in high fire risk areas (HFRA). The location of these weather stations is determined by Business Resilience team meteorologists and installed by Distribution Automation crews. Western Weather Group facilitates installation material to the Business Resilience team and provides field support to the Automation crews. Construction details are located in DAP, AP 810.

M. 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 California Public Utilities Commission (CPUC). 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 T&D G.O. 95 representative and provide the following:

- ☐ 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.
- ☐ 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.
- ☐ 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.

N. Socket Based Router

The Socket Based Router (SBR) uses the 4G wireless technology currently supported by AT&T and Verizon Wireless. 4G wireless technology offers higher bandwidth (data speeds), lower latency with faster response times, and overall more resilient and robust network connectivity than 3G. The SBR will replace outdated Socket Based Cell Relays (SBCR) in pad-mount posted transformer, semi-buried pedestal, and overhead distribution applications where an existing socket exists. The SBR is also approved for new construction. For construction and installation details, refer to the Distribution Apparatus Construction Standards (DAP), section AP 725.

O. Pole Mounted Router

The Pole Mounted Router (PMR) uses 4G wireless technology currently supported by AT&T and Verizon Wireless. 4G wireless technology offers higher bandwidth (data speeds), lower latency with faster response times, and overall more resilient and robust network connectivity than 3G. The SBR will replace outdated Socket Based Cell Relays (SBCR) in overhead distribution applications for new and existing construction.

The PMR hosts a 120/240 VAC auto-ranging power supply and can be powered via 120 VAC or 240 VAC. The PMR has dual backhaul capabilities. The PMR is capable of failing-over to the alternate Ethernet network as an emergency backup to maintain persistent connectivity to SCE’s network. The PMR, like the SBR, supports dual carrier functionality, meaning the device is modular enough to enable the utility to utilize AT&T or Verizon by simply populating one SIM card slot or the other. For construction and installation details, refer to the Distribution Apparatus Construction Standards (DAP), section AP 726.

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 1 of 24)*

POLE LOADING GUIDELINES

- Pole-loading calculation will be performed and retained by the respondsible 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.

An intrusive pole inspection will be performed when:

- No online record exists.
- Online existing record is older than 20 years.

NEW POLE DESIGN

Table 10–28 and Table 10–29 identify the different types, sizes, and classes of poles purchased by SCE. They identify the top and ground-line circumference; and the usable pole strength for 6-, 8-, 12-, and 18-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 10–30 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.

Included in this appendix are three examples (Example 10–2, Example 10–3, Example 10–4) that use Table 10–28, Table 10–29 and Table 10–30.

Table 10–24: 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

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 2 of 24)*

Table 10–25: Safety Factors for Wood and Lightweight Steel (LWS) Poles — New and In-Service Construction

Pole Type	Design Criteria (lb)	New Construction		In-Service Construction	
		Grade A Construction Pole Load Safety Factor	Grade B Construction Pole Load Safety Factor	Grade A Construction Pole Load Safety Factor	Grade B Construction Pole Load Safety Factor
Wood	6	For joint-owned and joint-use poles, see Table 10–26	3.00	For joint-owned and joint-use poles, see Table 10–26	2.00
	8		3.00		2.00
	12		3.00		2.00
	18		3.00		2.00
	24		3.00		2.00
LWS	6	2.50	1.88	1.50	1.50
	8	2.50	1.88	1.50	1.50
	12	1.88	1.88	1.50	1.50
	18	1.88	1.88	1.50	1.50
	24	1.88	1.88	1.50	1.50
Guying Requirements[a/]	—	2.00	2.00	2.00	2.00

[a/] The safety factor of 1.33 will be applied for in-service anchored and span guys (Grade A or Grade B construction).

Table 10–26: Safety Factors for Joint-Owned and Joint-Use Poles

Design Criteria (lb)	New Construction		In-Service Construction
	Bending	Buckling	
6	4.00	4.00	2.67
8	4.00	4.00	2.67
12	3.00	4.00	2.00
18	3.00	4.00	2.00
24	3.00	4.00	2.00

IN-SERVICE POLE DESIGN

Poles must be capable of 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:

1. Replacing a deteriorated wood structure
2. SCE adds new equipment (for example, single or multiple transformers, capacitor banks, automatic reclosers), or adds/upgrades conductors.
3. SCE tenants transferring attachments
4. Installing "Third Party" communication facilities (wire line or wireless)
5. Pole-loading calculations must be performed by joint owners and licensees when adding/upgrading their facilities (including equipment and cables); 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:

1. Perform an intrusive inspection — Record proper shell thickness or remaining section modulus (from below ground line up to 96 inches (8 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.

2. 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.
3. 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.)
4. Determine the length of the span between wood structures.
5. Determine the height of each piece of equipment and conductor on the wood structure.
6. Determine the size of each piece of equipment and conductor type(s).
7. 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.
8. Determine conductor pole loading from Table 10–30. Included in this appendix are two examples using Table 10–28 and Table 10–29.
9. Use new Pole Load Form to capture information to perform pole-load calculation, see Figure 10–16.

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples ***(Sheet 4 of 24)***

FORMULAS

$$\text{Wood bending moment} = 0.000264 \times \text{average fiber stress} \times \text{ground-line circumference}^3$$

$$\text{Safety Factor} = \text{3 for Grade B, 4 for Grade A construction}$$

$$\text{Moment from wind on pole} = \frac{PH^2[D + 2d]}{72}$$

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 of 6,000 psi (average).

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 5 of 24)*

Table 10–27: 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 CIRCUM/DIA (in)	Top CIRCUM (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
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

Note(s):
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.

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 6 of 24)*

Table 10–27: 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 CIRCUM/DIA (in)	Top CIRCUM (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)
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
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
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

Note(s):

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.

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 7 of 24)*

Table 10–27: 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 CIRCUM/DIA (in)	Top CIRCUM (in)	6-lb Pole Load Usable ft-lb Grade A SF-4	6-lb Pole Load Usable ft-lb Grade B SF-3	8-lb Pole Load Usable ft-lb Grade A SF-4	8-lb Pole Load Usable ft-lb Grade B SF-3	12-lb Pole Load Usable ft-lb Grade A & Grade B SF-3	18-lb Pole Load Usable ft-lb Grade A & Grade B SF-3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11 & 12)	(13 & 14)
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
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

Note(s):

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.

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 8 of 24)*

Table 10–28: Unguyed Composite Fiberglass Poles—Usable Strength

Pole Length (ft)	ANSI Size Class	Height above Ground (ft)	Ground-Line CIRCUM/DIA (in)	Top CIRCUM (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 Southern California Edison (SCE). Other sizes are available by special order only.

[b/] Use Columns 8 and 9 for 6-pound wind.

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 9 of 24)*

Table 10–29: Pole Strengths for Unguyed Western Red Cedar—Class 1-5 T&D Standard

Pole Length (ft)	ASA Size Class	Height above Ground (ft)	Ground-Line CIRCUM/DIA (in)	Top CIRCUM/DIA (in)	Usable Strength ft-lb 8-lb Pole Load Grade A Construction	Usable Strength ft-lb 8-lb Pole Load Grade B Construction	Usable Strength ft-lb 12-lb Pole Load Grade A Construction	Usable Strength ft-lb 12-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[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 SCE. 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.

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 10 of 24)*

Table 10–30: Conductor Pole Loading

		Pole Loading per Foot (lb/ft)				
Conductor Size	**DIA (in)**	**6 lb/ft^2 Heavy Load (above 3,000 ft)**	**8 lb/ft^2 (below 3,000 ft)**	**12 lb/ft^2**	**18 lb/ft^2**	**24 lb/ft^2**
954 kcmil all Al	1.124	1.062	0.749	1.124	1.686	2.248
795 kcmil all Al	1.026	1.013	0.684	1.026	1.539	2.052
795 kcmil ACSR	1.108	1.054	0.739	1.108	1.662	2.216
636 kcmil all Al	0.918	0.959	0.612	0.918	1.377	1.836
653.9 kcmil ACSR	0.953	0.977	0.635	0.953	1.430	1.906
477 kcmil all Al	0.793	0.897	0.529	0.793	1.190	1.586
336.4 kcmil all Al	0.666	0.833	0.444	0.666	0.999	1.332
336.4 kcmil ACSR	0.684	0.842	0.456	0.684	1.026	1.368
4/0 all Al	0.527	0.764	0.351	0.527	0.791	1.054
4/0 ACSR	0.563	0.782	0.375	0.563	0.845	1.126
4/0 bare Cu	0.528	0.764	0.352	0.528	0.792	1.056
4/0 WP Cu	0.678	0.839	0.452	0.678	1.017	1.356
2/0 all Al or BC	0.419	0.710	0.279	0.419	0.629	0.838
2/0 ACSR	0.447	0.724	0.298	0.447	0.671	0.894
2/0 WP Cu	0.570	0.785	0.380	0.570	0.855	1.140
1/0 ACSR	0.398	0.699	0.265	0.398	0.597	0.796
1/0 bare Cu	0.373	0.687	0.249	0.373	0.560	0.746
1/0 WP Al or Cu	0.493	0.747	0.329	0.493	0.740	0.986
No. 1 bare Cu	0.332	0.666	0.221	0.332	0.498	0.664
No. 2 all Al or BC	0.292	0.646	0.195	0.292	0.438	0.584
No. 2 ACSR	0.316	0.658	0.211	0.316	0.474	0.632
No. 2 WP Al or Cu	0.386	0.693	0.257	0.386	0.579	0.772
No. 4 all Al	0.232	0.616	0.155	0.232	0.348	0.464
No. 4 ACSR	0.250	0.625	0.167	0.250	0.375	0.500
No. 4 Str BC	0.232	0.616	0.155	0.232	0.348	0.464
No. 4 bare Cu	0.204	0.602	0.136	0.204	0.306	0.408
No. 4 WP Cu	0.329	0.665	0.219	0.329	0.494	0.658

Note(s):

1. Heavy-loading areas computed with 6-pound (48.41 mph) wind with one-half inch radial ice. Light-loading areas computed with 8-pound (55.90 mph) wind, 12-pound wind (68.47 mph), 18-pound (83.85 mph) wind, or 24-pound (96.82 mph) wind.
2. Horizontal pole loading per foot of conductor for conductors not listed above is determined by the following formulas:

6-lb heavy loading	=	(Diameter + 1.0) x 0.5
8-lb light loading	=	(Diameter + 12) x 8
12-lb light loading	=	(Diameter + 12) x 12
18-lb light loading	=	(Diameter + 12) x 18
24-lb light loading	=	(Diameter + 12) x 24

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 11 of 24)*

Table 10–30: Conductor Pole Loading *(Continued)*

		Pole Loading per Foot (lb/ft)				
Conductor Size	**DIA (in)**	**6 lb/ft^2 Heavy Load (above 3,000 ft)**	**8 lb/ft^2 (below 3,000 ft)**	**12 lb/ft^2**	**18 lb/ft^2**	**24 lb/ft^2**
No. 6 bare Cu	0.162	0.581	0.108	0.162	0.243	0.324
No. 6 WP Cu	0.287	0.644	0.191	0.287	0.431	0.574
No. 8 bare Cu	0.129	0.564	0.086	0.129	0.193	0.257
No. 8 WP Cu	0.254	0.627	0.169	0.254	0.381	0.508
No. 6 Al Dup	0.450	0.725	0.300	0.450	0.675	0.900
No. 4 Al Dup	0.565	0.783	0.377	0.565	0.848	1.130
No. 4 Al triplex	0.640	0.820	0.427	0.640	0.960	1.280
No. 2 Al triplex	0.760	0.880	0.507	0.760	1.140	1.520
1/0 Al triplex	0.990	0.995	0.660	0.990	1.485	1.980
4/0 Al triplex	1.341	1.171	0.894	1.341	2.012	2.682
No. 4 Al quad	0.848	0.924	0.565	0.848	1.272	1.696
1/0 Al quad	1.120	1.060	0.747	1.120	1.680	2.240
4/0 Al quad	1.490	1.245	0.993	1.490	2.235	2.980
No. 6 Cu triplex	0.548	0.774	0.365	0.548	0.822	1.096
No. 4 Cu triplex	0.646	0.823	0.431	0.646	0.969	1.292
No. 2 Cu triplex	0.772	0.886	0.515	0.772	1.158	1.544
1/0 aerial cable	3.088	2.044	2.059	3.088	4.632	6.176
350 aerial cable	3.884	2.442	2.589	3.884	5.826	7.768
4/0 aerial cable	4.440	2.720	2.960	4.440	6.660	8.880
700 aerial cable	5.200	3.100	3.467	5.200	7.800	10.400
No. 2 Str. Aerial	3.040	2.020	2.027	3.040	4.560	6.080
No. 8 B.C. Aerial	3.040	2.020	2.027	3.040	4.560	6.080
#2 Cu XLPE	0.622	0.807	0.409	0.613	0.920	1.226
1/0 ACSR HDPE[a/,b/]	0.698	0.831	0.441	0.661	0.992	1.322
1/0 ACSR HDPE[a/c/]	0.728	0.864	0.485	0.728	1.092	1.456
1/0 ACSR XLPE	0.728	0.864	0.485	0.728	1.092	1.456
2/0 Cu XLPE	0.744	0.866	0.488	0.732	1.098	1.464
4/0 Cu XLPE	0.850	0.918	0.557	0.836	1.254	1.672
336.4 kcmil XLPE	1.013	1.007	0.675	1.013	1.520	2.026
653.9 kcmil XLPE	1.2833	1.142	0.856	1.283	1.925	2.567
GUYS						
7/32 inch	0.219	0.610	0.146	0.219	0.329	0.438
1/4 inch	0.250	0.625	0.167	0.250	0.375	0.500
9/32 inch	0.281	0.641	0.187	0.281	0.422	0.562
5/16 inch	0.313	0.657	0.209	0.313	0.470	0.626
3/8 inch	0.375	0.688	0.250	0.375	0.563	0.750
7/16 inch	0.438	0.719	0.292	0.438	0.657	0.876

Note(s):

1. Heavy-loading areas computed with 6-pound (48.41 mph) wind with one-half inch radial ice. Light-loading areas computed with 8-pound (55.90 mph) wind, 12-pound wind (68.47 mph), 18-pound (83.85 mph) wind, or 24-pound (96.82 mph) wind.
2. Horizontal pole loading per foot of conductor for conductors not listed above is determined by the following formulas:

   6-lb heavy loading = (Diameter + 1.0) x 0.5

   8-lb light loading = (Diameter + 12) x 8

   12-lb light loading = (Diameter + 12) x 12

   18-lb light loading = (Diameter + 12) x 18

   24-lb light loading = (Diameter + 12) x 24

[a/] Not approved for use on new construction.

[b/] 75 degrees Celsius rated ACSR. Refer to DOH, Table CC 110-1.

[c/] 90 degrees Celsius rated ACSR. Refer to DOH, Table CC 110-2.

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 12 of 24)*

Table 10–30: Conductor Pole Loading *(Continued)*

		Pole Loading per Foot (lb/ft)				
Conductor Size	**DIA (Includes Messenger) (in)**	**6 lb/ft^2 Heavy Load (above 3,000 ft)**	**8 lb/ft^2 (below 3,000 ft)**	**12 lb/ft^2**	**18 lb/ft^2**	**24 lb/ft^2**
TELEPHONE CABLE						
25 pair-5/16 msgr	0.943	0.972	0.629	0.943	1.415	1.886
50 pair-5/16 msgr	1.153	1.077	0.769	1.153	1.730	2.306
100 pair-5/16 msgr	1.513	1.257	1.009	1.513	2.270	3.026
200 pair-7/16 msgr	1.938	1.469	1.292	1.938	2.907	3.876
400 pair-7/16 msgr	2.538	1.769	1.692	2.538	3.807	5.076
600 pair-7/16 msgr	2.938	1.969	1.959	2.938	4.407	5.876
900 pair-7/16 msgr	3.438	2.219	2.292	3.438	5.157	6.876
No. 9 iron wire	0.148	0.574	0.099	0.148	0.222	0.296
No. 12 iron wire	0.109	0.555	0.073	0.109	0.164	0.218
1/2" DIA - 1/4" msgr	0.750	0.875	0.500	0.750	1.125	1.500
1/2" DIA - 5/16" msgr	0.810	0.905	0.540	0.810	1.215	1.620
1/2" DIA - 7/16" msgr	0.940	0.970	0.627	0.940	1.410	1.880
1/2" DIA - 1/2" msgr	1.000	1.000	0.667	1.000	1.500	2.000
3/4" DIA - 1/4" msgr	1.000	1.000	0.667	1.000	1.500	2.000
3/4" DIA - 5/16" msgr	1.060	1.030	0.707	1.060	1.590	2.120
3/4" DIA - 7/16" msgr	1.190	1.095	0.793	1.190	1.785	2.380
3/4" DIA - 1/2" msgr	1.250	1.125	0.833	1.250	1.875	2.500
1" DIA - 1/4" msgr	1.250	1.125	0.833	1.250	1.875	2.500
1" DIA - 5/16" msgr	1.310	1.155	0.873	1.310	1.965	2.620
1" DIA - 7/16" msgr	1.440	1.220	0.960	1.440	2.160	2.880
1" DIA - 1/2" msgr	1.500	1.250	1.000	1.500	2.250	3.000
1.25" DIA - 1/4" msgr	1.500	1.250	1.000	1.500	2.250	3.000
1.25" DIA - 5/16" msgr	1.560	1.280	1.040	1.560	2.340	3.120
1.25" DIA - 7/16" msgr	1.690	1.345	1.127	1.690	2.535	3.380
1.25" DIA - 1/2" msgr	1.750	1.375	1.167	1.750	2.625	3.500
1.5" DIA - 1/4" msgr	1.750	1.375	1.167	1.750	2.625	3.500
1.5" DIA - 5/16" msgr	1.810	1.405	1.207	1.810	2.715	3.620
1.5" DIA - 7/16" msgr	1.940	1.470	1.293	1.940	2.910	3.880
1.5" DIA - 1/2" msgr	2.000	1.500	1.333	2.000	3.000	4.000
2" DIA - 1/4" msgr	2.250	1.625	1.500	2.250	3.375	4.500
2" DIA - 5/16" msgr	2.310	1.655	1.540	2.310	3.465	4.620
2" DIA - 7/16" msgr	2.440	1.720	1.627	2.440	3.660	4.880
2" DIA - 1/2" msgr	3.000	2.000	2.000	3.000	4.500	6.000
2.5" DIA - 1/4" msgr	2.750	1.875	1.833	2.750	4.125	5.500
2.5" DIA - 5/16" msgr	2.810	1.905	1.873	2.810	4.215	5.620

Note(s):

1. Heavy-loading areas computed with 6-pound (48.41 mph) wind with one-half inch radial ice. Light-loading areas computed with 8-pound (55.90 mph) wind, 12-pound wind (68.47 mph), 18-pound (83.85 mph) wind, or 24-pound (96.82 mph) wind.
2. Horizontal pole loading per foot of conductor for conductors not listed above is determined by the following formulas:

6-lb heavy loading	=	(Diameter + 1.0) x 0.5
8-lb light loading	=	(Diameter + 12) x 8
12-lb light loading	=	(Diameter + 12) x 12
18-lb light loading	=	(Diameter + 12) x 18
24-lb light loading	=	(Diameter + 12) x 24

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 13 of 24)*

Table 10–30: Conductor Pole Loading *(Continued)*

		Pole Loading per Foot (lb/ft)				
Conductor Size	**DIA (Includes Messenger) (in)**	**6 lb/ft^2 Heavy Load (above 3,000 ft)**	**8 lb/ft^2 (below 3,000 ft)**	**12 lb/ft^2**	**18 lb/ft^2**	**24 lb/ft^2**
TELEPHONE CABLE (Cont'd)						
2.5" DIA - 7/16" msgr	2.940	1.970	1.960	2.940	4.410	5.880
2.5" DIA - 1/2" msgr	3.000	2.000	2.000	3.000	4.500	6.000
3" DIA - 1/4" msgr	3.250	2.125	2.167	3.250	4.875	6.500
3" DIA - 5/16" msgr	3.310	2.155	2.207	3.310	4.965	6.620
3" DIA - 7/16" msgr	3.440	2.220	2.293	3.440	5.160	6.880
3" DIA - 1/2" msgr	3.500	2.250	2.333	3.500	5.250	7.000
3.5" DIA - 1/4" msgr	3.750	2.375	2.500	3.750	5.625	7.500
3.5" DIA - 5/16" msgr	3.810	2.405	2.540	3.810	5.715	7.620
3.5" DIA - 7/16" msgr	3.940	2.470	2.627	3.940	5.910	7.880
3.5" DIA - 1/4" msgr	4.000	2.500	2.667	4.000	6.000	8.000
4" DIA - 1/4" msgr	4.250	2.625	2.833	4.250	6.375	8.500
4" DIA - 5/16" msgr	4.310	2.655	2.873	4.310	6.465	8.620
4" DIA - 7/16" msgr	4.440	2.720	2.960	4.440	6.660	8.880
4" DIA - 1/2" msgr	4.500	2.750	3.000	4.500	6.750	9.000

Note(s):

1. Heavy-loading areas computed with 6-pound (48.41 mph) wind with one-half inch radial ice. Light-loading areas computed with 8-pound (55.90 mph) wind, 12-pound wind (68.47 mph), 18-pound (83.85 mph) wind, or 24-pound (96.82 mph) wind.
2. Horizontal pole loading per foot of conductor for conductors not listed above is determined by the following formulas:

6-lb heavy loading = (Diameter + 1.0) x 0.5

8-lb light loading = (Diameter + 12) x 8

12-lb light loading = (Diameter + 12) x 12

18-lb light loading = (Diameter + 12) x 18

24-lb light loading = (Diameter + 12) x 24

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 14 of 24)*

Figure 10–16: 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

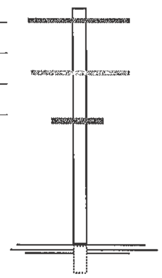
Wood Pole Information

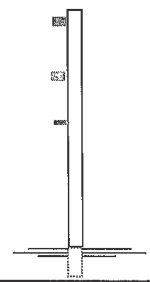
District Name ____________________City ______________
Pole Number Ex. ______________ NEW _______________
Substation ____________________
Circuit Name ____________________ ____kV
Planner Name ____________________ T.G. Pg. ______
Date Perf. Pole loading __________________
Wood Species Ex_______New_____
Length of Pole Ex_______New_____
Class of Pole Ex_______New_____
Year Set Ex_______New_____

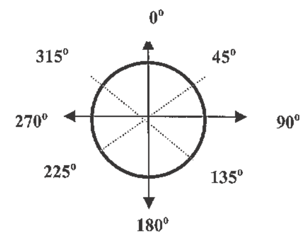
Ahead - Feet Back - Feet

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

Appendix 10–1: Pole Strength/Pole Loading Tables and Examples *(Sheet 15 of 24)*
Figure 10–17: 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

EXAMPLE 10–2: DETERMINING CLASS OF POLE FOR 55-FOOT POLES—NEW POLE SETS ONLY

SCENARIO A 55-foot pole under the following conditions:

- Light-loading area (8-pound wind)
- Grade A construction
- Length of span (one-half of each adjacent span) = 150 feet
- 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"

PROBLEM What class of pole is necessary?

SOLUTION Calculation(s):

To calculate the total horizontal loading of conductors on a pole, use the following formula:

From (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)	x	No. of Conductors	x	Span (ft)	x	Height above Ground	=	Total Horizontal Load (ft-lb)
653.9 kcmil	0.635	x	3	x	150	x	48	=	13,716
336 ACSR	0.456	x	3	x	150	x	44	=	9,029
100 pair AWG	1.009	x	1	x	150	x	29.5	=	4,465
								Total	27,210

a/ See Table 10–30.

Example 10–3: Determining Maximum Span for Class 4, 45-Foot Poles, Heavy Loading—New Pole Sets Only

Scenario A 45-foot pole under the following conditions:

- Heavy-loading area (6-pound wind) (see)
- Grade B construction
- Conductors

Level	Size	Number	Height above Ground
Top	336 ACSR	3	38'-6"
Second	#2 ACSR	3	34'-6"

Problem Determine the maximum span that a Class 4, 45-foot pole will support in the above scenario:

Solution Calculation(s):

To determine the maximum span, first calculate the horizontal load per foot of span. Use the following formula:

Conductor Size	Load per Foot[a]	x	No. of Conductors	x	Height above Ground (ft)	=	Horizontal Load per Foot of Span (lb)
336 ACSR	0.842	x	3	x	38.5	=	97.25
#2 ACSR	0.658	x	3	x	34.5	=	68.10
						Total	165.35

[a] See Table 10–30.

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 (ft)
22,943[a]	÷	165.35	=	139

[a] Usable pole strength for 8-lb wind Table 10–28, Columns 8 and 9 are used for 6-lb wind.

From , 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, which is the **total horizontal load-per-foot of span**. This equals a maximum span of 139 feet.

Example 10–4: Determining Class of Pole for 45-Foot Wood Poles, Light Loading— New Pole Sets Only

Scenario A 45-foot wood pole under the following conditions:

- Light-loading area (12-pound wind)
- Grade A construction
- Length of span (one-half of each adjacent span) = 250 feet
- Conductors/cables

Level	Size	Number	Height above Ground
Top	336 ACSR[a/]	3	38'
Second	#2 ACSR	4	32'
Communication(s)	200 pair	1	24'

[a/] Not approved for use on new construction.

Problem Determine the class of pole.

Solution 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/]	x	No. of Conductors	x	Height above Ground (ft)	x	Span (ft)	=	Total Horizontal Load (ft-lb)
336 ACSR	0.684	x	3	x	38	x	250	=	19,494
#2 ACSR	0.316	x	4	x	32	x	250	=	10,112
200 pair	1.938	x	1	x	24	x	250	=	11,628
								Total	41,234

[a/] See Table 10–30.

From the pole strength , a Class 1, 45-foot pole with a usable strength of 47,534 ft-lb in a 12-pound wind area would be required for this job. The Safety Factor requirement for a new wood pole installation is 3.00 in a 12-pound design area.See Table 10–26.

NOTE The SAP number for a Class 1, 45-foot pole is 10060850.

EXAMPLE 10–5: SAFETY FACTORS AND CALCULATIONS FOR USE OF 80-FOOT POLE

SCENARIO: Use of an 80-foot pole is under consideration.

SAFETY FACTORS: Determine if the pole meets the following minimal safety factors:

1. Light loading area (8-pound wind)
2. Grade A construction (because it includes communications)
3. Length of span (one-half 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
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 .

CALCULATIONS:

Moments from Wind on Conductors

Conductor Size	Load-per-Foot[a/]	x	No. of Conductors	x	Height above Ground (ft)	x	Span (ft)	=	Total Horizontal Load (ft-lb)
653.9 ACSR	0.635	x	1	x	69	x	182	=	7,974
653.9 ACSR	0.635	x	1	x	65	x	182	=	7,512
653.9 ACSR	0.635	x	1	x	61	x	182	=	7,050
653.9 ACSR	0.635	x	2	x	51	x	185	=	11,788
336.4 ACSR	0.436	x	1	x	51	x	182	=	4,233
653.9 ACSR	0.635	x	2	x	46	x	182	=	10,632
653.9 ACSR	0.635	x	2	x	41	x	182	=	9,477
Fiberoptics[b/]	0.335	x	2	x	25	x	182	=	3,049
25 pair	0.629	x	1	x	25	x	182	=	2,862
100 pair[c/]	1.009	x	1	x	24	x	75	=	1,816
								Total	66,393

[a/] See Table 10–31.

[b/] Visual estimate of cable diameter is 0.5 inch. Load-per-foot = diameter × 0.67 for an 8-pound pole load = 0.335

[c/] New attachment

(Continued on next page)

EXAMPLE 10–5: SAFETY FACTORS AND CALCULATIONS FOR USE OF 80-FOOT POLE *(Continued)*

CALCULATIONS: (CONT'D)

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 10–28.

C = 50.5 inches (ground-line circumference)

c = 25 inches (top circumference)

$$\text{Moments from Wind on Pole} = \frac{8 \times 70^2[50.5 + 2 \times 25]}{226.2}$$

$$= 17{,}417 \text{ ft-lb}$$

(Continued on next page)

EXAMPLE 10–5: SAFETY FACTORS AND CALCULATIONS FOR USE OF 80-FOOT POLE ***(Continued)***

CALCULATIONS:
(CONT'D)

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

$$\begin{aligned}\text{Wood Pole Moment} &= 0.000264 \times 8{,}000 \times 50.5^3 \\ &= 272{,}000 \text{ ft-lb}\end{aligned}$$

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

$$\begin{aligned}\text{Void Moment} &= 0.000264 \times 8{,}000 \times [50.5 - 6.2832 \times 1]^3 \\ &= 182{,}581 \text{ ft-lb}\end{aligned}$$

Safety Factor

$$\begin{aligned}\text{Safety Factor} &= \frac{\text{Wood Pole Moment} - \text{Void Moment}}{\text{Moments from Wind on (Conductor + Pole)}} \\ &= \frac{272,000 - 182,581}{66,393 + 17,417} \\ &= 1.07\end{aligned}$$

SAFETY FACTOR CALCULATION RESULT

The minimum in-service safety factor for Grade A construction, including measured deterioration is 2.67. See .

The calculated 1.07 safety factor is below 2.67; therefore, replace the pole.

Example 10–6: Safety Factors and Calculations for Use of 55-Foot Pole

Scenario: Use of a 55-foot pole is under consideration.

Safety Factors: Determine if the pole meets the following minimal safety factors:

1. Light loading area (8-pound wind)
2. Grade A construction (because it includes communications)
3. Length of span (one-half of each adjacent span) = 150 feet
4. Number of conductors and/or cables (visual identification)
5. Class and length = 3/55 (pole brand)
6. Groundline circumference = 41 inches (online record or physical measurement), top circumference = 23 inches from .
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) × (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 .

Level	Size	Number	Height above Ground
Top	653.9 ACSR	3	48'
Second	336.4 ACSR	3	44'
Transformer	37.5 kVA	2	38'
Communications	100 pair	1	29'-6"

Calculations:

Moments from Wind on Conductors

Conductor Size	Load-per-Foot[a/]	x	No. of Conductors	x	Height above Ground (ft)	x	Span (ft)	=	Total Horizontal Load (ft-lb)
653.9 ACSR	0.635	x	3	x	48	x	150	=	13,716
336.4 ACSR	0.436	x	3	x	44	x	150	=	9,029
100 pair	1.009	x	1	x	29.5	x	150	=	4,465
								Total	27,210

a/ See Table 10–31.

(Continued on next page)

EXAMPLE 10–6: SAFETY FACTORS AND CALCULATIONS FOR USE OF 55-FOOT POLE *(Continued)*

CALCULATIONS: (CONT'D)

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 10–27.

C = 41 inches, ground-line circumference

c = 23 inches, top circumference

$$\text{Moment from Wind on Pole} = \frac{8 \times 47.5^2[41 + 2 \times 23]}{226.2}$$

$$= 6{,}942 \text{ ft-lb}$$

Moment from Wind on Equipment

$$\text{Moment from Wind on Equipment} = (W_e) \times (H_e) \times P \times (H_a) \times Q$$

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)

$$\text{Moment from Wind on Equipment} = 2.5 \times 2.5 \times 8 \times 38 \times 2$$

$$= 3{,}800 \text{ ft-lb}$$

Wood Pole Moment

$$\text{Wood Pole Moment} = 0.000264 \times (A_{fs})C^3$$

(A_{fs}) = 8,000-pound average fiber stress for Douglas fir

C = 41 inches, ground-line circumference

$$\text{Wood Pole Moment} = 0.000264 \times 8{,}000 \times 41^3$$

$$= 145{,}561 \text{ ft-lb}$$

(Continued on next page)

EXAMPLE 10–6: SAFETY FACTORS AND CALCULATIONS FOR USE OF 55-FOOT POLE *(Continued)*

CALCULATIONS: (CONT'D)

Void Moment

$$\text{Void Moment} = 0.000264 \times (A_{fs})[C - 2\pi(S_t)]^3$$

(A_{fs}) = 8, 000-pound average fiber stress for Douglas fir

C = 41 inches, ground-line circumference

(S_t) = 1.5 inches, shell thickness

$$\text{Void Moment} = 0.000264 \times 8,000 \times [41 - 6.2832 \times 1.5]^3$$
$$= 66{,}486 \text{ ft-lb}$$

Safety Factor

$$\text{Safety Factor} = \frac{\text{Wood Pole Moment} - \text{Void Moment}}{\text{Moments from Wind on (Conductor + Pole + Equipment)}}$$
$$= \frac{145{,}561 - 66{,}486}{27{,}210 + 6{,}942 + 3{,}800}$$
$$= 2.08$$

SAFETY FACTOR CALCULATION RESULT

The minimum in-service safety factor for Grade A construction, including measured deterioration, is 2.67. See .

The calculated 2.08 safety factor is below 2.67, therefore, replace the pole.

Appendix 10–2: Dead-End and Angle Construction Tables and Examples ***(Sheet 1 of 10)***

DEAD-END REQUIREMENTS

Table 10–31, when used with Figure 10–18, provides the data necessary to determine wood crossarm requirements for dead-ending. Table 10–32 and Figure 10–19 provide the data necessary to determine composite crossarm requirements for dead-ending.

Table 10–31: Wood Crossarm Dead-Ending Requirements for Copper and ACSR Conductors

Wire Size	6-Conductor 10-ft. Arm	4-Conductor 10-ft. Arm	4-Conductor 8-ft. Arm	2-Conductor 5-ft. Arm	3-Conductor 10-ft. Arm	3-Conductor 8-ft. Arm
No. 4 ACSR[a/]	Double arm	Double arm	Double arm	Single arm	Single arm[b/]	Single arm[b/]
No. 2 ACSR	Double arm	Double arm	Double arm	Single arm	Double arm	Single arm[b/]
1/0 ACSR	Diagram A	Double arm	Double arm	Double arm	Double arm	Double arm
4/0 ACSR	Diagram B	Diagrams C or D	Diagram C	—	—	—
336.4 kcmil ACSR	Diagram B	Diagrams C or D	Diagram C	—	Diagram A	Diagram A
653.9 kcmil ACSR	Diagram B	Diagrams B or C	Diagram B	—	Diagram C	Diagram C
No. 6 Cu	Double arm	Double arm	Single arm	Single arm	Single arm[b/]	Single arm[b/]
No. 4 Cu	Double arm	Double arm	Double arm	Single arm	Single arm[b/]	Single arm[b/]
No. 2 Cu	Double arm	Double arm	Double arm	Single arm	Double arm	Double arm
2/0 Cu	Diagrams B or C	Diagram A	Diagram A	—	Double arm	Double arm
4/0 Cu	Diagram B	Diagrams B, C, or D	Diagram B	—	Diagram A	Diagram A

Note(s):

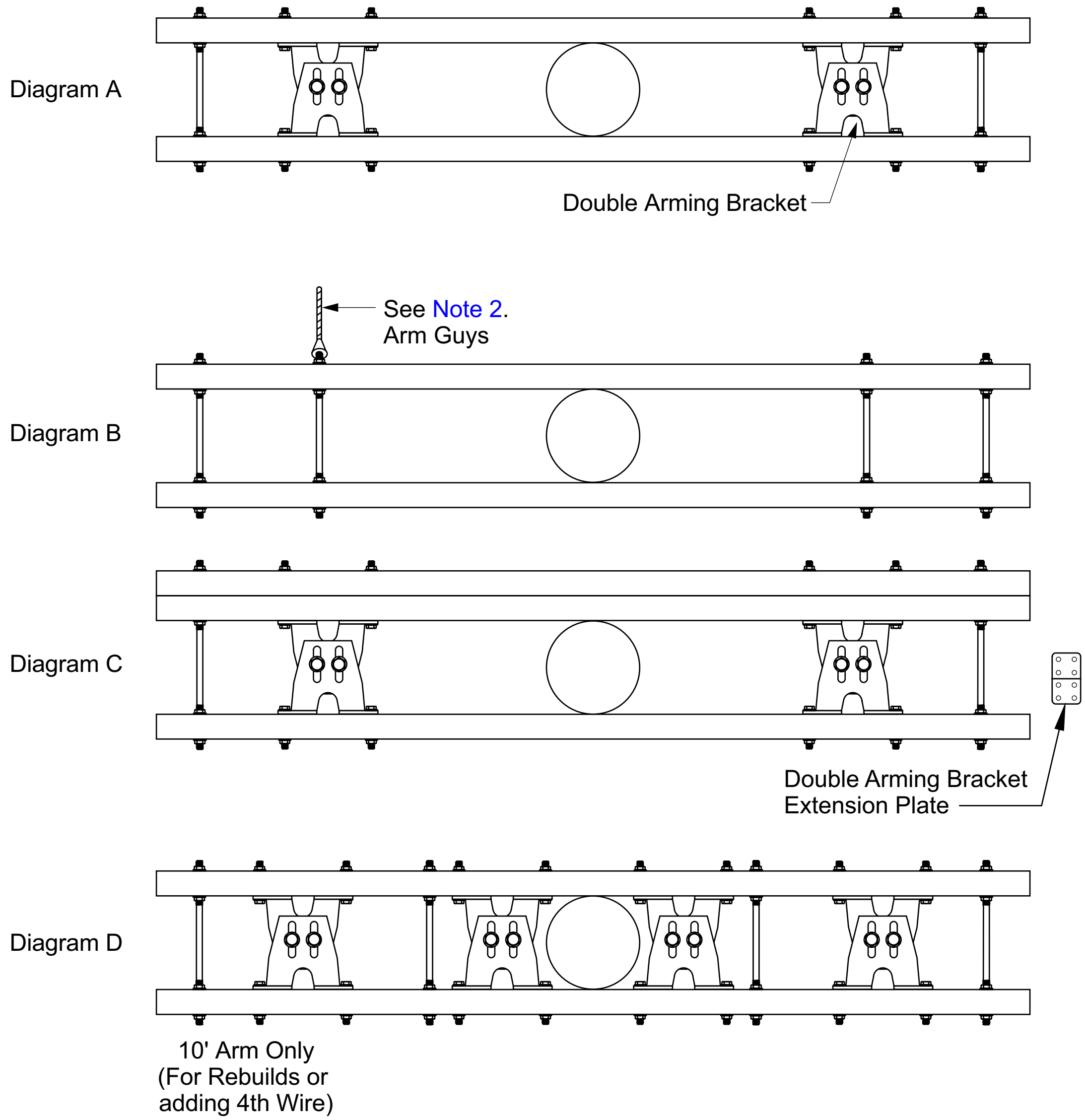
1. See Figure 10–18 for special dead-end construction relating to Diagrams A, B, C, and D.

[a/] Not approved for use on new construction.

[b/] Not approved for heavy loading.

Appendix 10–2: Dead-End and Angle Construction Tables and Examples *(Sheet 2 of 10)*

Figure 10–18: Dead-End Construction Diagrams for Wood Crossarms



Note(s):

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 DOH, Section PO.
3. For Diagram A, Diagram C, and Diagram D, use anchor guys only.

Appendix 10–2: Dead-End and Angle Construction Tables and Examples *(Sheet 3 of 10)*

Table 10–32: Composite Crossarm Dead-Ending Requirements for Copper and ACSR Conductors

Wire Size	Full Tension	Reduced Tension Guyed	Reduced Tension Un-guyed
#4 ACSR	Single Arm[a/]	Single Arm[a/]	Single Arm
#2 ACSR	Single Arm[a/]	Single Arm[a/]	Single Arm
1/0 ACSR	Double Arm	Double Arm	Single Arm
4/0 ACSR	Double Arm	Double Arm	Double Arm
336.4 kcmil ACSR	Double Arm	Double Arm	Double Arm
653.9 kcmil ACSR	Double Arm	Double Arm	Double Arm
#6 Copper	Single Arm[a/]	Single Arm[a/]	Single Arm
#4 Copper	Single Arm[a/]	Single Arm[a/]	Single Arm
#2 Copper	Double Arm	Double Arm	Single Arm
2/0 Copper	Double Arm	Double Arm	Double Arm
4/0 Copper	Double Arm	Double Arm	Double Arm

Note(s):

1. See Figure 10–19 for dead-end construction for composite crossarms.
2. See DOH CO 212 for composite crossarm configurations.
3. This table applies to both bare wire and covered conductors.
4. See DOH CC 121 and DOH CO 168 for reduced tension spans.
5. When re-conductoring with covered conductor in HFRA, Double Composite Arms shall be used for all conductor sizes. See Table 10–32.
6. Double arms (and insulators) shall be used on all pole types in extra heavy loading areas above 5,000 feet elevation.

[a/] Double Arms may be installed on a project needed basis.

Appendix 10–2: Dead-End and Angle Construction Tables and Examples *(Sheet 4 of 10)*

Figure 10–19: Composite Crossarm Dead-Ending Requirements for Copper and ACSR Conductors

Figure 10–19.1: 8-foot Single

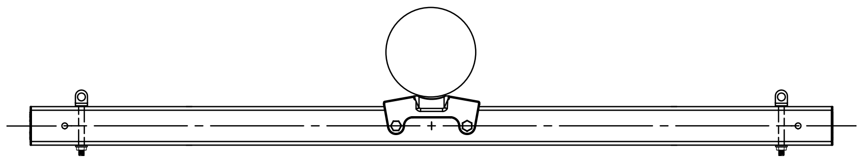


Figure 10–19.2: 8-foot Double

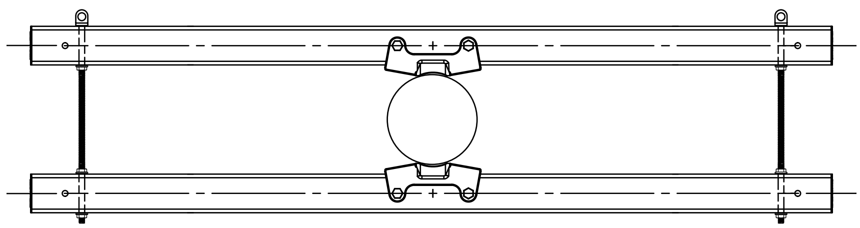


Figure 10–19.3: 10- and 12-foot Single

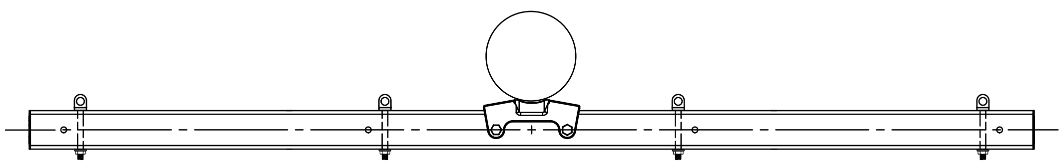
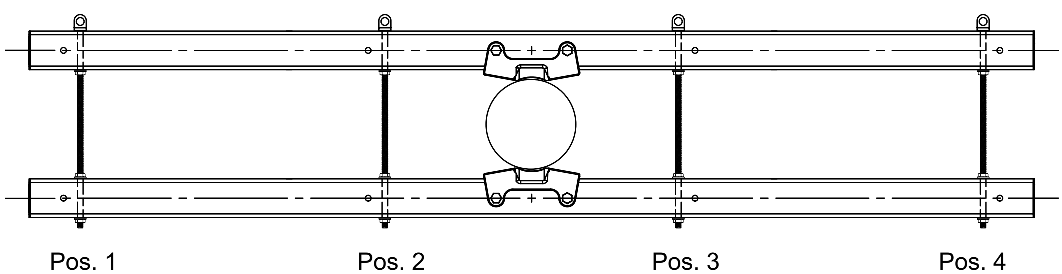


Figure 10–19.4: 10- and 12-foot Double



(See Note 4.)

Note(s):

1. Mount arm bracket to pole with 3/4-inch bolts and spring washers.
2. Use 4"x4"x1/4" square flat washer (SAP 10071859) on all crossarm bolts.
3. Use spring washers on all crossarm and hardware bolts. Tighten only until spring washer fully compresses (30 foot-pounds). Do not over-tighten.
4. DA bolt is required for positions 1 & 4 for all types of installations. For 3-wire configurations utilizing positions 2 or 3, DA bolt is only needed when conductor is dead-ended to it.
5. These requirements are applicable when dead-ending bare or covered conductors, as shown on DOH Figure CO 212-1.

Appendix 10–2: Dead-End and Angle Construction Tables and Examples *(Sheet 5 of 10)*

LIMITING DEVIATION ANGLES ON CROSSARMS/INSULATORS

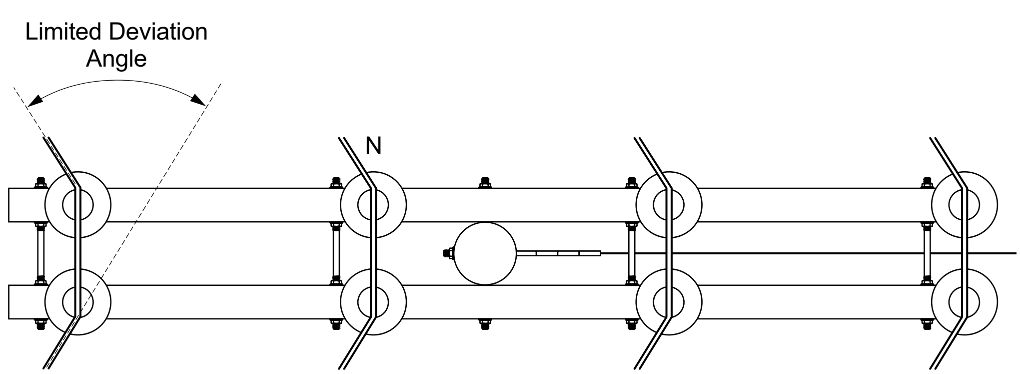
When the deviation angle exceeds the *limiting deviation angle* for wood and composite crossarms, then dead-end construction shall be used. The limiting deviation angle is the angle above which side tension exceeds the G.O. 95 safety factor for insulators and hardware.

Table 10–18 may be used to determine the limiting deviation angle allowed for 12/16/33 kV angle construction using single or double crossarms with angle pin-type insulators. Table 10–34 provides the limiting deviation angles for angle construction in extra heavy-loading areas above 5,000 feet using double crossarms with post-type and post-type with angle base insulators. Table 10–35 provides limiting deviation angles for secondary multiplex construction. Table 10–37 is used to calculate the deviation angle of a pole line based on the span and the “out-of-line” pole distance.

Table 10–33: Limiting Deviation Angle for 12 kV, 16 kV, and 33 kV Angle Pole Construction for Wood and Composite Arms[a/]

Conductor Size	Limiting Deviation Angle	
	Single Arm	**Double Arm**
653.9 ACSR / CC	5	10
336.4 ACSR (30X7) / CC	5	10
336.4 ACSR (18X1) / CC	6	12
101.8 Petrel / CC	5	10
4/0 ACSR Bare [a/]	6	12
1/0 ACSR / CC	13	26
#4 ACSR Bare [a/]	30	60
4/0 CU CC	6	12
2/0 CU CC	10	20
#2 CU CC	20	40
#6 CU Bare [a/]	45	60
350 kcmil CU CC	5	10
500 kcmil CU CC	5	10

[a/] See Figure 10–20 for 3- or 4-wire construction.



Appendix 10–2: Dead-End and Angle Construction Tables and Examples *(Sheet 6 of 10)*

Figure 10–20: 12/16/33 kV or 4-Wire Double Dead-End Construction for Wood and Composite Arms

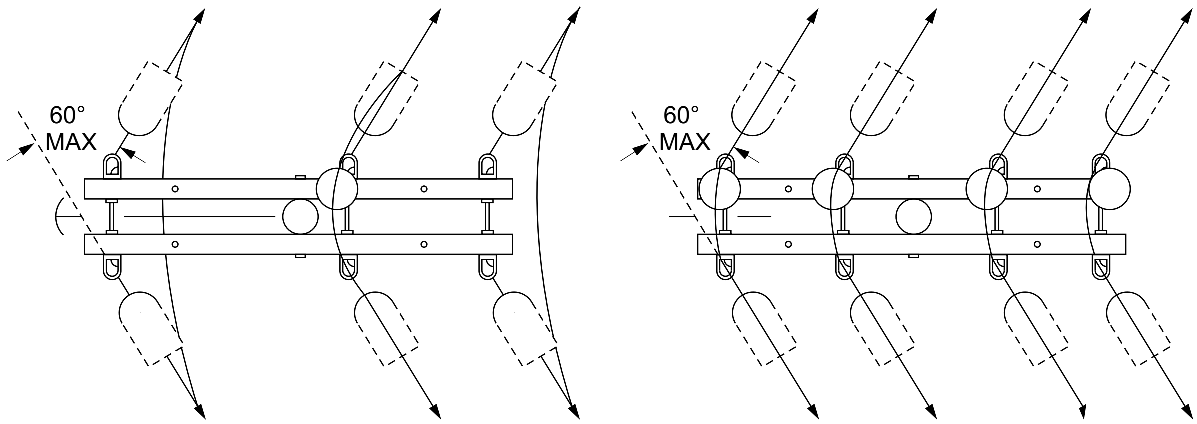
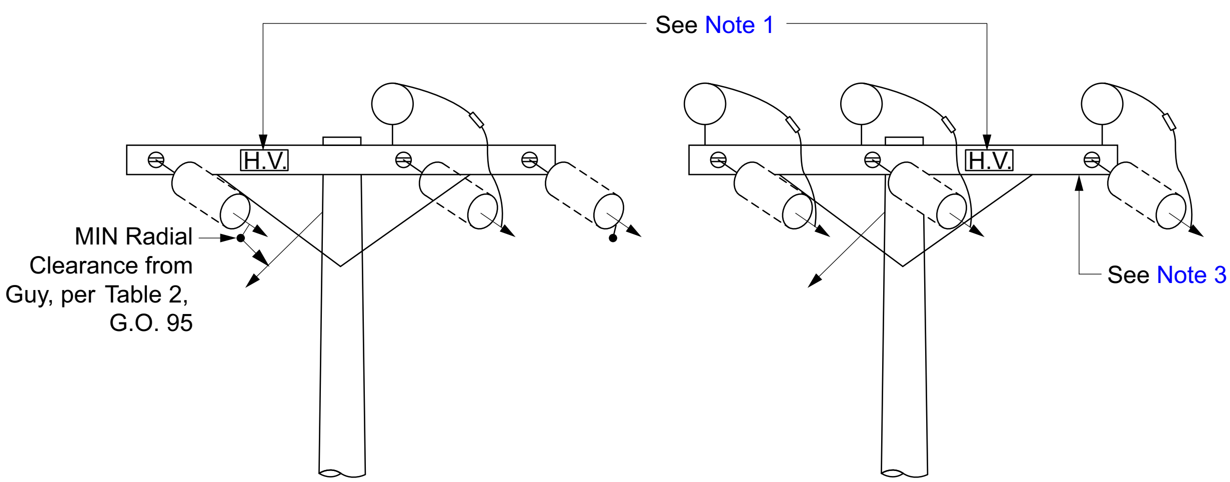


Figure 1 **Figure 2**



Note(s):

1. Place jumper under arm as shown in the 3-wire construction diagram whenever clearance to circuit below is obtainable. If it is not obtainable, the 4-wire diagram may be used.
2. When 33 kV circuits are below 33 kV or higher-voltage circuits, the conductors shall not be less than 24 inches from center of pole to provide climbing space.
3. For dead-end details, see Table 10–31 and Figure 10–18 for wood crossarms and Table 10–32 and Figure 10–19 for composite crossarms.

Table 10–34: Limiting Deviation Angle for Construction in Extra Heavy-Loading Areas above 5,000 Feet (All Distribution Voltages)

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)
1/0 (7 x 1) [a/]	10	20	25	50
336.4 (18 x 1) [a/]	6	12	15	30
336.4 (30 x 7) [a/]	3	6	7	14
653.9 [a/] (18 x 3)	3	6	9	18

Note(s):

1. Pin-Type insulators are not approved for new construction in Extra Heavy-Loading areas.

[a/] Aluminum strands versus steel strands.

= For Reference Only

Table 10–35: Limiting Deviation Angle for Angle Pole Construction in Extra Heavy-Loading Areas above 5,000 Feet (for All Secondary Voltages)

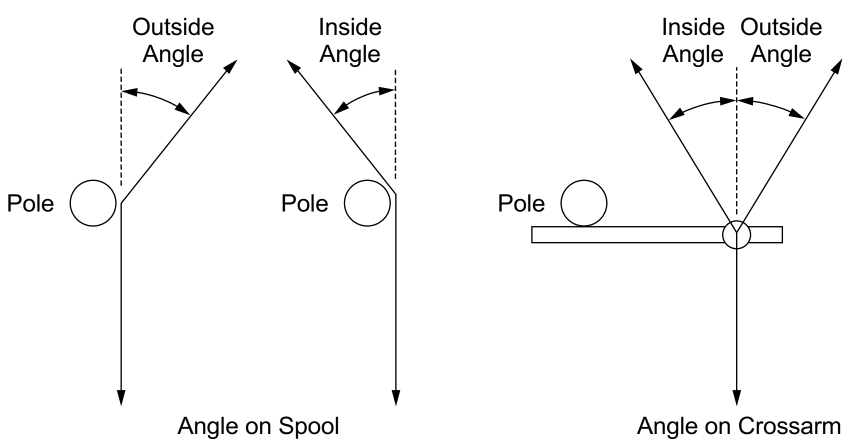
Angle on Spool

Conductor Size		Limiting Deviation Angle	
Aluminum	**Copper**	**Outside (degrees)**	**Inside (degrees)**
1/0	—	40	30
4/0	—	20	20

Angle on Crossarm

Conductor Size		Limiting Deviation Angle	
Aluminum	**Copper**	**Outside (degrees)**	**Inside (degrees)**
1/0	—	15	30
4/0	—	7	15

Note(s):
1. On double arms use double pins.



Appendix 10–2: Dead-End and Angle Construction Tables and Examples *(Sheet 9 of 10)*

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 mounted below the line arm shall be used for installation having a line or elevation angle greater than 45 degrees. Refer to DAP, AP 336.2 for Omni-Rupter® switches mounted below the line arm utilizing the Hughes adapter.

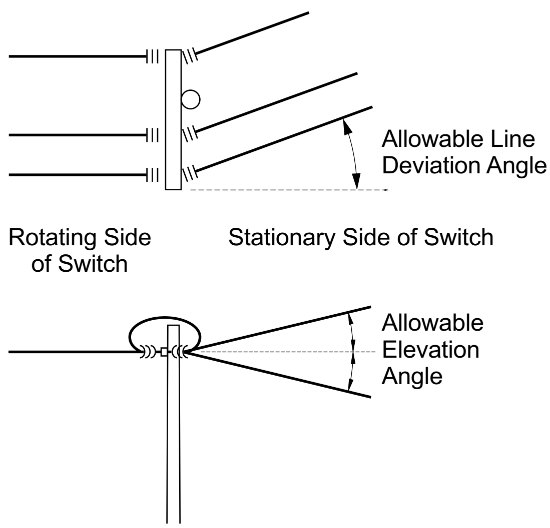
Table 10–36: MAX Line Deviation or Elevation Angle for Switches

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°

Note(s):

1. Line-angle switches shall be used where the allowable angle is exceeded. The maximum angle for these switches is 45 degrees.

[a/] Not approved for use on new construction.



Appendix 10–2: Dead-End and Angle Construction Tables and Examples *(Sheet 10 of 10)*

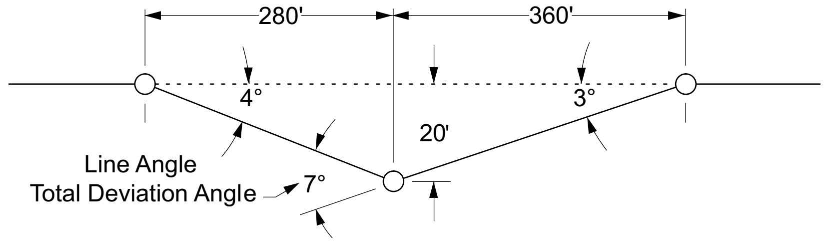
Table 10–37: Determination of Line Deviation Angles

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 10–7: HOW TO DETERMINE LINE DEVIATION ANGLES

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:

STEP 1. Look in Table 10–37 under a span of 360 feet for an out-of-line distance closest to 20 feet; as shown here, it is 19 feet (shaded area).

STEP 2. Look to the left of 19 feet, the line angle is 3 degrees (shaded area).

STEP 3. Look in the table under a span of 280 feet for an out-of-line distance of 20 feet (shaded area).

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 10–38 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 10–38: 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/] 1/0 336.4 kcmil 653.9 kcmil	604 1,415 2,846 3,267
Copper Triplex	#4 #2	484 761
Aluminum Triplex or quadruplex	1/0 4/0	1,415 2,780
Weather-resistant copper	#6 #4 #2 2/0 4/0	375 540 830 1,590 2,455
Bare copper	#6 #4 #2 2/0 4/0	320 484 761 1,482 2,288

[a/] Not approved for use on new construction.

Appendix 10–3: Guying Tables and Examples *(Sheet 2 of 12)*

DETERMINATION OF CONDUCTOR SIDE TENSIONS

Table 10–39 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 10–43 and Table 10–44, the proper guy wire size may be determined. To determine the deviation angle, use Table 10–40. Example 10–10 illustrates the use of side guys.

Table 10–39: 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	761	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 OF USING TABLE 10–29

One 1/0 ACSR conductor at a deviation angle of 30 degrees has a side tension of 732 pounds (see shaded areas).

Appendix 10–3: Guying Tables and Examples *(Sheet 3 of 12)*

Determination of Deviation Angle

To determine the deviation angle, use Table 10–40 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 10–40. 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 10–40 below. The deviation angle is used with Table 10–39 to determine the resultant conductor tension on an angle pole.

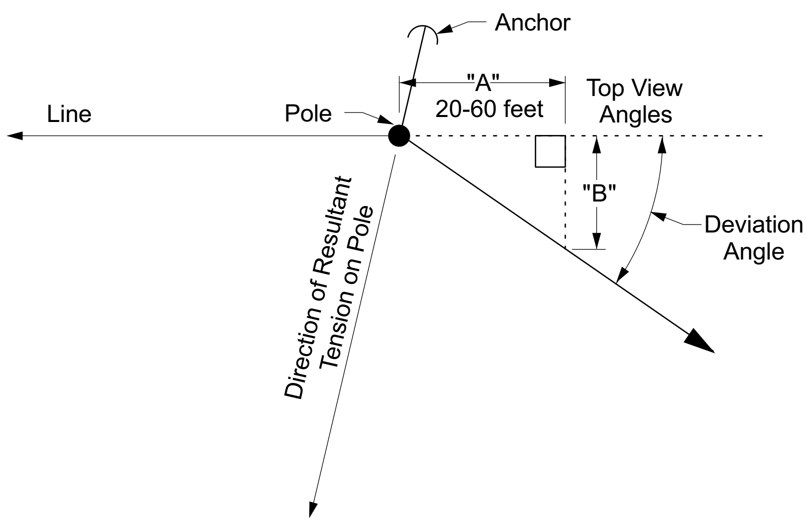


Table 10–40: Deviation Angles

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 of Using Table 10–30

If Distance “A” = 50 feet and Distance “B” = 29 feet, the deviation angle is 30 degrees (see shaded areas).

Appendix 10–3: Guying Tables and Examples *(Sheet 4 of 12)*

DETERMINATION OF ANGLE FROM GUY TO POLE

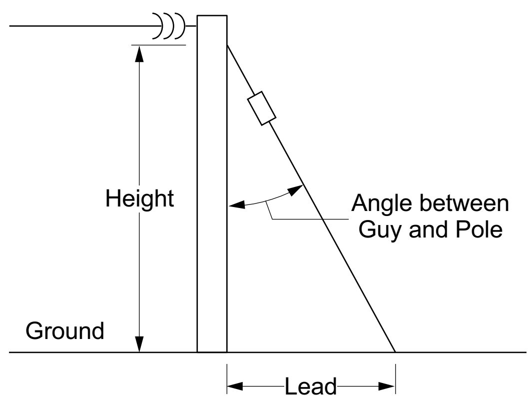
Table 10–41 is used to determine the angle created by the guy wire and the pole. When used with Table 10–43 and Table 10–44, the guying tensions for dead-ended conductors and side guying may be determined.

Table 10–41: Angle between Guy and Pole

Height (Guy to Ground) (ft)	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 OF USING TABLE 10–31

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 (see shaded areas).



Determination of Angle From Guy to Pole for Sidewalk Anchors

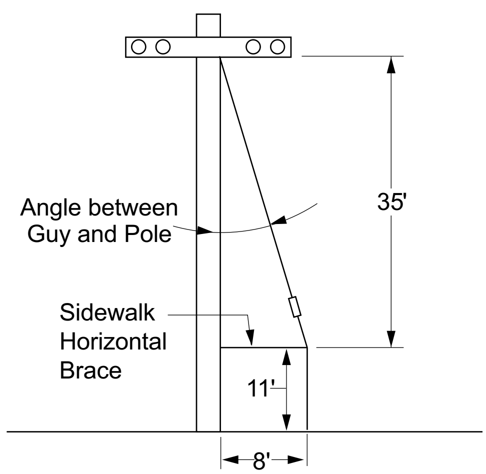
Table 10–42 is used to determine the angle from the guy to the pole created by a sidewalk anchor. When used with Table 10–43 and Table 10–44, the guying tensions for sidewalk anchoring may be determined.

Table 10–42: Angle between Guy and Pole for Sidewalk Anchor

Height (Guy Attachment to Sidewalk Horizontal Brace) (ft)	Length of Sidewalk Horizontal Brace (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 of Using Table 10–32

A sidewalk anchor is installed with the guy wire attached 35 feet above an 8-foot sidewalk horizontal brace. The angle between the guy and pole is 13 degrees (see shaded areas).



Appendix 10–3: Guying Tables and Examples *(Sheet 6 of 12)*

DETERMINATION GUY WIRE SIZE

Table 10–42 list the types, sizes, and safety factors of guy wires purchased by Southern California 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 10–43: Maximum Conductor Tension for Guy Wires — Grade A or B Construction

Table Note: (Safety Factor = 2)

Maximum Safe Conductor Tension (lb) for One Guy Wire[a/]			
Angle—Guy-to-Pole (Degrees)	**Guy Size**		
	9/32 (EHS)	**3/8 (EHS)**	**7/16 (EHS)**
3	234	403	544
5	390	671	906
7	545	938	1,267
9	700	1,205	1,627
11	854	1,469	1,984
13	1,007	1,732	2,339
15	1,158	1,993	2,590
20	1,531	2,634	3,420
25	1,891	3,254	4,230
30	2,238	3,850	5,000
35	2,567	4,417	5,735
40	2,876	4,949	6,430
45	3,164	5,445	7,070
50	3,428	5,899	7,660
55	3,666	6,307	8,190
60	3,875	6,668	8,660
Level (Overhead Guy)	4,475	7,700	10,000

[a/] Ultimate conductor tension divided by safety factor (from “Table 24” of 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 OF USING TABLE 10–33

A single 3/8-inch guy wire installed at a 40-degree angle, between the pole and guy, is capable of supporting a conductor tension of 4,949 pounds in Grade A construction.

Appendix 10–3: Guying Tables and Examples *(Sheet 7 of 12)*

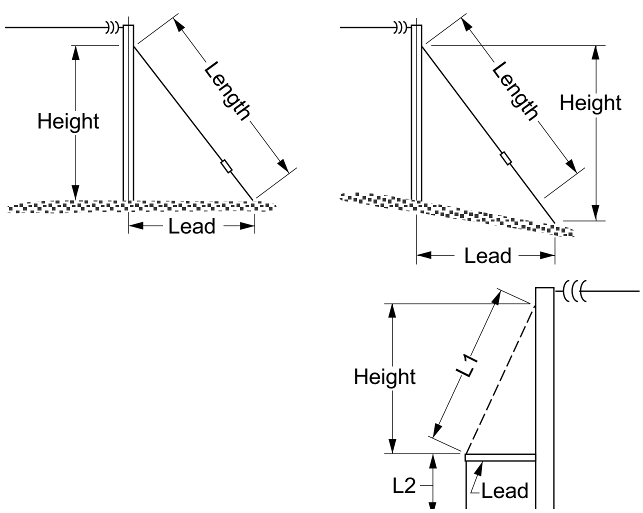
Determination of Downguy Length

Table 10–44 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 10–44: 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

Figure Note: L1 is the length from the table. L1 and L2 = total length of guy wire for a sidewalk anchor.



Appendix 10–3: Guying Tables and Examples *(Sheet 8 of 12)*

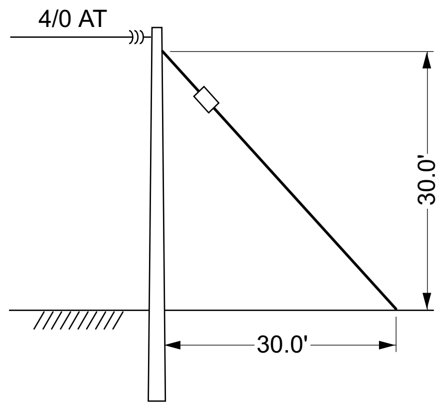
The following examples illustrate the use of Table 10–38 through Table 10–44 to determine guying requirements.

EXAMPLE 10–8: MINIMUM ANCHOR GUY LEAD	
SCENARIO:	Given three 653.9 kcmil ACSR conductors sagged at 3,267 pounds 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-inch anchor guys are to support the line in Grade A construction. Each guy wire will support one-half of the total conductor pull.
PROBLEM 1:	From , determine the conductor tension on each guy wire. Multiply 3,267 pounds by 3 and divide by 2.
SOLUTION 1:	4,900 pounds
PROBLEM 2:	Find in , under 3/8-inch guy, a conductor pull safe for one guy that exceeds 4,900 pounds.
SOLUTION 2:	4,949 pounds. Determine that the angle of guy to pole is 40 degrees.
PROBLEM 3:	Find in , the value under the Height (guy to ground) of 80 feet.
SOLUTION 3:	Read across row to the 40 degrees column (angle guy to pole) and see that the lead distance is 67 feet.
PROBLEM 4:	This 67 feet (see Solution 3) is the minimum lead required for the top guy. If the lower guy is attached at 70 feet on the pole, find in , find what is the minimum lead required for a second anchor.
SOLUTION 4:	59 feet.

Appendix 10–3: Guying Tables and Examples *(Sheet 9 of 12)*

EXAMPLE 10–9: SIZE OF ANCHOR GUY WIRE

SCENARIO: 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.



PROBLEM 1: Find in , the tension for 4/0 aluminum triplex conductor.

SOLUTION 1: 2,780 pounds.

PROBLEM 2: Next, find in , the guy angle most nearly corresponding to a height of 30 feet and a lead of 30 feet.

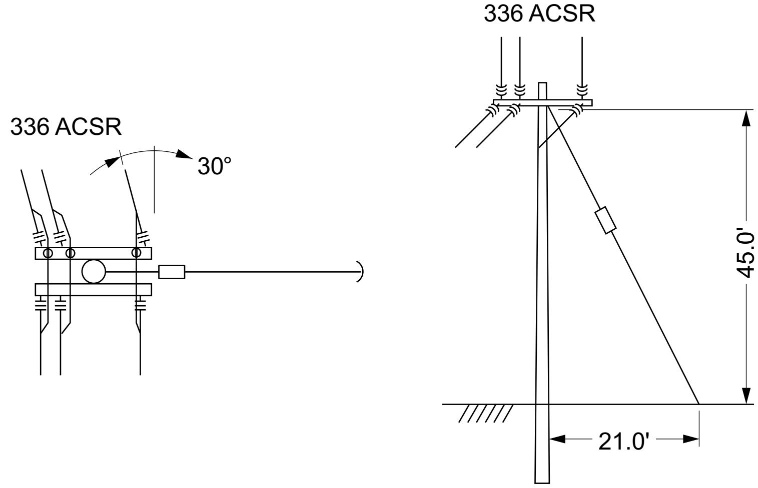
SOLUTION 2: 45 degrees

PROBLEM 3: Then find in the required size for guy to hold a conductor tension of 2,780 pounds (Solution 1) at a guy angle of 45 degrees (Solution 2) 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.

SOLUTION 3: Since 5/16 inch is no longer a standard guy size, one 9/32-inch guy with a maximum conductor tension of 3,164 pounds should be used.

EXAMPLE 10–10: SIZE OF SIDE ANCHOR GUY WIRE

SCENARIO: 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 Grade B construction.



PROBLEM 1: Find in , the resultant side pull for three 336.4 kcmil ACSR conductors at a deviation angle of 30 degrees. 3 × 1,473 = 4,419 lb

SOLUTION 1: 4,419

PROBLEM 2: Next, find in , the guy angle most nearly corresponding to a height of 45 feet and a lead of 21 feet.

SOLUTION 2: 25 degrees

PROBLEM 3: For a Grade A construction, find in , the required size of guy for a resultant pull of 4,419 pounds (Solution 1) and a guy angle of 25 degrees (Solution 2), 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.

SOLUTION 3: Use one 9/32-inch guy and one 3/8-inch guy (standard guy sizes).

PROBLEM 4: For Grade B construction find in , the required size guy for a resultant pull of 4,419 pounds (Solution 1), and a guy angle of 25 degrees (Solution 2) 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.

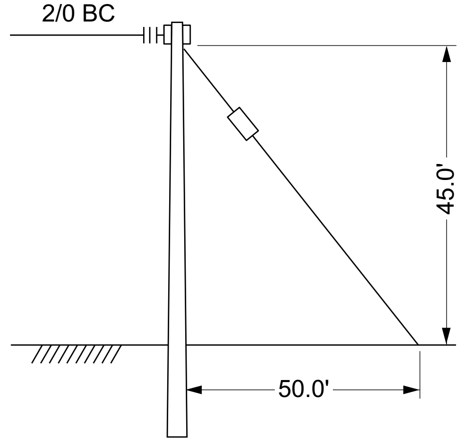
SOLUTION 4: Use two 9/32-inch guys (standard guy sizes).

Appendix 10–3: Guying Tables and Examples *(Sheet 11 of 12)*

NOTE 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.

EXAMPLE 10–11: SIZE OF ANCHOR GUY WIRE

SCENARIO: 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.



PROBLEM 1: Find in , the tension for one 2/0 bare copper conductor (1,482 pounds) Multiply 1,482 × 3 = 4,446 pounds.

SOLUTION 1: 4,446 pounds

PROBLEM 2: Next, find in , the guy angle most nearly corresponding to a height of 45 feet and a lead of 50 feet.

SOLUTION 2: 50 degrees

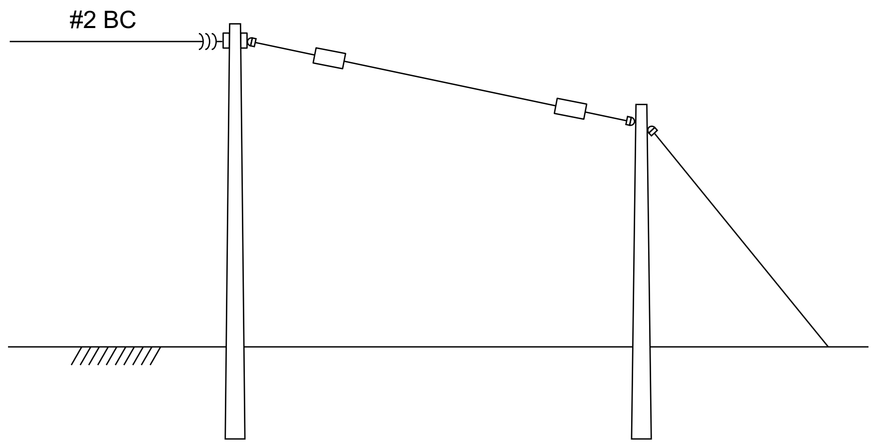
PROBLEM 3: Then, find in , the required size of guy for conductor tension of 4,446 pounds (Solution 1) at a guy angle of 50 degrees (Solution 2), using the next larger tension above 4,446 pounds. In this case, the next larger figure in the column for a 50-degree angle is 4,570 pounds.

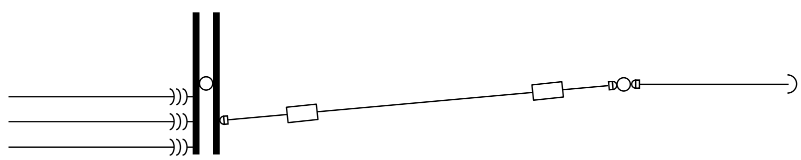
SOLUTION 3: Use one 9/32-inch guy (standard guy size).

Appendix 10–3: Guying Tables and Examples *(Sheet 12 of 12)*

EXAMPLE 10–12: OVERHEAD SPAN/ARM GUY

SCENARIO: Given three No. 2 bare copper conductors at dead-end on a crossarm, find the size of guy to hold the total load.





Arm Guy

Span Guy

PROBLEM 1: Find in , the tension for one No. 2 bare copper conductor. Multiply this tension by 3. 761 $\times$ 3 = 2,283 pounds.

SOLUTION 1: 2,283 pounds

PROBLEM 2: Next, find in , the row labeled “Level-Overhead Guys” the required size of guy for a conductor tension of 2,283 pounds (Solution 1), 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.

SOLUTION 2: 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 10–45 lists the holding strength for standard anchors and rods used by SCE. 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 in Table 10–43 and Table 10–44.

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 10–45: 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	—	—	—	—	—	5,000 lb
	2	—	5,000	—			1-9/32
	3	5,000	—	—			—
1-3/8" or 1-1/2" anchor hub. 1" × 7' Triple Eye	4	—	—	10,000			10,000 lbs
	5	—	10,000	—			2-9/32 or 1-3/8 or 1-7/16
	6	—	—	—			—
	7	10,000	—	15,000			15,000 lbs
	8	—	15,000	—			1-9/32 and 1-3/8 or 1-7/16
1-1/2" anchor hub only. 1" × 7' Triple Eye	9	15,000	16,000	—	—	—	18,000 lbs
	10	16,500	18,000	—	—	—	2-9/32 and 1-3/8
	11	17,500	—	—	—	—	or 2-3/8 or 1-3/8 and 1-7/16
	12	18,000	—	—	—	—	
	13	—	MAX rating of 1" rod 18,000 lbs			—	
	14	—				—	
4-Inch	9	—	—	—	10,000	—	2-9/32 or 1-3/8 or 1-7/16
Granite Anchors	10	—	—	—	15,000	—	1-9/32 and 1-3/8 or 1-7/16
1" × 7' Triple Eye	12	—	—	—	18,000	18,000	2-9/32 and 1-3/8 or 2-3/8 or 1-3/8 and 1-7/16
Anchor Rod and Plate	**Holding Strength (lb)**						
5/8" × 6'/Single Eye[a/]	8,000						1-3/8
3/4" × 8'/Double Eye[a/]	11,500						2-9/32 or 1-3/8 or 1-7/16
1" × 10'/Triple Eye[a/]	18,000						2-3/8
1-1/4" X 10'/Triple Eye[a/]	29,000						2-7/16 or 3-3/8 or 2-3/8 and 1-9/32
Expanding Rock	**Holding Strength (lb)**						
3/4" ×15"/Double Eye	11,500						2-9/32 or 1-3/8 or 1-7/16

Note(s):

1. New anchor installations shall have a loading safety factor of 2 to 1. Existing anchor installations shall have a loading safety factor of 1.33 to 1.
2. PISA anchors shall be installed with a minimum spacing of 4 times the largest helix. For example, two-8 inch anchors, the minimum spacing between the two shall be 32 inches.
3. It is recommended that there be a minimum of 6 feet of spacing between the plate anchors. If the recommended spacing can't be obtained, then the following criteria shall be used:
   - 4 feet for installations up to 10,000 lbs.
   - 5 feet for installations up to 15,000 lbs.
   - 6 feet for installations up to 18,000 lbs.
   - 7 feet for installations greater than 18,000 lbs.
4. Refer to DOH PO 320, Table 9 for placement of anchor plate relative to anchor eye rod.
5. For multiple backhoe installations, trenches should be perpendicular to guy wire.

[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.

Appendix 10–4: Anchors and Rods Tables and Examples *(Sheet 2 of 2)*

EXAMPLE 10–13: SELECTING PROPER SCREW ANCHOR, OR ANCHOR AND PLATE

SCENARIO 1: One 3/8-inch and one 9/32-inch extra-high strength (EHS) guys are to be attached to an anchor in an urban area, Grade A construction.

PROBLEM 1: What size guy anchor should be selected?

SOLUTION 1: 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, one 3/8–inch EHS guy has a working tension of 7,700 pounds, and one 9/32-inch 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-inch double helix screw anchor with eight loading pins sheared will meet the required holding strength. If an anchor rod and plate is required, 1" x 10' / triple eye should be selected.

SCENARIO 2: One 3/8-inch and two 9/32-inch EHS guys are to be installed on an anchor in an urban area, Grade A construction.

PROBLEM 2: What size guy anchor should be selected?

SOLUTION 2: According to Table 10–33, the full rated working tension for guys with a safety factor of “2” can be found under level angle.
One 3/8–inch EHS, with a working tension of 7,700 pounds, and two 9/32-inch EHS of 4,475 pounds x 2. The total pull will be 7,700 pounds + 8,950 pounds = 16,650 pounds.

In accordance with Table 10–35, an anchor with a holding strength above 16,650 pounds should be used. Therefore, a single 8-inch PISA should be selected to shear eleven loading pins. If an anchor rod and plate are to be installed, a 1" x 10' ÷ triple eye having a holding strength of 18,000 pounds should be selected.

Appendix 10–5: Unguyed Spans — Light-Loading and Heavy-Loading Tables and Examples *(Sheet 1 of 8)*

Based on typical unguyed span measurements, Table 10–47 through Table 10–50 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 10–28. 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 10–46 below).

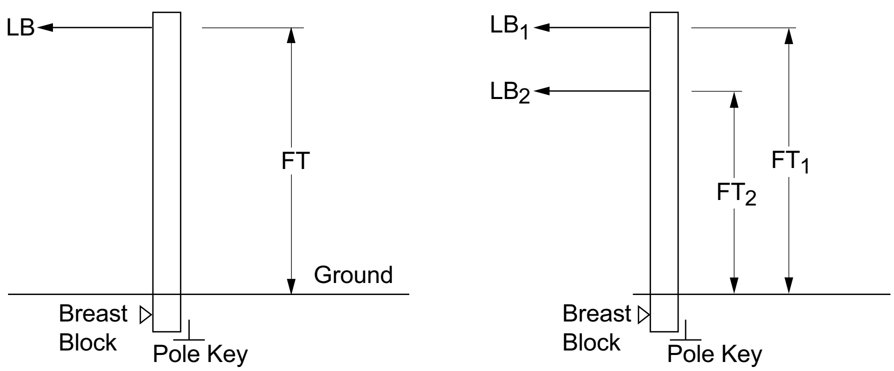
With the conductor tensions from Table 10–47 through Table 10–50, the resultant moment can be calculated using Formulas A or B.

A

Resultant Moment = LB x FT

B

Resultant Moment = LB_1 x FT_1+ LB_2x FT_2



A

B

Table 10–46: Types of Soil

Class	Description	Pole-Key Resisting Moment (ft-lb)
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

Appendix 10–5: Unguyed Spans — Light-Loading and Heavy-Loading Tables and Examples *(Sheet 2 of 8)*

Table 10–47: 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

Note(s):

1. Example: A 1/0 Al triplex unguyed span with a final sag of 3 feet will have a dead-end tension of 399 pounds.

Appendix 10–5: Unguyed Spans — Light-Loading and Heavy-Loading Tables and Examples *(Sheet 3 of 8)*

Table 10–48: Unguyed Span Tensions — Primary Conductors Light Loading

Table Note: Use on all 4 kV, 12 kV, 16 kV, and 33 kV systems; 4 kV requires 20 inches minimum pin spacing; 4 kV, 12 kV, 16 kV, and 33 kV require 36 inches minimum pin spacing.

	Span (ft)	Final Sag at 130°F — Unguyed Span Dead-End Tension per Conductor (lb)				
		1-Foot Sag	2-Foot Sag	3-Foot Sag	4-Foot Sag	5-Foot Sag
#4[a/] 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/] Not approved for use on new construction.

Appendix 10–5: Unguyed Spans — Light-Loading and Heavy-Loading Tables and Examples *(Sheet 4 of 8)*

Table 10–49: 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 Al Triplex	60	1,073	447	274	201	160
	80	—	838	508	364	286
	100	—	1,266	818	584	454
	120	—	—	1,169	855	665
4/0 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

Appendix 10–5: Unguyed Spans — Light-Loading and Heavy-Loading Tables and Examples *(Sheet 5 of 8)*

Table 10–50: Unguyed Span Tensions — Primary Conductors Heavy Loading

Table Note: Use on all 4 kV, 12 kV, 16 kV, and 33 kV systems; 4 kV requires 20 inches minimum pin spacing; 4 kV, 12 kV, 16 kV, and 33 kV require 36 inches minimum pin spacing.

	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[a/] 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

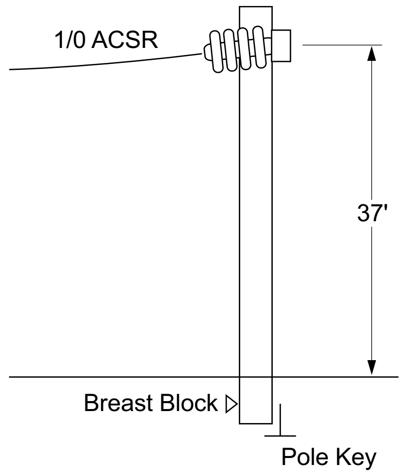
[a/] Not approved for use on new construction.

Appendix 10–5: Unguyed Spans —
Light-Loading and Heavy-Loading Tables and Examples ***(Sheet 6 of 8)***

Example 10–14 and Example 10–15 illustrate the method of determining usable pole strength in unguyed spans.

EXAMPLE 10–14: UNGUYED SPAN—45-FOOT POLE

SCENARIO: 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 , and the construction is Grade B in light loading area.



PROBLEM 1: Find in the tension for one 1/0 ACSR conductor with a final sag of 3 feet (49 pounds). Multiply the tension by 4. 49 pounds × 4 = 196 pounds.

SOLUTION 1: 196 pounds

PROBLEM 2: 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

SOLUTION 2: 7,252 ft-lb

PROBLEM 3: Next, compare the moment from Solution 2 to the usable pole strengths to select , , or , based on the type of pole, the proper class of pole.

SOLUTION 3: 45-foot Class 5 pole

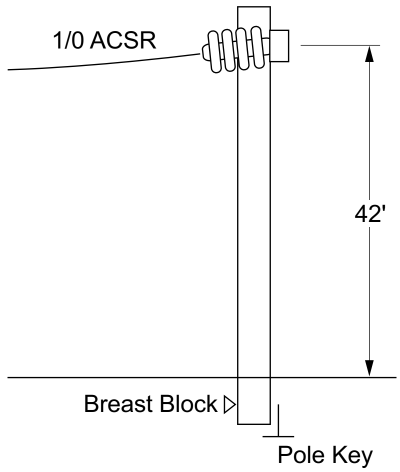
PROBLEM 4: Compare the moment from Solution 2 to the pole-key resisting moment, which should be used for all unguyed poles.

SOLUTION 4: The moment applied to the pole does not exceed the pole-key resisting moment of 36,750 ft-lb. See .

Appendix 10–5: Unguyed Spans — Light-Loading and Heavy-Loading Tables and Examples *(Sheet 7 of 8)*

EXAMPLE 10–15: UNGUYED SPAN—50-FOOT POLE

SCENARIO: 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.



PROBLEM 1: Find in 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 4.

SOLUTION 1: 346 × 4 = 1,384 pounds

PROBLEM 2: 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.

SOLUTION 2: 58,128 ft-lb

PROBLEM 3: Next, compare the moment from Solution 2 to the usable pole strengths to select the proper class of pole.

SOLUTION 3: A 50-foot pole does not provide enough usable pole strength.

PROBLEM 4: Assuming there is enough clearance for additional sag, the sag will be extended to 5 feet for a new tension (269 pounds): 269 × 4 = 1,076 pounds

SOLUTION 4: 1,076 pounds

PROBLEM 5: Repeat Problem 2 for the new maximum resultant moment: 1,076 × 42 = 45,192 ft-lb.

SOLUTION 5: 45,192 ft-lb

(Continued on next page)

EXAMPLE 10–15: UNGUYED SPAN—50-FOOT POLE *(Continued)*

PROBLEM 6: Next, compare the answer from Solution 5 to the usable pole strengths , , or , based on the type of pole, to select the proper class of pole.

SOLUTION 6: Select a 50-foot Class 1 pole.

PROBLEM 7: Compare the answer from Solution 6 to pole-key resisting moment, which should be used for all unguyed poles. Refer to the DOH Manual, Section PO.

SOLUTION 7: The moment applied to the pole does not exceed the pole-key resisting moment of 55,125 ft-lb. See .