SOUTHERN CALIFORNIA EDISON
TRANSMISSION AND DISTRIBUTION

Distribution Overhead Construction Standards (DOH)

2019 — SECOND QUARTER ISSUE

April 26, 2019

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Distribution Overhead Construction Standards (DOH)

Revision Summary

2019 — Second Quarter Issue

Effective Date: April 26, 2019

Overview

The main purpose of this revision summary is to describe new revisions to this manual. (Some or all of the information may have been previously communicated to field personnel by other means.)

Table 1 lists the revisions. Clickable page/sheet numbers link directly to individual revisions or the first of a series of revisions.

Table 2 defines four types of revisions: (1) Admin (Administrative), (2) Technical, (3) New, and (4) Pilot.

Note: **Admin** *and* **Technical** *revisions to existing standards or existing* **Pilot** *projects are identified with change bars* **I** *in the left margin.* **New** *standards (as well as new pilot projects) do not receive change bars. Editorial revisions, such as corrections to spelling, do not receive change bars.*

A Getting Help section provides contact information.

Table 1: Revisions

Division Standard	Page/Sheet	Description	Type
AP 109	2	Added 25 kVA, 240/480 V transformer SAP number to “with Taps” list under Table 109–1.	Admin
AP 180	Various	Added new column in Table 180–1 for current ratings of voltage regulators. Added Note 2 to Table 180–1. Revised SAP number for Netcomm radio on various sheets.	Admin
AP 336	1–3, 9–12	Various figures and notes have been updated to show use of additional insulators for easier formation of jumpers from mainline tap to switch termination. Added table for SAP numbers for insulators.	Technical
AP 337	2–6	Various figures and notes have been updated to show use of additional insulators for easier formation of jumpers from mainline tap to switch termination. Added table for SAP numbers for insulators.	Technical
AP 338	1–6, 10	Various figures and notes have been updated to show use of additional insulators for easier formation of jumpers from mainline tap to switch termination. Added table for SAP numbers for insulators.	Technical
AP 339	2–5	Various figures and notes have been updated to show use of additional insulators for easier formation of jumpers from mainline tap to switch termination. Added table for SAP numbers for insulators.	Technical

Table 1: Revisions *(Continued)*

Division Standard	Page/Sheet	Description	Type
AP 400	3	Added Subsection 5.6 for Surge Arrester application for covered conductor.	Admin
AP 511P	All	Initial Issue construction standard for the IntelliRupter Pilot	Technical
AP 610	All	Standards has been made For Reference Only. GridSense Remote Fault Indicator Line Monitoring System are no longer being installed.	Admin
AP 712	All	Pilot watermark has been removed. Figure AP 712–1 was updated to include a rigging hole. Figure AP 712–2 Note 1. was updated to include an elevation angle of 55 degrees.	Technical
CC 150	3–4	Added Figure depicting double-dead end construction in covered conductor systems. Added Scope 3 for details on covered conductor tap connections.	Admin
CC 180	1	Updated figure depicting dead-end transition from covered conductor to bare wire. Bare wire dead-ends will also be covered with dead-end clamps.	Admin
CO 104	1	Updated Section 1.0 to clarify on when bare or covered conductor is to be used in coastal areas.	Admin
CO 106	1	Revised “Cable” to “Conductor” in Table 106–1 title. Added Note 3.	Admin
CO 168	Various	Added new paragraph describing the difference between all tables presented throughout standard. Differentiated stringing tension tables by including “Stringing” in table titles.	Admin
CO 212	1	Updated Note 2 to used 4"×4"×1/4" square flat washer.	Admin
CO 410	3	Updated Table CO 410-3 with new Repair Splice SAP Column.	Admin
CO 420	3–4	Updated Table CO 420–1 to include #6 Cu Sol and Covers for bolted wedge connector. Removed installation instructions.	Admin
CO 450	Various	Revised application section of overhead wire spacers for clarity. Moved Line Guard and Armor Rod tables to Subsection 2.1 and added information on when they need to be used for specific conductor sizes. Other updates for clarity.	Admin
DC 535	13–15	Added to statement to allow small pothead cover to be used on bolted wedge connectors. Added two bolted wedge connector covers. Removed FRO from triangular crossarm guard.	Admin
	28	New section for the installation of Swan Diverters.	Technical
GR 205	1–2	Updated references to CO 510 in notes	Admin

Table 1: Revisions *(Continued)*

Division Standard	Page/Sheet	Description	Type
PO 300	1	Removed reference to automatic guy dead-ends	Admin
PO 310	1	Revised SAP number for 8" single PISA anchor.	Admin
PO 315	All	Revised SAP number for 2-3/8" row for 20" cross plate. Made Tables for Automatic dead-ends for guy wires FRO	Admin
PO 340	4	Removed references to using automatic dead-ends for guy wires.	Admin
PO 350	All	Revised Figure 350–2 to show preform dead-end attached at the end of the guy wire. Removed reference to using automatic guy dead-ends in Note 1 on Sheet 2. Updated eye rod minimum distance above grade to match anchor standards.	Admin
PO 370	1, 9	Revised Note 3 and added Note 5 on Sheet 1. Updated Table PO 370–13.	Admin
SL 318	All	SL 318 has been updated to include all approved LED luminaires.	Admin

Table 2: Revision Types

Type	Definition
Admin	Administrative revisions do not significantly affect design, construction, maintenance or operation of the electrical distribution, substation, and transmission systems. They do not require Standards Review Team (SRT) or management approval; however, they have been approved by other organizations, as appropriate. They may include updates to material codes, updates to references, updates to standards for clarity, or deletions of outdated information.
Technical	Technical revisions are engineering changes to existing standards. They affect the design, construction, maintenance or operation of the electrical distribution, substation, and transmission systems. They require SRT and management approval.
New	Refers to a new standard. New technical standards require SRT and management approval.
Pilot	A *Pilot* is an in-field evaluation of a piece of equipment or work method, with the intention of approving for standardized use. Pilot standards will have a PILOT watermark so that they are easily identified throughout this manual.

Getting Help

Technical Revisions

If you have any comments, corrections, questions, or suggestions concerning manual revisions, please contact one of the following individuals at the numbers provided, or click on the name to send an email:

- Juan Castaneda (Manager) — PAX: 54782 Outside: (714) 895-0782
- Alaira Bilek — PAX: 54156 Outside: (714) 895-0156
- Gabriel Mercado — PAX: 54706 Outside: (714) 895-0198
- Jaimen Sanders — PAX: 54142 Outside: (714) 895-0142

Allen Thiel
Principal Manager Lead, Engineering

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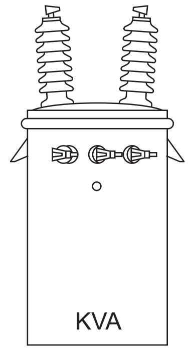
STANDARD | **TITLE**

AP 109 Single-Phase Overhead Transformers (All Primary Voltages)

Scope AP 109.1 Single-Phase Overhead Transformer

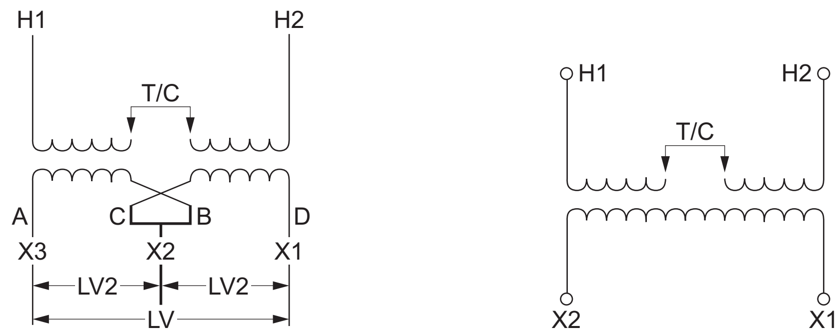
Figure AP 109–1: Typical Single-Phase Overhead Transformer



Note(s):

1. For the most accurate transformer wiring and rating information, always consult transformer nameplate.
2. TTR and Megger tests shall always be performed on each transformer before it is installed on the structure.
3. Always relieve the transformer tank pressure by pulling PRV ring before removing the transformer cover.
4. If equipped, the transformer tap changer is designed for de-energized operation only.
5. See AP 106 for transformer pole mounting and weight limitations.
6. See AP 108 for typical transformer weights and dimensions.
7. See AP 131 and AP 132 for cluster mounting bracket requirements.
8. See AP 140 for 15'–0" platform rack installation requirements.
9. See AP 145 and DC 640 for 17'–4" platform rack installation requirements.
10. See GR 106 for transformer ground conductor size requirements.
11. See GR 120 for transformer secondary grounding requirements.
12. See PO 120 for High Voltage sign installation requirements
13. See DC 535 for Wildlife Protection requirements
14. When banking transformers in a closed-delta configuration on the secondary:
    a. Leave one leg open and check voltage (< 20 V) before closing the delta.
    b. Bank transformers of like manufacturers whenever possible to ensure impedances match (+/– 25%).

Figure AP 109–2: Typical Overhead Wiring Schematics (Additive Polarity)



Low Voltage Ratings:
120/240 V and 240/480 V

Low Voltage Ratings:
277/480Y and 2400/4160 Y

Note(s):

1. Tap changer (T/C) shown in schematics above may or may not be equipped. See tables below.

Table AP 109–1: 2400 V, Single-Phase Transformer List

Without Taps			
HV	**LV**	**kVA**	**SAP**
2400/4160 Y	120/240	25	10103960
		37.5	10104016
		50	10104135
		75	10104202
		100	10104319
	277/480Y	50	10104134

With Taps			
HV	**LV**	**kVA**	**SAP**
2400/4160 Y	120/240	25	10103926
		50	10104083
		75	10104059
	240/480	25	10103964

Table AP 109–2: 4160 V, Single-Phase Transformer List

Without Taps			
HV	**LV**	**kVA**	**SAP**
4160 Y	120/240	25	10103971
		50	10104144
	277/480 Y	75	10104213
		100	10104325

With Taps			
HV	**LV**	**kVA**	**SAP**
4160	120/240	100	10104313
	277/480 Y	167	10104404

Table AP 109–3: 4800 V, Single-Phase Transformer List

Without Taps			
HV	**LV**	**kVA**	**SAP**
4800	120/240	25	10103966
		50	10104150
		75	10104207
	240/480	100	10104317

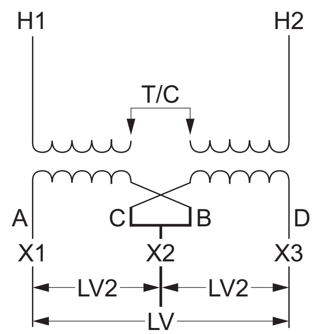
With Taps			
HV	**LV**	**kVA**	**SAP**
4800	120/240	100	10104316
	240/480	50	10104151
	277/480 Y	50	10104140
		100	10104318

Table AP 109–4: 7200 V, Single-Phase Transformer List

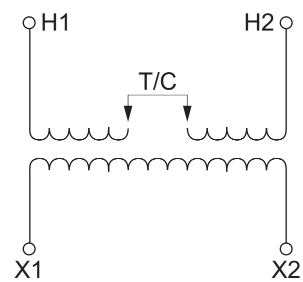
Without Taps			
HV	**LV**	**kVA**	**SAP**
7200/12470 Y	120/240	37.5	10104024
		50	10104147
		100	10104326
	240/480	50	10104149
		100	10104327

With Taps			
HV	**LV**	**kVA**	**SAP**
7200/12470 Y	120/240	25	10103969
		167	10104408
	2400/4160 Y	100	10104296

Figure AP 109–3: Typical Overhead Wiring Schematics (Subtractive Polarity)



Low Voltage Ratings:
120/240 V and 240/480 V



Low Voltage Ratings:
All Other Voltages

Note(s):

1. Tap changer (T/C) shown in schematic above may or may not be equipped. See tables below.

Table AP 109–5: 12000 V, Single-Phase Transformer List

Without Taps

HV	LV	kVA	SAP
12000	120/240	25	10103973
		37.5	10104027
		50	10104152
		75	10104214
		100	10104330
		167	10104410
		250	10104461
	240/480	25	10103978
		50	10104157
		100	10104335
	277/480 Y	25	10103979
		37.5	10104028
		50	10104160
		75	10104221
		100	10104338
		167	10104417

With Taps

HV	LV	kVA	SAP
12000	120/240	50	10104108
		100	10104303
		167	10104389
		333	10104499
	277/480 Y	50	10104114
		100	10104306
		250	10104465
		333	10104502
		500	10104552
	2400/4160 Y	50	10104162
		100	10104340
		167	10104418
		333	10104504
		500	10104563
	4800/8320 Y	167	10104420
	6930/12000 Y	167	10104430
		250	10104466
		333	10104505

Table AP 109–6: 14400/24940 Y, Single-Phase Transformer List

Without Taps
None

With Taps

HV	LV	kVA	SAP
14400/24940 Y	120/240	25	10103972
		50	10104180
		100	10104329
		167	10104416
	240/480	25	10103982
		50	10104181
	277/480 Y	25	10103940
		50	10104096
		100	10179654

Table AP 109–7: 16340 V, Single-Phase Transformer List

Without Taps

HV	LV	kVA	SAP
16340	120/240	25	10103991
		37.5	10104033
		50	10104169
		75	10104229
		100	10104351
		167	10104422
	240/480	25	10103986
		50	10104165
	277/480 Y	25	10103992
		37.5	10104034
		50	10104171
		75	10104232
		100	10104347
		167	10104429

With Taps

HV	LV	kVA	SAP
16340	120/240	250	10104470
		333	10104506
	277/480 Y	250	10104477
		333	10104511
	2400/4160 Y	50	10104168
		100	10104344
		167	10104427
		250	10104475
		333	10104510
		500	10104559
	9435/16340 Y	167	10104440
		250	10104473
		333	10104516

Table AP 109–8: 34400 V, Single-Phase Transformer List

Without Taps
None

With Taps			
HV	**LV**	**kVA**	**SAP**
34400	120/240	25	10103996
		50	10104170
		100	10104358
		167	10104442
		333	10104522
	240/480	25	10103997
		50	10104183
	277/480 Y	50	10104182
		100	10104359
		167	10104445
		250	10104485
		333	10104521
		500	10104544
	2400/4160 Y	25	10103998
		100	10201244
		250	10104482
		333	10104519
	4800	333	10104496
	7200/12470 Y	25	10182556
		100	10104360
		333	10104523
		500	10104542
	12470	100	10203346

AP 180 Line Voltage Regulators

Scope AP 180.1 Line Voltage Regulators

1.0 Application

Install single phase voltage regulators (phase-to-phase or phase-to-neutral configurations) on a single distribution pole and meet the minimum clearance and construction requirements as specified in Scope AP 180.2.

The installation of two or more voltage regulators for 2.4 kV through 25 kV circuits open delta, closed delta, or WYE configurations will require a 17'-4" platform rack. The 17'-4" platform rack is available in a 2-pole or 3-pole configuration, depending on the overall equipment weight. Installations on the 17'-4" platform rack shall meet minimum clearance and construction requirements as specified in Scope AP 180.3, AP 180.4, and AP 180.5. For 17'-4" platform rack selection, installation, and construction requirements (see DC 640).

The preferred installation for 33 kV regulators are pad-mounted designs up to 200 A. For larger installations of two or more voltage regulators for 33 kV circuits a surface mounted design is required. The installation shall meet minimum clearance and construction requirements as specified in Scope AP 180.5.

A 17'-4" platform rack (3-Pole Design) shall be used when a surface mounted design is not feasible for 33 kV applications due to location or real estate availability. For 17'-4" platform rack selection, installation, and construction requirements (see DC 640). Weight restrictions for regulator mounting may impact configuration and sizing.

For a complete list of available distribution voltage regulators see Table AP 180–1.

2.0 Equipment Anchorage

2.1 Platform Mounting

Properly anchor each voltage regulator installed onto a platform using two cable anchor assemblies. Install the cable anchor assembly between the regulator lifting lugs and the wood platform planks In addition install four Type III Snubbers on each regulator, one at each corner of the regulator base. See DC 640 for equipment anchorage details.

2.2 Surface Mounting

Properly anchor the regulator base to the concrete pad (Refer to UGS SS 503).

3.0 Voltage Regulator Control and Automation

Each voltage regulator shall come supplied with a control from the manufacturer. For new and replacement of existing voltage regulators, the control shall be automated for monitoring and control. A radio is required for automation and is ordered separately (SAP 10175268). Refer to DOM TR-4 for Netcom radio details. See Figure AP 180–12 for NetComm radio installation location.

Distribution construction shall contact the Distribution Automation Hotline when installing, relocating, or removing automated equipment at 714-285-4325.

4.0 Voltage Regulator Prior to Commissioning After Construction

After the installation of the voltage regulator, the equipment needs to be commissioned by Distribution Apparatus Test. The construction crew shall configure the equipment for Distribution Apparatus Test as follows: Verify that the source (S), load (L), and common (SL) disconnects are open, and that the bypass switch is closed. Power and Control Function switches should be "OFF."

Table AP 180–1: Voltage Regulators kVA Ratings, Weight, Dimensions and SAP Numbers

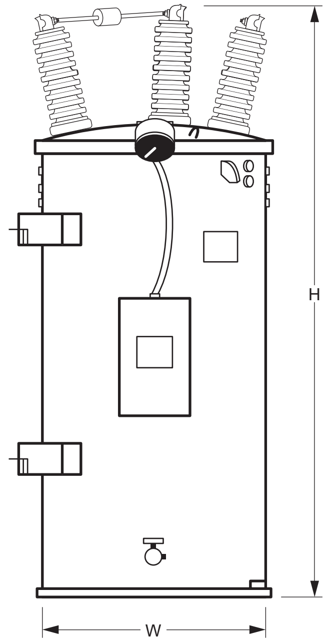
System Voltage	kVA	Current @ Full Reg. (Amps) (See Note 2)	SAP	Weight (lb) (See Note 1)	Height – H (in) (See Note 1)	Width – W (in) (See Note 1)
2.4 kV	75	300	10105157	1,800	80	25
	100	400	10105154	1,950	80	25
2.4 kV, 4.16 kV and 4.8 kV	50	100	10203494	1,150	73	21
	100	200	10169126	1,600	75	22
	167	334	10169127	2,850	80	25
	250	500	10203496	3,050	88	27
6.9 kV, 12 kV and 25 kV	144	100	10105160	2,050	75	25
	288	200	10105147	2,750	82	25
	333	231	10203497	3,600	86	27
	416	289	10203498	4,100	90	29
	432	300	10203499	4,100	90	29
	500	347	10203500	5,000	98	31
16 kV	100	50	10203501	1,750	79	22
	200	100	10203502	2,550	79	25
	333	167	10169135	3,450	91	27
	400	200	10169136	3,950	91	27
34.5 kV	863	250	10203493	10,100	134	40

= For Reference Only

Note(s):

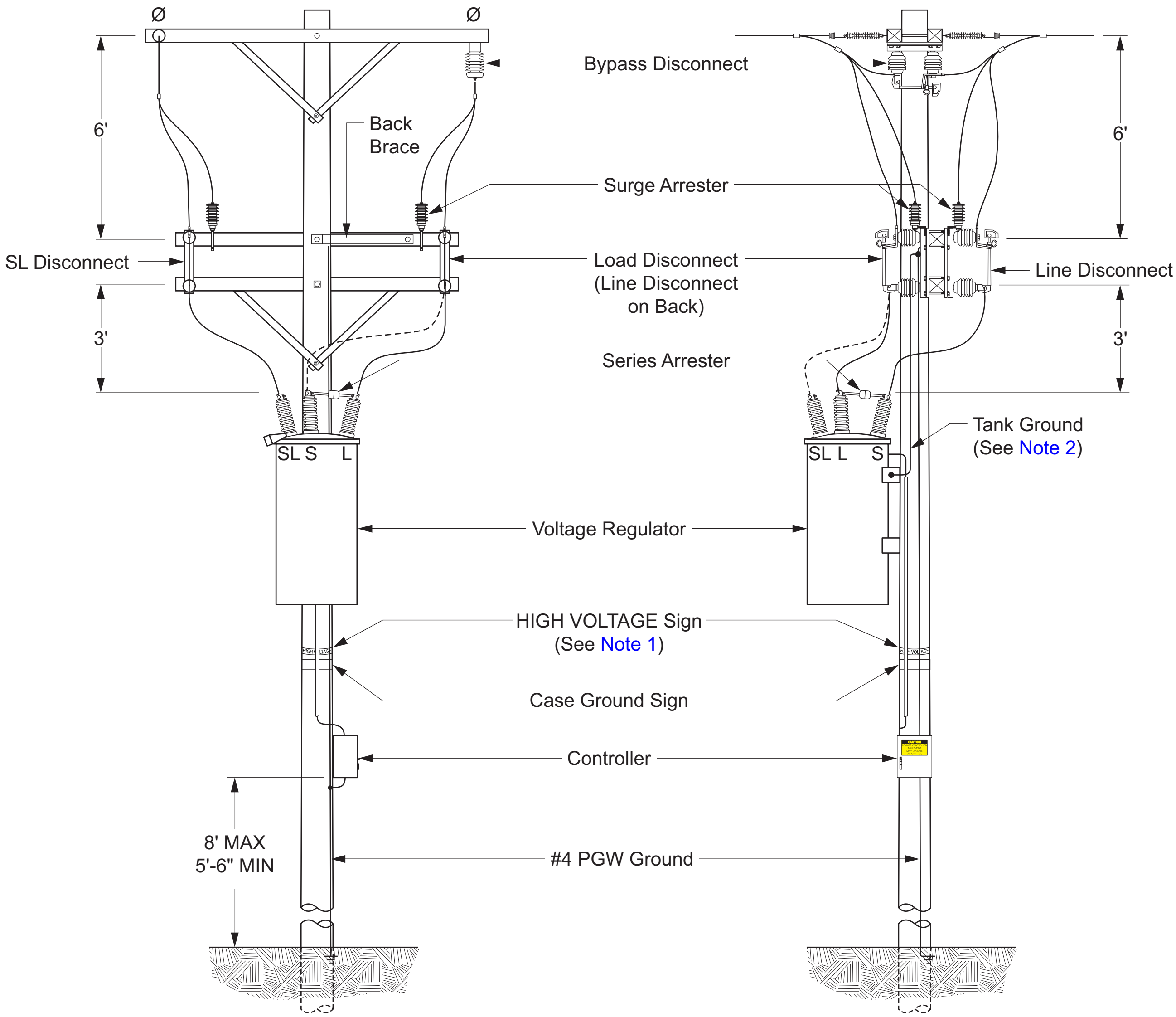
1. Table AP 180–1 specifies maximum weights and dimensions for each respective voltage regulator.
2. Regulators connected as single-phase, three-phase wye or three-phase open-delta can regulate up to ±10%. Regulators connected as three-phase closed-delta can regulate up to ±15%. If needed, % regulation can be reduced to accommodate larger load currents than what is listed above. Contact Field Engineering for any questions.

Figure AP 180–1: Typical Single-Phase Voltage Regulator



Scope AP 180.2 Single Phase Voltage Regulators

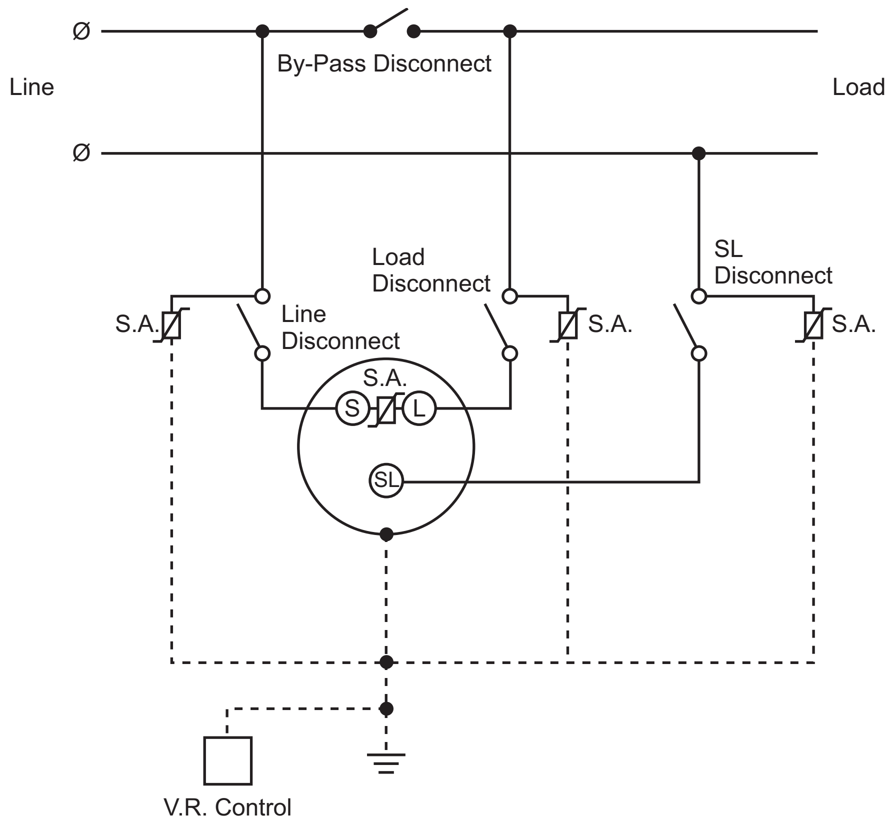
Figure AP 180–2: Phase to Phase Voltage Regulator Construction



Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. Ground the voltage regulator tank with one continuous run of #4 PGW. The tank ground shall be brought up to the pole top and terminated to the ground conductor directly beneath the surge arrester crossarm. Terminating the tank ground at this location limits the magnitude of voltage impressed upon the regulator during transient conditions. DO NOT terminate the tank ground to the ground conductor at any other location on the pole.
3. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

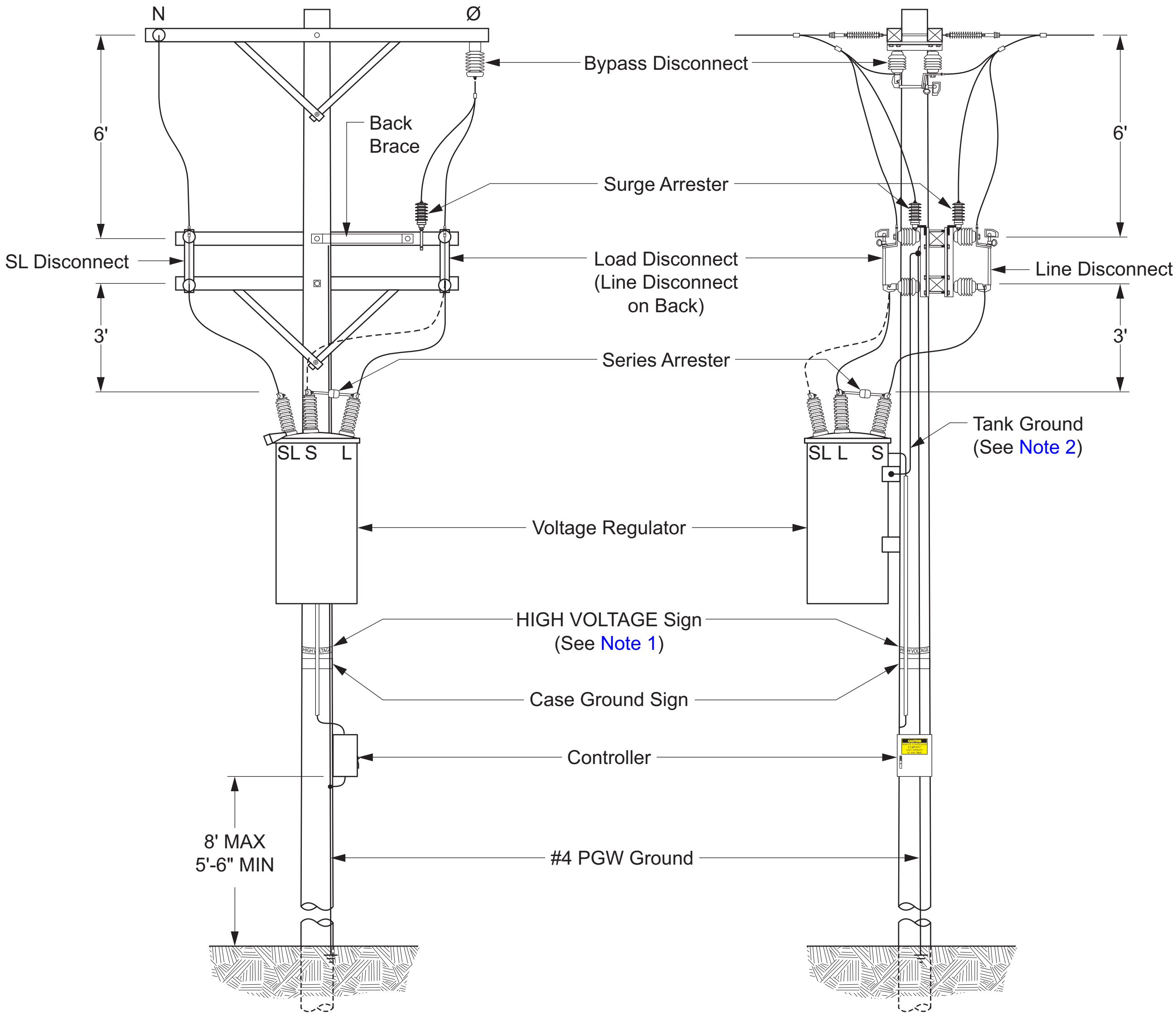
Figure AP 180–3: Phase to Phase Voltage Regulator Schematic



Note(s):

1. Each voltage regulator shall be supplied with a controller from the manufacturer. When remote control is desired, each controller will require a radio to be ordered separately (SAP 10175268). Refer to DOM TR-4 for NetComm Radio details.

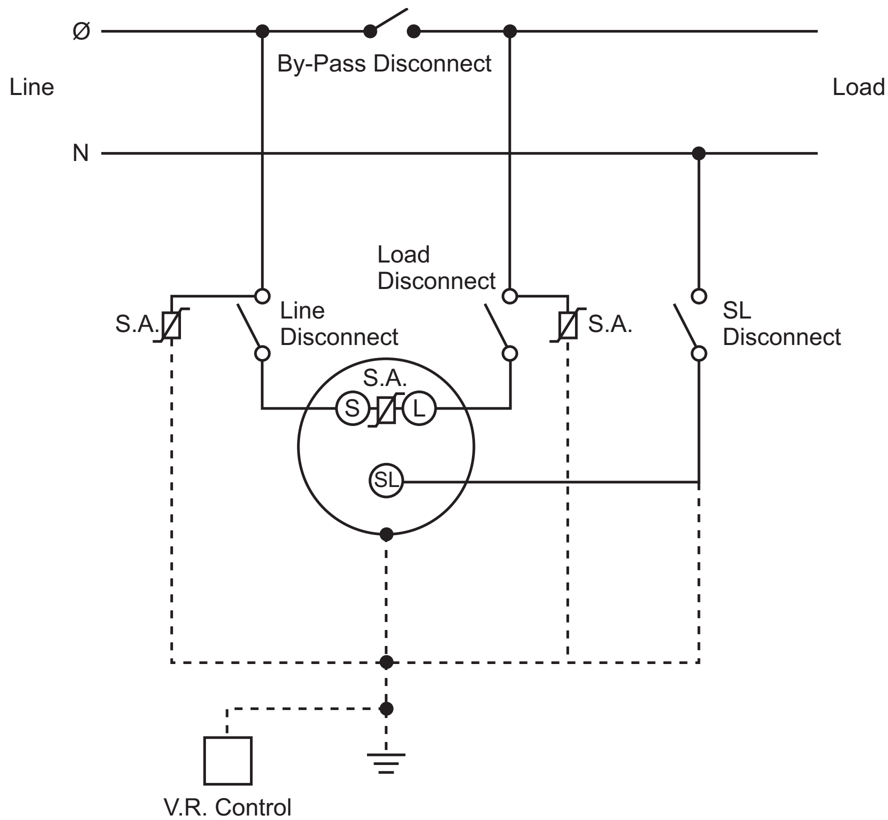
Figure AP 180–4: Phase to Neutral Voltage Regulator Construction



Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. Ground the voltage regulator tank with one continuous run of #4 PGW. The tank ground shall be brought up to the pole-top and terminated to the ground conductor directly beneath the surge arrester crossarm. Terminating the tank ground at this location limits the magnitude of voltage impressed upon the regulator during transient conditions. DO NOT terminate the tank ground to the ground conductor at any other location on the pole.
3. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

Figure AP 180–5: Phase to Neutral Voltage Regulator Schematic

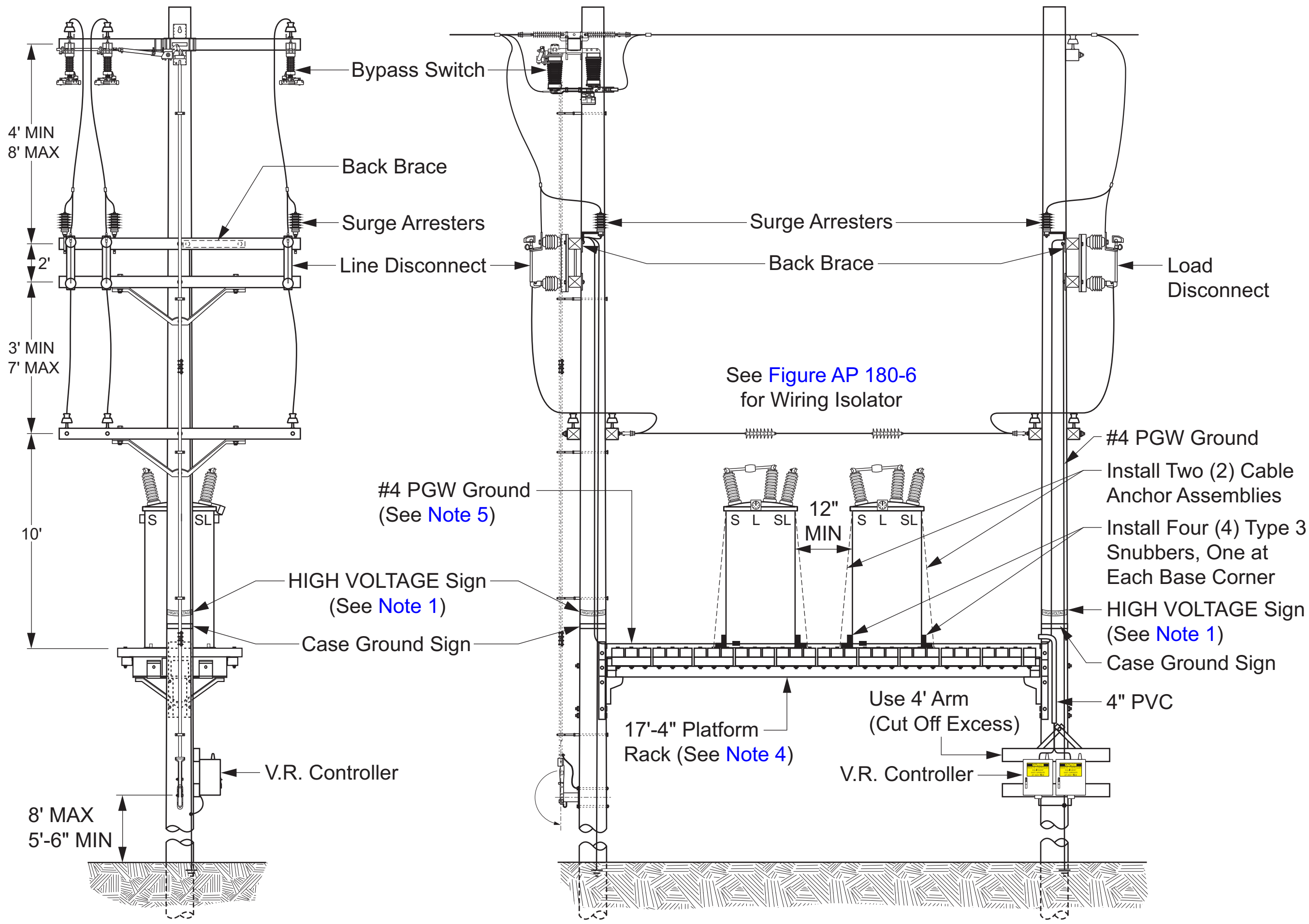


Note(s):

1. Each voltage regulator shall be supplied with a controller from the manufacturer. When remote control is desired, each controller will require a radio to be ordered separately (SAP 10175268). Refer to DOM TR-4 for NetComm Radio details.

Scope AP 180.3 Open Delta Voltage Regulators

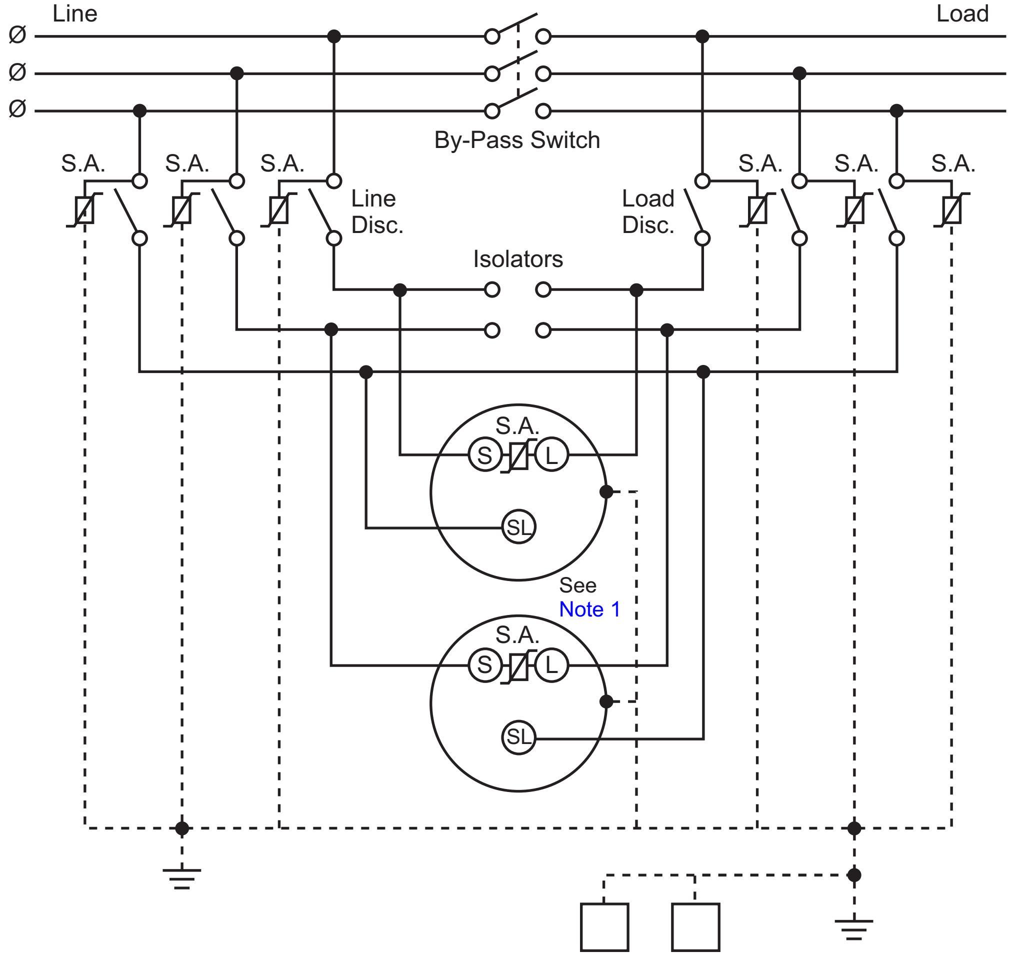
Figure AP 180–6: Open Delta Voltage Regulator Construction



Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. Install the bypass switch on the line side pole of the 17'-4" rack.
3. Install the VR controllers on the load side pole of the 17'-4" rack.
4. For selecting appropriate 17'-4" Platform Rack see DC 640.
5. Ground the voltage regulator tank with one continuous run of #4 PGW. Each end of this continuous run shall be brought up to the pole top and terminated to the ground conductor directly beneath the surge arrester crossarm. Terminating the tank ground at this location limits the magnitude of voltage impressed upon the regulator during transient conditions. DO NOT terminate the tank ground to the ground conductor at any other location on the pole.
6. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

Figure AP 180–7: Open Delta Voltage Regulator Schematic

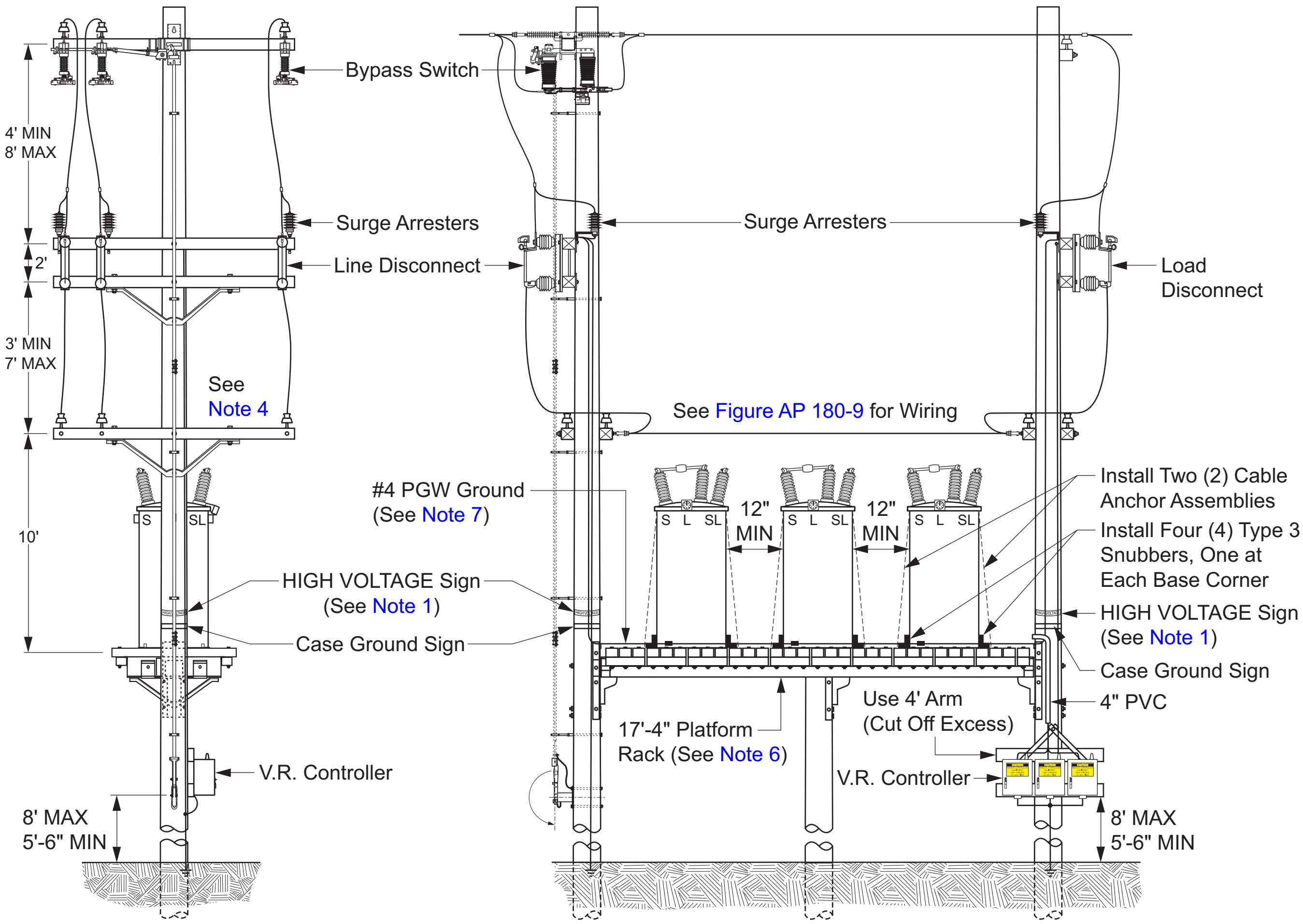


Note(s):

1. Each voltage regulator shall be supplied with a controller from the manufacturer. When remote control is desired, each controller will require a radio to be ordered separately (SAP 10175268). Refer to DOM TR-4 for NetComm Radio details.

Scope AP 180.4 Closed Delta Voltage Regulators

Figure AP 180–8: Closed Delta Voltage Regulator Construction

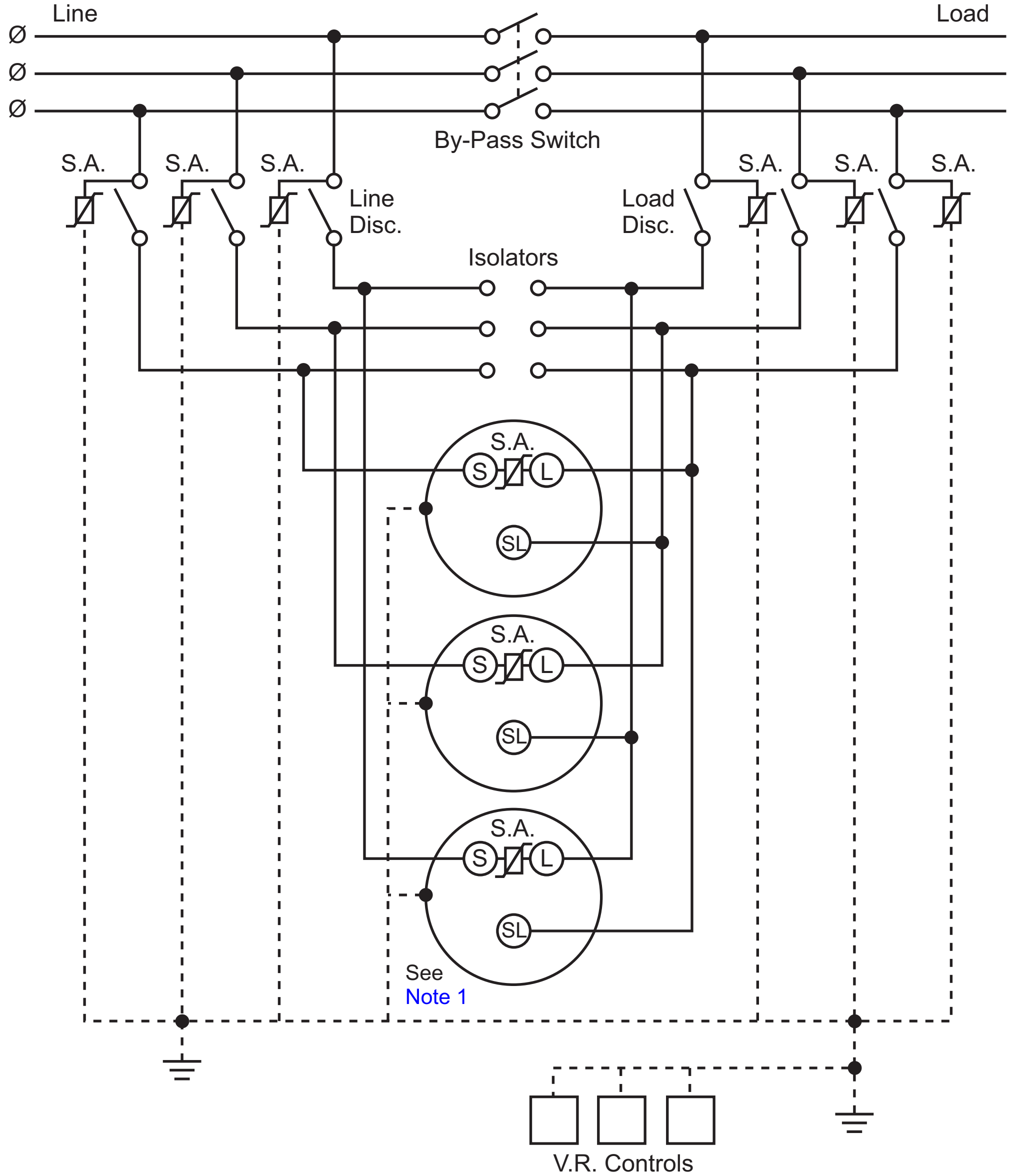


Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. An 8 foot crossarm shall be mounted on each pole of the 17'-4" rack to accommodate a line insulator in order to safely tap the primary line to the voltage regulator bus. Be sure to maintain all phase-to-phase and phase-to-ground clearances while routing the taps between the primary line and voltage regulator bus.
3. The taps shown in Figure AP 180–7 connecting the primary line to the line side VR bus shall be mirrored on the opposite pole to connect the primary line to the load side VR bus. All phases of the line bus shall be located on one side of the crossarm, while all phases of the load bus shall be located on the other side of the crossarm.
4. Install the bypass switch on the line side pole of the 17'-4" rack.
5. Install the VR controllers on the load side pole of the 17'-4" rack.
6. For selecting appropriate 17'-4" Platform Rack see DC 640.

7. Ground the voltage regulator tank with one continuous run of #4 PGW. Each end of this continuous run shall be brought up to the pole top and terminated to the ground conductor directly beneath the surge arrester crossarm. Terminating the tank ground at this location limits the magnitude of voltage impressed upon the regulator during transient conditions. DO NOT terminate the tank ground to the ground conductor at any other location on the pole.
8. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

Figure AP 180–9: Closed Delta Voltage Regulator Schematic



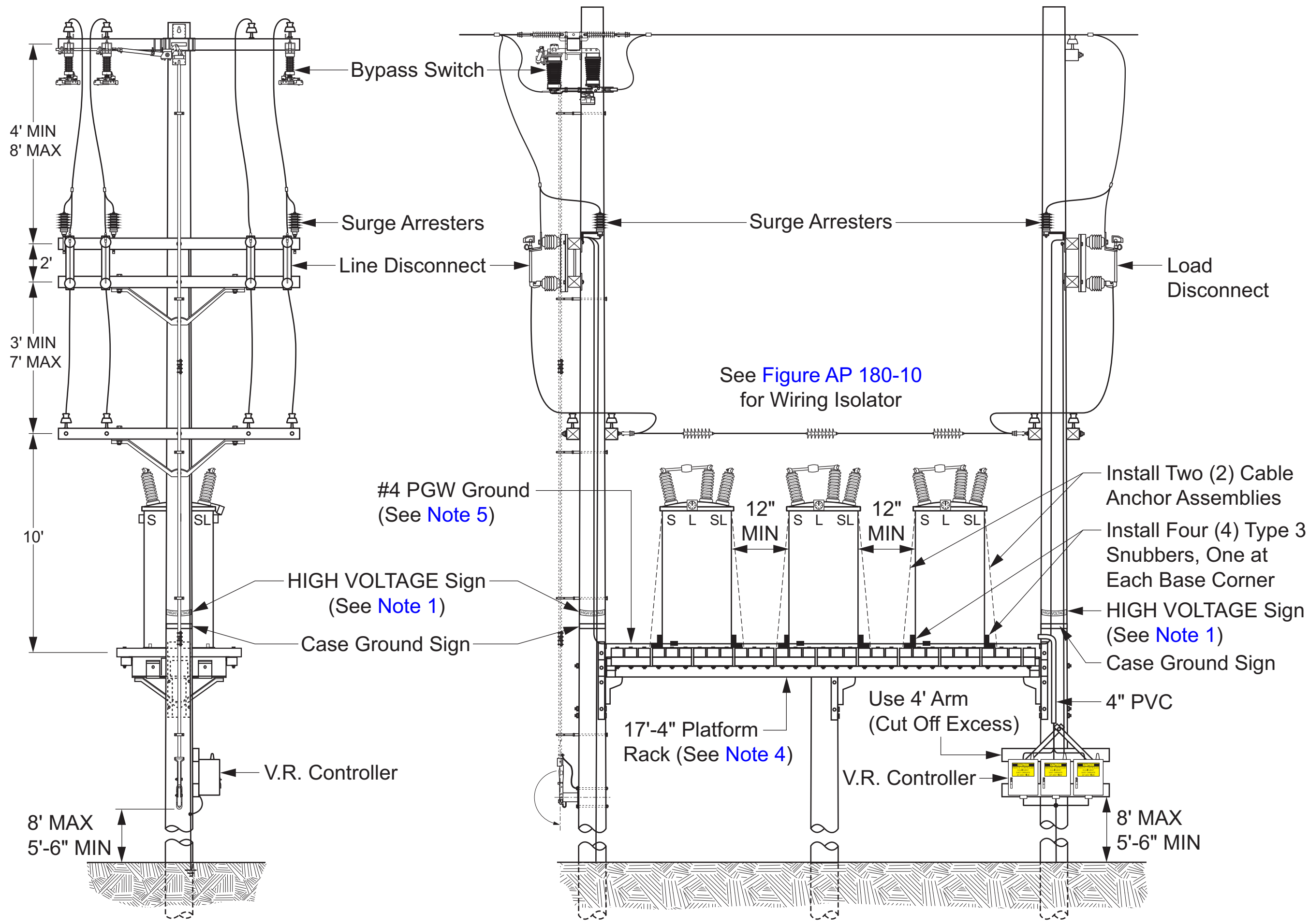
Note(s):

1. Each voltage regulator shall be supplied with a controller from the manufacturer. When remote control is desired, each controller will require a radio to be ordered separately (SAP 10175268). Refer to DOM TR-4 for NetComm Radio details.

What's Changed? Revised SAP number for voltage regulator NetComm radio.

Scope AP 180.5 Wye Configuration Voltage Regulators

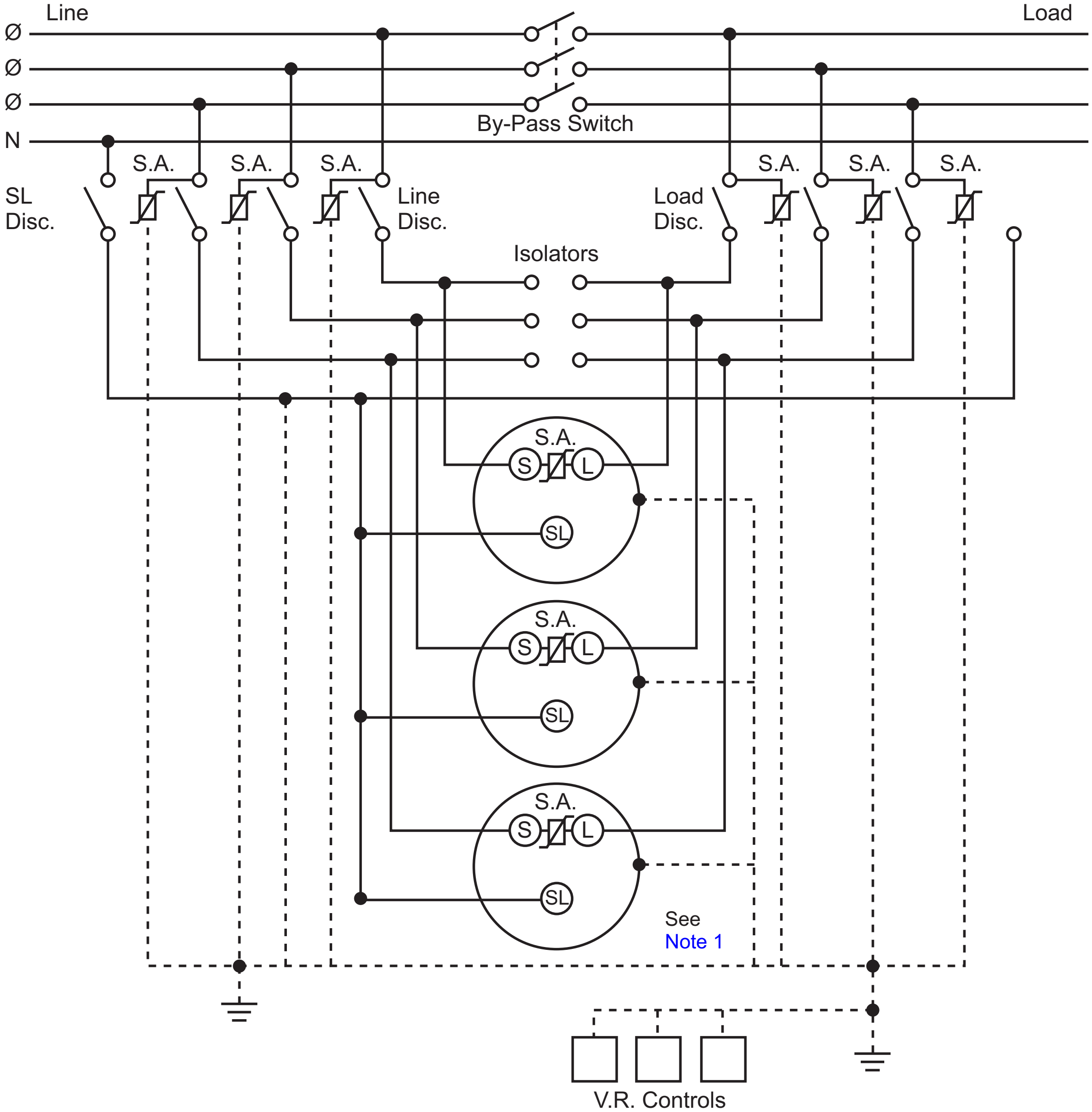
Figure AP 180–10: Wye Configuration Voltage Regulator Construction



Note(s):

1. See PO 120 for HIGH VOLTAGE signs installation requirements.
2. Install the bypass switch on the line side pole of the 17'-4" rack.
3. Install the VR controllers on the load side pole of the 17'-4" rack.
4. For selecting appropriate 17'-4" Platform see DC 640.
5. Ground the voltage regulator tank with one continuous run of #4 PGW. Each end of this continuous run shall be brought up to the pole top and terminated to the ground conductor directly beneath the surge arrester crossarm. Terminating the tank ground at this location limits the magnitude of voltage impressed upon the regulator during transient conditions. DO NOT terminate the tank ground to the ground conductor at any other location on the pole.
6. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

Figure AP 180–11: Wye Configuration Voltage Regulator Schematic

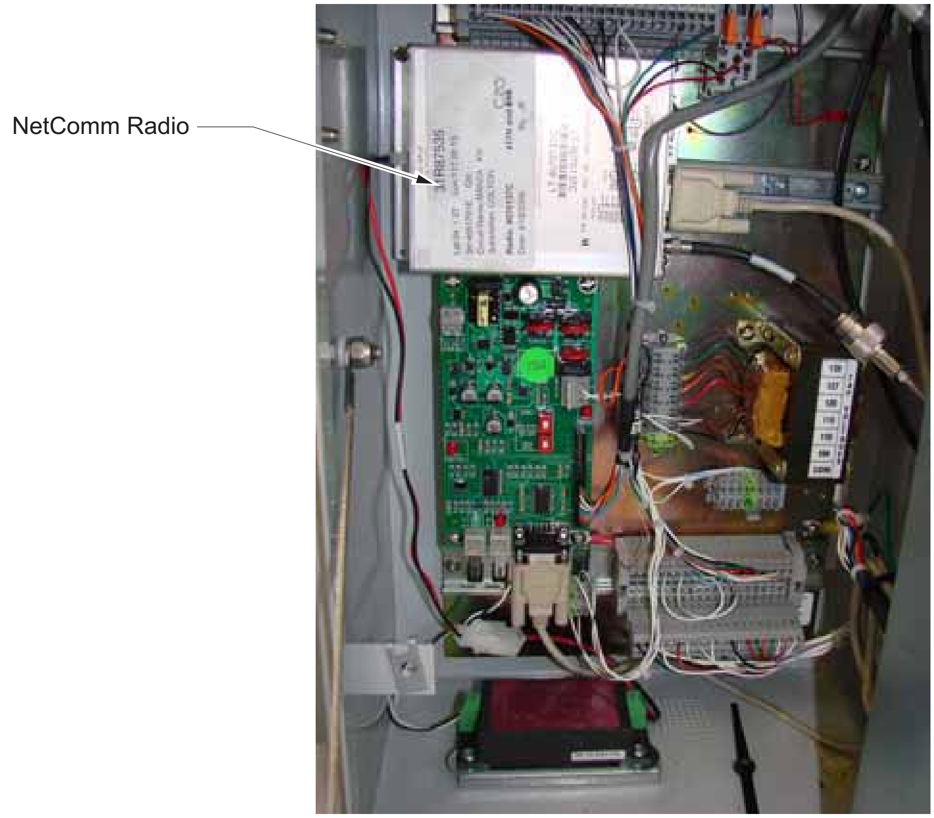


Note(s):

1. Each voltage regulator shall be supplied with a controller from the manufacturer. When remote control is desired, each controller will require a radio to be ordered separately (SAP 10175268). Refer to DOM TR-4 for NetComm Radio details.
2. No neutral disconnect is required on load side.

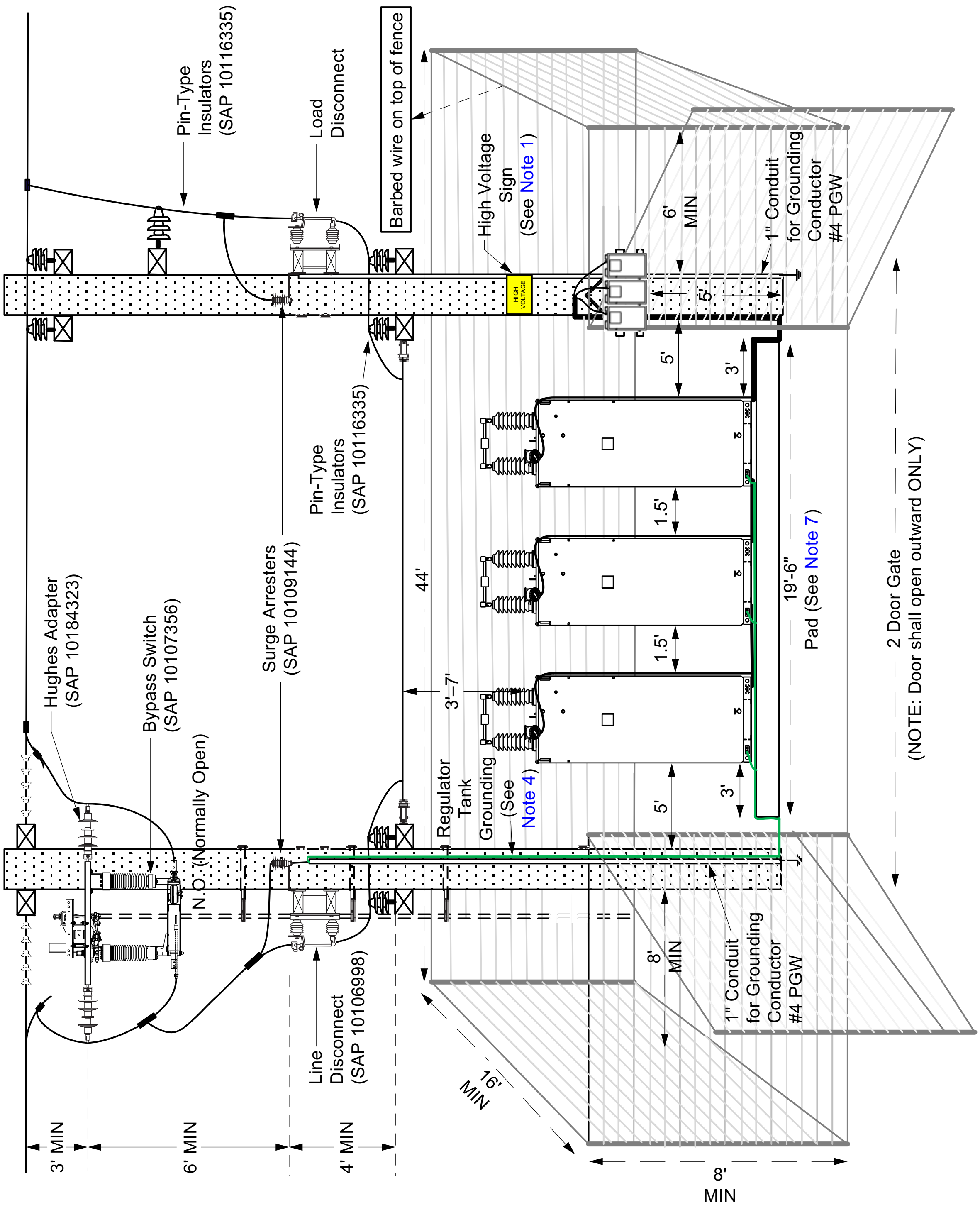
What's Changed? Revised SAP number for voltage regulator NetComm radio.

Figure AP 180–12: Voltage Regulator NetComm Radio Installation



Scope AP 180.6 33 kV Surface Mounted Voltage Regulators

Figure AP 180–13: Surface Mounted Voltage Regulator Construction



Note(s):

1. See PO 120 for HIGH VOLTAGE signs installation requirements.
2. Install the bypass switch on the line side pole.
3. Clearance between concrete pad and the fence shall be minimum of 5 feet.
4. Ground the voltage regulator tank and the voltage regulator controls with one continuous run of #4 PGW. Each end of this continuous run shall be brought up to the pole top and terminated to the ground conductor directly beneath the surge arrester cross arm. Terminating the tank ground at this location limits the magnitude of voltage impressed upon the regulator during transient conditions. DO NOT terminate the tank ground to the ground conductor at any other location on the pole.
5. Per DC 535, Avian Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.
6. Containment berm shall be installed inside fenced in area.
7. Refer to UGS SS 503 for poured in place pad and additional grounding requirements.
8. Refer to UGS SS 549 for chain link fence.
9. Gate shall be constructed to open outward ONLY.

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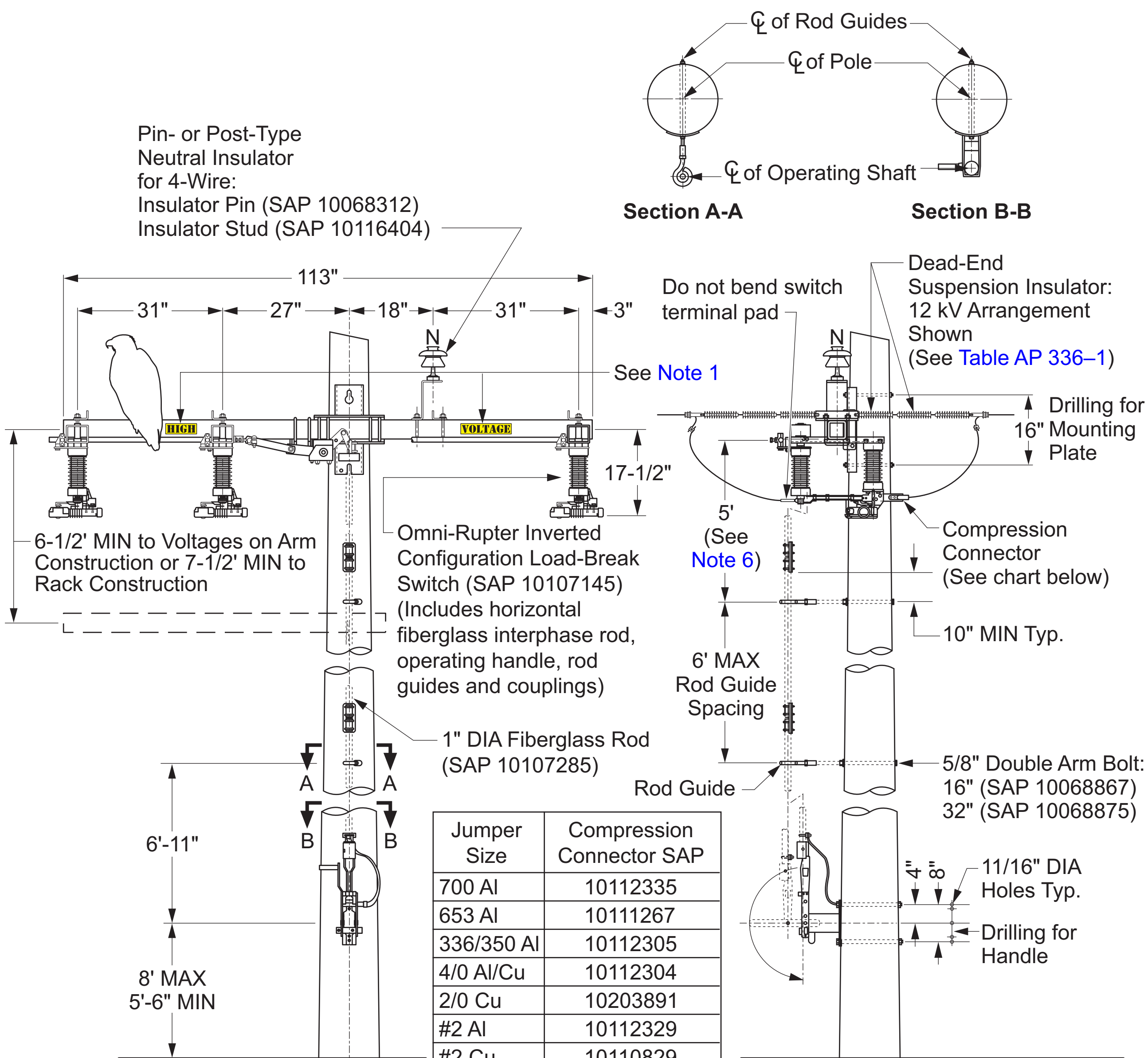
AP 336 600 A, 17 kV Omni-Rupter Load-Break Switches

Scope AP 336.1 Horizontal Inverted Omni-Rupter Switch, Line Dead-Ended Directly to Switch

Figure AP 336–1: Horizontal Inverted Omni-Rupter Switch, Line Dead-Ended Directly to Switch



Jumper Size	Compression Connector SAP
700 Al	10112335
653 Al	10111267
336/350 Al	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891
#2 Al	10112329
#2 Cu	10110829
#4 Cu	10110829

Table AP 336–1: Insulator Summary

Phase to Phase Voltage	Quantity Insulator Per Phase Per Side of Switch	SAP
4 kV & 12 kV	3	10116431
16 kV	2	10116332

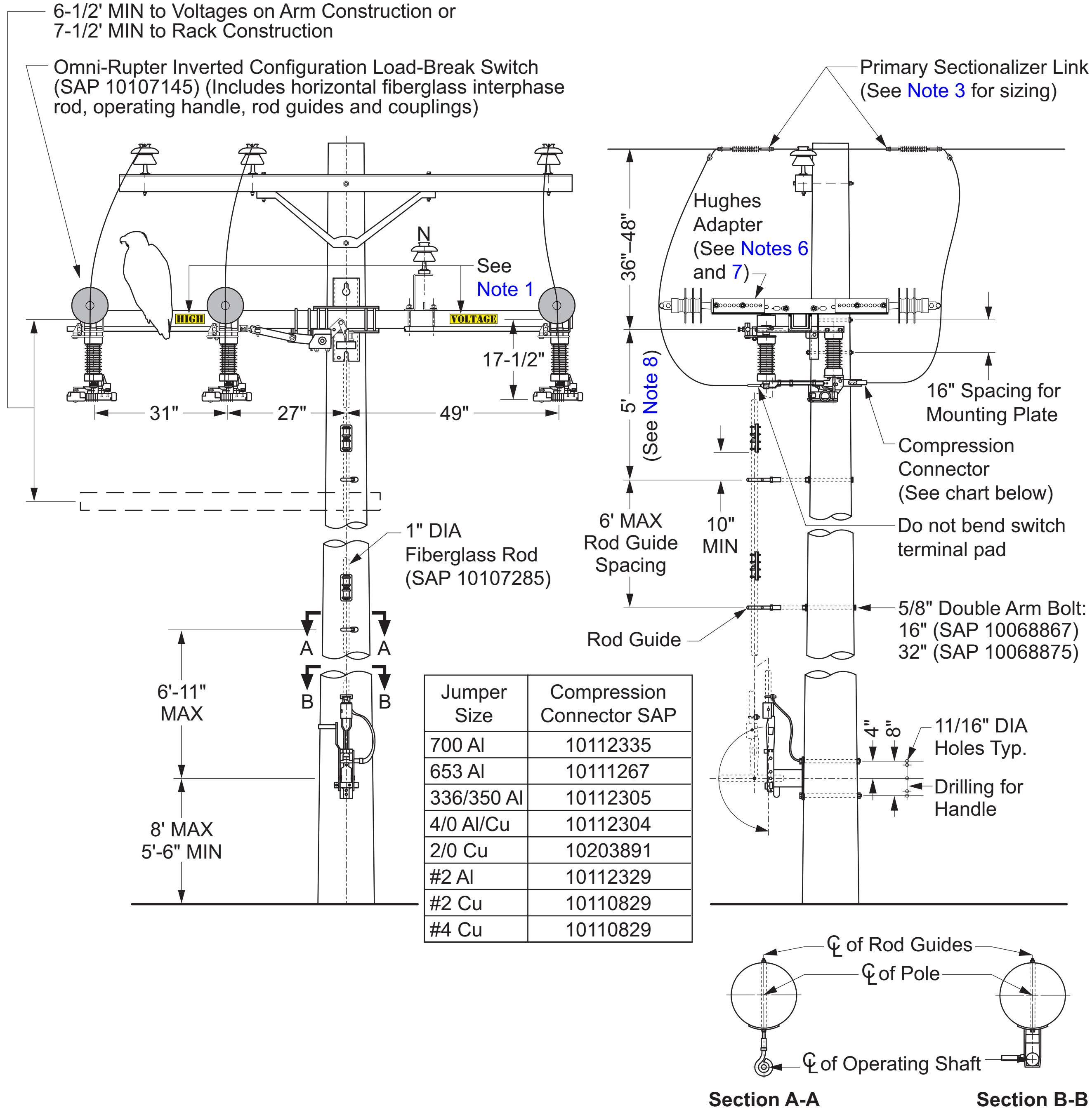
What's Changed? Updated Figure 336–1 to show increased amount of insulators. Added Insulator summary Table AP 336–1 for how many insulators to use.

Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. Place “HIGH VOLTAGE” stickers (SAP 10135407) on the face and back of each switcharm or plastic signs on the pole. The top of high voltage sign(s) shall be located between the level of the lowest circuit conductor no more than 40 inches below that conductor level.
3. Verify switch blades are fully closed when installing rod/handle assembly.
4. This switch to be used for wildlife-safe construction.
5. Per DC 535, Wildlife Protection shall be installed as applicable on insulators, taps, leads, arresters, cable terminations, and equipment bushings.
6. The uppermost rod guide shall be located 5 feet below the underside of the switch crossarm. The lowest rod guide shall be located 6'-11" above the switch handle pivot. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 336.2 Horizontal Inverted Omni-Rupter Switch Below Line Arm, Utilizing Hughes Adapter

Figure AP 336–2: Horizontal Inverted Omni-Rupter Switch Below Line Arm, Utilizing Hughes Adapter



Jumper Size	Compression Connector SAP
700 Al	10112335
653 Al	10111267
336/350 Al	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891
#2 Al	10112329
#2 Cu	10110829
#4 Cu	10110829

Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. Verify switch blades are fully closed when installing rod/handle assembly.
3. See CO 217 for primary sectionalizer link selection criteria and SAP numbers. Use 25 kV or 33 kV rated primary sectionalizer links. Double dead-ending on line arm is acceptable.
4. This switch is to be used for wildlife-safe construction.
5. Per DC 535, Wildlife Protection shall be installed as applicable on insulators, taps, leads, arrestors, cable terminations, and equipment bushings.
6. Hughes Adapter can accommodate a 25 kV Hendrix insulator or 35 kV Hendrix Insulator. See GR 200 for appropriate insulator selection.
7. For detailed Hughes Adapter installation procedures for inverted Omni-Rupter switches installed below the line arm, see AP 336.3.
8. The uppermost rod guide shall be located 5 feet below the underside of the switch crossarm. The lowest rod guide shall be located 6'-11" above the switch handle pivot. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 336.3 Installation of Hughes Adapter for Inverted Omni-Rupter Switches Installed Below the Line Arm

1.0 Hughes Adapter Installation Details

Refer to DOM SW-2 for retrofit criteria for existing inverted Omni-Rupter switches installed below the line arm. Refer to DDS-10 and this standard for new construction of Inverted Omni-Rupter switches installed below the line arm.

The Hughes Adapter is configurable from 40 inches to 48 inches in length to accommodate the bending radius of jumper wire from switch termination pad to horizontally-mounted Hendrix insulator. The Adapter is designed for new and retrofit construction of the Inverted Omni-Rupter switch.

2.0 Procedures for Installing Hughes Adapter

1. Install the Hendrix insulator (with appropriate insert) onto the short shank steel pins. Rotate the insulator clockwise approximately 4-1/2 to 5 turns until contact with insulator mastic.
2. Insert the short shank steel pin threaded head into the end of the adjustment plate. Align the jaws of the insulator to vertical orientation.
3. Attach a 13/16 inch round washer, 5/8 inch lock washer and nut to the steel pin thread. Tighten the nut to secure the short shank steel pin to the adjustment plate.
4. Position the Hughes Adapter against the backside of the Omni-Rupter switch factory angle iron. Align the adapter mounting holes to the Omni-Rupter bracket mounting.
5. Adjust the Hughes Adapter end-plates to accommodate the natural wire bending radius. See Table AP 336–3 for recommended end-plate spacing.

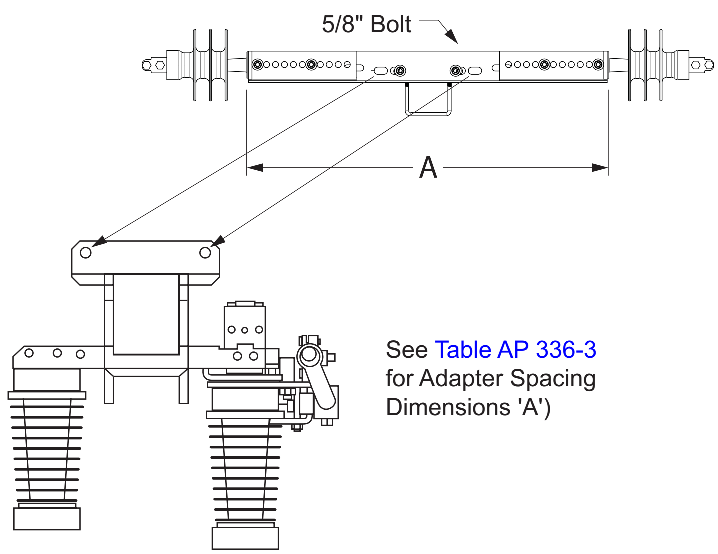
Table AP 336–2: Hughes Adapter Components for Installation on Inverted Omni-Rupters Mounted Below the Line Arm

Description	SAP	Quantity
Hughes Bracket	10184323	3
Short Shank Steel Pin	10068309	6
Hendrix Insulator	See GR 200	6
Round Flat Washer	10072007	6

Table AP 336–3: Jumper Sizes, Compression Connector and Hughes Adapter Spacing Dimension ‘A’ (See Figure AP 336–3)

Jumper Size	Compression Connector SAP	Hughes Adapter Spacing Dimension “A” (in)
700 Al	10112335	44
653 Al	10111267	40–42
336/350 Al	10112305	40–42
4/0 Al/Cu	10112304	40–42
2/0 Cu	10203891	40
#2 Al	10112329	40
#2 Cu	10110829	40
#4 Cu	10110829	40

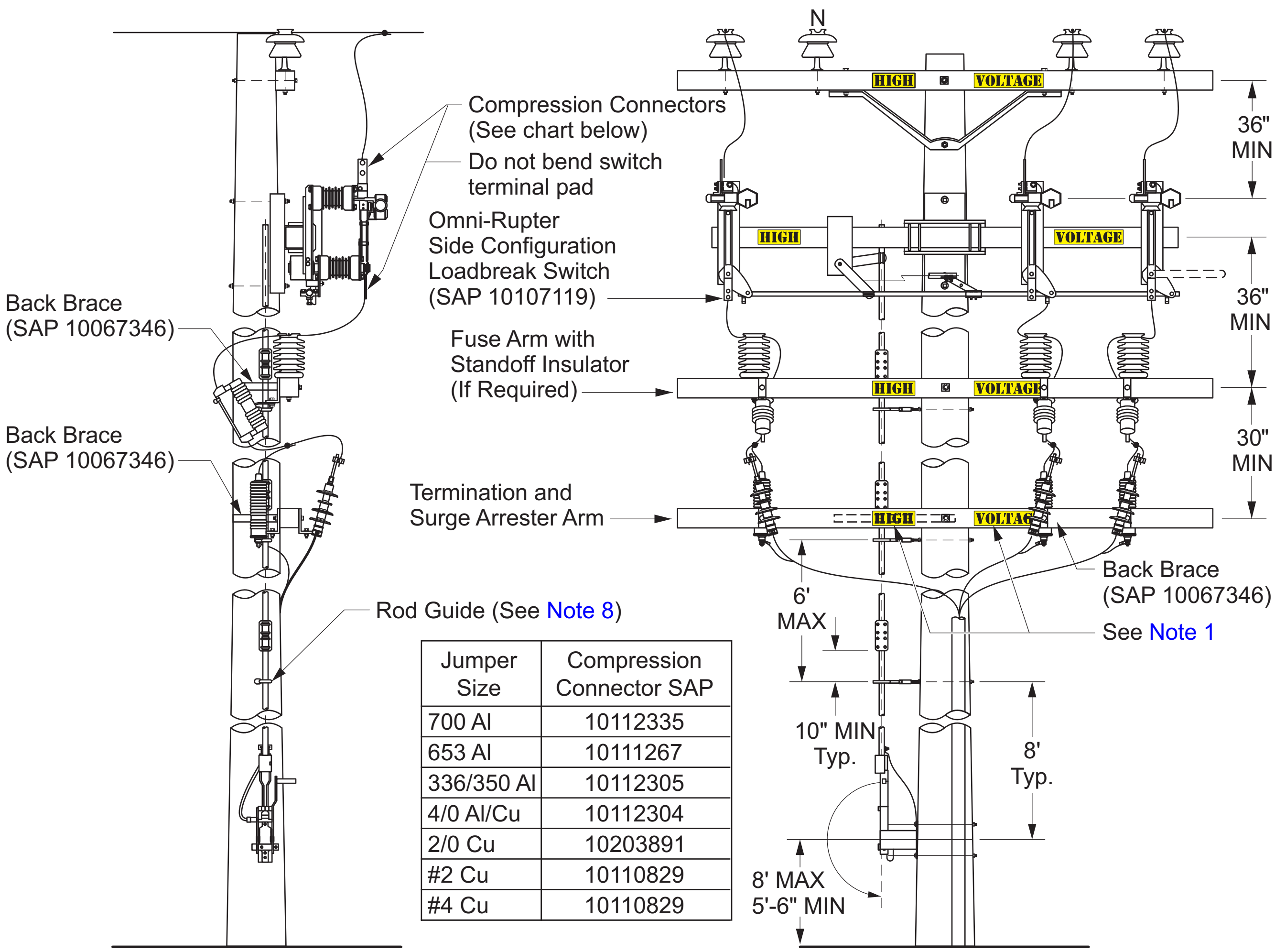
Figure AP 336–3: Typical Mounting of Hughes Adapter, Side View



What’s Changed? Updated table reference in Figure AP 336–3.

Scope AP 336.4 Horizontal Side Arm Omni-Rupter Switch, Primary Dip Application

Figure AP 336–4: Horizontal Side Arm Omni-Rupter Switch, Primary Dip Application



Jumper Size	Compression Connector SAP
700 Al	10112335
653 Al	10111267
336/350 Al	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891
#2 Cu	10110829
#4 Cu	10110829

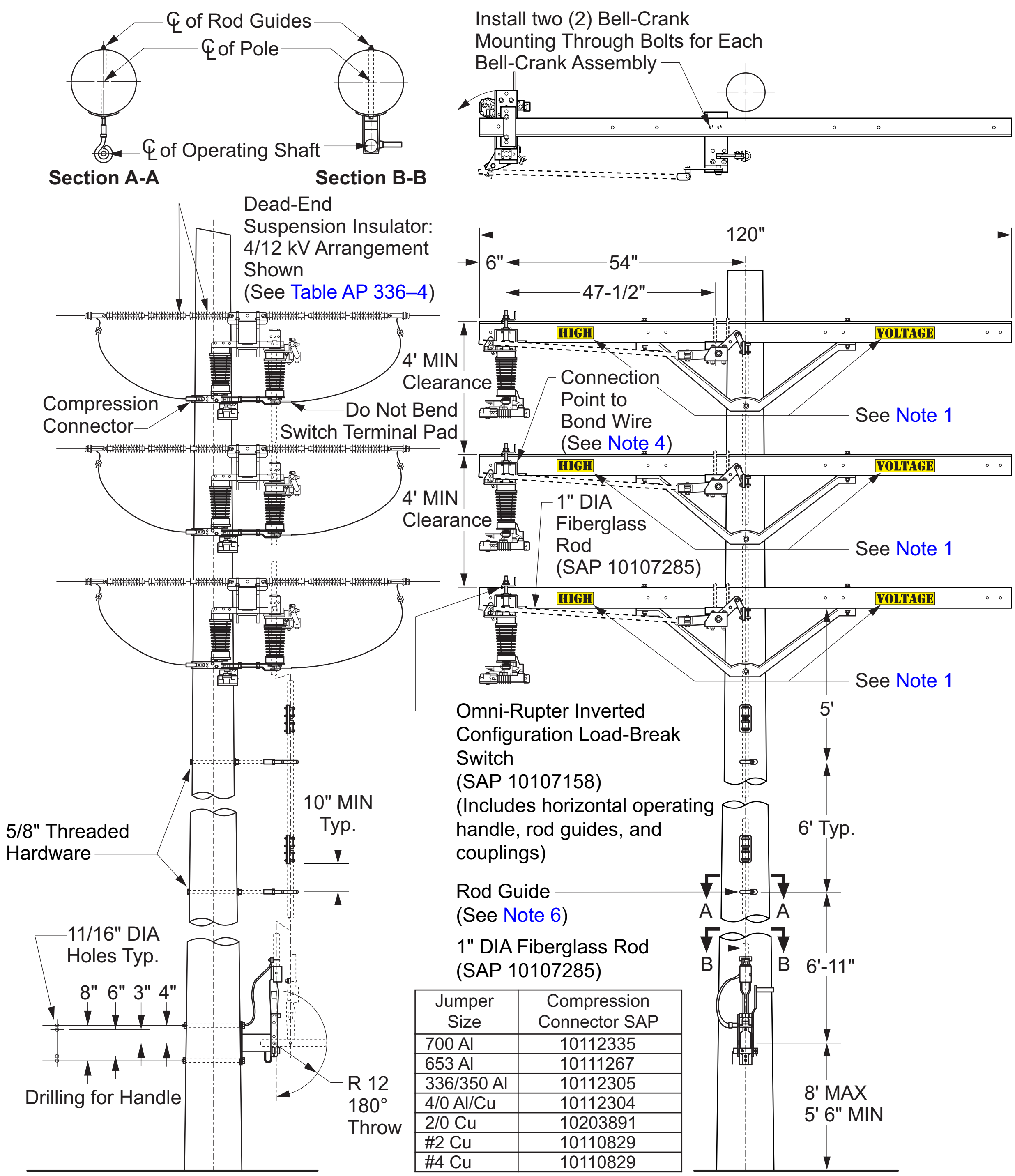
Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. See Figure AP 336–1 for Omni-Rupter switch and operating rod installation details.
3. If fusing is not required on the pole, the minimum spacing between the switch and pothead arms shall be 36 inches.
4. Refer to TP 209 of the Distribution Underground Construction Standards (DUG) for the standards required to connect the surge arrester ground and the concentric neutrals to the termination ground. For the primary neutral riser, refer to DUG CR 140 (neutral must be in PVC as it passes the switch).
5. Verify switch blades are fully closed when installing rod/handle assembly.
6. Horizontal-Type Side-Arm Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch shall not be automated for Primary Dip applications.
7. Per DC 535, Wildlife Protection shall be and installed as applicable on insulators, taps, leads, arresters, cable terminations, and equipment bushings.

8. The uppermost rod guide shall be located 8 feet below the underside of the switch crossarm. The lowest rod guide shall be located 8 feet above the switch handle pivot. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 336.5 Vertical Inverted Omni-Rupter Switch

Figure AP 336–5: Vertical Inverted Omni-Rupter Switch



Jumper Size	Compression Connector SAP
700 Al	10112335
653 Al	10111267
336/350 Al	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891
#2 Cu	10110829
#4 Cu	10110829

Table AP 336–4: Insulator Summary

Phase to Phase Voltage	Quantity Insulator Per Phase Per Side of Switch	SAP
4 kV & 12 kV	3	10116431
16 kV	2	10116332

Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. Verify switch blades are fully closed when installing rod/handle assembly.
3. This switch to be used for wildlife-safe construction.
4. Do not bond Bell Cranks.
5. Per DC 535, Wildlife Protection shall be installed as applicable on insulators, taps, leads, arresters, cable terminations, and equipment bushings.
6. The uppermost rod guide shall be located 5 feet below the underside of the switch crossarm. The lowest rod guide shall be located 6'-11" above the switch handle pivot. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

What's Changed? Removed Note 3 regarding use of insulators. Revised note numbering. Removed reference to CO 217 in Note 3.

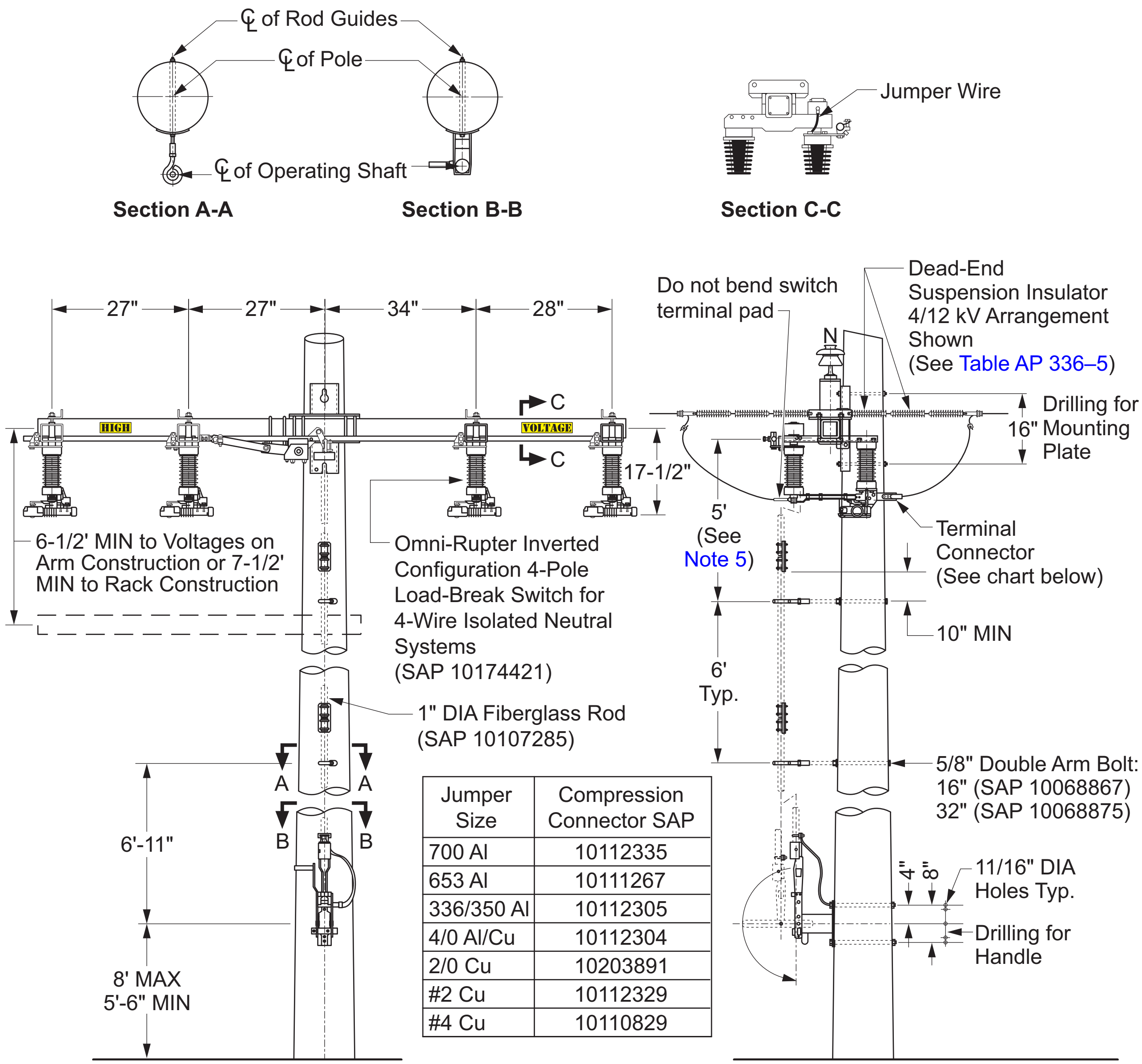
Effective Date: 04-26-2019

Scope AP 336.6 Horizontal Inverted Omni-Rupter 4-Pole Switch, for 4 kV Isolated Neutral Systems

1.0 Applications

The 4-Pole overhead Omni-Rupter is approved for use on 4-wire 4 kV isolated neutral systems.

Figure AP 336–6: Horizontal Inverted 4-Pole Switch, for 4 kV Isolated Neutral Systems



Jumper Size	Compression Connector SAP
700 Al	10112335
653 Al	10111267
336/350 Al	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891
#2 Cu	10112329
#4 Cu	10110829

What's Changed? Updated Figure AP 336–6 to show increased amount of insulators. Added Insulator summary Table AP 336–5 for how many insulators to use.

Table AP 336–5: Insulator Summary

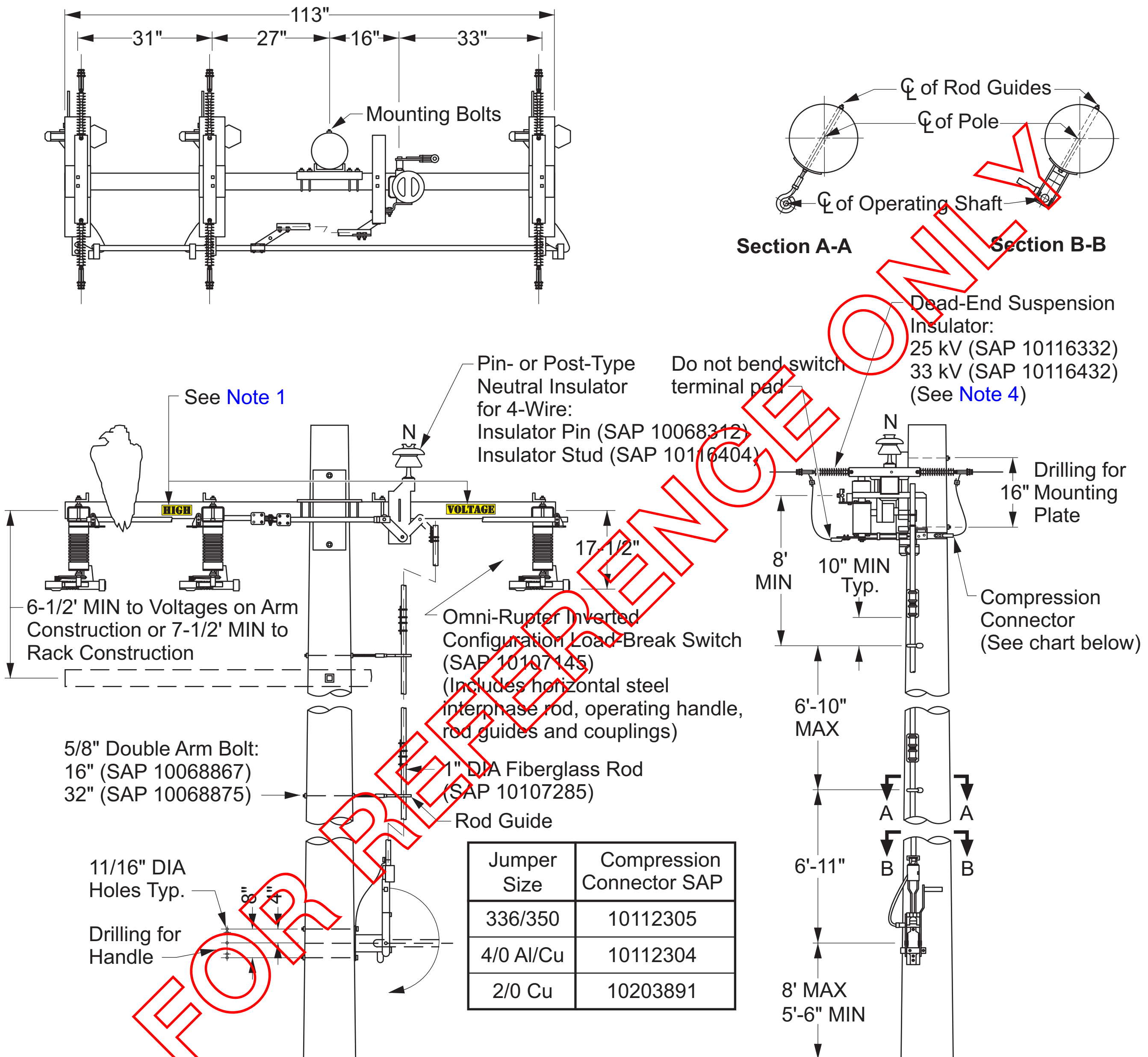
Phase to Phase Voltage	Quantity Insulator Per Phase Per Side of Switch	SAP
4 kV & 12 kV	3	10116431
16 kV	2	10116332

Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. Verify switch blades are fully closed when installing rod/handle assembly.
3. This switch is to be used for wildlife-safe construction.
4. Per DC 535, Wildlife Protection shall be installed as applicable on insulators, taps, leads, arrestors, cable terminations and equipment bushings.
5. The uppermost rod guide shall be located 5 feet below the underside of the switch crossarm. The lowest rod guide shall be located 6'-11" above the switch handle pivot. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 336.7 **Horizontal-Type Inverted Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch for Wildlife-Safe Construction on 3-Wire or 4-Wire Pole Applications**

Figure AP 336–7: Horizontal-Type Inverted Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch for Wildlife-Safe Construction on 3-Wire or 4-Wire Pole Applications



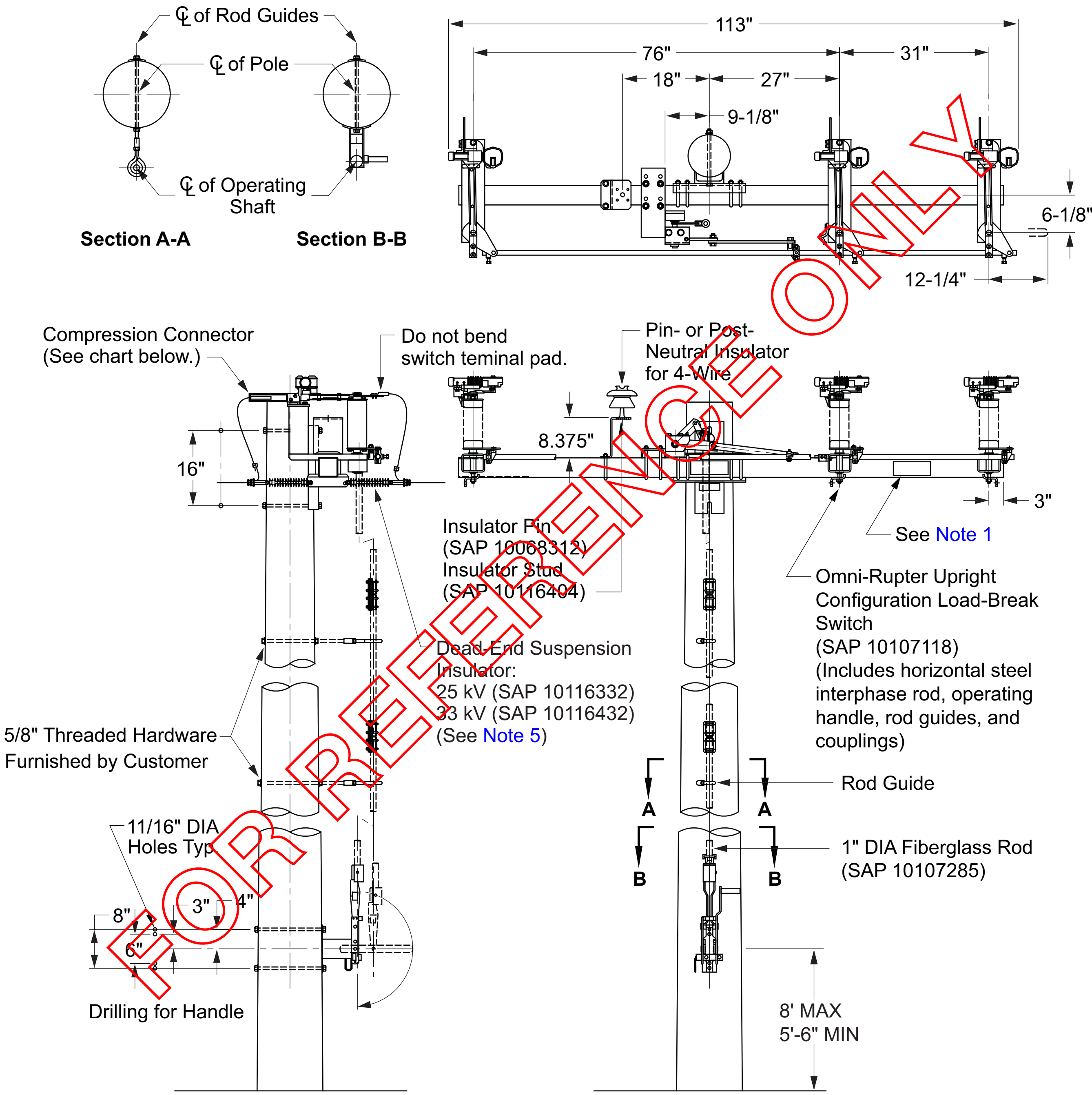
Jumper Size	Compression Connector SAP
336/350	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891

Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. Verify switch blades are fully closed when installing rod/handle assembly.
3. HIGH VOLTAGE warning provisions can be made either by placing “HIGH VOLTAGE” stickers (SAP 10135407) on the face and back of each switcharm or by plastic signs on the pole. The top of such sign(s) shall be located between the level of the lowest line conductor of each circuit to no more than 40 inches below that conductor level.
4. Do not install 15 kV dead-end suspension insulators, use 25 kV or 33 kV dead-ends.
5. This switch to be used for wildlife-safe construction.
6. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

Scope AP 336.8 **Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch for 3-Wire or 4-Wire Pole-Top Applications**

Figure AP 336–8: Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch for 3-Wire or 4-Wire Pole-Top Applications

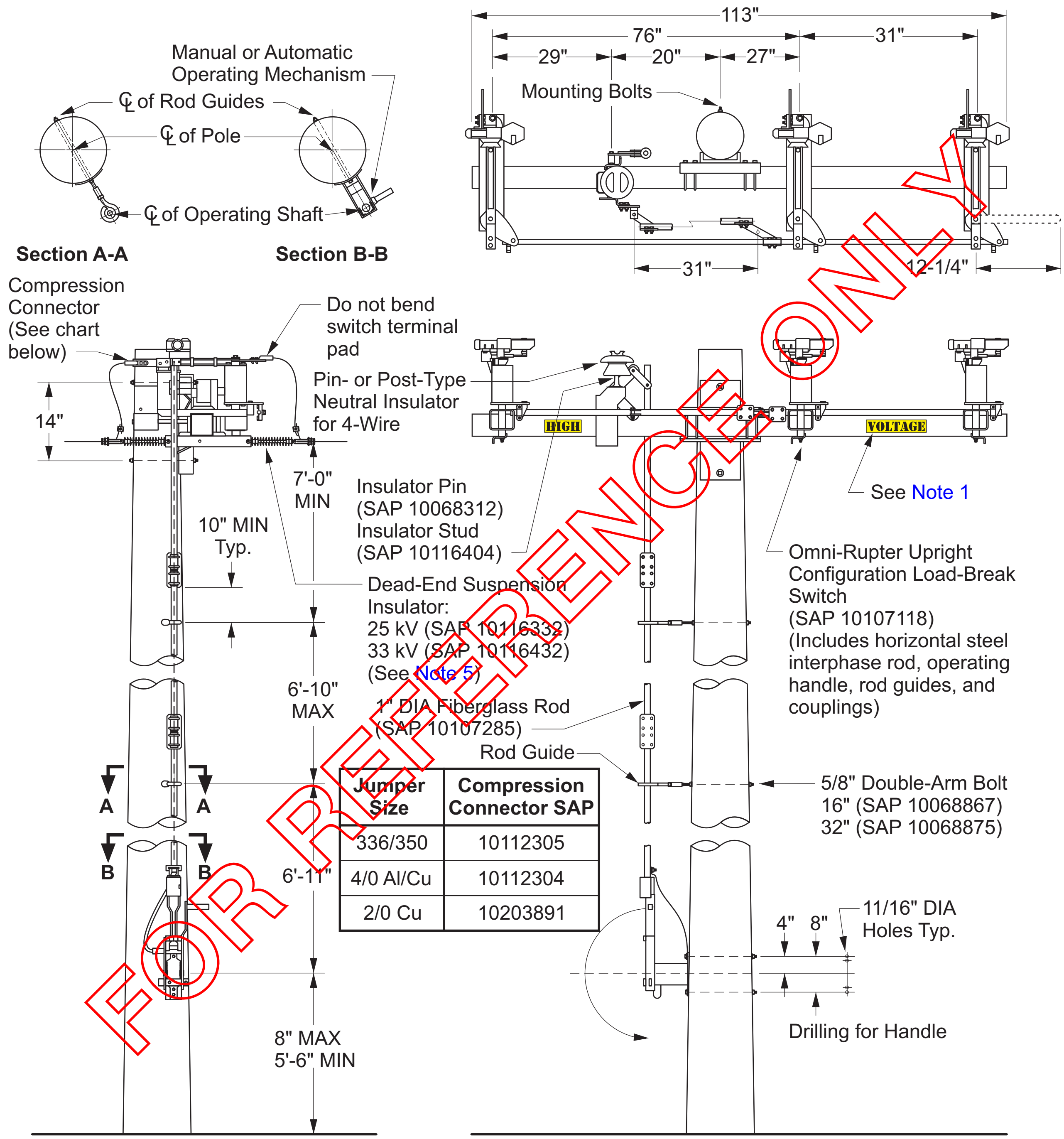


Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. Verify switch blades are fully closed when installing rod/handle assembly.
3. As an alternative installation, the switcharm may be placed above or below an existing line or dead-ending crossarm, provided there is enough pole clearance.
4. HIGH VOLTAGE warning provisions can be made either by placing “HIGH VOLTAGE” stickers (SAP 10135407) on the face and back of each switcharm or by plastic signs on the pole. The top of such sign(s) shall be located between the level of the lowest line conductor of each circuit to no more than 40 inches below that conductor level.
5. Do not install 15 kV dead-end suspension insulators, use 25 kV or 33 kV insulators.
6. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

Scope AP 336.9 Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch for 3-Wire or 4-Wire Pole-Top Applications

Figure AP 336–9: Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch for 3-Wire or 4-Wire Pole-Top Applications



Jumper Size	Compression Connector SAP
336/350	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891

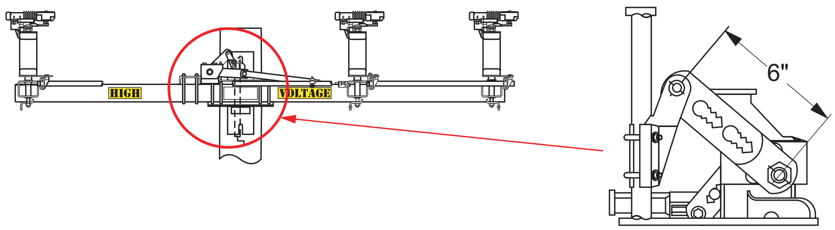
Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. Verify switch blades are fully closed when installing rod/handle assembly.
3. As an alternative installation, the switcharm may be placed above or below an existing line or dead-ending crossarm, provided there is enough pole clearance.
4. HIGH VOLTAGE warning provisions can be made either by placing “HIGH VOLTAGE” stickers (SAP 10135407) on the face and back of each switcharm or by plastic signs on the pole. The top of such sign(s) shall be located between the level of the lowest line conductor of each circuit to no more than 40 inches below that conductor level.
5. Do not install 15 kV dead-end suspension insulators, use 25 kV or 33 kV insulators.
6. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

AP 337 Automated 600 A, 17 kV Omni-Rupter Load-Break Switches

Scope AP 337.1 Automation Equipment Information for 600 A, 17 kV Omni-Rupter Load-Break Switches

Figure AP 337–1: Not Over-Toggled Bell Crank Rocker Arm and Switch Rod



Note(s):

1. See AP 360 for Cleaveland/Price® Automated Distribution Motor Operated (ADMO) and joint pole PVC operating rod cover installation.
2. See AP 336 for Omni-Rupter switch and operating rod installation details.
3. See AP 363 for 12/16 kV to 120 V, Dry Type voltage transformer installation details.
4. Verify the switch rocker arm is adjusted to 6 inches (older design) or to its respective hole position (newer design), as shown in Figure AP 337–1.
5. Verify that the ADMO stroke is set to 9-1/8-inches (Hole 2). Refer to DOM SW-11 Section 4.3 for details on stroke adjustment.
6. Verify switch blades are fully closed and the bell crank in over-toggled when installing fiberglass rod assembly.
7. Distribution construction shall contact the Distribution Automation Hotline when installing, relocating, or removing automated equipment at 714-285-4325. Hours: Mon–Fri 7 a.m.–4 p.m. Available after hours/weekends upon request.

Table AP 337–1: SAP Number

Description	SAP
ADMO Control	10107141
12/16 kV to 120 V, 0.5 kVA, Dry Type VT (Vented)	10105091
VT Mounting Bracket	10104923
VT Mounting Bracket Extension	10067312
CLD for 12/16 kV VT	10159438
Fiberglass Rod 1" Diameter	10107285
Butt Splices (for 120 VAC connections)	10111371

Table AP 337–2: Insulator Summary

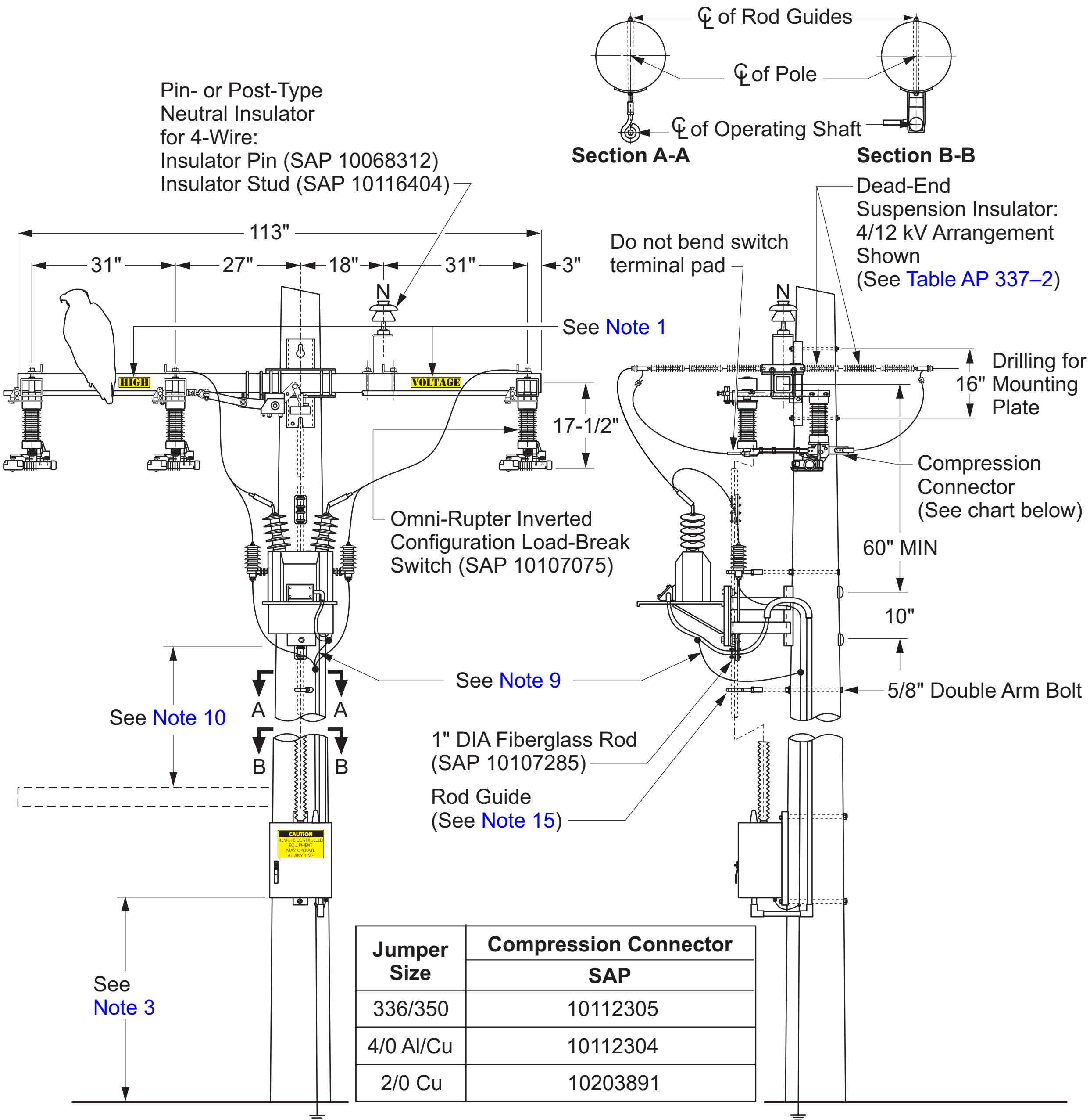
Phase to Phase Voltage	Quantity Insulator Per Phase Per Side of Switch	SAP
4 kV & 12 kV	3	10116431
16 kV	2	10116332

Table AP 337–3: ADMO Mounting Height Criteria

Preferred	8' above ground
Higher Than 8 Feet	At a specified height, as determined by the planner due to the following conditions: • Ability to work over fence with bucket • Bus Stop • Communications obstacles • Fences and walls • Parking area • Slopes • Traffic — vehicle and pedestrian • Trees and shrubs Examples: • 6' below communication cable (usually 12'–15' above ground) • 4' below communication cable with no junction box (usually 14'–17' above ground) • 13'-6" above ground level to clear truck traffic Note: Contact the responsible Apparatus Foreman if the control is planned to be mounted above 8'.
Lower (4-8 Feet)	4' minimum if the following conditions are met: • Away from obstacles - fences and walls • Away from parking area • Away from traffic signals • Away from traffic - vehicle and pedestrian • Rural areas • SCE Substation and locked fence areas

Scope AP 337.2 Automated Horizontal Inverted Omni-Rupter Switch, Line Dead-Ended Directly to Switch

Figure AP 337–2: Automated Horizontal Inverted Omni-Rupter Switch, Line Dead-Ended Directly to Switch



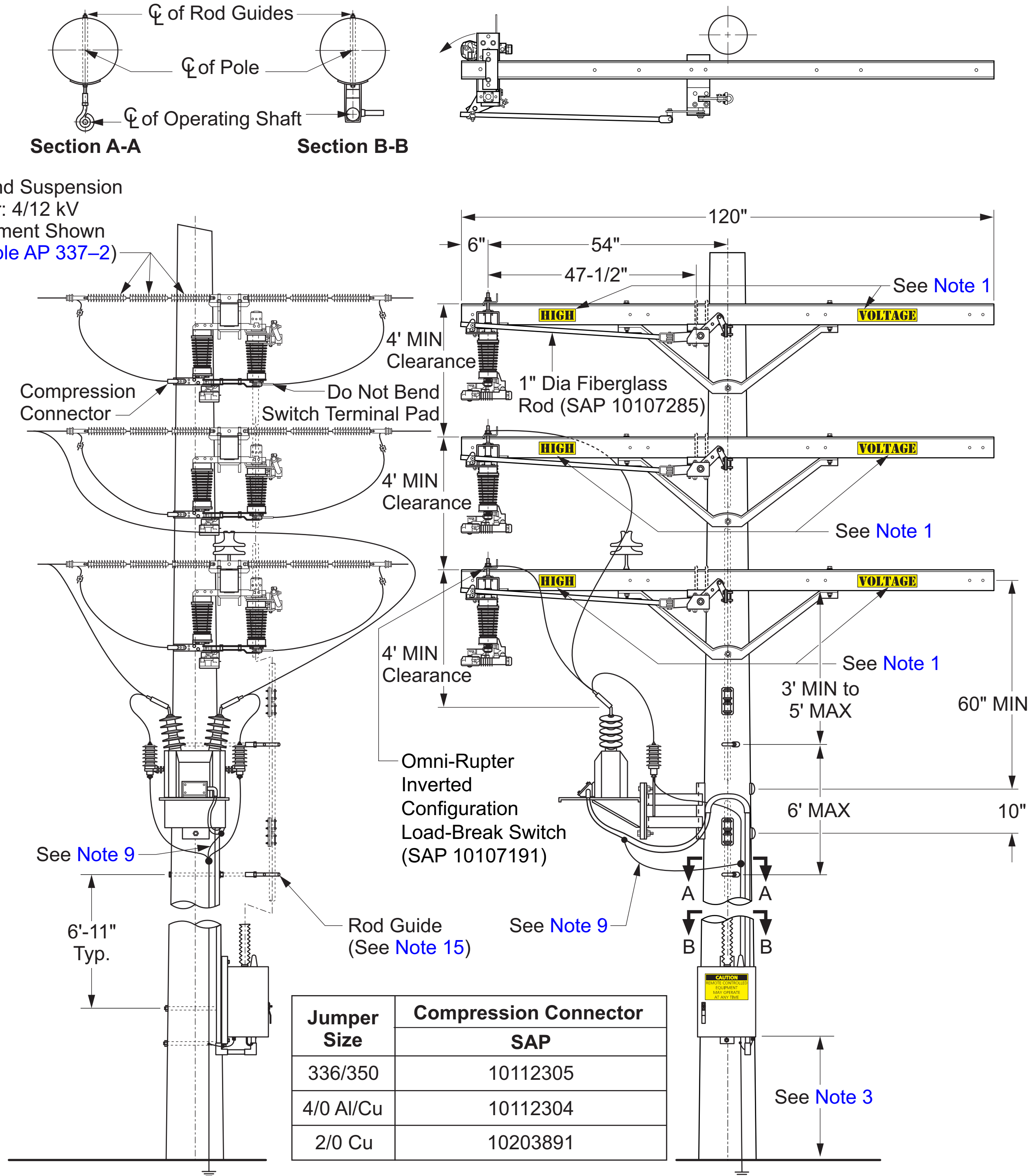
Jumper Size	Compression Connector SAP
336/350	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891

Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. See AP 336 for Omni-Rupter switch and operating rod installation details.
3. See Table AP 337–3 for ADMO mounting height criteria.
4. See AP 360 for Cleveland Price Automated Motor Operator (ADMO) and joint pole PVC operating rod cover installation.
5. See AP 363 for dry type potential transformer installation details.
6. Verify switch blades are fully closed and the bell crank over-toggled when installing rod/handle assembly.
7. Verify that the switch rocker arm is adjusted to 6 inches (older design) or to its respective hole position (newer design) as shown in Figure AP 337–1.
8. Verify that the ADMO stroke is set to 9-1/8-inches (Hole 2). Refer to DOM SW-11 Section 4.3 for details on stroke adjustment.
9. Surge arrestors, potential transformers secondary neutral, and the ADMO cabinet shall be connected to a common equipment ground to minimize any potential ground differences between the equipment (see GR 105 and Scope AP 337.5).
10. For secondary maintain a minimum clearance of 10 inches from top of insulator to lowest point of PT bracket. For under built, maintain a minimum clearance of 3 feet from middle of crossarm to lowest point of PT bracket.
11. Use insulated butt-splices (SAP 10111371) to connect the secondary PT, black and white wires (120 VAC) inside the ADMO.
12. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.
13. Construction crew shall coordinate the installation of new and updated RCS with Distribution Automation Engineering in order to perform an end point test (EPT) and commission unit in service.
14. When primary neutral ground exist on the same pole, it shall be a separately installed ground from that of the common equipment ground.
15. The uppermost rod guide shall be located 5 feet to 6 feet below the underside of the switch crossarm. The lowest rod guide shall be located 6'-11" above the switch handle pivot. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 337.3 Automated Vertical Inverted Omni-Rupter Switch

Figure AP 337–3: Automated Vertical Inverted Omni-Rupter Switch



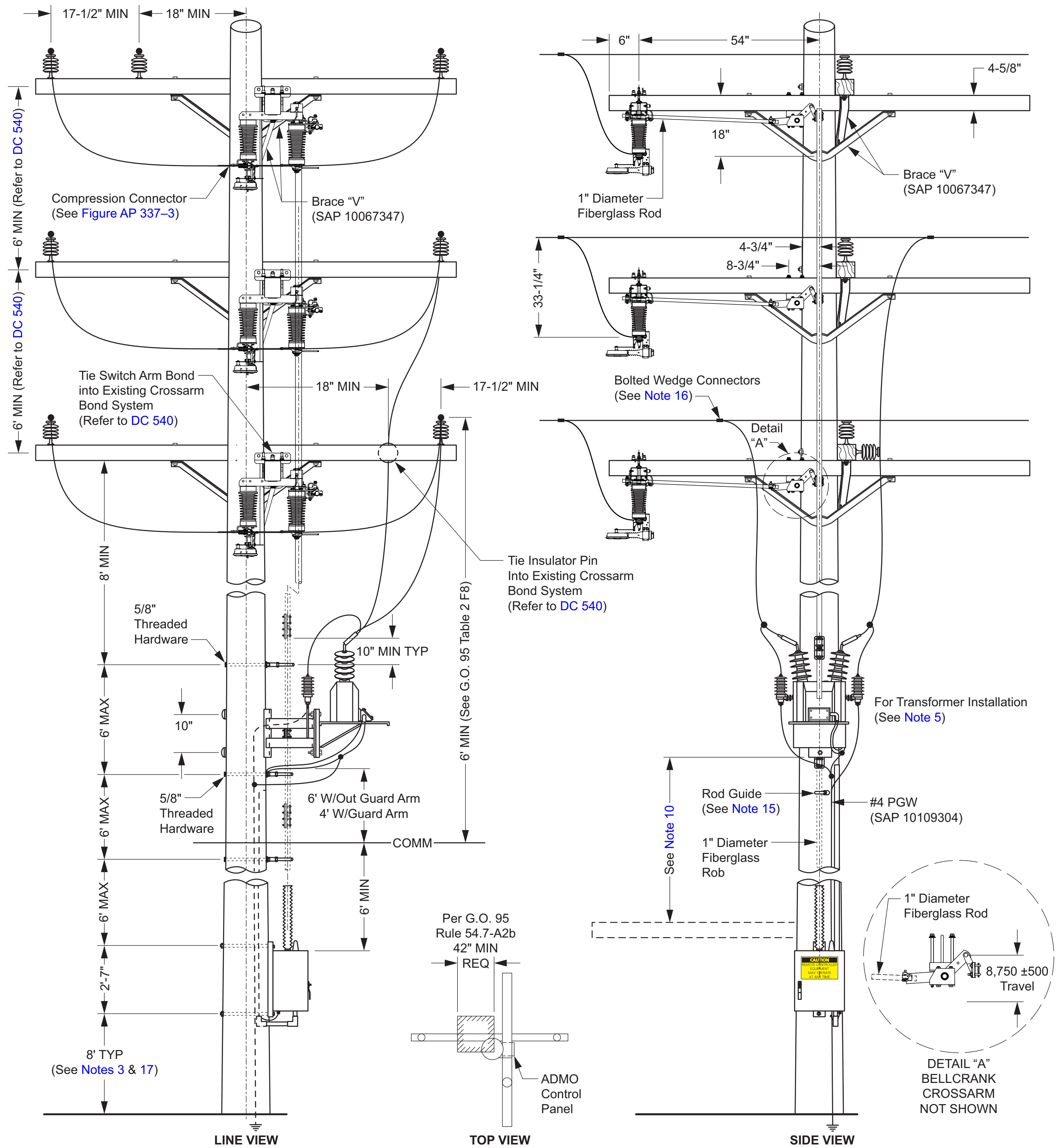
Jumper Size	Compression Connector SAP
336/350	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891

Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. See AP 336 for Omni-Rupter switch and operating rod installation details.
3. See Table AP 337–3 for ADMO mounting height criteria.
4. See AP 360 for Cleveland Price Automated Motor Operator (ADMO) and joint pole PVC operating rod cover installation.
5. See AP 363 for dry type potential transformer installation details.
6. Verify switch blades are fully closed and the bell crank over-toggled when installing rod/handle assembly.
7. Verify that the switch rocker arm is adjusted to 6 inches (older design) or to its respective hole position (newer design) as shown in Figure AP 337–1.
8. Verify that the ADMO stroke is set to 9-1/8-inches (Hole 2). Refer to DOM SW-11 Section 4.3 for details on stroke adjustment.
9. Surge arrestors, potential transformers secondary neutral, and the ADMO cabinet shall be connected to a common equipment ground to minimize any potential ground differences between the equipment (see GR 105 and Scope AP 337.5).
10. For secondary maintain a minimum clearance of 10 inches from top of insulator to lowest point of PT bracket. For under built, maintain a minimum clearance of 3 feet from middle of crossarm to lowest point of PT bracket.
11. Use insulated butt-splices (SAP 10111371) to connect the secondary PT, black and white wires (120 VAC) inside the ADMO.
12. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.
13. Construction crew shall coordinate the installation of new and updated RCS with Distribution Automation Engineering in order to perform an end point test (EPT) and commission unit in service.
14. When primary neutral ground exist on the same pole, it shall be a separately installed ground from that of the common equipment ground.
15. The uppermost rod guide shall be located 3 feet MIN to 5 feet MAX below the underside of the switch crossarm. The lowest rod guide shall be located 6'-11" above the upper mounting bolt of the ADMO cabinet. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 337.4 Automated 600 A, 17 kV Omni-Rupter Vertical Dual Circuit Switch

Figure AP 337–4: Automated 600 A, 17 kV Omni-Rupter Vertical Dual Circuit Switch

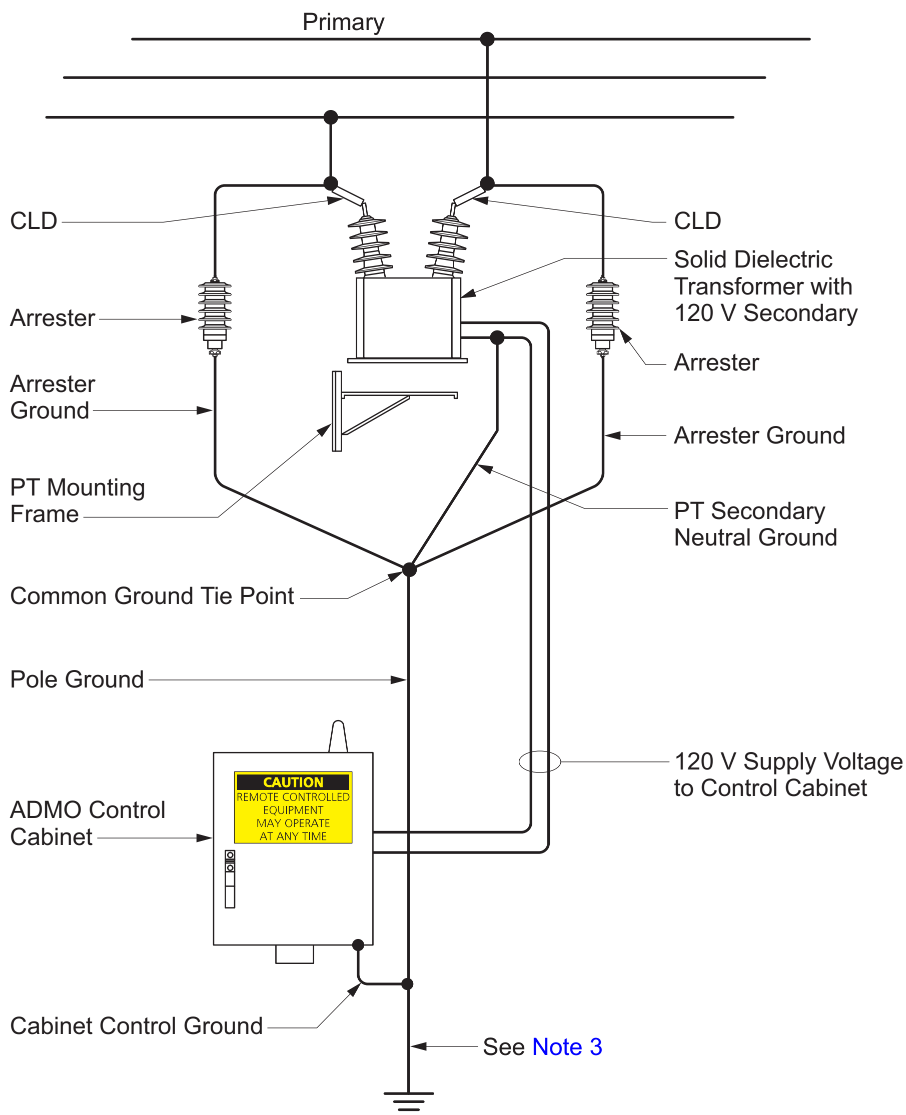


Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. See AP 336 for Omni-Rupter switch and operating rod installation details.
3. See Table AP 337–3 for ADMO mounting height criteria.
4. See AP 360 for Cleveland Price Automated Motor Operator (ADMO) and joint pole PVC operating rod cover installation.
5. See AP 363 for dry type potential transformer installation details.
6. Verify switch blades are fully closed and the bell crank over-toggled when installing rod/handle assembly.
7. Verify that the operating rod clamp at the bell crank is connected at the most outward position hole (see Detail A).
8. Verify that the ADMO stroke is set to 9-1/8-inches (Hole 4). Refer to DOM SW-11 Section 4.3 for details on stroke adjustment.
9. Surge arrestors, potential transformers secondary neutral, and the ADMO cabinet shall be connected to a common equipment ground to minimize any potential ground differences between the equipment (see GR 105 and Scope AP 337.5).
10. For secondary maintain a minimum clearance of 10 inches from top of insulator to lowest point of PT bracket. For under built, maintain a minimum clearance of 3 feet from middle of crossarm to lowest point of PT bracket.
11. Use insulated butt-splices (SAP 10111371) to connect the secondary PT, black and white wires (120 VAC) inside the ADMO.
12. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.
13. Construction crew shall coordinate the installation of new and updated Remote Control Switch (RCS) with Distribution Automation Engineering in order to perform an end point test (EPT) and commission unit in service.
14. When primary neutral ground exists on the same pole, it shall be a separately installed ground from that of the common equipment ground.
15. The uppermost rod guide shall be located 8 feet MIN below the underside of the switch crossarm. The lowest rod guide shall be located 6'-11" above the upper mounting bolt of the ADMO cabinet. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.
16. For Bolted Wedge Connector see CO 420. If the cable size exceeds the limits of the Bolted Wedge Connector CO 300 or CO 305 to determine which Hot Line Clamp shall be used.
17. If installing ADMO cabinet over traffic lanes, consult Apparatus Engineering for height requirements.
18. Verify phase of both circuits to ensure suitability of this application. Only identical phase can be joined with this method.

Scope AP 337.5 Typical Automation Common Equipment Grounding Connections for 600 A, 17 kV Omni-Rupter Load-Break Switches

Figure AP 337–5: Typical Automation Common Equipment Grounding Connections for 600 A, 17 kV Omni-Rupter Load-Break Switches

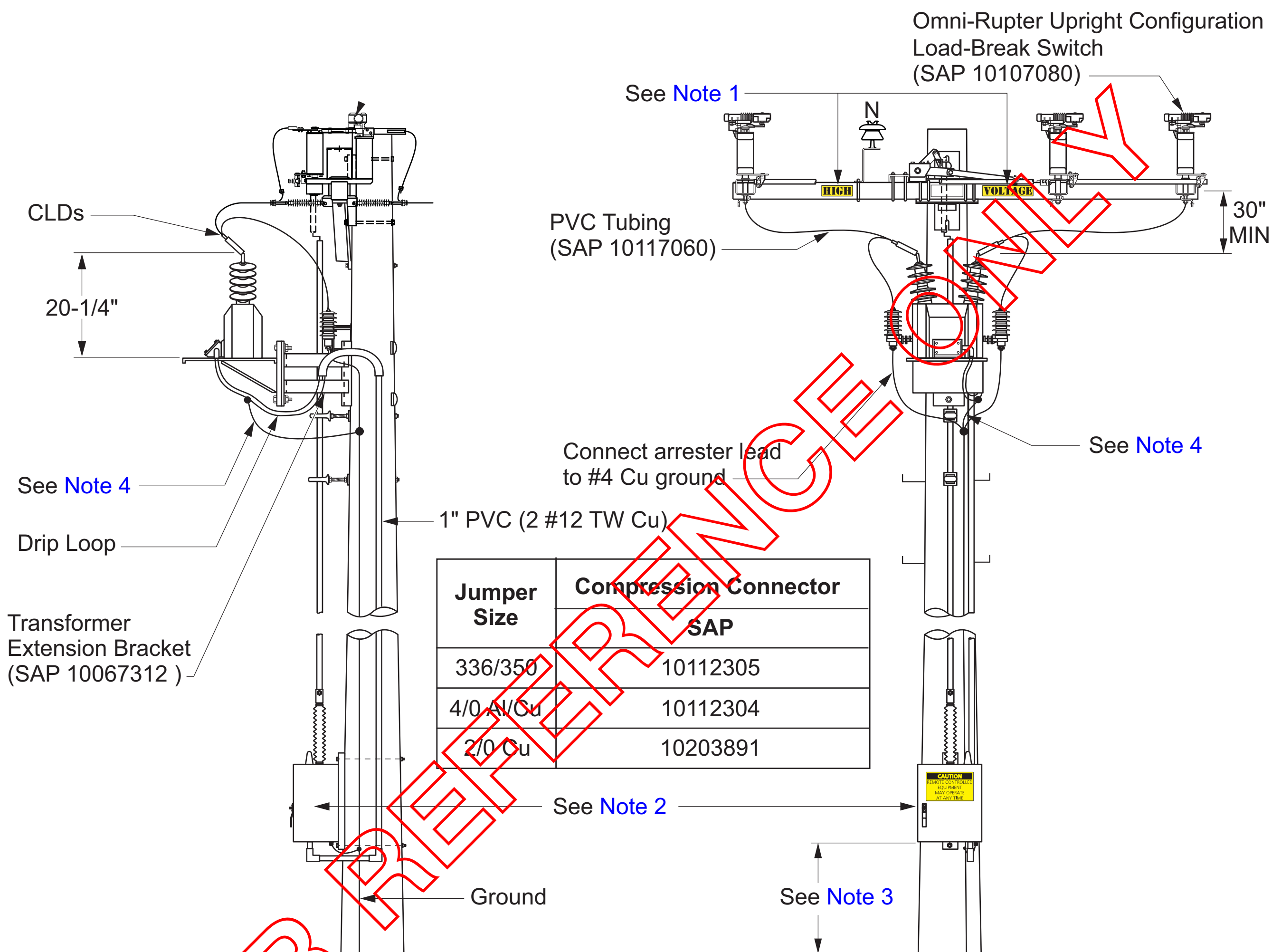


Note(s):

1. The Control PT shall serve no load other than the ADMO control.
2. Surge arresters, potential transformers secondary neutral, and the ADMO cabinet shall be connected to a common equipment ground to minimize any potential ground differences during a surge between the equipment.
3. Preferred method will be to ground with two (2) ground rods per GR 105. If bare copper must be used then it shall be installed in PVC conduit. Maintain proper clearance between the ground and bond or bonded equipment.
4. All Control PT installations shall be protected by surge arresters.
5. When primary neutral ground exists on the same pole, it shall be a separately installed ground from that of the common equipment ground.

Scope AP 337.6 Automated Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch Dead-Ended on Switch Base

Figure AP 337–6: Automated Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch Dead-Ended on Switch Base



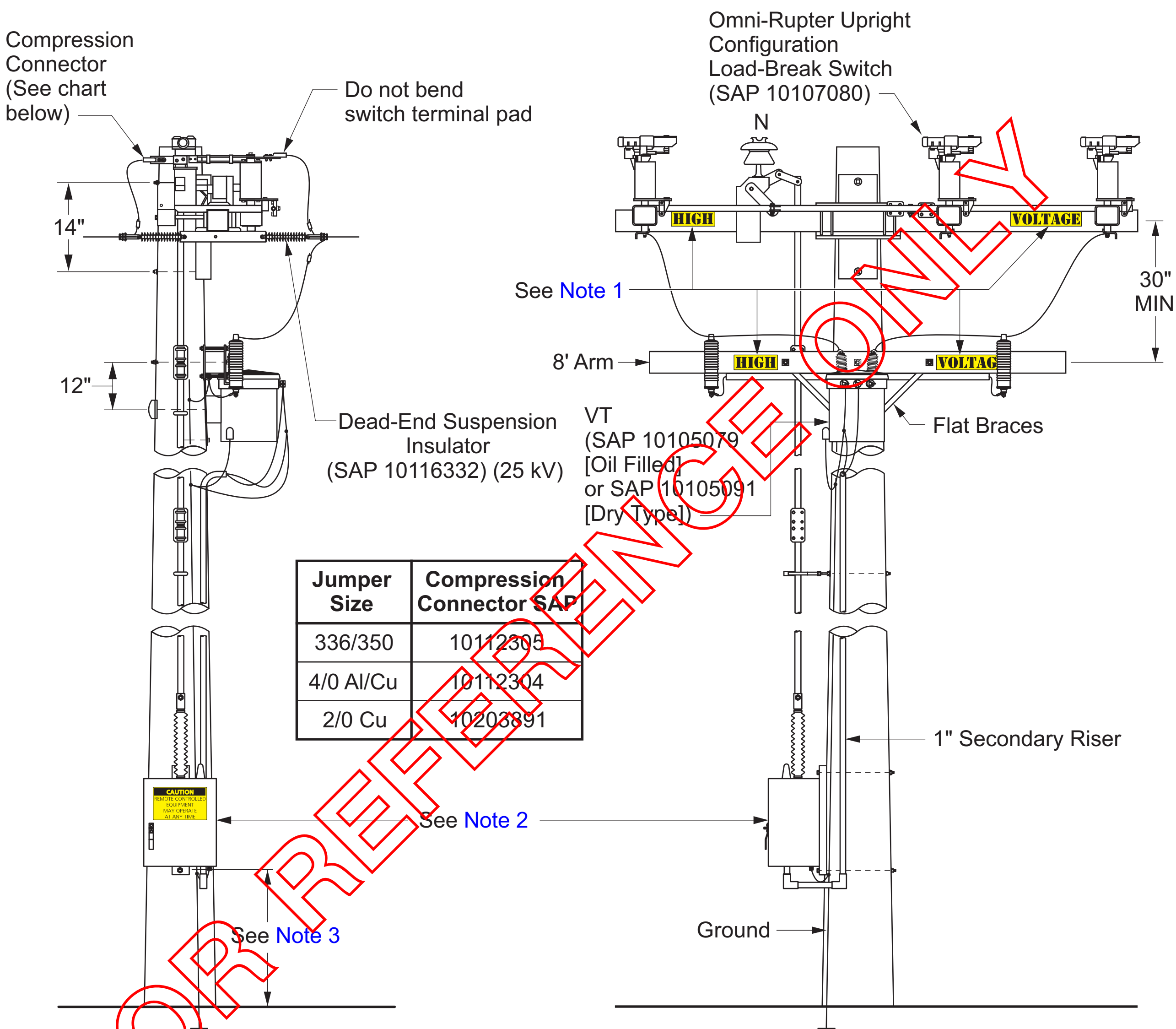
Jumper Size	Compression Connector SAP
336/350	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891

Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. ADMO SAP 10107141.
3. See Table AP 337–3.
4. Surge arrestors, potential transformers secondary neutral, and the ADMO cabinet shall be connected to a common ground to minimize any potential ground differences between the equipment (see GR 105 and Scope AP 337.5).
5. Use insulated butt-splices (SAP 10111371) to connect the secondary PT, black and white wires (120 VAC) inside the ADMO.
6. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

Scope AP 337.7 Automated Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch Dead-Ended on Switch Base

Figure AP 337–7: Automated Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch Dead-Ended on Switch Base



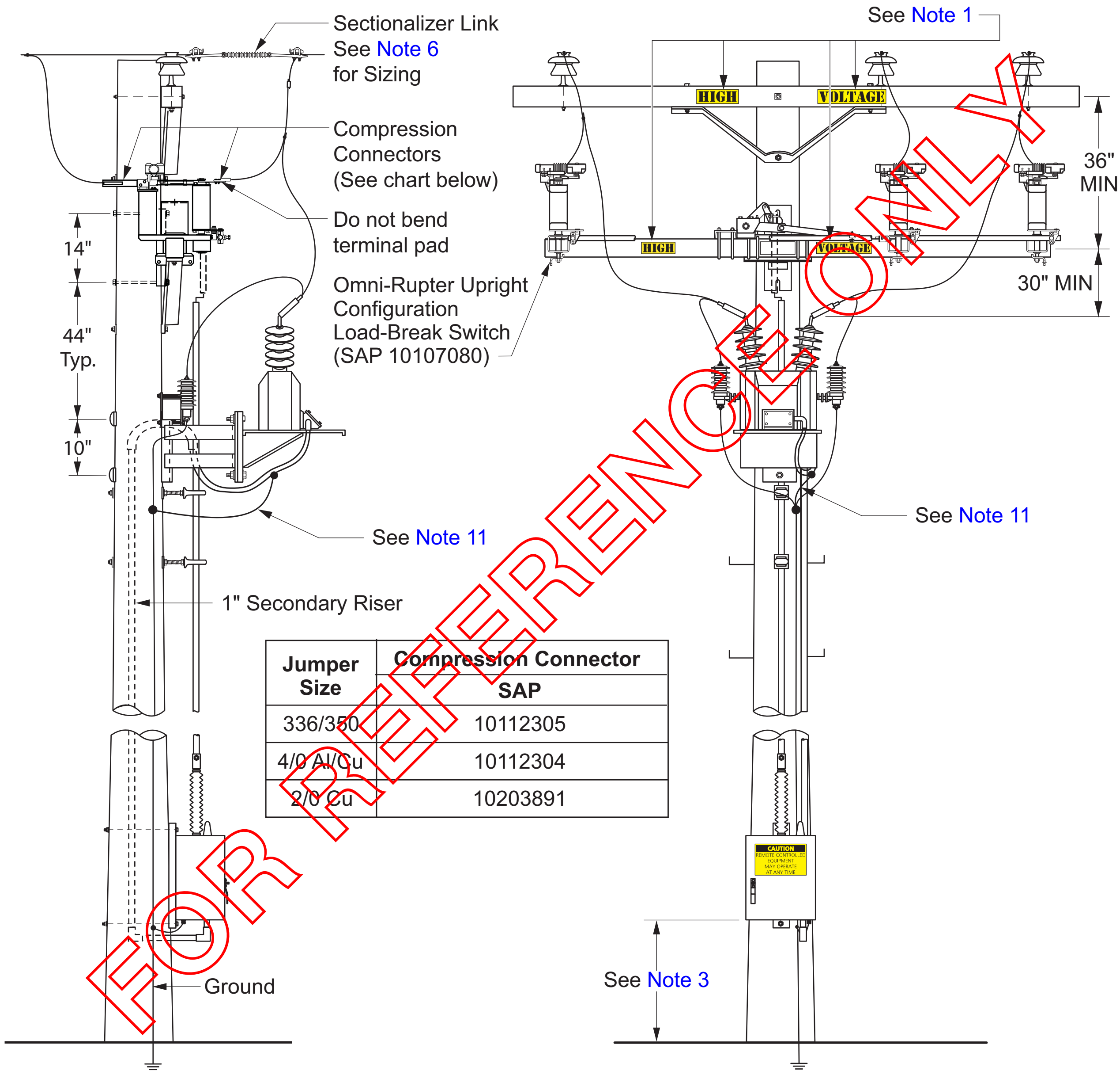
Jumper Size	Compression Connector SAP
336/350	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891

Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. ADMO (SAP 10107141)
3. See Table AP 337–3.
4. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

Scope AP 337.8 Automated Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Switch Below Existing Line Arm, Underbuild

Figure AP 337–8: Automated Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Switch Below Existing Line Arm, Underbuild



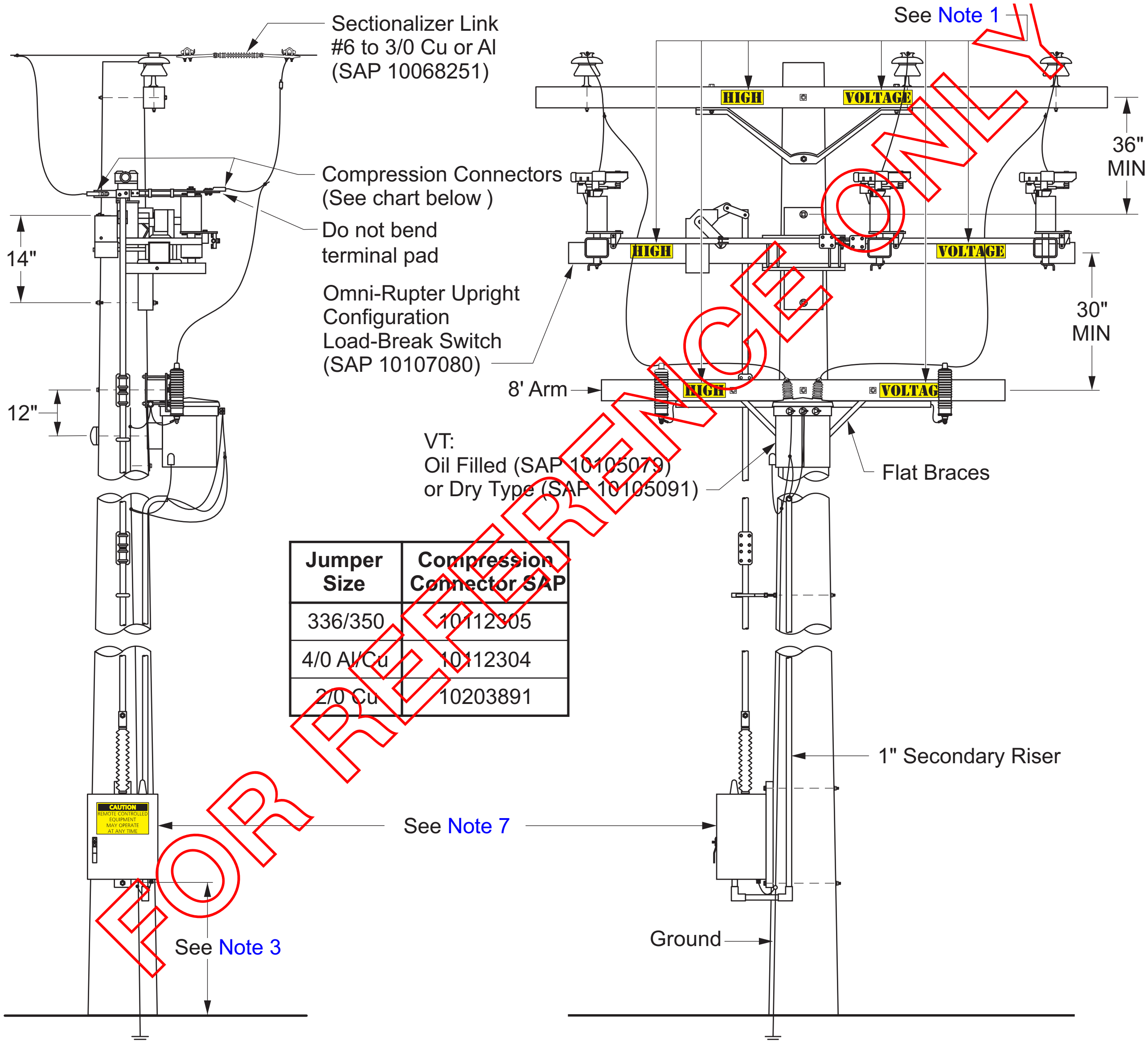
Jumper Size	Compression Connector SAP
336/350	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891

Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. See AP 336 for Omni-Rupter switch and operating rod installation details.
3. See Table AP 337–3 for ADMO mounting height criteria.
4. See AP 360 for Cleveland Price Automated Motor Operator (ADMO) and joint pole PVC operating rod cover installation.
5. See AP 363 for dry type potential transformer installation details.
6. See CO 217 for Dead Ending and Isolators.
7. Verify switch blades are fully closed and the bell crank over-toggled when installing rod/handle assembly.
8. Do not install 15 kV dead-end suspension insulators; use 25 kV or 33 kV dead-ends.
9. Verify that the switch rocker arm is adjusted to 6 inches (older design) or to its respective hole position (newer design) as shown in Figure AP 337–1.
10. Verify that the ADMO stroke is set to 9-1/8-inches (Hole 2). Refer to DOM SW-11 Section 4.3 for details on stroke adjustment.
11. Surge arrestors, potential transformers secondary neutral, and the ADMO cabinet shall be connected to a common equipment ground to minimize any potential ground differences between the equipment (see GR 105 and Scope AP 337.6).
12. For secondary maintain a minimum clearance of 10 inches from top of insulator to lowest point of PT bracket. For under built, maintain a minimum clearance of 3 feet from middle of crossarm to lowest point of PT bracket.
13. Use insulated butt-splices (SAP 10111371) to connect the secondary PT, black and white wires (120 VAC) inside the ADMO.
14. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.
15. Construction crew shall coordinate the installation of new and updated RCS with Distribution Automation Engineering in order to perform an end point test (EPT) and commission unit in service.
16. When primary neutral ground exist on the same pole, it shall be a separately installed ground from that of the common equipment ground.
17. Ensure jumper wire taps will not contact adjacent jumper wire taps. Refer to DOM SW-2 for below line arm construction inspection criteria.

Scope AP 337.9 Automated Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch Below Existing Line Arm

Figure AP 337–9: Automated Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch Below Existing Line Arm



Jumper Size	Compression Connector SAP
336/350	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891

Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. See AP 360 for Cleaveland/Price® Automated Distribution Motor Operator (ADMO) and joint pole PVC operating rod cover installation.
3. See Table AP 337–3 for ADMO mounting height criteria.
4. See AP 336 for Omni-Rupter switch and operating rod installation details.
5. Switch throw needs to correlate with the Cleaveland/Price® ADMO throw. To accomplish this, the switch rocker arm should be adjusted to 6 inches (see Figure AP 337–1) and the 9-1/8-inch stroke-hole of the Cleaveland/Price® ADMO should be used (Hole 2).
6. Verify switch blades are fully closed when installing rod assembly.
7. ADMO SAP 10107141.
8. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

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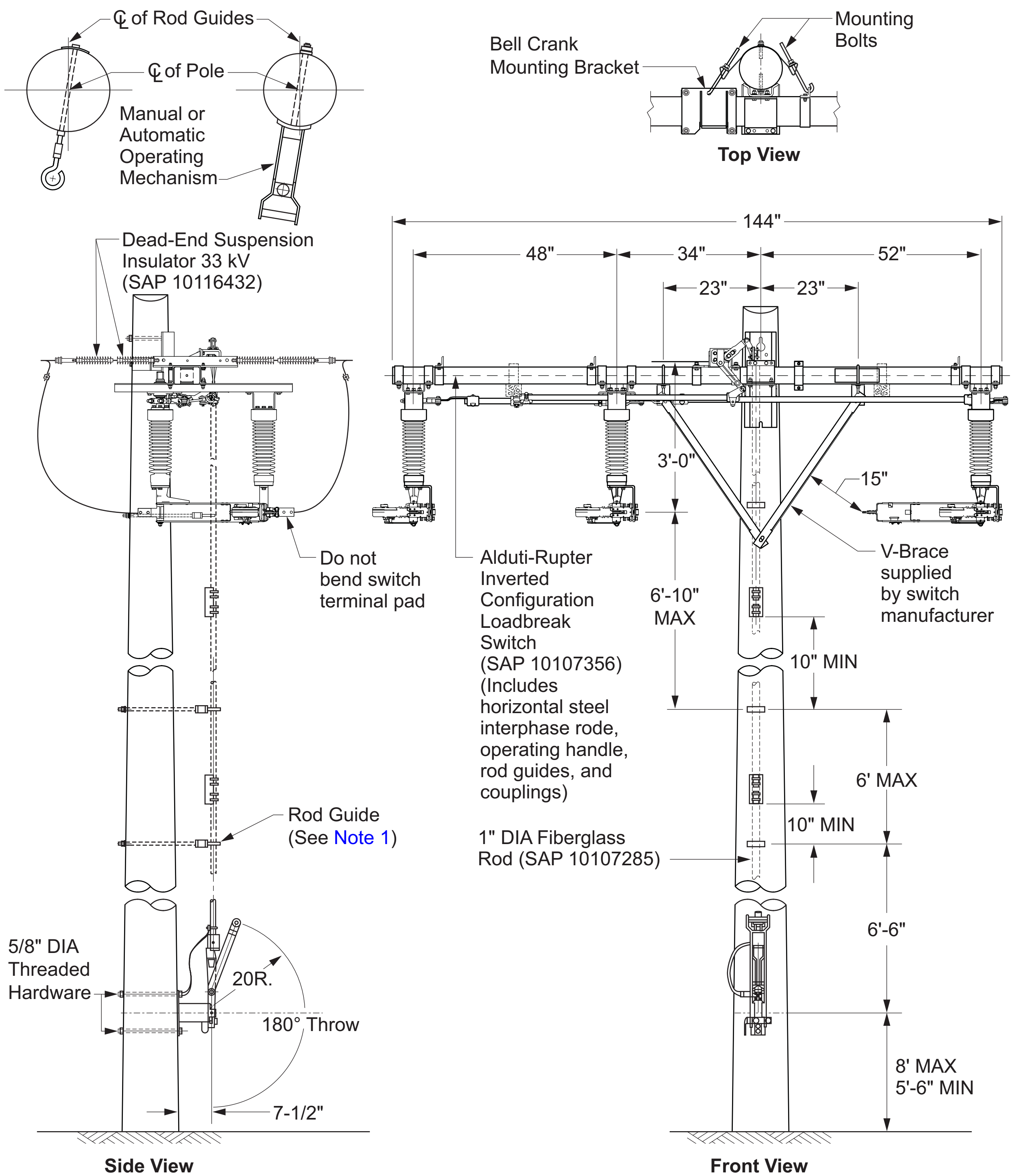
AP 338 600 A, 38 kV Alduti-Rupter Load-Break Switches

Scope AP 338.1 Horizontal Inverted Alduti-Rupter Switch

Figure AP 338–1: Horizontal Inverted Alduti-Rupter Switch



Note(s):

1. The uppermost rod guide shall be located 3 feet below the centerline of the switch operating lever. The lowest rod guide shall be located 6'-6" above the operating handle pivot. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 338.2 Horizontal Configuration Inverted-Type, 600 A, 38k V Alduti-Rupter Load-Break Switch, for 33 kV Riser Applications

Figure AP 338–2: Horizontal Configuration Inverted-Type, 600 A, 38 kV Alduti-Rupter Load-Break Switch, for 33 kV Riser Applications

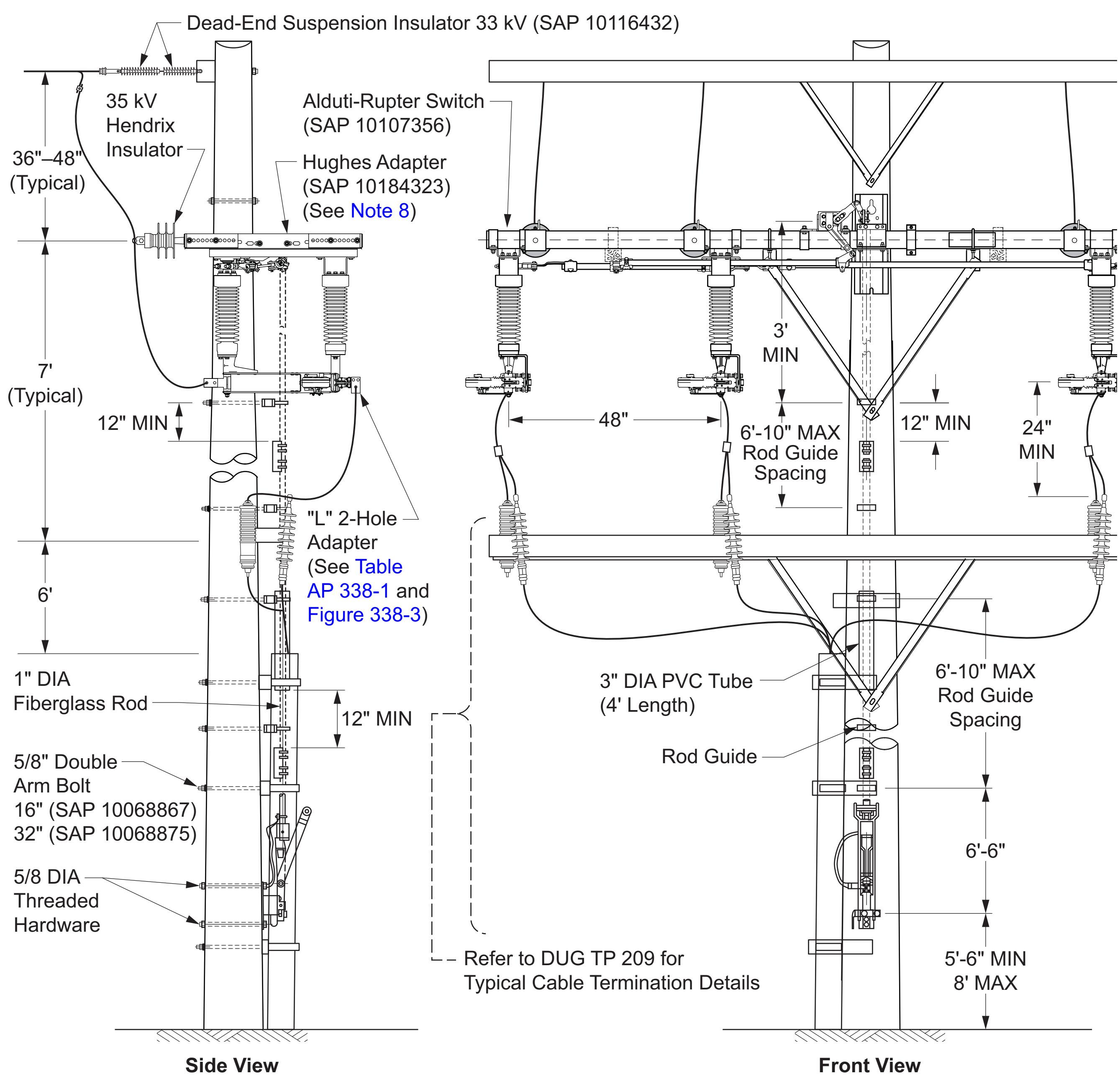


Figure AP 338–3: 2-Hole Adapter Connection Details

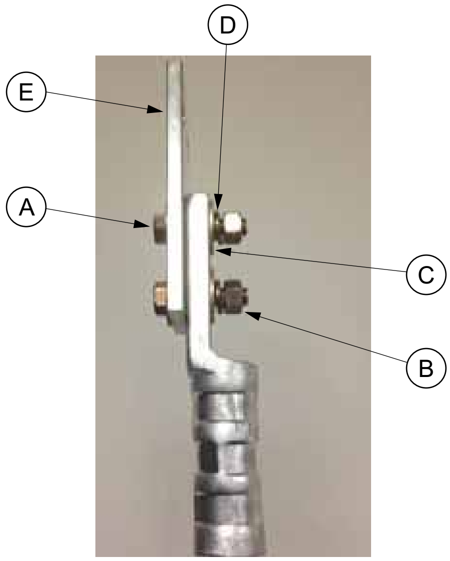


Table AP 338–1: NEMA 2-Hole Adapter Connection Details

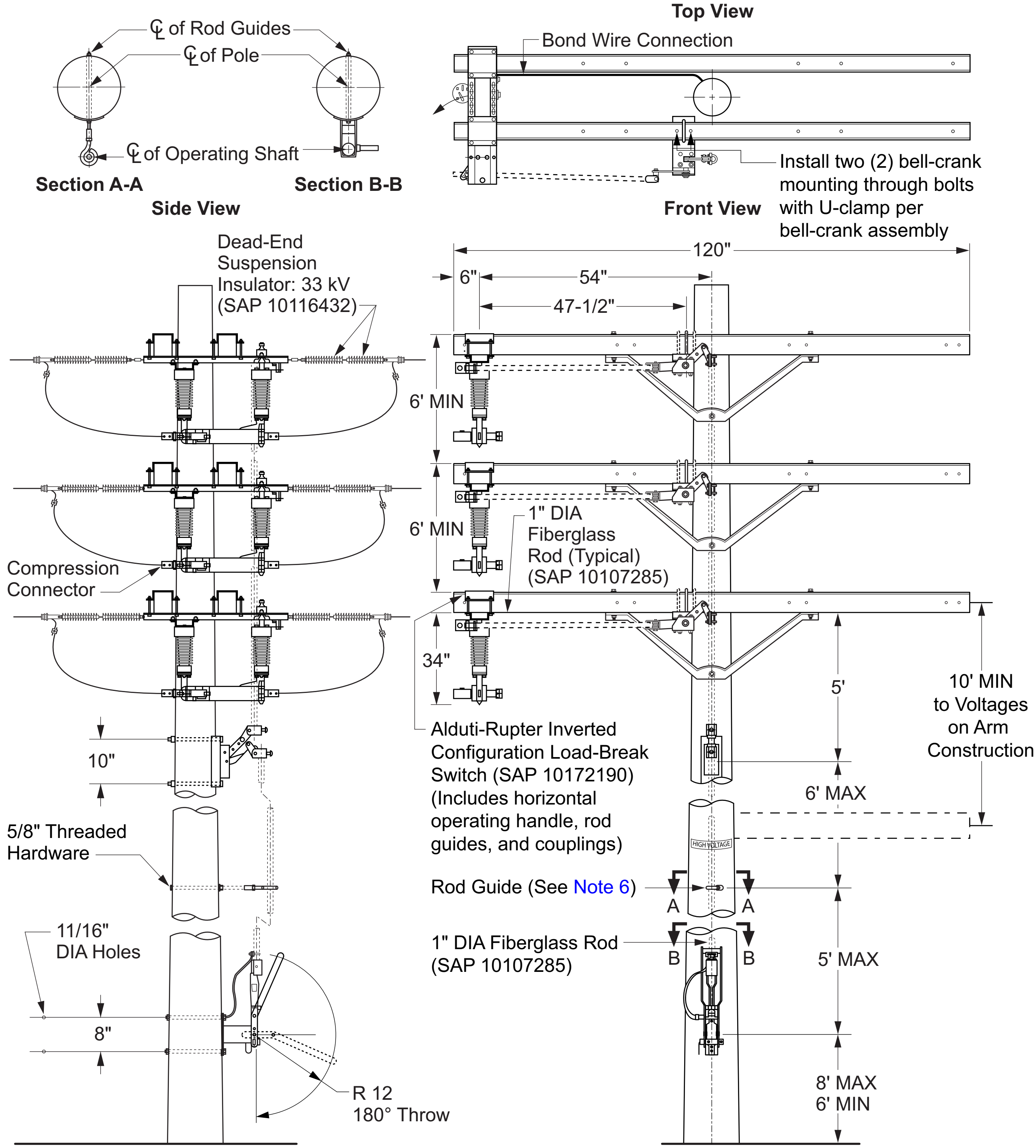
Key	Description	SAP
A	Everdur 1/2" Bolt	10070832
B	Everdur 1/2" Nut	10069558
C	Brass Flat Washer 1/2"	10072028
D	Brass Lock Washer 1/2"	10072314
E	NEMA 2-HOLE Adapter Plate	10205302

Note(s):

1. Verify switch blades are fully closed when installing rod/handle assembly.
2. See PO 120 for HIGH VOLTAGE sign installation requirements.
3. Use only 33 kV dead-end-type suspension insulators.
4. DO NOT bond the switch bellcranks.
5. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.
6. Back Brace is required on Pothead arms with 750+ kcmil cable. See Back Brace standard DC 615.
7. The uppermost rod guide shall be located 3 feet below the centerline of the switch operating lever. The lowest rod guide shall be located 6'-6" above the operating handle pivot. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.
8. See Scope AP 363.3 for typical installation details of Hughes Adapter on switch angle iron.
9. Maintain minimum 12-inch clearance between rod guides and rod couplers.
10. The 2-Hole NEMA adapter for the tap connection of the potheads shall be installed on the stationary contact side of the switch.

Scope AP 338.3 Vertical Alduti-Rupter Switch

Figure AP 338–4: Vertical Alduti-Rupter Switch



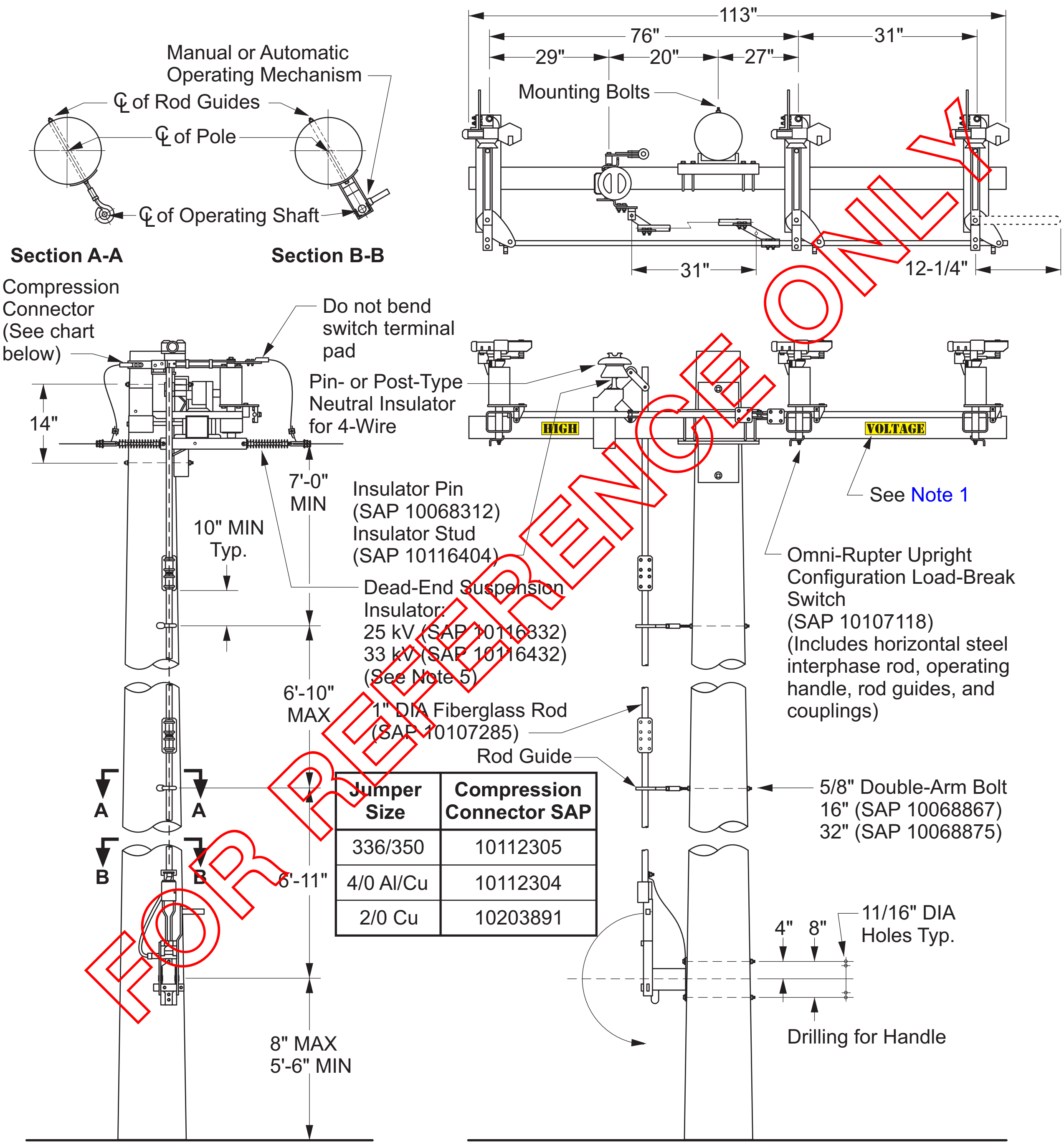
What's Changed? Updated Figure AP 338–4 to show increased number of insulators for easier formation of jumper wires.

Note(s):

1. Verify switch blades are fully closed when installing rod/handle assembly.
2. See PO 120 for HIGH VOLTAGE sign installation requirements.
3. Use only 33 kV dead-end-type suspension insulators.
4. DO NOT bond the switch bellcranks. Switch shall be bonded by running the bond wire on the back crossarm. See GR 300 and GR 305 for bonding methods.
5. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.
6. The uppermost rod guide shall be located 5 feet below the underside of the switch crossarm. The lowest rod guide shall be located 5 feet above the operating handle pivot. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 338.4 Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch for 3-Wire or 4-Wire Pole-Top Applications

Figure AP 338–5: Horizontal-Type Upright Configuration, 600 A, 17 kV, Omni-Rupter Load-Break Switch for 3-Wire or 4-Wire Pole-Top Applications



Jumper Size	Compression Connector SAP
336/350	10112305
4/0 Al/Cu	10112304
2/0 Cu	10203891

Note(s):

1. See PO 120 for HIGH VOLTAGE sign installation requirements.
2. Verify switch blades are fully closed when installing rod/handle assembly.
3. As an alternative installation, the switcharm may be placed above or below an existing line or dead-ending crossarm, provided there is enough pole clearance.
4. HIGH VOLTAGE warning provisions can be made either by placing "HIGH VOLTAGE" stickers (SAP 10135407) on the face and back of each switcharm or by plastic signs on the pole. The top of such sign(s) shall be located between the level of the lowest line conductor of each circuit to no more than 40 inches below that conductor level.
5. Do not install 15 kV dead-end suspension insulators, use 25 kV or 33 kV insulators.
6. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

Scope AP 338.5 Horizontal Side-Arm Configuration Upright-Type, 600 A, 38 kV, Alduti-Rupter Load-Break Switch for 3 Pole-Top Application

Figure AP 338–6: Horizontal Side-Arm Configuration Upright-Type, 600 A, 38 kV, Alduti-Rupter Load-Break Switch for 3 Pole-Top Application

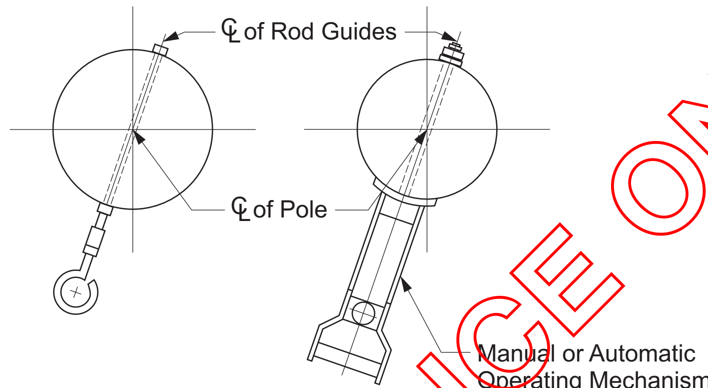


Figure AP 338–6.1

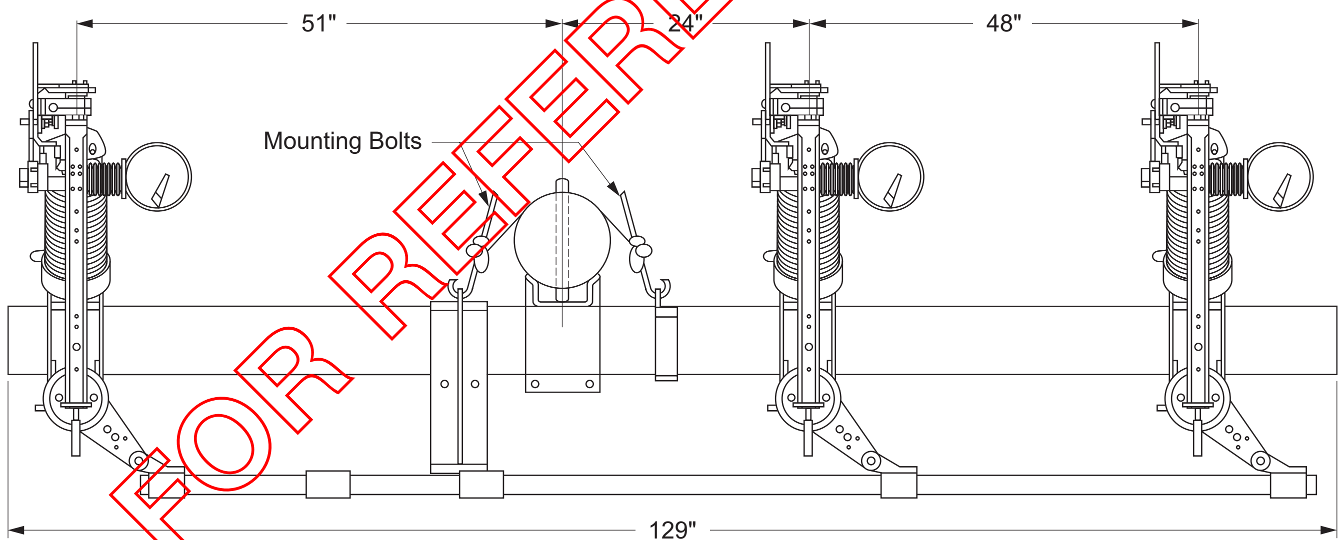
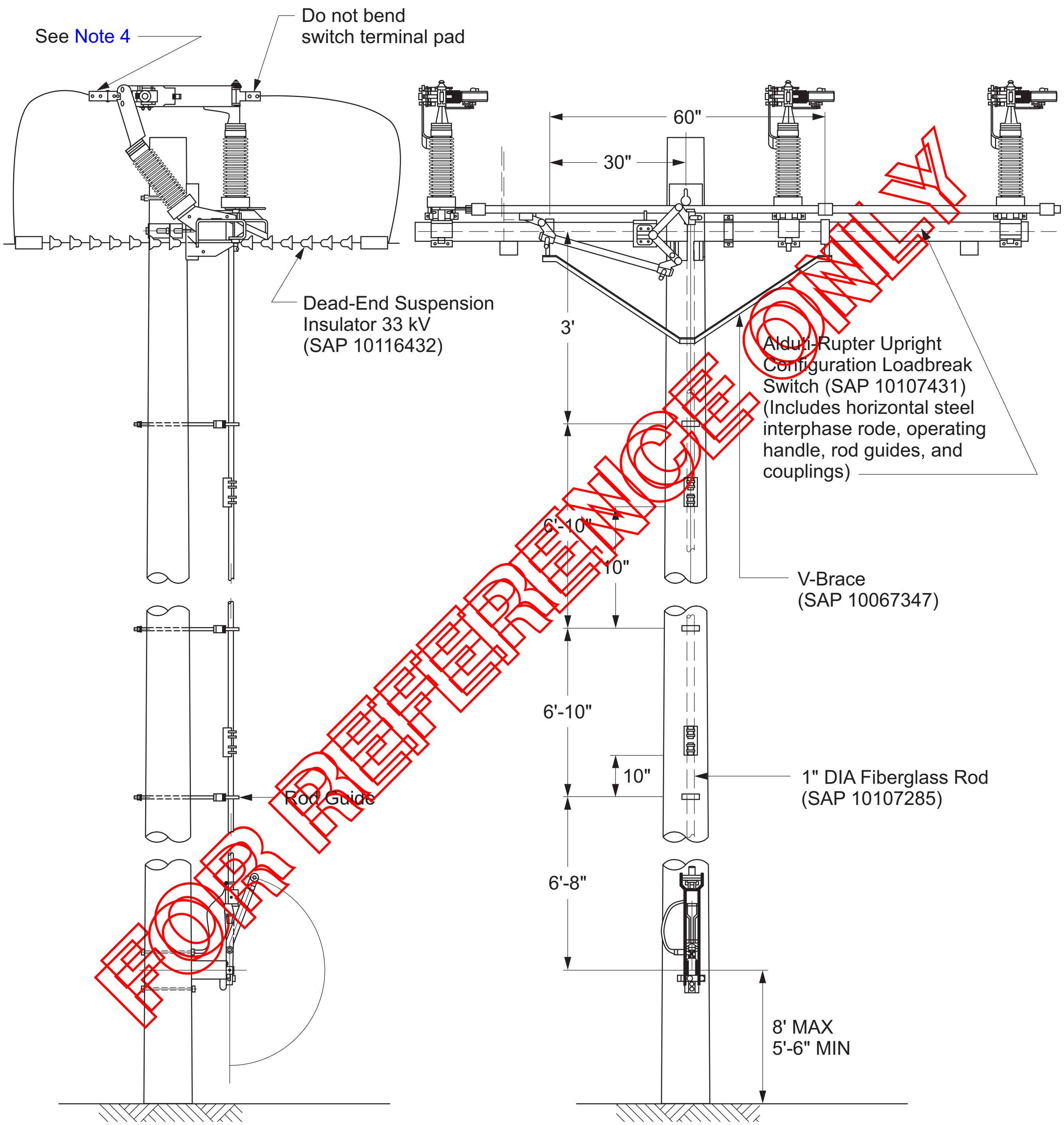


Figure AP 338–6.2

Figure AP 338–7: Horizontal Side-Arm Configuration Upright-Type, 600 A, 38 kV, Alduti-Rupter Load-Break Switch for 3 Pole-Top Application



Note(s):

1. Verify switch blades are fully closed when installing rod/handle assembly.
2. As an alternative installation, the switcharm may be placed above or below an existing line or dead-ending crossarm, provided there is enough pole clearance.
3. See PO 120 for HIGH VOLTAGE sign installation requirements.
4. Use only 33 kV dead-end-type suspension insulators.
5. Compression Connector. (See SAP numbers, Figure AP 300–7.
6. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

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AP 339 Automated 600 A, 38 kV Alduti-Rupter Load-Break Switches

Scope AP 339.1 Automation Equipment Information for 600 A, 38 kV Alduti-Rupter Load-Break Switches

Table AP 339–1: SAP Numbers — 33 kV Switch Automation

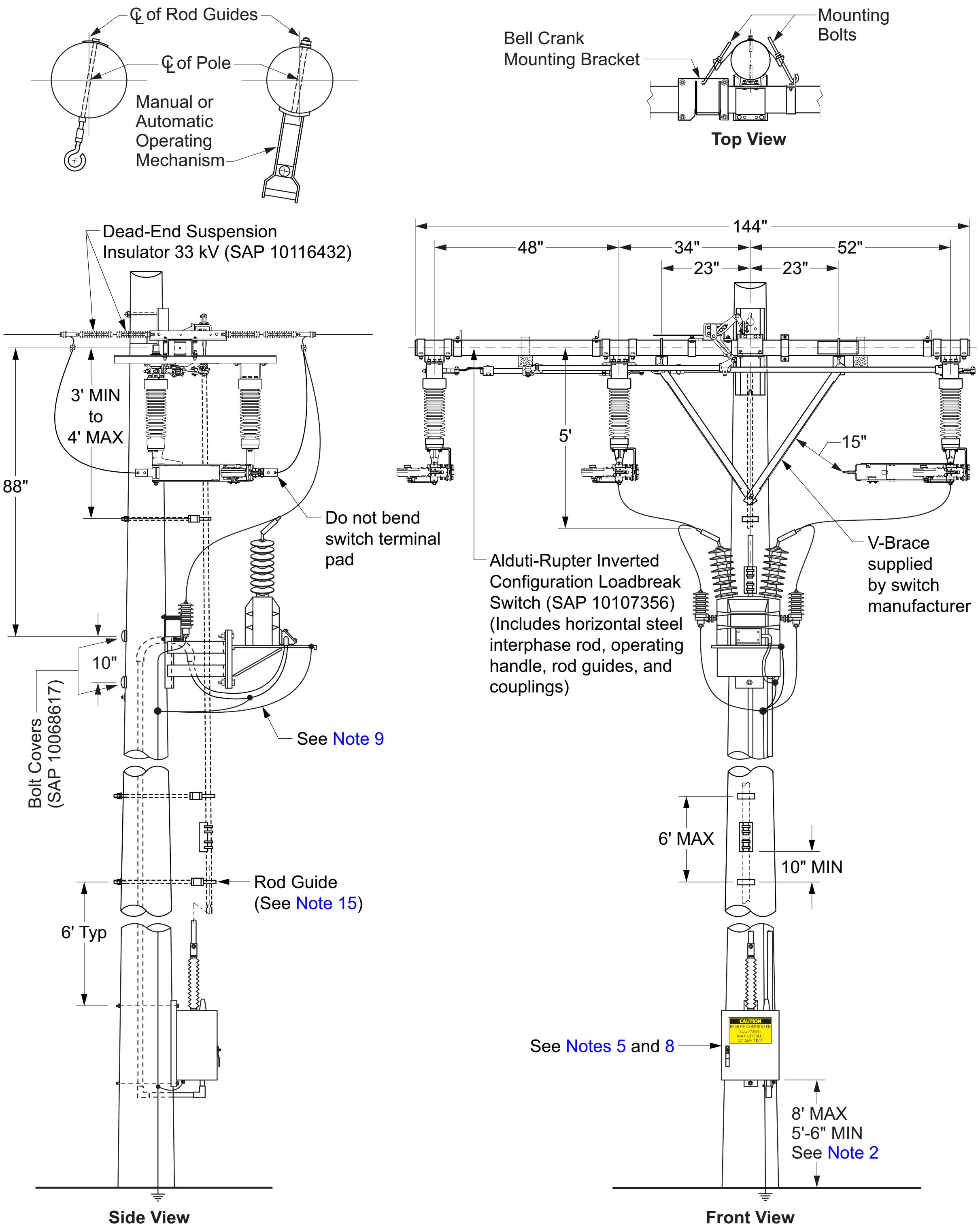
Description	SAP
ADMO Control	10107141
34.5 kV to 115 V, 1.0 kVA, Dry Type VT	10167672
VT Bracket	10067317
Transformer Extension Bracket	10067338
33 kV Dead End Suspension Insulator	10116432
CLD for 33 kV	10159439
33 kV Polymer Pin-Type Insulator	10116351
33 kV Surge Arrester	10109144
Wildlife Guard	10067793
Fiberglass Rod 1" Diameter	10107285
VT Secondary Fuse (16 Amp)	10108639
VT Secondary Fuse Holder (no fuse)	10006562

Note(s):

1. See AP 410 for surge arrestor class guide.
2. Verify the switch rocker arm is adjusted to 6 inches (older design) or to its respective hole position (newer design) shown in Figure AP 337–1.
3. Refer to DOM SW-11, Section 4.3 for details on operated lever arm stroke adjustment.
4. Verify switch blades are fully closed and the bell crank is over-toggled when installing fiberglass rod assembly.
5. Distribution Construction shall contact the Distribution Automation Hotline when installing, relocating, repairing, or removing automated equipment at 714-285-4325. Hours: Mon–Fri 7 a.m.–4 p.m. Available after hours/weekends upon request.

Scope AP 339.2 Automated Horizontal Inverted Alduti-Rupter Switch

Figure AP 339–1: Automated Horizontal Inverted Alduti-Rupter Switch



Automated 600 A, 38 kV Alduti-Rupter Load-Break Switches

Approved by: *[signature]*

What's Changed? Updated Figure AP 339–1 to show increased number of insulators for easier formation of jumper wires.

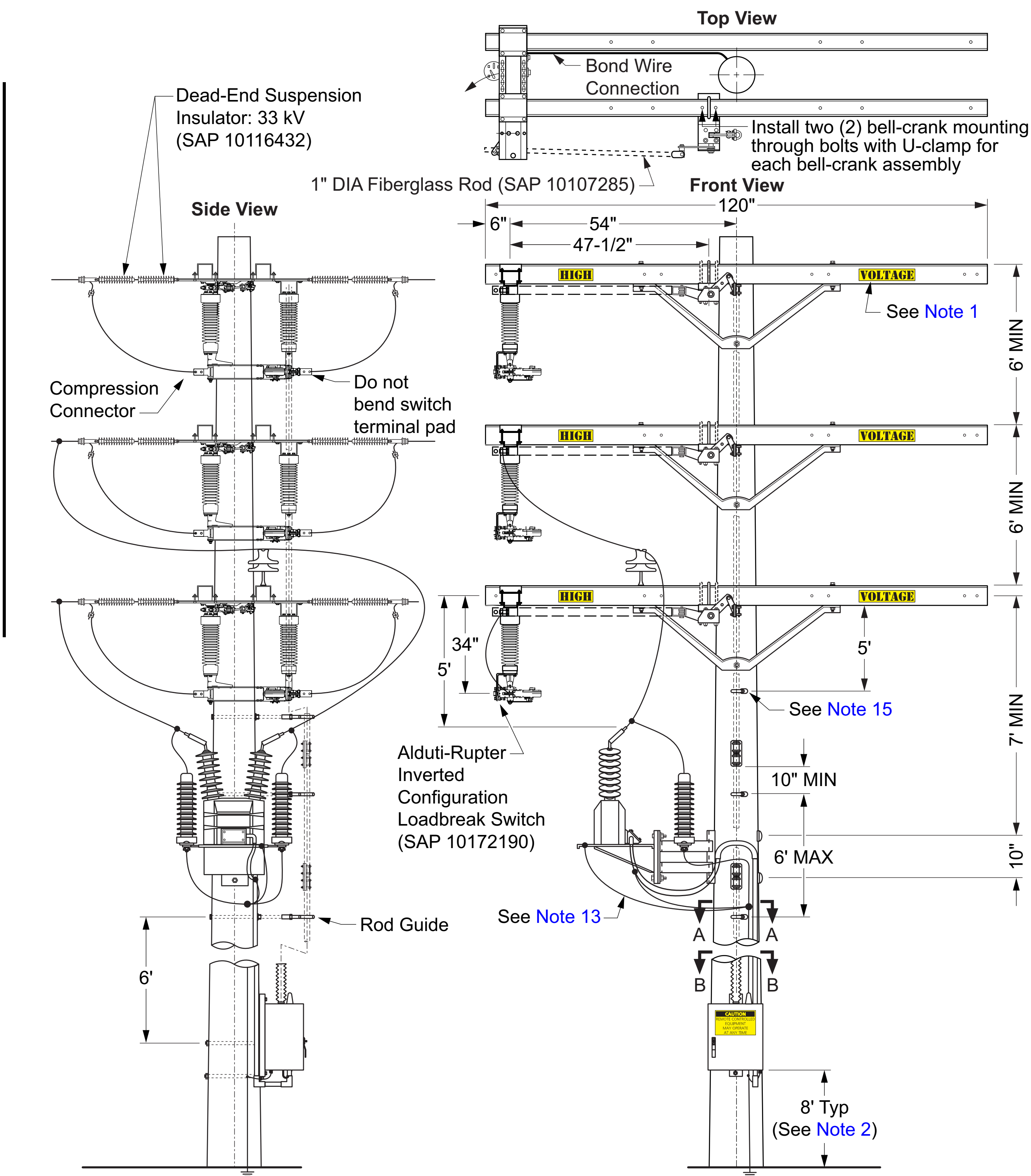
Effective Date: 04-26-2019

Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. See Figure AP 337–2 for ADMO mounting height criteria.
3. See AP 360 for Cleveland Price Automated Motor Operator (ADMO) and joint pole PVC operating rod cover installation.
4. See CO 217 for Dead Ending.
5. Verify switch blades are fully closed and the bell crank over-toggled when installing rod/handle assembly.
6. Use only 33 kV dead-end-type suspension insulators.
7. Verify that the switch rocker arm is adjusted to 6 inches (older design) or to its respective hole position (newer design) as shown in Figure AP 337–1.
8. Verify that the ADMO stroke is set to fully open and fully close the switch. Refer to DOM SW-11 for details on stroke adjustment.
9. Surge arrestors and the ADMO cabinet shall be connected to a common equipment ground to minimize any potential ground differences between the equipment (See GR 105) and Scope AP 339.4.
10. For secondary maintain a minimum clearance of 10 inches from top of insulator to lowest point of PT bracket. For under built, maintain a minimum clearance of 3 feet from middle of crossarm to lowest point of PT bracket.
11. Use insulated butt-splices (SAP 10111371) to connect the secondary PT, black and white wires (120 VAC) inside the ADMO.
12. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.
13. Construction crew shall coordinate the installation of new and updated RCS with Distribution Automation Engineering in order to perform an end point test (EPT) and commission unit in service.
14. When primary neutral ground exist on the same pole, it shall be a separately installed ground from that of the common equipment ground.
15. The uppermost rod guide shall be located 3 feet to 4 feet below the centerline of the switch operating lever. The lowest rod guide shall be located approximately 6 feet above the ADMO Control Cabinet. Distribute additional rod guides uniformly at of 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 339.3 Automated Vertical Inverted Alduti-Rupter Load-Break Switch

Figure AP 339–2: Automated Vertical Inverted Alduti-Rupter Switch



Automated 600 A, 38 kV Alduti-Rupter Load-Break Switches

Approved by:

What's Changed? Updated Figure AP 339–2 to show increased number of insulators for easier formation of jumper wires.

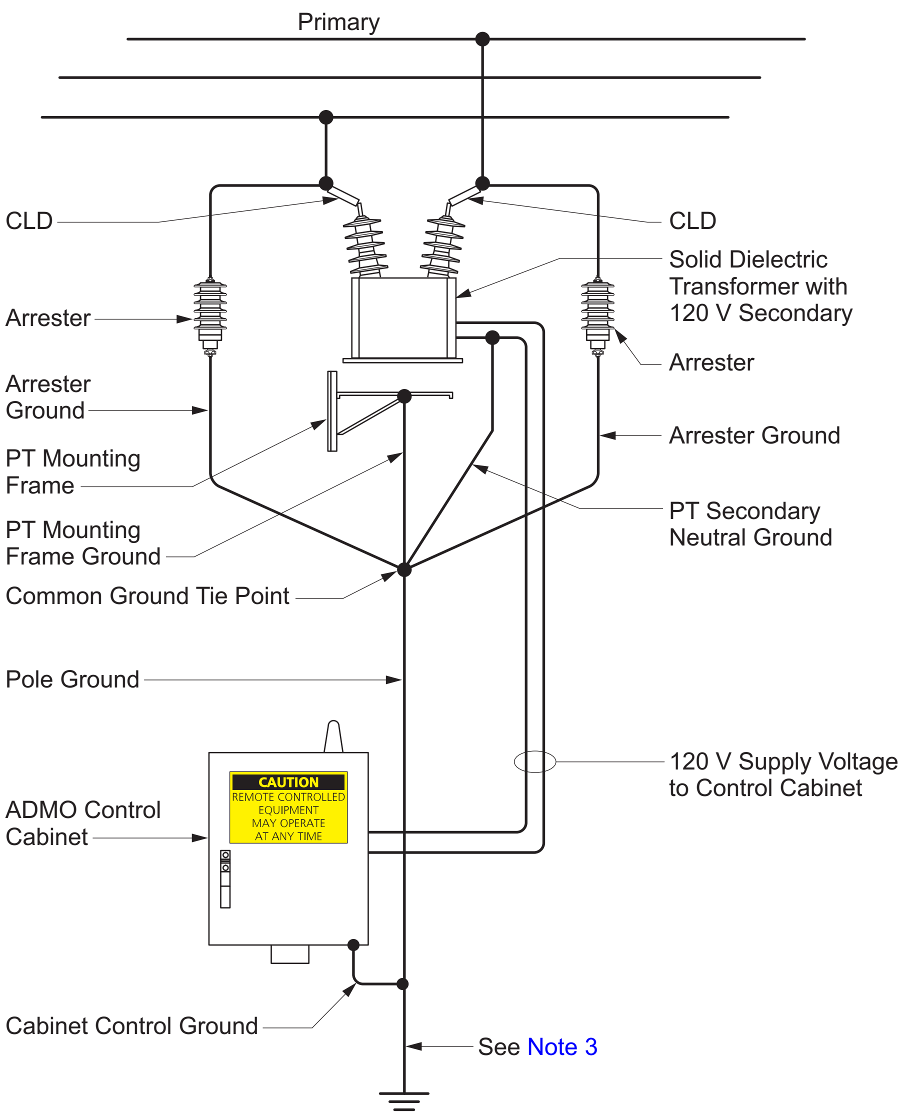
Effective Date:
04-26-2019

Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. See Figure AP 337–2 for ADMO mounting height criteria.
3. See AP 360 for Cleveland Price Automated Motor Operator (ADMO) and joint pole PVC operating rod cover installation.
4. See CO 217 for Dead Ending.
5. Verify switch blades are fully closed and the bell crank over-toggled when installing rod/handle assembly.
6. Verify that the switch rocker arm is adjusted to 6 inches (older design) or to its respective hole position (newer design) shown in Figure AP 337–1.
7. Verify that the ADMO stroke is set to fully open and fully close the switch. Refer to DOM SW-11, Section 4.3 for details on stroke adjustment.
8. For secondary, maintain a minimum clearance of 10 inches from top of insulator to lowest point of VT bracket. For under built, maintain a minimum clearance of 3 feet from middle of crossarm to lowest point of VT bracket.
9. Use insulated butt-splices (SAP 10111371) to connect the secondary VT, black and white wires (120 VAC) inside the ADMO.
10. Distribution Construction shall contact the Distribution Automation Hotline when installing, relocating, repairing, or removing automated equipment at 714-285-4325. Hours: Mon–Fri 7 a.m.–4 p.m. Available after hours/weekends upon request.
11. When primary neutral ground exist on the same pole, it shall be a separately installed ground from that of the common equipment ground.
12. Use only 33 kV dead-end-type suspension insulators.
13. Surge arrestors, potential transformer secondary neutral, VT bracket, and the ADMO cabinet shall be connected to a common ground to minimize any potential ground differences between the equipment.
14. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arrestors, cable terminators, and equipment bushings.
15. The uppermost rod guide shall be located 5 feet below the centerline of the switch operating lever. The lowest rod guide shall be located approximately 6 feet above the ADMO Control Cabinet. Distribute additional rod guides uniformly at 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 339.4 Typical Automation Common Equipment Grounding Connections for 600 A, 38 kV Alduti-Rupter Load-Break Switch

Figure AP 339–3: Typical Automation Common Equipment Grounding Connections for 600 A, 38 kV Alduti-Rupter Load-Break Switch

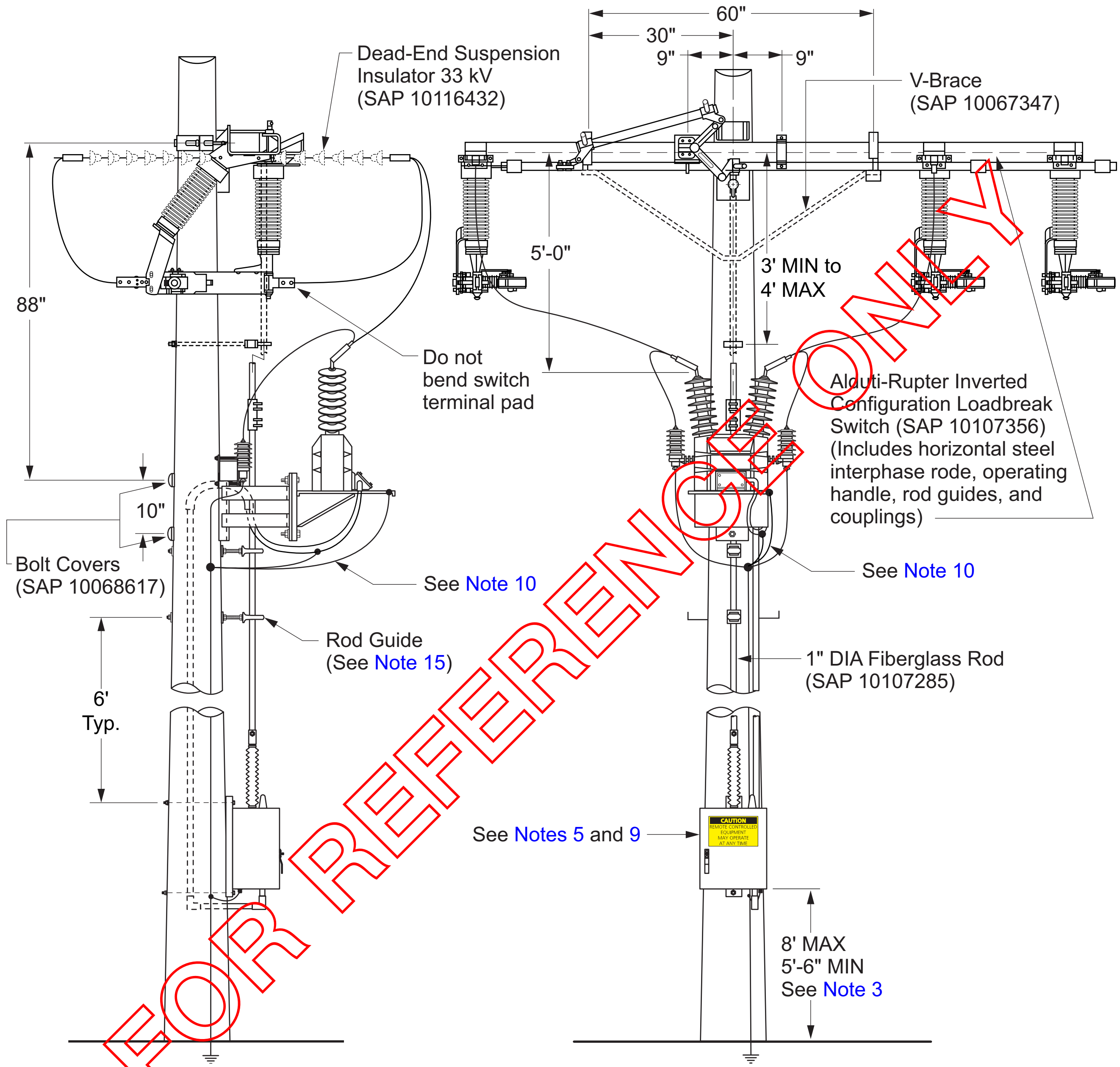


Note(s):

1. The Control PT shall serve no load other than the ADMO control.
2. Surge arresters, potential transformers secondary neutral, PT mounting frame and the ADMO cabinet shall be connected to a common equipment ground to minimize any potential ground differences during a surge between the equipment.
3. Preferred method will be to ground with two (2) ground rods per GR 105. If bare copper must be used then it shall be installed in PVC conduit. Maintain proper clearance between the ground and bond or bonded equipment.
4. All Control PT installations shall be protected by surge arresters.
5. When primary neutral ground exist on the same pole, it shall be a separately installed ground from that of the common equipment ground.

Scope AP 339.5 Automated Horizontal Inverted Alduti-Rupter Switch

Figure AP 339–4: Automated Horizontal Inverted Alduti-Rupter Switch

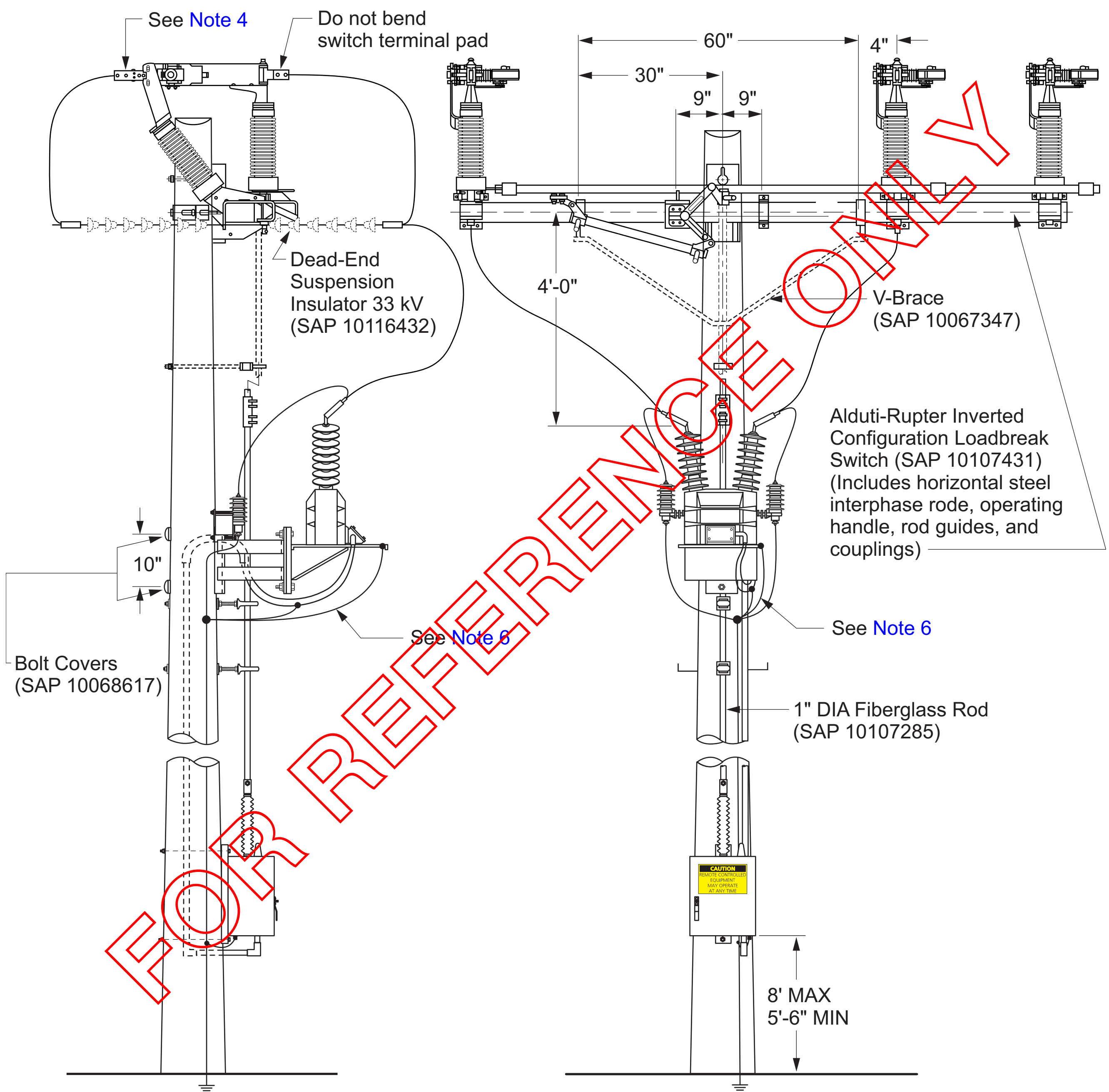


Note(s):

1. See PO 120 for High Voltage sign installation requirements.
2. See Figure AP 337–2 for ADMO mounting height criteria.
3. See AP 360 for Cleveland Price Automated Motor Operator (ADMO) and joint pole PVC operating rod cover installation.
4. See CO 217 for Dead Ending and Isolators.
5. Verify switch blades are fully closed and the bell crank over-toggled when installing rod/handle assembly.
6. Use only 33 kV dead-end-type suspension insulators.
7. Verify that the switch rocker arm is adjusted to 6 inches (older design) or to its respective hole position (newer design) as shown in Figure AP 337–1.
8. Verify that the ADMO stroke is set to fully open and fully close the switch. Refer to DOM SW-11 for details on stroke adjustment.
9. Surge arrestors, potential transformers secondary neutral, VT bracket and the ADMO cabinet shall be connected to a common equipment ground to minimize any potential ground differences between the equipment (See GR 105) and Scope AP 339.4.
10. For secondary maintain a minimum clearance of 10 inches from top of insulator to lowest point of PT bracket. For under built, maintain a minimum clearance of 3 feet from middle of crossarm to lowest point of PT bracket.
11. Use insulated butt-splices (SAP 10111371) to connect the secondary PT, black and white wires (120 VAC) inside the ADMO.
12. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.
13. Construction crew shall coordinate the installation of new and updated RCS with Distribution Automation Engineering in order to perform an end point test (EPT) and commission unit in service.
14. When primary neutral ground exist on the same pole, it shall be a separately installed ground from that of the common equipment ground.
15. The uppermost rod guide shall be located 3 feet to 4 feet below the centerline of the switch operating lever. The lowest rod guide shall be located approximately 6 feet above the ADMO Control Cabinet. Distribute additional rod guides uniformly at of 6 feet maximum and maintain at least 10 inches clearance between the upper edge of each rod guide and the lower edge of the straight coupler.

Scope AP 339.6 Automated Horizontal Side-Arm Configuration Upright-Type, 600A, 38 kV, Alduti-Rupter Load-Break Switch for 3-Wire Pole Application

Figure AP 339–5: Automated Horizontal Side-Arm Configuration Upright-Type, 600 A, 38 kV, Alduti-Rupter Load-Break Switch for 3-Wire Pole Application



Note(s):

1. Verify switch blades are fully closed when installing rod/handle assembly.
2. HIGH VOLTAGE warning provisions can be made either by placing “HIGH VOLTAGE” stickers (SAP 10135407) on the face and back of each switch arm or using other approved signs and work methods. (See PR 100)
3. Use only 33 kV dead-end-type suspension insulators.
4. Compression Connector. (See SAP numbers, Figure AP 336–6).
5. ADMO SAP 10107141.
6. Surge arrestors, potential transformers secondary neutral, VT bracket, and the ADMO cabinet shall be connected to a common ground to minimize any potential ground differences between the equipment (See GR 105) and Scope AP 339.4.
7. Use insulated butt-splices (SAP 10111371) to connect the secondary PT, black and white wires (120 VAC) inside the ADMO.
8. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, arresters, cable terminations, and equipment bushings.

AP 400 Surge Arrester Application Guide

Scope AP 400.1 Application Guide for Distribution Surge Arresters

This guide is to assist in the selection application of distribution surge arresters so that lightning-caused damage can be held to a minimum.

1.0 Location of Arresters

An important factor in using an arrester effectively is its location relative to the apparatus being protected. Line and ground leads offer high impedance paths to lightning surge current. During a lightning surge discharge, these paths can develop voltages that place additional stress on the insulation of the protected equipment. Therefore, it is important to have the arrester placed as close as possible to the apparatus to be protected, keeping all leads as short as possible. Surge arresters used to protect fused overhead apparatus should be mounted adjacent to the fuseholders and connected to the line side of the fuses. Surge arresters used to protect underground cable should be mounted adjacent to the potheads and connected to the load side of any fuses used. When arresters are installed to protect underground cable, the arrester grounds must be connected to the pothead to minimize the effect of ground resistance.

Pole- or rack-mounted transformers with secondary voltage ratings of 2,400 or higher can sustain secondary winding damage, even though proper arrester protection is applied to the primary. This is particularly true where high ground resistances are encountered. To minimize this, arresters should be installed on the secondary side as well as the primary side of the transformer(s). The secondary arrester ground must be separate from the primary arrester ground to comply with the provisions of section 33.3B of G.O. 95; however, it must be connected, through its own tank discharge gap, to the transformer tank(s) in order to provide an effective surge path around the transformer(s).

2.0 How to Identify Types of Arresters

Basically, there are four types of surge arresters, which may be distinguished by their physical appearance. These are the metal oxide (MOV), valve, valve with external gap, and the expulsion types as shown in the arrester identification example pages, AP 405. If there is any doubt as to the type of arrester, the manufacturer's data on the arrester body will show this information.

3.0 Selection of Surge Arresters

AP 410 shows the ordering information for distribution-class surge arresters.

4.0 Purpose of Ground Lead Insulators

Arresters are furnished with ground lead isolators with attached flexible ground leads. The ground lead isolators automatically disconnect the ground lead from the arrester in the event that the arrester fails internally. The flexible ground lead is factory installed. It should not be detached, and no part of it should be cut when the arrester is removed from service.

5.0 Surge Arrester Applications

For the purpose of lightning protection, districts will be divided into categories of low/medium and high lightning density to lightning damage. Individual standards have been developed for both lightning density categories.

5.1 Low/Medium lightning density districts:

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

For these districts, the following lightning protection standards apply: (1) for lightning protection, only metal oxide (MOV) type surge arresters will be installed; and (2) surge arresters will be installed for the following applications:

- Underground dips from overhead lines;
- On reclosers, sectionalizers, remote-controlled switches (RCS), PE gear, capacitor banks and pole top substations;
- Overhead transformer installations of 750 kVA and larger.

Silicon carbide arresters will be replaced with the equivalent metal oxide arrester, if: (1) the above criteria for installation has been met; and (2) crew is performing major construction; that is, replacing or rebuilding equipment, reconductoring, or facility rearrangement, on or adjacent to the pole with the silicon carbide arrester.

When installing metal oxide arresters, a minimum of two ground rods are required.

5.2 High lightning density districts:

Antelope Valley	Ridgecrest
Barstow	Shaver Lake
Bishop	Twentynine Palms
Blythe	Victorville
Menifee	Wildomar
Palm Springs	

For these districts, the following lightning protection standards apply: (1) for lightning protection only metal oxide (MOV) type surge arresters will be installed; and (2) metal oxide arresters will be installed for the following applications:

- Underground dips from overhead lines;
- On all overhead equipment installations.

Silicon carbide arresters will be replaced with the equivalent metal oxide arrester, if: (1) the above criteria for installation has been met; and (2) crew is performing major construction, that is, replacing or rebuilding equipment, reconductoring, or facility rearrangement, on or adjacent to the pole with the silicon carbide arrester.

When installing metal oxide arresters, a minimum of two grounds rods are required.

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 the Reliability Engineering Group for a more in-depth analysis with specific location requirements to be provided.

5.3 In cases where distribution lines suffer repeated storm damage, install arresters where the pole line is on a ridge or in an exposed location.

5.4 Aerial Cable

Install arrester at both ends of all aerial cable sections on the system.

5.5 Surge arresters, when placed on a pole for the protection of apparatus of 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, see GR 100 and GR 105.

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.

5.6 Covered Conductor

Surge Arresters shall be installed on all overhead equipment and potheads that are connected to covered conductor, regardless of whether the covered conductor is located in Low/Medium Lightning density areas, or in High Lightning-Density areas.

AP 511P S&C IntelliRupter® PulseCloser Fault Interrupter

Scope AP 511P.1 IntelliRupter® Installation Details

1.0 General Information

The S&C IntelliRupter® can be applied on the 12 kV systems. The IntelliRupter® has a continuous current rating of 630 A[1/] and an interrupting rating of 16 kA symmetrical.

2.0 Power Modules[2/] and Arresters for Three Phase Four Wire Form Factor

The three phase four wire compatible IntelliRupter® is equipped with two integral single phase connected power modules and six arresters.

2.1 The three phase four wire compatible IntelliRupter® ground lug must be connected to both pole ground and the primary neutral wire. Ground the primary neutral at the IntelliRupter® installation location.

2.2 #6PGW (SAP 10109302) suitable wire from ground lug to primary neutral. Utilize 1-inch PVC conduit (SAP 10112582), PVC couplers (SAP 10113957), and PVC elbows (SAP 10114092) for routing of PGW between ground lug and primary neutral.

2.3 #6PGW (SAP 10109302) suitable wire from ground lug to pole ground. Follow GR 105 for ground preparation at pole base.

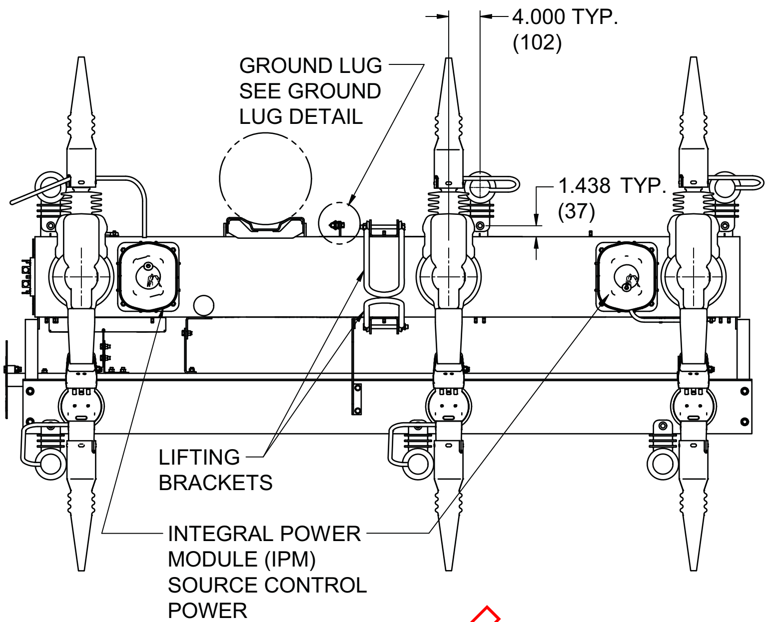
2.4 Primary and secondary connections for the two power modules is by the factory and completed on IntelliRupter® primary terminals and bus-work, one connection on line side and one connection on load side of recloser vacuum modules (see Figure AP 511P–1).

2.5 Surge arresters are required for protection of the IntelliRupter® and are factory installed (see Figure AP 511P–2).

2.6 There is one factory connected arrester per phase on line and load sides of the apparatus. Primary connections are to the primary terminals.

1/ 800 Amps with a minimum wind velocity of 2 ft/sec.
2/ Integral power modules cannot be applied on completely ungrounded systems.

Figure AP 511P–1: Single Phase Connected Power Modules (By Factory)



3.0 Installation Details for Three Phase Four Wire Form Factor

All IntelliRupter® installations shall be automated with the installation of a NetComm radio.

Follow DC 535 for wildlife-safe power line construction. See Table DC 535–1 for Wildlife cover options.

- Install wildlife guards (SAP 10067753) on all IntelliRupter® primary line and load side terminals. Slot the wildlife guards as necessary to allow fitment over arrester and power module primary leads.
- Wire covers shall be installed on all bare conductor leads.
- To provide a location for grounding at the disconnect switch terminals; leave six-inches of uncovered conductor on the leads that terminate on the IntelliRupter®.

To increase the space for maintenance of the IntelliRupter®, 12-foot crossarms are recommended for primary underbuild applications.

Underbuild circuits shall have a minimum four-foot clearance between the conductors and the bottom of the IntelliRupter® frame. Communication conductors shall have a minimum four-foot clearance to the bottom of the IntelliRupter® frame. See DC 200 for clearances between conductors and communication levels.

Hard drawn copper wire is required for IntelliRupter® taps for mechanical strength and to prevent interactions of aluminum with the IntelliRupter® copper alloy terminals. The IntelliRupter® tap requirements are detailed in Table AP 511P–1. The standard IntelliRupter® terminals will accept conductor range between #2-500MCM. For larger wire sizes NEMA style terminals can be attached to the IntelliRupter® terminals.

Figure AP 511P–2: Surge Arrester Mounting Detail (By Factory)

Dimensions in inches (mm)

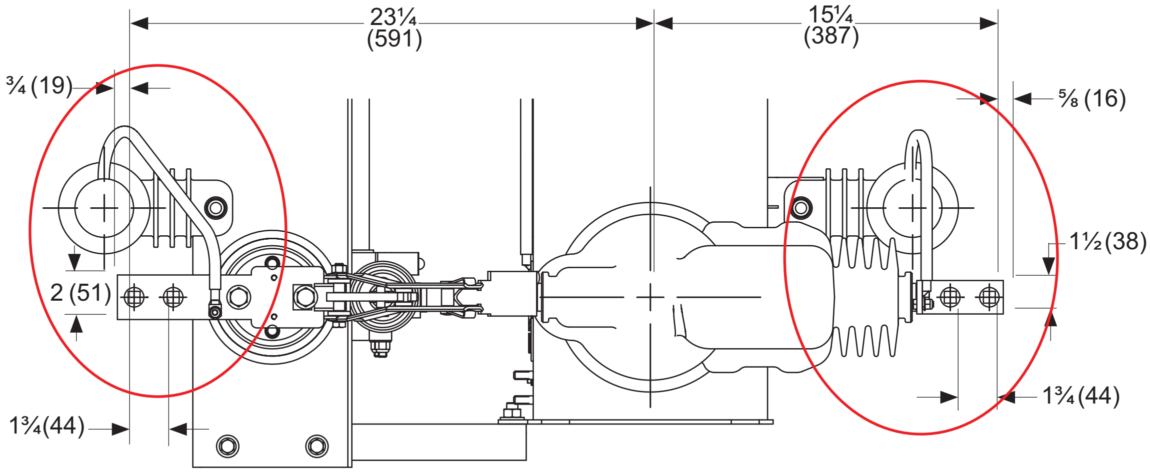


Figure AP 511P–2.1: Detail 1, Plan View Single Pole Zoom

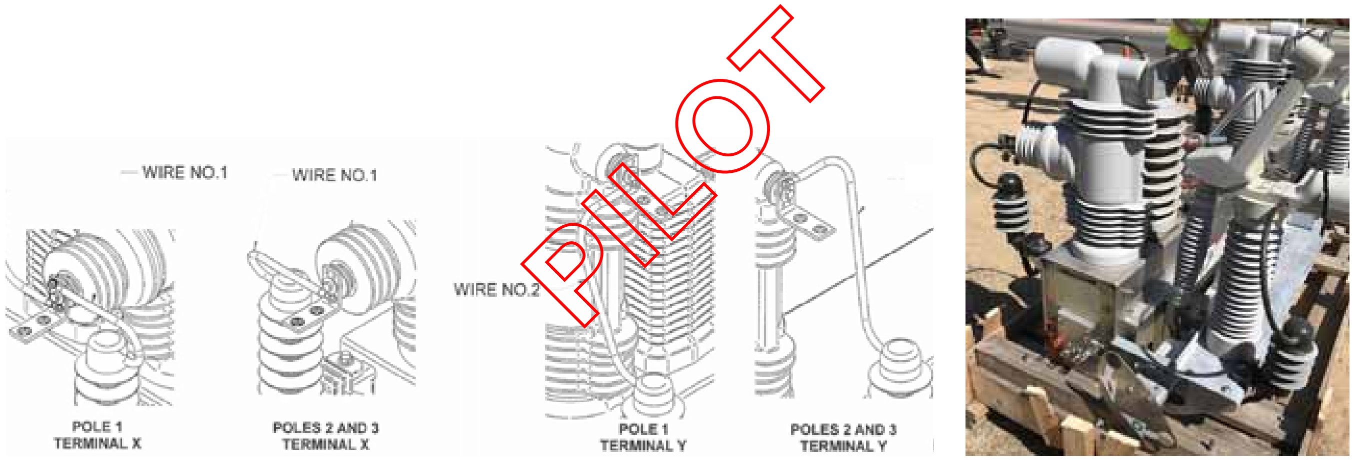


Figure AP 511P–2.2: Detail 2, Profile View All Poles and Photo

Table AP 511P–1: IntelliRupter® Tap Requirement Chart

Item	IntelliRupter® Conductor Requirements	Aluminum Span Conductor			Copper Span Conductor	
		#4 through #2 ACSR	1/0 through 4/0 ACSR	336.4 ACSR	#4 through 2/0 Cu	4/0 Cu
1	Leads between the span conductors and disconnect switches	#2 Cu Hard Drawn SAP 10109330	2/0 Cu Hard Drawn SAP 10109331	4/0 Cu Hard Drawn SAP 10109332	2/0 Cu Hard Drawn SAP 10109331	4/0 Cu Hard Drawn SAP 10109332
2	Leads between the disconnect switches and the IntelliRupter® terminals	2/0 Cu Hard Drawn SAP 10109331	4/0 Cu Hard Drawn SAP 10109332	4/0 Cu Hard Drawn SAP 10109332	4/0 Cu Hard Drawn SAP 10109332	4/0 Cu Hard Drawn SAP 10109332
3	Maximum Loading (amps)[a/]	160–210	280–415	540	195–405	540

[a/] Loading can be limited by the IntelliRupter® ratings, tap sizes, and span wire sizes. The values in the chart assume an IntelliRupter® continuous rating of 630 A, the range is based on the available range of the span conductors.

4.0 IntelliRupter Prior to Commissioning after Construction

After the installation of the IntelliRupter®, the equipment needs to be commissioned by Distribution Apparatus Test. The construction crew shall configure the equipment for Distribution Apparatus Test as follows:

- ☐ Hot line tag lever in the 'Up Position', this is 'Disabled' (see Figure AP 511P–3).
- ☐ Ground Trip Block Lever in the 'Up Position', this is 'Disabled' (see Figure AP 511P–3).
- ☐ Line and Load disconnects connected to both the source and the IntelliRupter®.
- ☐ Line and Load disconnects in the OPEN position.
- ☐ IntelliRupter® factory gang-operated disconnect switches in the CLOSED position.
- ☐ IntelliRupter® breaker in the OPEN position.
- ☐ By-pass switch in CLOSED position, unless otherwise indicated on the Work Order.
- ☐ Primary neutral connected to the ground boss and also the to the pole ground.
- ☐ Release to substation jurisdiction that IntelliRupter® has been installed and is NOT READY FOR SERVICE. Follow the procedure stated in System Operating Bulletin #25.

PILOT

Figure AP 511P–3: Hot Line Tag Lever, Ground Trip Block Lever, and Gang Operated Disconnect Switch Lever

Hot Line and Ground Trip Block levers shown in Up position. Feature is disabled in this position.

Ground Trip Block Lever

(if furnished)

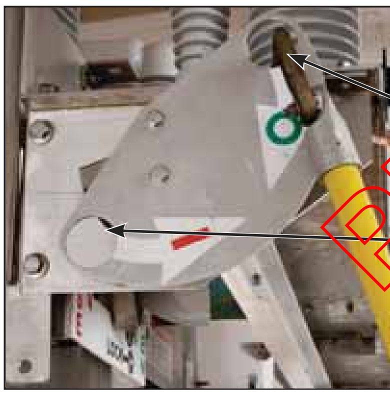
To manually apply ground trip block:
Pull down on ground trip block lever. (When in the applied position the selected elements will be blocked or change as indicated in the setup, see S&C Instruction Sheet 766-530.)

To remove a manually applied GTB:
Push up on ground trip block lever. (Placing the ground trip block lever in the up position will not enable any elements that have not been enabled in the active protection profile.)

Hot Line Tag Lever

To manually apply a hot line tag:
Pull down on hot line tag lever.

To clear a manually applied hot line tag:
Push up on hot line tag lever.



Disconnect Operating Lever

(if furnished)

To open disconnect:
Place the open/close/ready lever in the Lock open position. Then pull down on right side of disconnect operating lever. Interrupters can now be closed and opened for testing.

To close disconnect:
Place the open/close/ready lever in the Lock open position. Then pull down on left side of disconnect operating lever.

PILOT

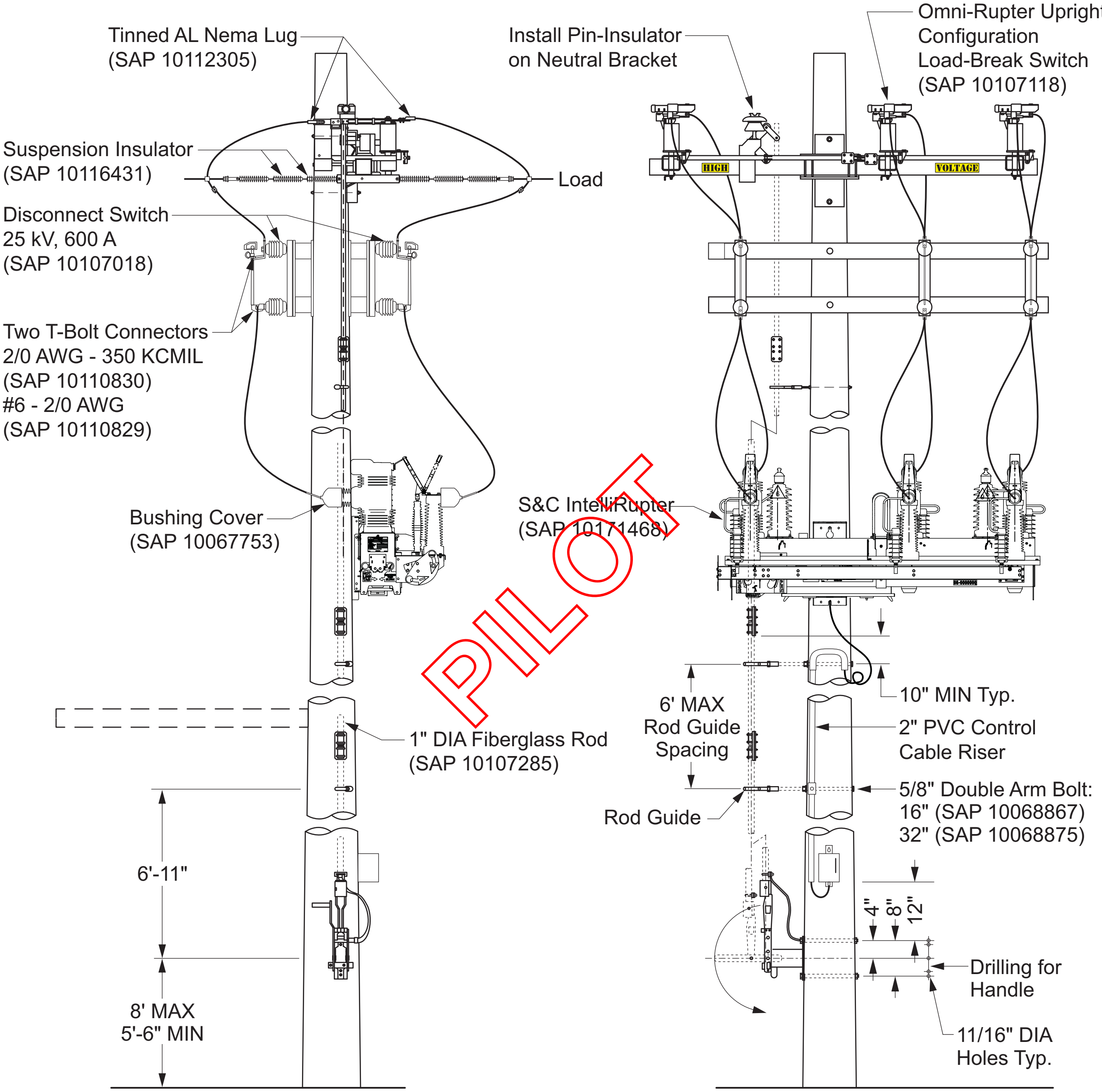
5.0 Controller Mounting Height Requirements

Table AP 511P–2: IntelliRupter® Controller Interface Enclosure Mounting Height Requirements

Table Note: Height criteria is as measured from ground to bottom of communication cable	
Preferred 8 Feet Above Ground	**Standard Installation and Where Accessible to Pedestrians**
Lower (4-8 feet)	All the following conditions shall be met (Usually in Rural Areas): • Away from obstacles — fences and walls • Away from parking area • Away from traffic signals • Away from traffic — vehicle and pedestrian OR in SCE Substation and locked fence areas
Higher than 8 feet	At a specified height, as determined by the planner, after contacting the responsible Apparatus Foreman due to the following conditions: • Ability to work over fence with bucket truck • Bus Stop • Communications obstacles • Fences and walls • Parking area • Slopes • Traffic — vehicle • Trees and shrubs Examples: • 6 feet below communication cable (usually 12'–15' above ground) • 4 feet below communication cable with no junction box (usually 14'–17' above ground) • 13'-6" above ground level to clear truck traffic Note: Contact the responsible Apparatus Foreman if the control is planned to be mounted above 8 feet and consult G.O. 95 Table 1 for required minimum height requirement
Control and Manual Handle Interference	Ensure mounting bolts for Manual Omni Handle and Control Interface Enclosure are separated by a minimum 1-foot vertically. Manual Handle shall have position priority.

6.0 General Arrangement for Construction S&C IntelliRupter

Figure AP 511P–4: Typical S&C IntelliRupter® for 12 kV Three Phase Four Wire Form Factor

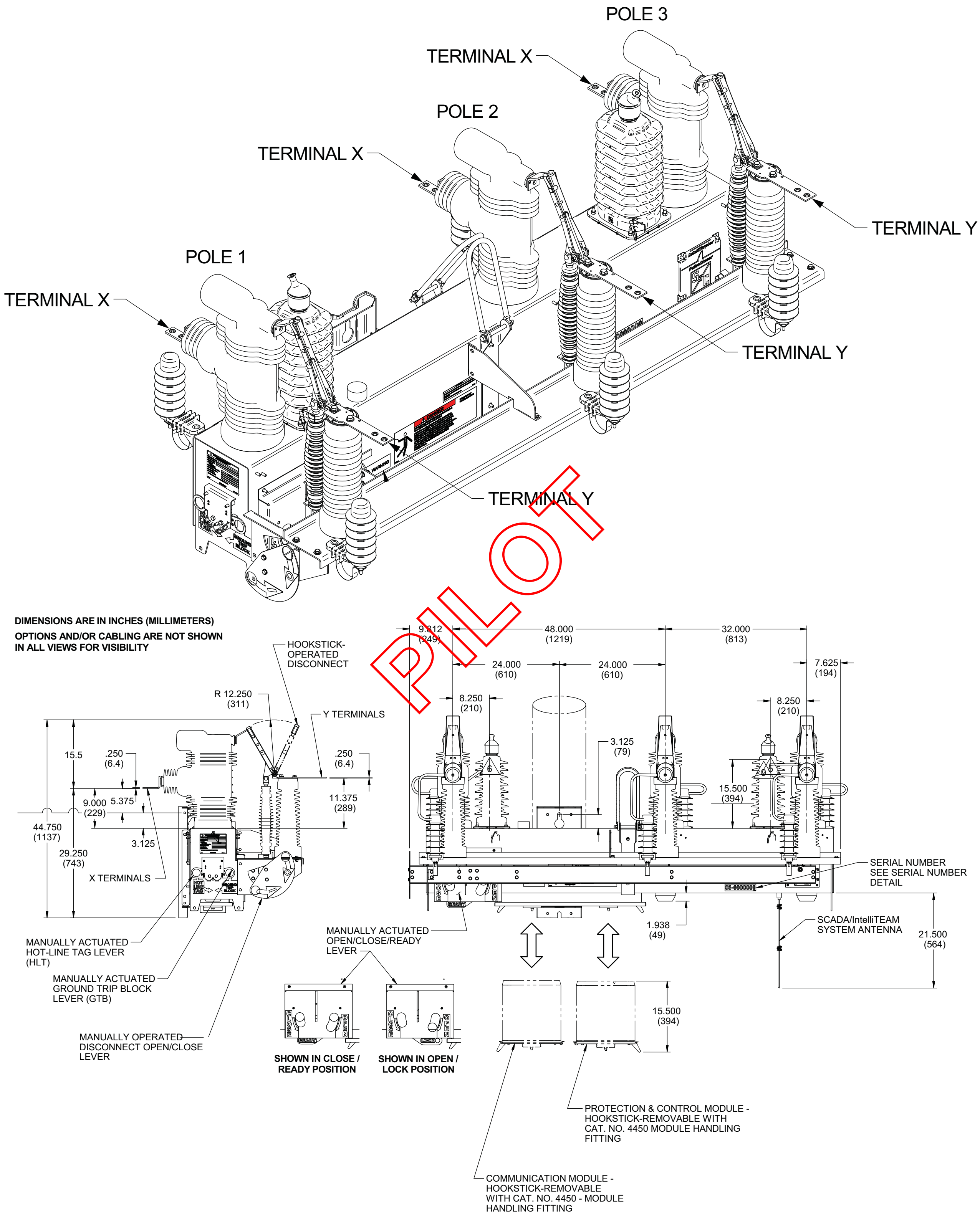


Note(s):

1. See Figure AP 511P–5 for IntelliRupter®, control, and Primary Neutral grounding. See GR 105 for ground conductor and connection requirements.
2. See AP 336 for installation requirements for Omni-Rupter bypass switch, the supply conductors shall be dead-ended to the switch crossarm.

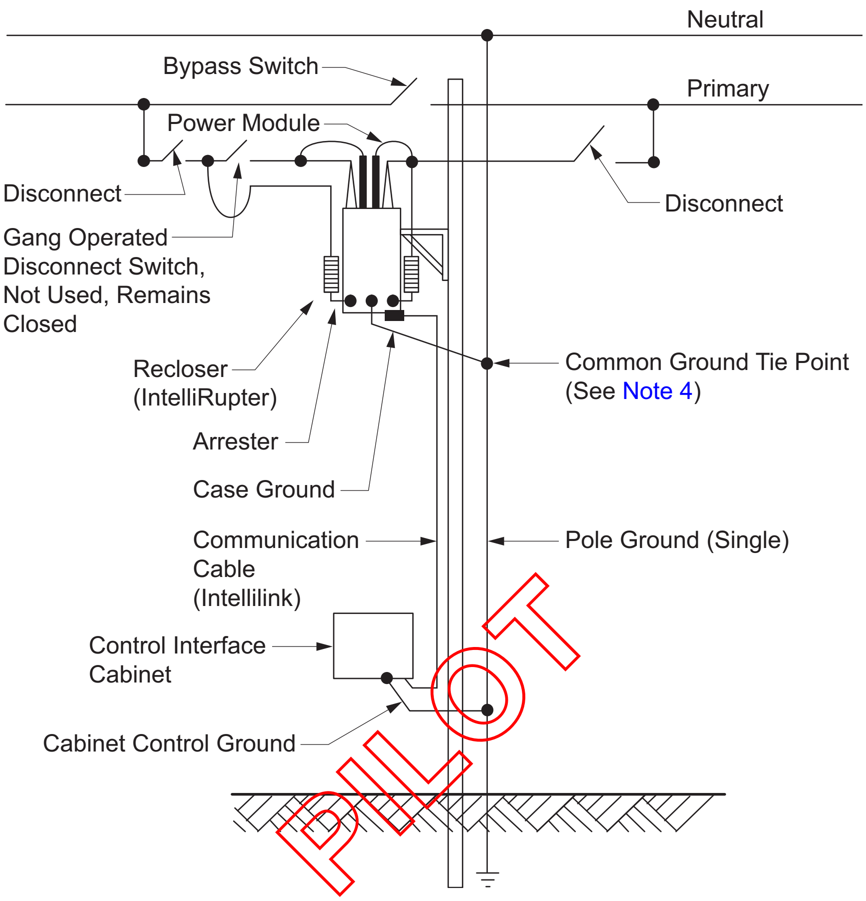
3. To provide a location for grounding at the disconnect switch terminals, leave 6-inches of uncovered conductor on the leads that terminate on the IntelliRupter®.
4. Per DC 535, Wildlife Protection shall be constructed and installed as applicable for insulators, taps, leads, cable terminations, and equipment bushings.
5. Use two T-Bolt connectors (2/0 AWG — 350 kcmil SAP 10110830; #6 AWG — 2/0 AWG SAP 10110829) per terminal pad to make connections at disconnect switches.
6. See PO 120 for High Voltage sign installation requirements.

Figure AP 511P–5: S&C IntelliRupter® for Three Phase Four Wire Form Factor



Approved by: *ajt*	S&C IntelliRupter® PulseCloser Fault Interrupter	AP 511P Sheet 9 of 10
Effective Date: 04-26-2019	**What's Changed?**	DOH

Figure AP 511P–6: Typical Connections for S&C IntelliRupter® for Three Phase Four Wire Form Factor



Note(s):

1. Control enclosure shall be grounded to the pole ground.
2. Primary neutral, IntelliRupter® tank, and control enclosure shall be connected to the same ground to minimize any potential ground differences.
3. IntelliRupter® primary bushings, either side can be used for source or load.
4. IntelliRupter® tank and frame and control cabinet shall be connected to the same ground to minimize any potential ground differences between equipment. Ground shall be connected to Primary Neutral for 4 wire application.
5. Surge arresters are factory connected to IntelliRupter® frame, no field wiring required.
6. Surge arresters are factory connected to IntelliRupter® frame, no field wiring required.

AP 610 GridSense Remote Fault Indicator (RFI) Line Monitoring System

Scope AP 610.1 Installation of the GridSense LIQ-60 Line Monitoring System

1.0 General Description

The purpose of the GridSense LIQ-60 Line Monitoring System is to remotely monitor the status of overhead distribution circuits via DMS, thereby allowing Field Personnel and Engineering to respond to circuit faults, distribution equipment-related outages, circuit over-load conditions, circuit troubleshooting, and circuit reliability issues.

For SCE applications, the GridSense LIQ-60 system may be utilized at any distribution circuit meeting the following criteria:

- Nominal Voltage: 4.16 kV to 33 kV
- Conductors Size: 1/0 AWG to 653.9 kcmil (if required, the sensor will fit other nonstandard conductors up to a maximum of 1.25 inches in diameter)

The GridSense System detects, stores, and remotely indicated the following data:

- Fault Current
- Load Current
- Power Factor
- Phase Angle
- Voltage

1.1 GridSense LIQ-60 Line Monitoring System

Consists of three LIQ-60 Conductor Mounted Sensors (CMS) with one CMS installed per phase and one LIQ-Gateway for SCADA communication via DMS. The NetComm radio is not supplied by the manufacturer, a NetComm radio request needs to be processed separately.

The following accessories are also included in each new GridSense LIQ system kit:

- ☐ LIQ Local Link modem, used for local-wireless communication to the CMS and the Gateway
- ☐ LIQ Charger for CMS, used to charge the CMS battery
- ☐ AC Power Cable for Gateway with standard 120 VAC outlet plug, used to charge the Gateway
- ☐ A Compact Disc (CD) which provides the required GridSense Lineman software and LocalLink drivers

Figure AP 610–1: Conductor Mounted Sensor (CMS)

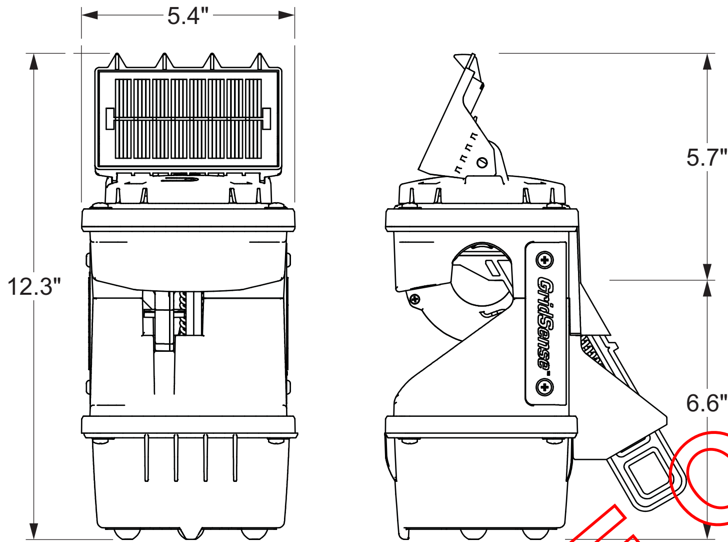
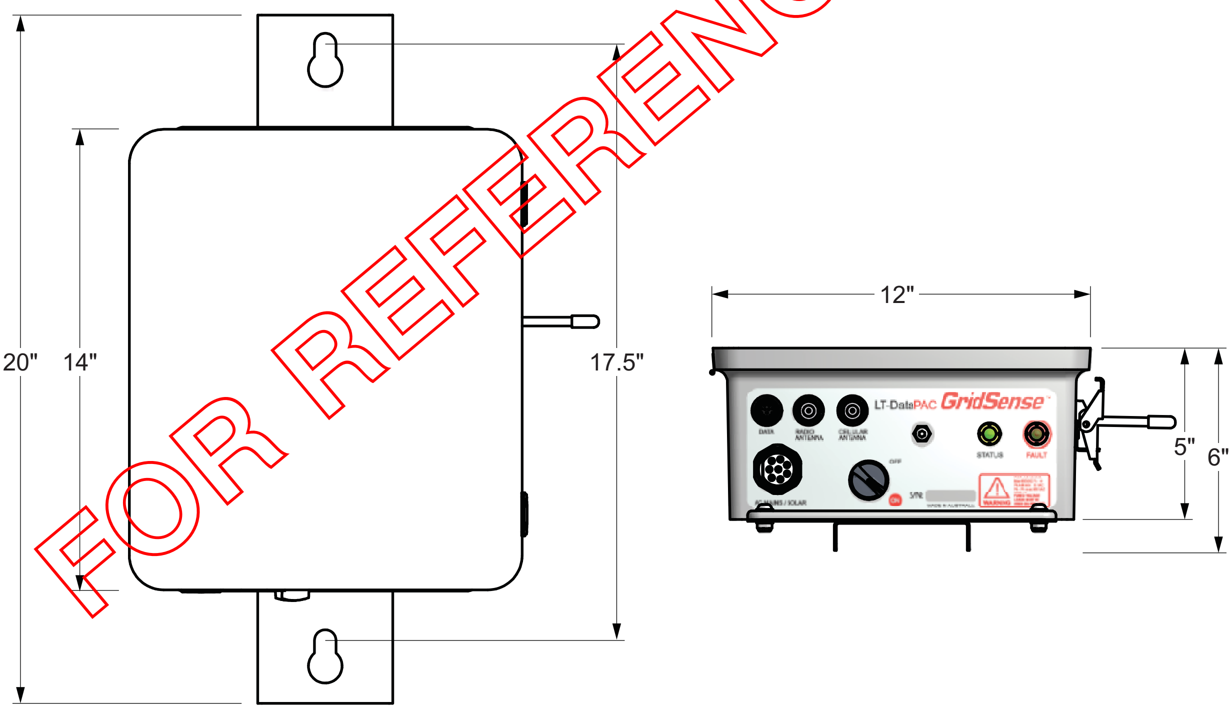


Figure AP 610–2: GridSense LIQ Gateway



Note(s):

1. 1. Weight of one CMS is 4.4 lb.
2. 2. Weight of Gateway is 17 lb.

GridSense Remote Fault Indicator (RFI) Line Monitoring System

What's Changed? Standard made For Reference Only.

Approved by: ajf

Effective Date: 04-26-2019

The GridSense LIQ-60 (CMS) can be used without the LIQ Gateway to act as a LOCAL data collection device tool. The LIQ Local Link will allow the user to locally download CMS stored data on-site through a laptop. The GridSense LineMan software and Local Link modem are required for local and wireless data download from the CMS with a maximum range of 100 feet.

The installation of the GridSense LIQ-60 CMS with the LIQ-Gateway allows for SCADA remote monitoring and communication via DMS. The Gateway requires an external 120 VAC power source from an existing secondary line on the same pole or by installation of a PT. A solar panel kit may be installed if the previous options are unavailable.

- ☐ A NetComm radio installed inside the LIQ-Gateway is required to communicate to the device via DMS. The radio must be ordered separately by submitting a NetComm request form.
- ☐ Field crews shall notify Distribution Automation Engineering of the installation of the LIQ-60 Line Monitoring system in order to perform an end point test (EPT) and commission unit in service.

  Field crews shall contact Distribution Automation Hotline twice: (1) first call to provide advance notification prior to equipment installation and, (2) second call after completing equipment installation to perform an EPT.

Note(s):

NOTE

A laptop with the GridSense's LineMan software and the LIQ-Local Link modem may be required for troubleshooting purposes during installation. The required software and drivers are provided on a CD in each LIQ system.

Table AP 610–1: SAP Numbers for New Installation

Description	SAP
Remote LIQ-60 Line Monitoring System (3-Sensors, 1-Gateway and Accessories)	10185620
Solar Panel Kit (20 Watt) w/ mounting bracket	10177524
Local LIQ-60 Line Monitoring System (3-Sensors and Accessories). No Gateway.	10185615
PT for 2.4, 4.16, 4.8, 12 and 16 kV Selection. For 2.4 kV Installation: 2.4 kV to 120 V, 1.0 kVA, Dry Type PT, Vented CLD for 2.4 kV, 4.16 kV, and 4.8 kV Surge Arrester for 2.4 kV and 4.16 kV	— 10177910 10159437 10109138
For 4.16 kV Installation: 4.16 kV to 120 V, 1.0 kVA, Dry Type PT, Vented CLD for 2.4 kV, 4.16 kV, and 4.8 kV Surge Arrester for 2.4 kV and 4.16 kV	 10177919 10159437 10109138

Table AP 610–1: SAP Numbers for New Installation *(Continued)*

Description	SAP
For 4.8 kV Installation: 4.8 kV to 120 V, 1.0 kVA, Dry Type PT, Vented CLD for 2.4 kV, 4.16 kV, and 4.8 kV Surge Arrester for 4.8 kV	 10177922 10159437 10109139
For 12 kV Installation: 12/16 kV to 120 V, 0.5 kVA Dry Type PT, Vented CLD for 12 kV and 16 kV Surge Arrester for 12 kV	 10105091 10159438 10109142
For 16 kV Installation: 12/16 kV to 120 V, 0.5 kVA Dry Type PT, Vented CLD for 12 kV and 16 kV Surge Arrester for 16 kV	 10105091 10159438 10109143
PT Mounting Bracket for 2.4 kV, 4.16 kV, 4.8 kV, 12 kV, and 16 kV PT Extension Bracket for 2.4 kV, 4.16 kV, 4.8 kV, 12 kV, and 16 kV Wildlife Guard	10104923 10067312 10067793
PT for 25 kV Installation: 14.4 kV to 120 V, 750 VA Dry Type PT (Phase to Neutral Connection) CLD for 25 kV Surge Arrester for 25 kV PT Mounting Bracket for 25 kV PT Extension Bracket for 25 kV Wildlife Guard	 10105069 10159439 10109143 10174769 10067312 10037793
PT for 33 kV Installation: 34.5 kV to 115 V, 1 kVA Dry Type PT, Vented CLD for 33 kV Surge Arrester for 33 kV PT Mounting Bracket for 33 kV PT Extension Bracket for 33 kV Wildlife Guard	 10167672 10159439 10109144 10067317 10067312 10067793

Note(s):

1. A 2.4 kV PT may be used on a 4.16 kV circuit, connected phase to neutral or on a 2.4 kV circuit connected phase to phase.
2. For 25 kV Circuit installations, a 14.4 kV PT is connected phase to neutral.
3. Solar Panel is available if PT installation is unfeasible.

2.0 Instructions for Preparing the LIQ-60 CMS prior to installation.

Figure AP 610–3: LIQ-60 CMS Base Panel in OFF Status

- ☐ Verify that all three of the CMS's are labeled and match with the provided Gateway Serial Number (SN). This will confirm the Gateway has been factory configured to the three CMS's. Otherwise pre-setting and configuration of the equipment will be required by the crews using the GridSense LineMan software.

Figure AP 610–4: Label on CMS showing Gateway Serial Number

☐ Verify that the Gateway is labeled and matches with each of the three provided CMS's Serial Numbers. This will confirm that the Gateway has been factory configured to the three CMS's. Otherwise pre-setting and configuration of the equipment will be required by the crews using the GridSense LineMan software.

Figure AP 610–5: Label on Gateway Showing Three CMS Serial Numbers

It is recommended for the three CMS to be set on the LIQ battery charger at least 24 hours prior to the scheduled installation. This will allow time to charge a CMS battery with the LIQ charger in the event that the CMS battery voltage is less than 2 V. Alternatively, the CMS battery can be charged using the CMS solar panel. However, charging a battery may require optimal sunlight for up to 50 hours.

Each LIQ-60 CMS is designed with a built-in 2 V battery. This battery is not removable or replaceable. The battery voltage in each CMS should be no less than 2 V at time of installation.

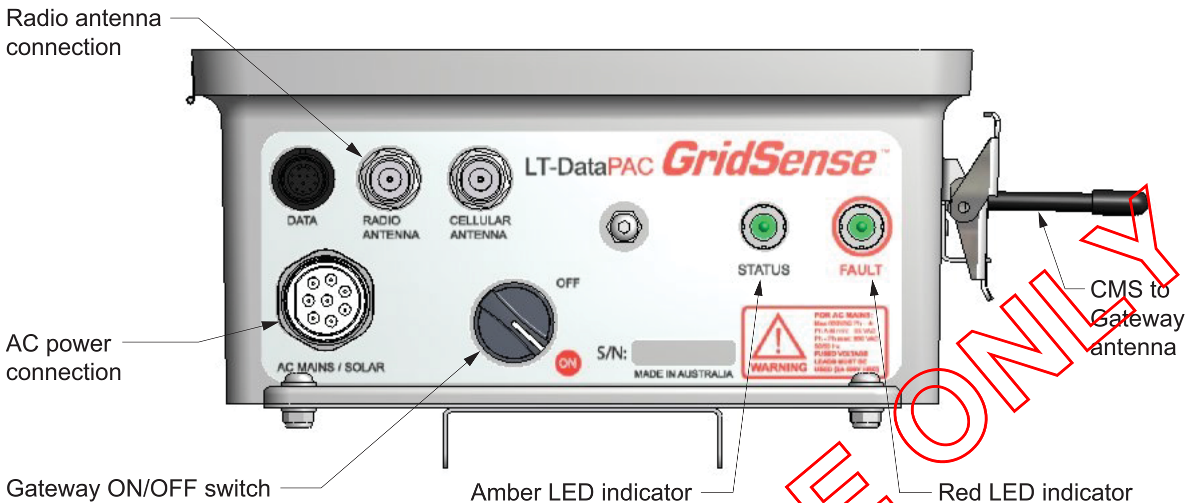
NOTE The CMS should be installed or re-charged within six months of purchase to maintain optimal battery health.

NOTE ***Do not*** mismatch any of the CMS from one system kit with that of another kit. The three CMS and Gateway are factory preset and configured to each other. Otherwise, the CMS and Gateway will need to be reconfigured using the GridSense LineMan software and LIQ Local Link modem. Contact Distribution Automation Hotline for configuration support.

NOTE In the event that any CMS or Gateway requires replacement, a replacement CMS or Gateway should be purchased separately. Refer to DOM CO-5 for replacement SAP numbers.

3.0 Instructions for Preparing the LIQ Gateway Prior to Installation.

Figure AP 610–6: LIQ Gateway Base Panel



Verify that the data reflected on the label on the supplied NetComm radio correlates with the information for the installation of the LIQ system:

- ☐ Device ID
- ☐ Structure Number
- ☐ Circuit Name
- ☐ Substation Name

It is recommended for the Gateway to be charged at least 24 hours prior to the scheduled installation by plugging it into a standard 120 VAC outlet using the provided AC power cable. This will allow time for the Gateway battery to charge in the event that the battery voltage is less than 12 V. The battery voltage in the Gateway should be no less than 12 V at time of installation.

NOTE The Gateway should be installed or re-charged within six months of purchase to maintain an optimal battery health.

NOTE ***Do not*** mismatch any of the Gateway from one system kit with that of another kit. The three CMS and Gateway are factory preset and configured to each other. Otherwise, the CMS and Gateway will need to be reconfigured using the GridSense LineMan software and LIQ Local Link modem. Contact Distribution Automation Hotline for configuration support.

What's Changed? Standard made For Reference Only.

4.0 Installation of LIQ Gateway

Step 1. Determine a safe mounting height on the pole for the Gateway;

- The bottom of the Gateway is to be a minimum of 12 feet from the ground level.
- If installed above a secondary line, maintain a 6 feet minimum clearance from the top of the Gateway bracket to the primary conductor. In addition to 10 inches minimum clearance from the bottom of the Gateway bracket to the top insulator on the secondary (see Figure AP 610–1, Figure AP 610–2, and Figure AP 610–3).

Step 2. The Gateway should be installed on the same side of the pole as the CMS to ensure proper communication between the Gateway and CMS.

Step 3. The distance between the Gateway and its furthest assigned CMS should not exceed 100 feet.

Step 4. Drill two 11/16-inch holes through the pole with a 17-1/2 inch vertical separation and install 5/8-inch through-bolts.

Step 5. Mount the Gateway on the pole using the 5/8-inch through-bolts and secure in place.

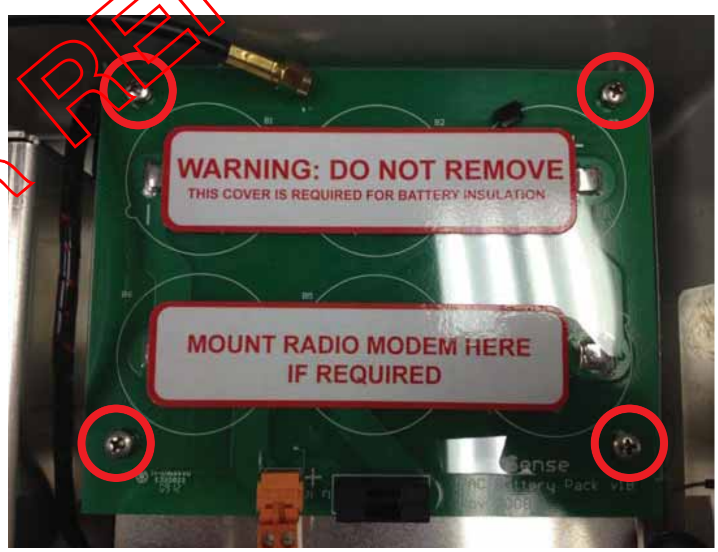
Step 6. Install the RF antenna on the small socket on the right hand side of the Gateway. The RF antenna will normally be found inside the enclosure.

Step 7. Install the Netcom radio antenna at the bottom of Gateway on the Radio Antenna port. (see Figure AP 610–10).

Step 8. Install and connect the NetComm radio inside the Gateway.

- Remove the four screws on top of the battery pack. Without removing the plastic cover, place the radio on top, with the antenna and R232 connectors facing left. Align the holes of the radio with those from the screws removed. Then reinstall the four screws holding the radio in place.

Figure AP 610–7: NetComm Radio Mounting



- Connect the serial connector from the Gateway to the transparent port on the radio.
- Connect the radio antenna cable from the Gateway to the radio. Ensure the antenna cable used is for the connection designated Radio Antenna on the Gateway.

Figure AP 610–8: Radio RS232 and Antenna Connections

What's Changed? Standard made For Reference Only.

- Connect the12 VDC Molex connector from the Gateway to the Radio.

Figure AP 610–9: 12 VDC Radio Connection

Step 9. Leave the Gateway OFF until the external 120 VAC source or a Gateway solar panel kit have been connected to the Gateway (see Figure AP 610–6).

Step 10. Use the AC power cable connector (provided in the system) with pig-tail-end to connect the Gateway to 120 VAC source (see Figure AP 610–10).

Figure AP 610–10: Gateway 120 VAC Connection and External Radio Antenna

Step 11. The 120 VAC power cable run along the pole from the source to the Gateway must be enclosed in 1-inch PVC conduit.

Step 12. Energize the 120 VAC or Solar power source.

Step 13. Turn the Gateway power switch to ON at the bottom of the enclosure. A sequence of LED flashings should be observed (see Figure AP 610–6).

5.0 Installation of LIQ CMS

Step 1. Turn On each CMS by rotating the red lever-switch 90 degrees clockwise to the On position, the red lever-switch will be in-line with the two red fault indicating LEDs.

- When powered On, the red LED will flash eight times followed by eight flashes from the amber LED, to complete the start-up sequence.
- After the start up sequence, both red LEDs will flash once every second and the amber LED will flash three times every 30 seconds until it is installed and commissioned.

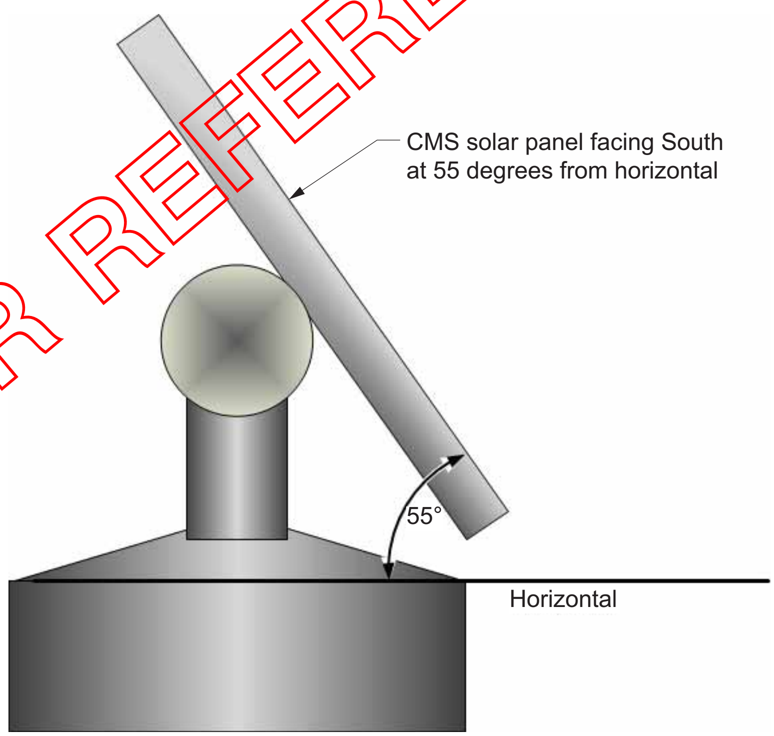
Step 2. Install a reflective label to each sensor to identify the CMS as 1, 2 or 3.

- The CMS with the lowest or first serial number should be labeled as 1, and should be installed on the phase closest to the street or road. If installed on a vertical circuit, install it on the lowest phase.
- The CMS with the middle serial number should be labeled as 2, and should be installed on the middle phase of the circuit.
- The CMS with the highest or last serial number should be labeled as 3, and should be installed on the phase furthest to the street or road. If installed on a vertical circuit, install it on the highest phase.

Step 3. The LIQ-60 CMS units must be installed in the same plane, facing the same direction and meeting the following criteria:

- Install the CMS with the RED directional arrow on the CMS base panel pointing to the load side of the circuit (see Figure AP 610–3).
- Ensure that the LIQ CMS is not installed in the shade, close to trees or other obstructions that could prevent direct sun light exposure to the CMS solar panels.
- Rotate the CMS solar panels facing south to improve sun energy exposure throughout the day.
- Set the angle of the solar panel at approximately 55 degrees from the horizontal (see Figure AP 610–11).

Figure AP 610–11: Side View of Solar Panel Set at 55 Degrees from the Horizontal



NOTE

Do not install the CMS on overhead insulated conductor.

Step 4. The CMS should be installed on the same side of the pole as the Gateway to ensure proper line-of-sight communication between the CMS and Gateway.

Step 5. Using a Grip-All hot stick, lock and lift the CMS from the sprung-slider on the CMS (see Figure AP 610–12).

Step 6. Pull the hook of the hot-stick to open the CMS clamp and slide the CMS over the conductor (see Figure AP 610–12).

Step 7. Verify the CMS clamp is fully closed once installed on the conductor.

Figure AP 610–12: CMS Side View

6.0 LIQ Gateway Power Source

The LIQ Gateway requires an external power source for normal and continuous operation. An internal battery pack provides backup support to maintain communication with the gateway during interruption of the main power source.

There are three available options to provide power to the Gateway, as listed below in order of preference:

6.1 Option 1 (Preferred): Existing Secondary Voltage

Connect the Gateway to an existing secondary voltage line (120 V) that may already be available on the same pole of the installation. Use the provided GridSense AC Power Cable for power connection at the Gateway from the 120 VAC secondary source.

6.2 Option 2: Install Potential Transformer (PT)

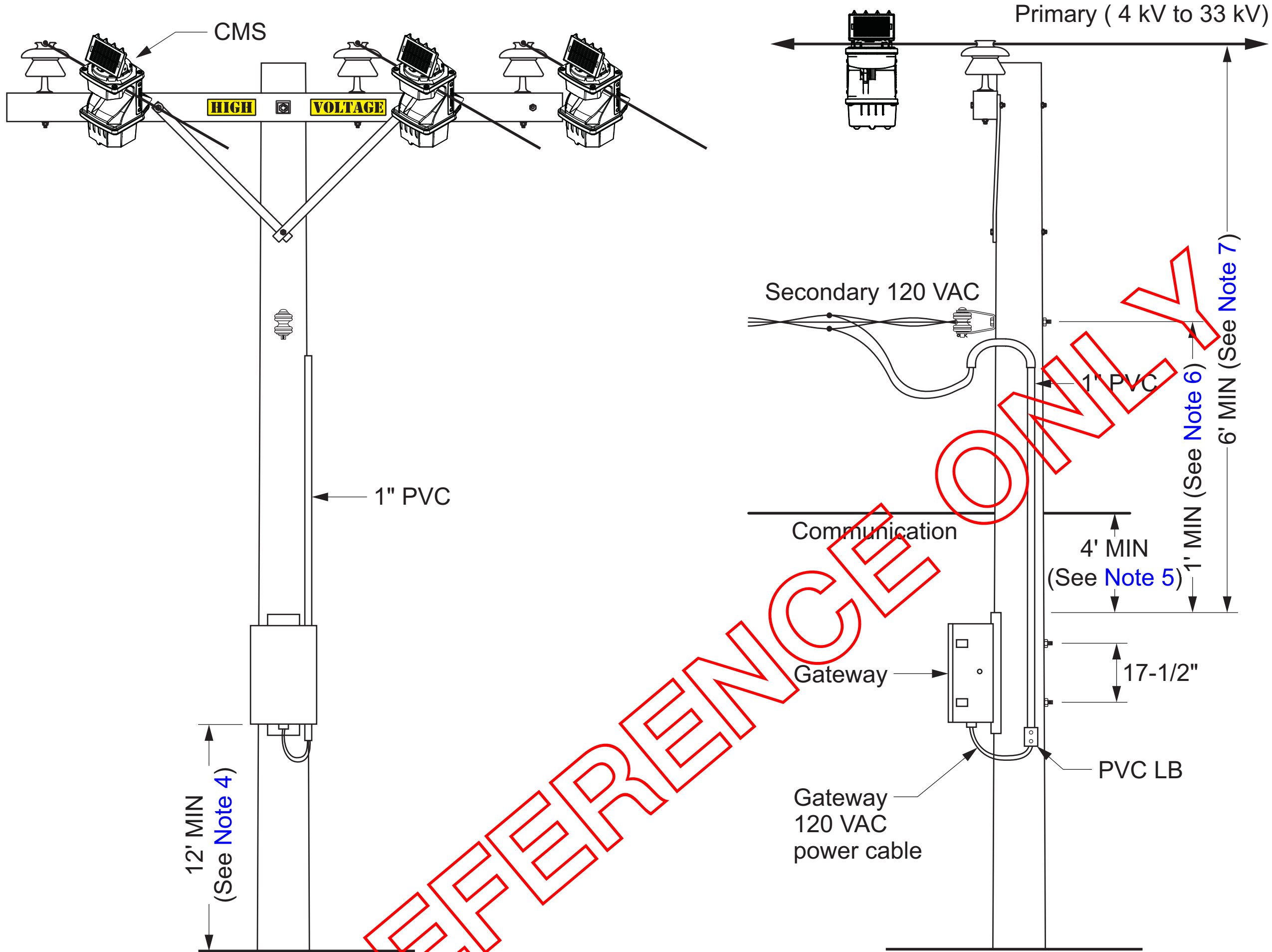
A PT with 120 V output may be used to provide power to the Gateway. Use the provided GridSense AC Power Cable for power connection at the Gateway from the PT.

For PT installation details, See Table AP 610–1 and AP 363 for 4/12/16 Dry Type PT Installation or AP 365 for 33 kV PT Installation.

6.3 Option 3: Install Solar Panel

If a secondary circuit is not available and a PT installation is unfeasible, the GridSense Solar Panel Kit which includes mounting brackets (SAP 10177524) may be purchased to power the Gateway.

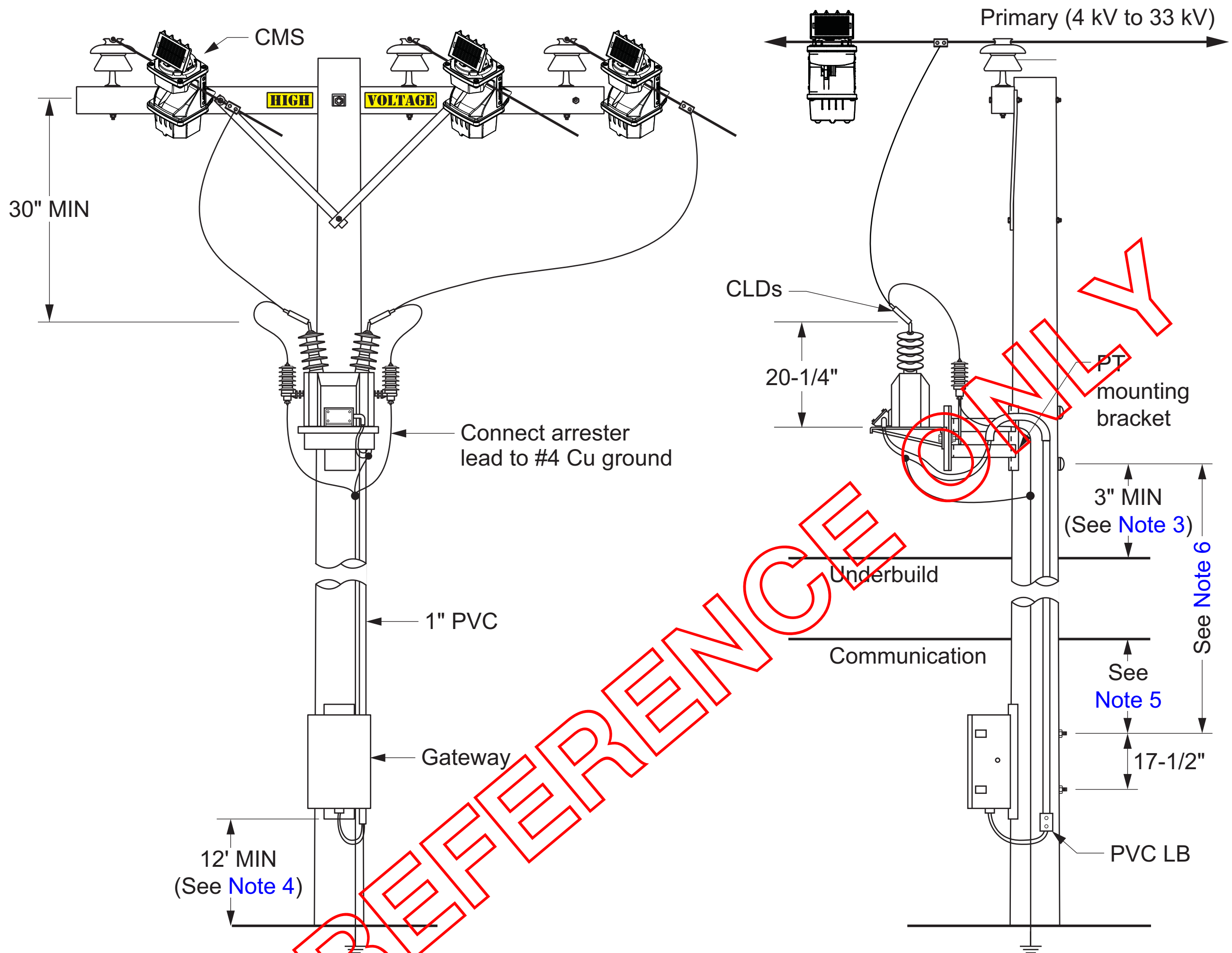
Figure AP 610–13: Providing Power to the Gateway Using Secondary Voltage (Preferred Option)



Note(s):

1. Install all three CMS within 100 feet from the Gateway with direct line of sight in between devices. Preferably close to the Gateway installation pole.
2. Use GridSense 120 VAC Cable (SAP 10177116) for connection to the available secondary power source.
3. The GridSense 120 VAC Cable is to be covered in protective covering (PVC conduit).
4. Maintain a minimum of 12 feet clearance from the ground level to the bottom of Gateway.
5. When installed below communication cables maintain a minimum of 4 feet clearance from the top of gateway to the communication cables. When installed above communication cables maintain a minimum of 4 feet clearance from the bottom of gateway to the communication cables.
6. Maintain a minimum of 1 foot clearance from the top of the gateway to the secondary cables.
7. Maintain a minimum of 6 feet clearance from the top of the gateway to the primary conductor.
8. The Gateway must be mounted on the same side of the pole that faces the LIQ CMS units to ensure proper communication.
9. For new installation SAP numbers see Table AP 610–1. For replacement components refer to DOM CO-5.
10. Use insulated butt-splices (SAP 10111371) for connection of the Gateway to the power source (120 VAC or Solar).

Figure AP 610–14: Providing Power to the Gateway Using a Potential Transformer

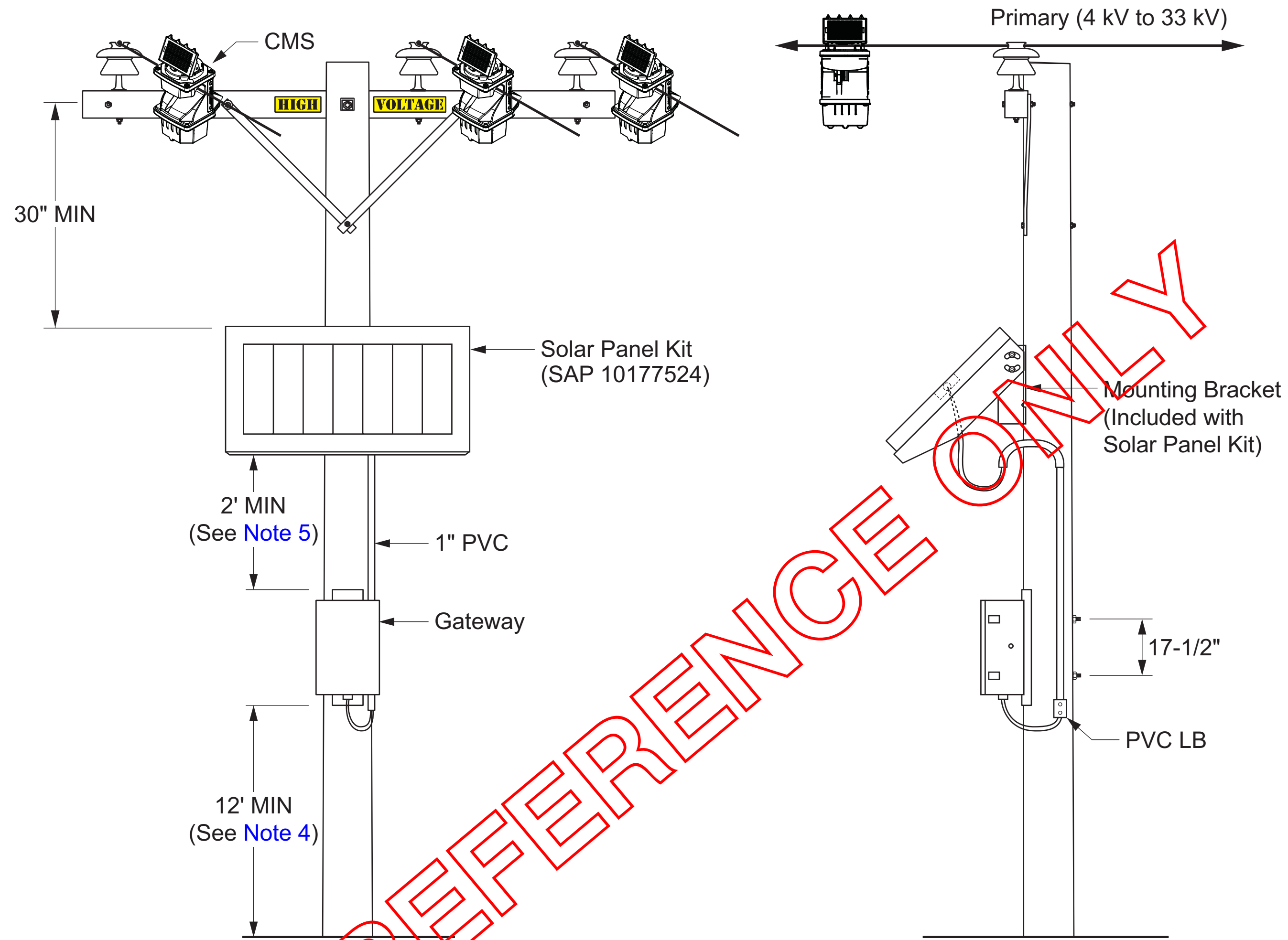


Note(s):

1. Install all three CMS within 100 feet from the Gateway with direct line of sight in between devices. Preferably close to the Gateway installation pole.
2. Use the GridSense 120 VAC Cable (SAP 10177116) for connection to the available PT secondary power source.
3. For under build, maintain a minimum clearance of 3 feet from middle of crossarm to lowest point of PT bracket.
4. Maintain a minimum of 12 feet clearance from the ground level to the bottom of Gateway.
5. When installed below communication cables maintain a minimum of 4 feet clearance from the top of gateway to the communication cables. When installed above communication cables maintain a minimum of 4 feet clearance from the bottom of gateway to the communication cables.
6. Maintain a minimum of 2 feet clearance from the top of the gateway to the bottom of the PT bracket.
7. Maintain a minimum of 6 feet clearance from the top of the Gateway bracket to the primary conductor.
8. The GridSense 120 VAC Cable is to be covered in protective covering (1-inch PVC conduit).
9. The Gateway must be mounted on the same side of the pole that faces the LIQ CMS units to ensure proper communication.
10. See AP 363 for 4 kV, 12 kV, and 16 kV PT installation details and to AP 365 for 33 kV PT installation details.

11. For new installation SAP numbers see Table AP 610–1. For replacement components refer to DOM CO-5.
12. Use insulated butt-splices (SAP 10111371) for connection of the Gateway to the power source (120 VAC or Solar) inside the PVC junction box.

Figure AP 610–15: Providing Power to the Gateway Using Solar Power



Note(s):

1. Install all three CMS within 100 feet from the Gateway with direct line of sight in between devices. Preferably close to the Gateway installation pole.
2. Mount the Solar Panel (SAP 10177524) on the same side of the pole as the Gateway and face the Solar Panel South if possible. The Solar panel measures 19-3/4" × 16-3/4" and weighs 7 lb.
3. The power cable between the solar panel and the Gateway is to be covered in protective covering (1-inch PVC conduit).
4. Maintain a minimum of 12 feet clearance from the ground level to the bottom of Gateway.
5. Maintain a minimum 2 feet clearance from the bottom of the solar panel to the top of the Gateway.
6. Maintain a minimum 6 feet clearance from the top of the Gateway bracket to the primary conductor.
7. The Gateway must be mounted on the same side of the pole that faces the LIQ CMS units to ensure proper communication.
8. For new installation SAP numbers see Table AP 610–1. For replacement components refer to DOM CO-5.
9. Use insulated butt-splices (SAP 10111371) for connection of the Gateway to the power source (120 VAC or Solar) inside the PVC LB.

7.0 Commissioning the LIQ System

Upon completion of installation, contact Distribution Automation Engineering Hotline to perform an End Point Test (EPT) on the newly installed LIQ Monitoring system.

AP 610 GridSense Line Monitoring System (FOR REFERENCE ONLY)

Scope AP 610.2 Installation of the GridSense Line Monitoring System (FOR REFERENCE ONLY)

1.0 General Description

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

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

The GridSense System consists of:

Step 1. Line Tracker Recorders (LT40CMS) that can be quickly installed on live lines at any point on the overhead distribution system to measure and record the aforementioned data.

Step 2. DataLink Transceiver for on-site access (non-remote) only.

Step 3. Data-PAC for remote control operation only.

2.0 Instructions for Preparing the LT40CMS

2.1 Assembly

Hand-tighten the RF antenna to the side of the LT40CMS (SAP 10100913).

2.2 Safety Lock Mechanism

The safety lock mechanism ensures that the LT40CMS is firmly attached to the conductor even when subjected to line whipping under severe fault, high wind, or storm conditions. The mechanism is a push/pull design with locking tabs. The safety lock mechanism can be configured for:

1. Installations on conductors that are 4/0 or less.
2. Installations on conductors greater than 4/0.

NOTE **It is important that the Safety Lock Mechanism is correctly configured according to the conductor size to ensure secure attachment when the conductor is exposed to line whipping.**

A. Setting the Safety Lock Mechanism for conductors greater than 4/0:

The LT40CMS is shipped with the Safety Lock already configured for installation on conductors greater than 4/0 (see Figure AP 610–16 (Sheet 22)).

Figure AP 610–16:

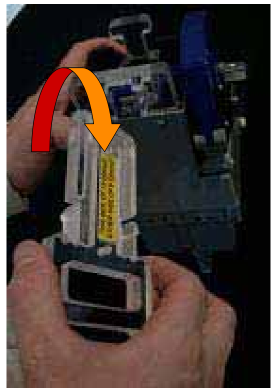
B. Configuring the Safety Lock Mechanism for conductors that are 4/0 or less:

Using a plier, push out the retaining pins to remove the slider from the LT40CMS (see Figure AP 610–17 (Sheet 22)).

Figure AP 610–17:

C. Flip the slider over before inserting it back as shown in Figure AP 610–18 (Sheet 23).

Figure AP 610–18:



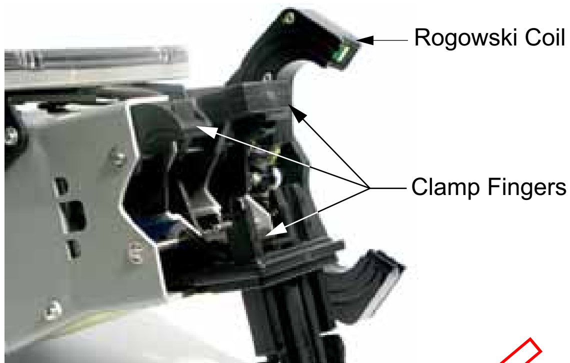
D. Using a plier, push back in the retaining pins as shown in Figure AP 610–19 (Sheet 23).

Figure AP 610–19:

2.3 Powering on the LT40CMS

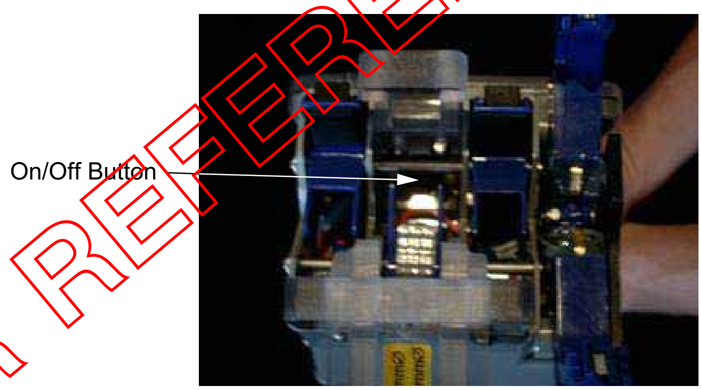
A. Open each of the 3 clamp fingers and Rogowski coil (see Figure AP 610–20 (Sheet 24)).

Figure AP 610–20:



B. Using the tip of a pen, push down the colored on/off power button (see Figure AP 610–21 (Sheet 24)).

Figure AP 610–21:



C. When the unit is powered on, the red and amber LEDs will start a flash sequence. Once settled, the red LED will flash once every second, and the amber LED will flash 3 times every 30 seconds.

D. For the first 5 minutes after the unit has been powered on, the LT40CMS conducts an RF interference check of the location. If the location has a high content of RF interference, the red LED will stay lit for the period of interference. If this is the case, relocate the LT40CMS to an adjacent structure.

3.0 Programming the LT40CMS

3.1 Programming the LT40CMS is only performed during the initial energization of each LT40CMS unit.

3.2 From a laptop with the Lineman software installed, use the Lineman software and LT-DataLink transceiver (SAP 10177526) (see Figure AP 610–22 [Sheet 25]) to configure each LT40CMS with the following settings:

A. Input the name of the circuit, substation, and structure number in the description field.

B. For remote operation, check the “Remotely Monitored” box.

C. Enter the Data-PAC serial number in the “PAC Serial No.” box.

D. Check the “Power Factor Logging” box.

E. Enter “5” minutes in the “Log Average” box for remote operation. For non-remote operation, enter “15” minutes in the “Log Average” box.

F. Enter “240” minutes in the “Fault Reset Time” box.

NOTE

the ID number of each LT40CMS, since each LT40CMS will be assigned to a different phase. The Lineman software labels the phases “1”, “2”, and “3”. Phase 1 is the phase closest to the street

3.3 Click “Apply Configuration” to apply the settings for each LT40CMS unit.

3.4 Enter the estimated distance between the phases and the conductor height above the ground (this is found under the menu: “Tools’ Power Factor Calibration”).

Figure AP 610–22: GridSense LT-DataLink Transceiver

4.0 Installation

4.1 Prior to installation, configure the safety lock mechanism based on the conductor size (see Section 2.2 (Sheet 21)).

4.2 Install the LT40CMS onto the conductor with the use of a Grip-All hot stick (see Figure AP 610–23 (Sheet 26)).

Figure AP 610–23:

NOTE **The LT40CMS units must all be installed in the same plane (for example, facing the same direction when installed). If possible, hang the LT40CMS units so that their solar panels face South.**

4.3 Once the LT40CMS has been securely clamped onto the conductor, close the safety lock mechanism by pushing the handle with the head of the Grip-All hot stick (see Figure AP 610–24 (Sheet 26)).

Figure AP 610–24:

5.0 Acquiring Line Data

5.1 Acquiring Line Data Non-Remotely

The data stored in the LT40CMS can be accessed from the ground level underneath it. The user must have a have a laptop with the GridSense LineMan Software installed and the GridSense LT-DataLink Transceiver.

5.2 Acquiring Line Data Remotely

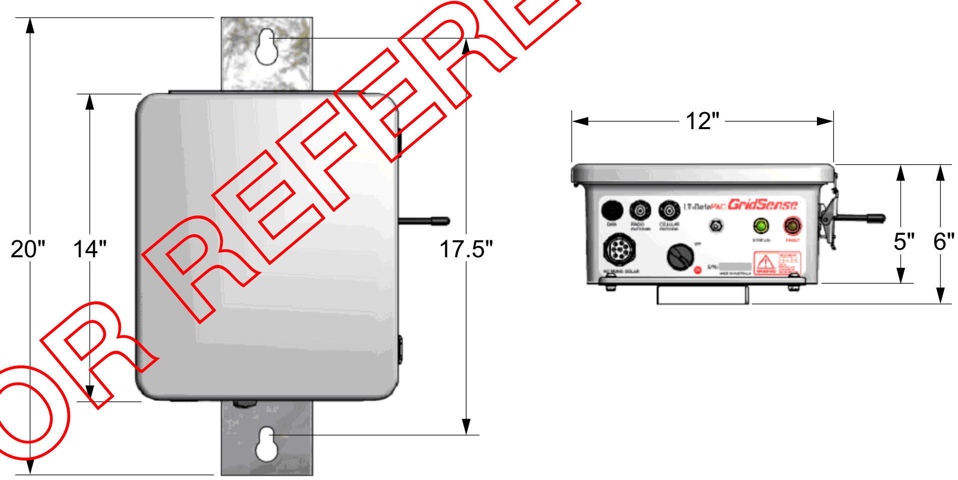
The data stored in the LT40CMS can be accessed from a remote location with the installation of a Data-PAC and a NetComm radio. The NetComm radio transmits the line data from the LT40CMS to the Metricomm Communications Center (MCC). At the MCC, the data is further processed so that it can be remotely accessed from any SCE computer via the Distribution Center Monitoring System (DCMS).

6.0 Using the GridSense System Remotely

6.1 NetComm Radio and Data-PAC

A. Place the NetComm radio inside the Data-PAC (SAP 10100914) and power on the Data-PAC (see Figure AP 610–25 (Sheet 27)).

Figure AP 610–25:



B. Initialize the GridSense Lineman Software and GridSense LT-DataLink Transceiver to configure the three LT40CMS units to be “children” of the “parent” Data-PAC by clicking “SCAN FOR DEVICES”.

C. Using the GridSense Lineman Software, click on the "communication settings" button to configure the Data-PAC with the following settings:

1. Check the "Permanently Power Radio" box.
2. Check the "Enable DNP3" box.
3. Check the "DNP3 Unsolicited Reporting" box.
4. Check the "DNP3 Static Polling" box.
5. Check the "DNP3 Support Waveform" box.
6. Enter "1" for the "Link Source Address".
7. Enter "60" seconds for the "App. Confirmation Timeout".
8. Enter "60" seconds for the "Unsolicited Short Retry Delay".
9. Uncheck the "Enable MODEM RTS/CTS Flow Control" box.

D. Click "Close" to save the settings and then confirm all of the settings by clicking on the "Commission" button in the next window.

6.2 Providing Power to the Data-PAC

There are three available options to provide power to the Data-PAC, **as listed below in preferred order:**

A. Option 1 (Preferred): Secondary Voltage — If a secondary voltage (120 V) is available, the Data-PAC can be powered from the secondary voltage by using the GridSense 600 VAC Power Cable (SAP 10177116) (see Figure AP 610–26 (Sheet 30)).

B. Option 2: Solar Power — If the Data-PAC is to be powered where PT installation is unfeasible, the GridSense Solar Panel Kit (including mounting bracket) (SAP 10177524) may be used to power the Data-PAC (see Figure AP 610–27 (Sheet 31)).

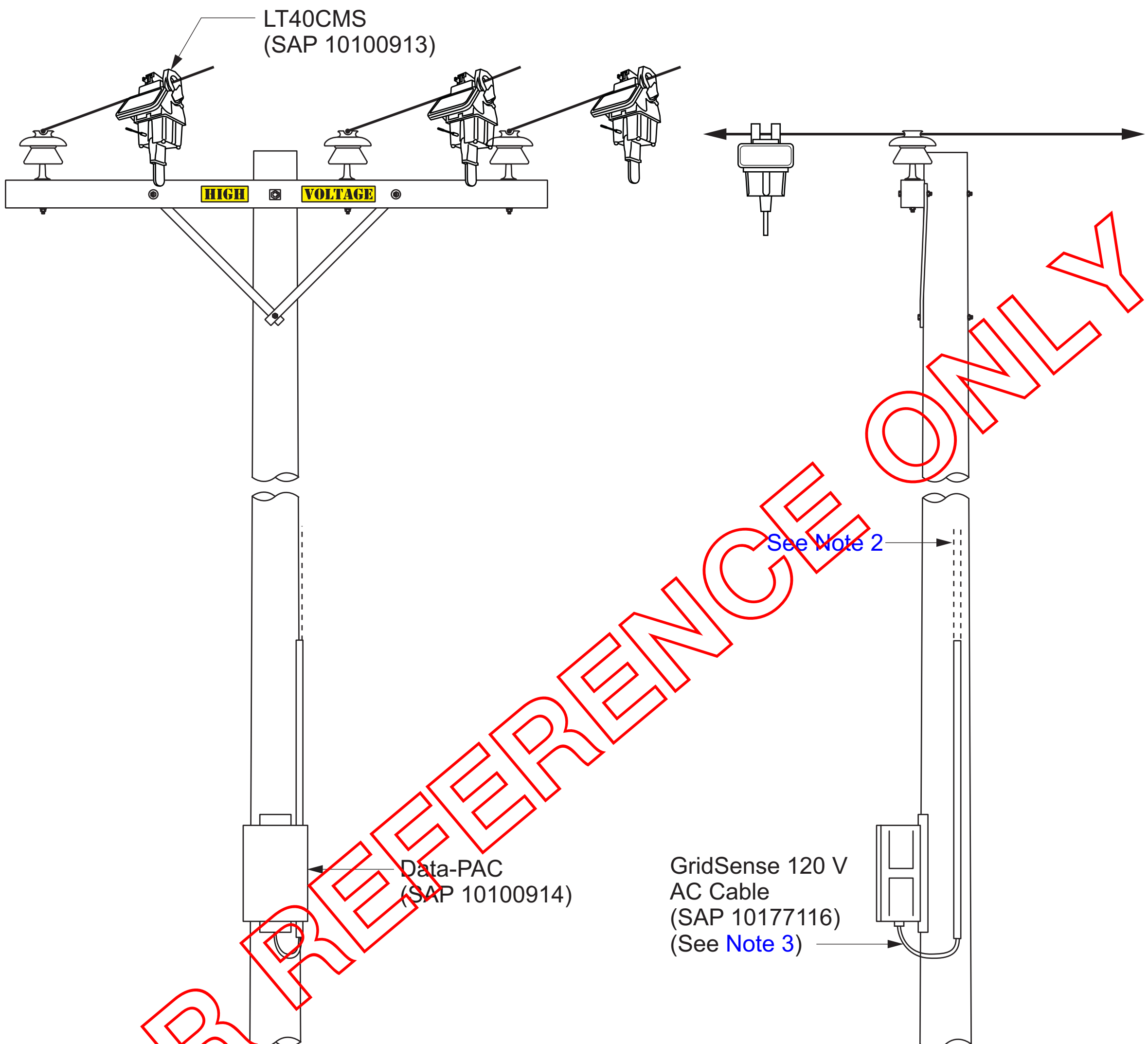
C. Option 3: Potential Transformer (PT) — A PT with 120 V output may be used to provide power to the Data-PAC. Use the GridSense 600 VAC Power Cable to provide power to the Data-PAC from the PT (see Figure AP 610–28 (Sheet 32)).

See Table AP 610–2 (Sheet 29) for the appropriate PT and Current Limiting Device (CLD) for the appropriate primary circuit voltage.

Table AP 610–2: Overhead PT and Associated CLD

Voltage (kV)	PT (SAP)	CLD (SAP) (2 per PT)
2.4	10105134	10159437
4.16	10103865	10159437
12/16	10105102	10159438
14.4	10105069	10109438
33	10167672	10159439

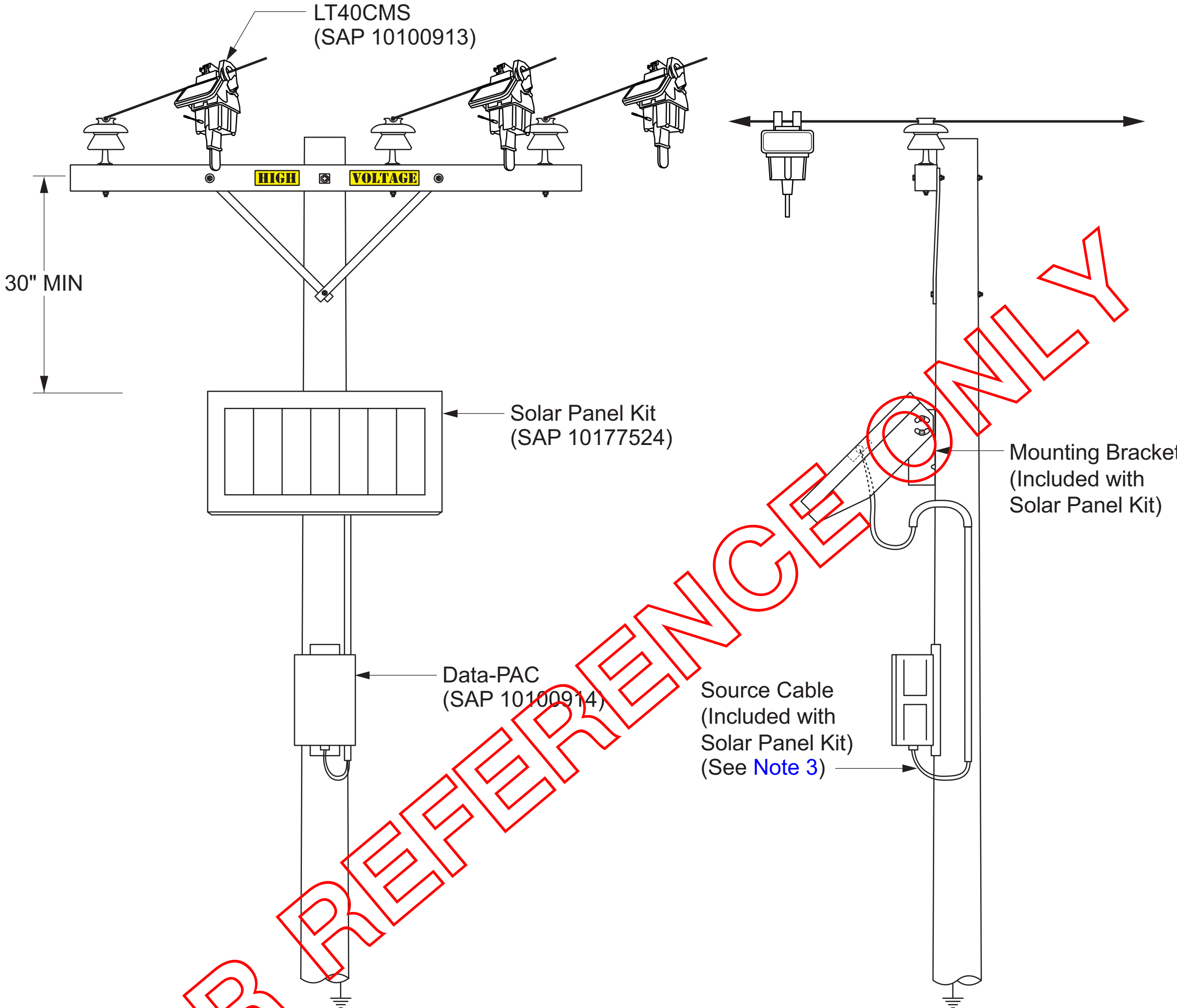
Figure AP 610–26: Providing Power to the Data-PAC Using Secondary Voltage (Preferred Option)



Note(s):

1. Data-PAC (SAP 10100914) is to be installed no greater than 100 feet from the furthest of the LT40CMS units.
2. Connect the Gridsense 120 VAC Cable (SAP 10177116) to the available secondary. Use electrical tape to seal and insulate the connection.
3. The GridSense 120 VAC Cable is to be covered in protective covering (PVC conduit), as required per G.O. 95.
4. Bottom of Data-PAC is to be a minimum of 8 feet clearance from the ground level.
5. If the Data-PAC is to be installed above the secondary, maintain a 6 foot minimum clearance from the primary crossarm.
6. Data-PAC must be mounted on the same side of the pole that faces the LT40CMS units to ensure proper communication.

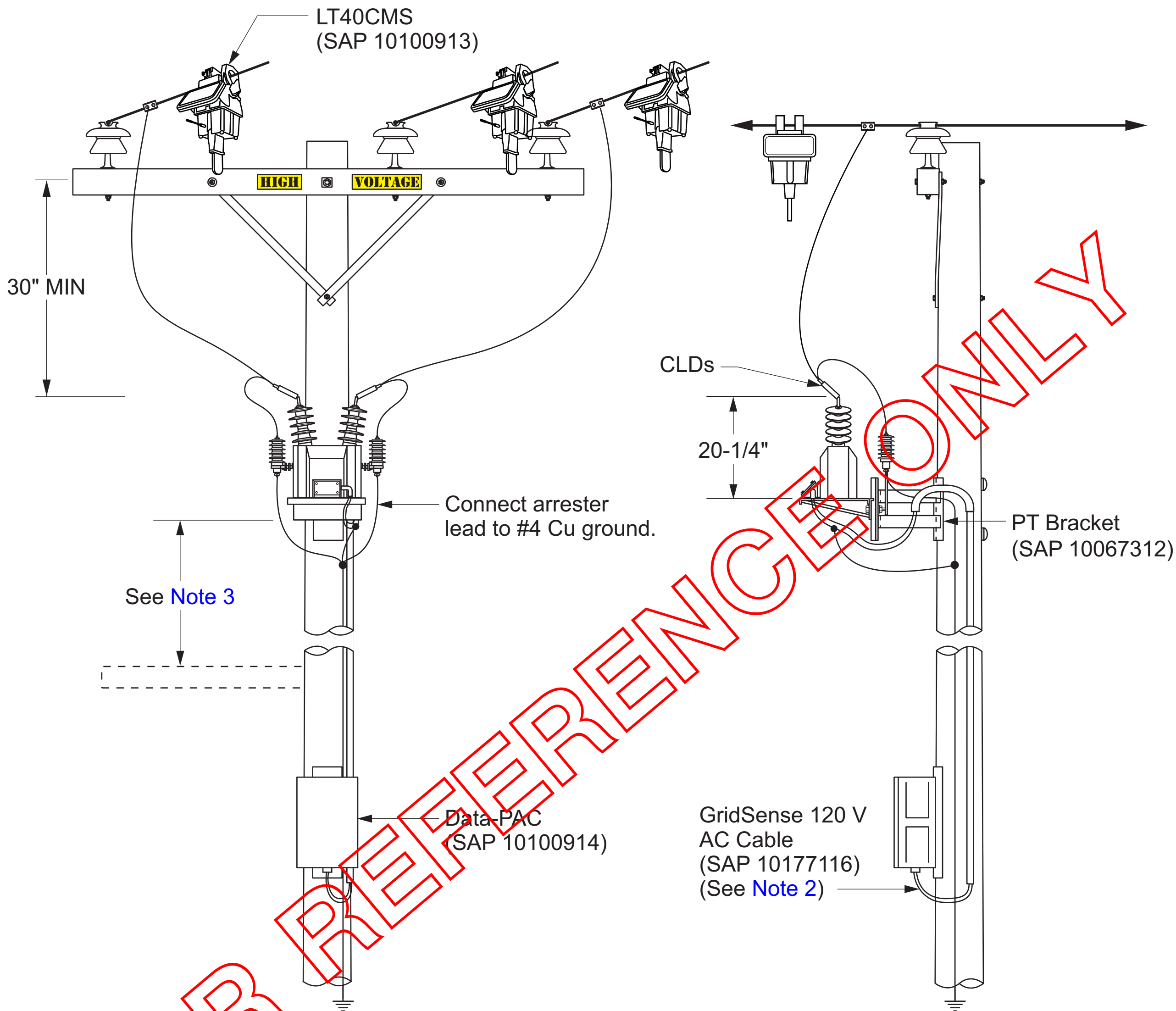
Figure AP 610–27: Providing Power to the Data-PAC Using Solar Power



Note(s):

1. Data-PAC (SAP 10100914) is to be installed no greater than 100 feet from the furthest of the LT40CMS units.
2. Place the Solar Panel (SAP 10177524) on the same side of the pole as the Data-PAC. Face the Solar Panel South if possible. The Solar panel measures 19-3/4" × 16-3/4" and weighs 7 pounds.
3. The Source Cable is to be covered in protective covering (PVC conduit), as required per G.O. 95.
4. Bottom of Data-PAC is to be a minimum of 8 feet from the ground level.
5. Data-PAC must be mounted on the same side of the pole that faces the LT40CMS units to ensure proper communication.

Figure AP 610–28: Providing Power to the Data-PAC Using a Potential Transformer



Note(s):

1. Data-PAC (SAP 10100914) is to be installed no greater than 100 feet from the furthest of the LT40CMS units.
2. The GridSense 120 VAC Cable is to be covered in protective covering (PVC conduit) as required per G.O. 95.
3. For secondary, maintain a minimum clearance of 10 inches from top of insulator to lowest point of PT bracket. For under built, maintain a minimum clearance of 3 feet from middle of crossarm to lowest point of PT bracket.
4. Bottom of Data-PAC to be a minimum of 8 feet from the ground level.
5. Data-PAC must be mounted on the same side of the pole that faces the LT40CMS units to ensure proper communication.

AP 712 Solar Powered Assembly with RRE — General Information

Scope AP 712.1 Typical Installation for Solar Powered Assembly with RRE on Wood Pole

Figure AP 712–1: Solar Powered Assembly with RRE

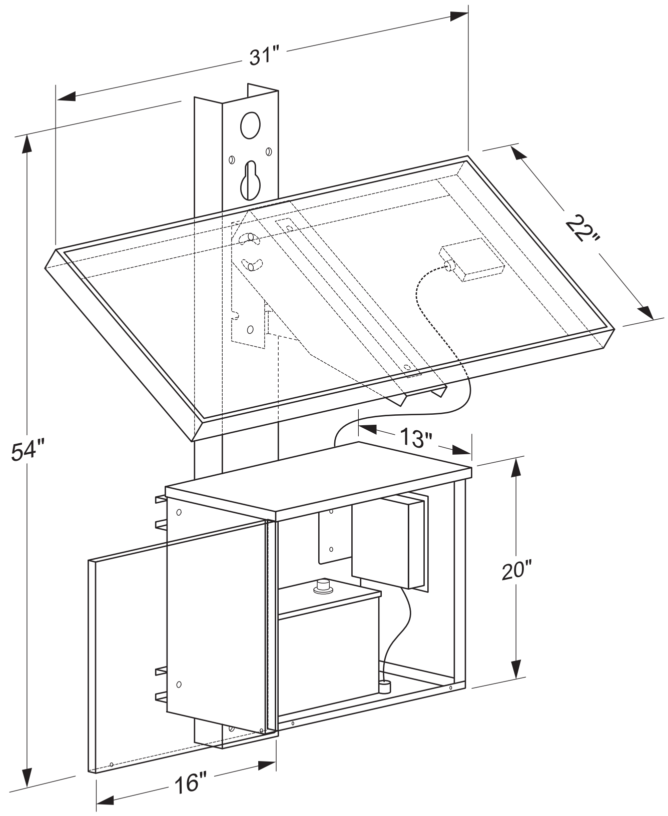
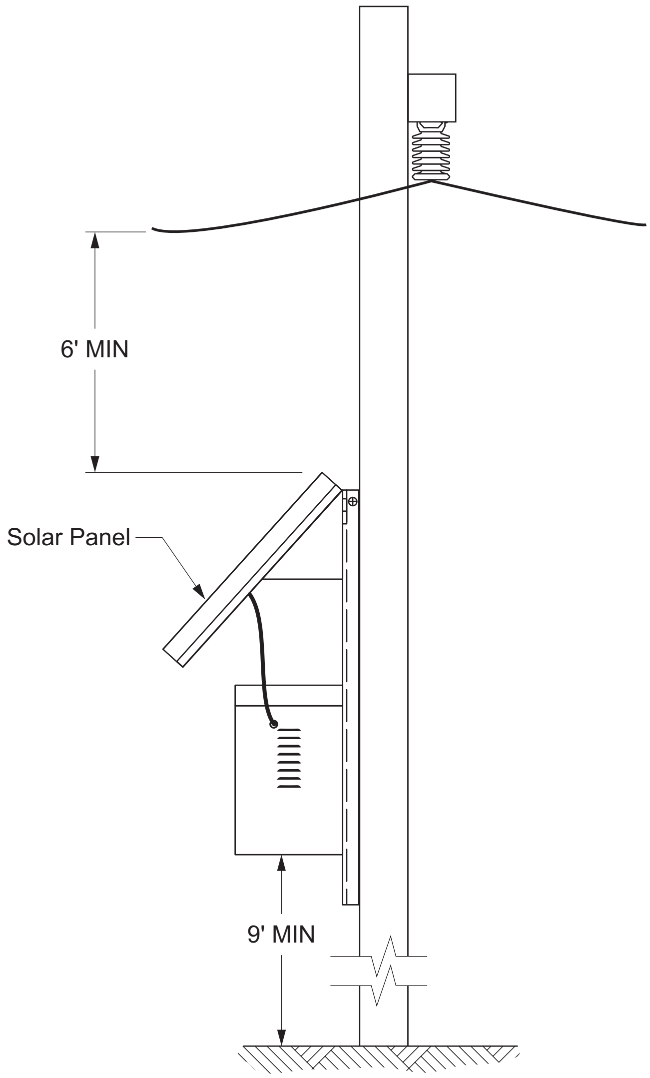


Figure AP 712–2: Solar Powered Assembly with RRE Mounted on Wood Pole



Note(s):

1. Install solar panel to maximize the southern exposure with an elevation of 55 degrees. When installed near vehicular traffic the equipment shall be placed at least 15-feet AGL minimum.
2. Maintain a minimum 6 feet clearance from bottom of the bracket to communication cables. If guard arm is installed, then the clearance may be reduced to 4 feet minimum for existing installations.
3. Distribution equipment shall not exist on the pole with the Solar Powered RRE.
4. Call the Grid Services Advanced Metering Operations (AMO) at (626) 543-6393 upon completion of installation to validate activation of device on the grid.

What's Changed? Figure AP 712–2 Note 1 was updated to include an elevation angle of 55 degrees.

Figure AP 712–3: Solar Powered Assembly with RRE Installation

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DOH–CC: Covered Conductor

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STANDARD **TITLE**

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CC 150 Covered Conductor Installation Materials and Equipment

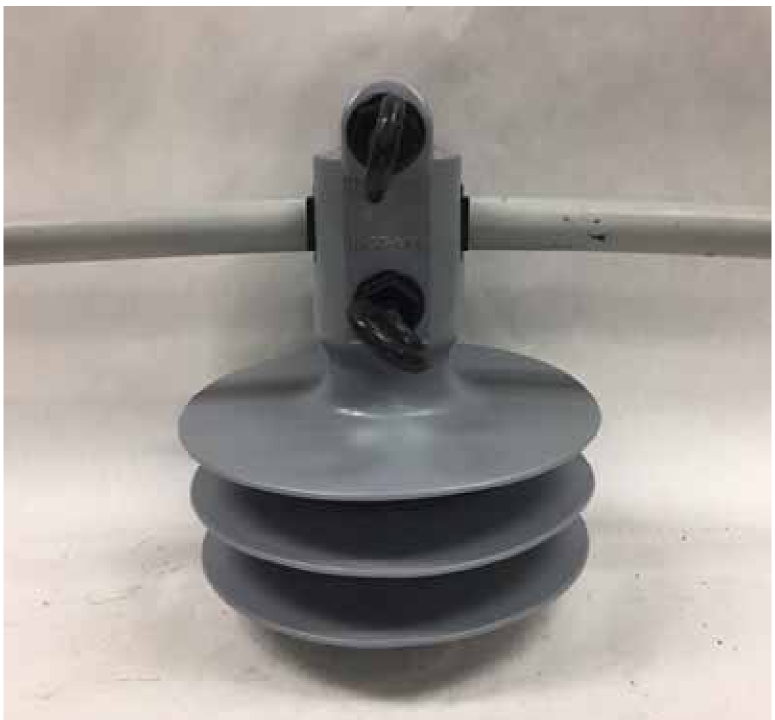
Scope CC 150.1 Covered Conductor Insulator

Vice-Top Polymer Pin-Type Line Insulators with Nylon Inserts are required for use with covered conductors. If covered conductors use equipment that has a different material than the covering, such as porcelain insulators or metallic inserts, the voltage gradient will cause tracking on the covering due to dielectric incompatibility. Tracking will erode the covering over time. To prevent damage on the covered conductor, polymer insulators and nylon inserts shall be used.

Do not strip the covering when installing the covered conductor on the insulator.

See Scope GR 200.5 for Polymer Pin-Type Line Insulators — Vice-Top, Nylon Inserts applications.

Figure CC 150–1: Covered Conductor on Vice-Top, Nylon Insert Insulator



Scope CC 150.2 Dead-Ending Covered Conductors

See CO 200 and CO 201 for dead-ending tables for wood crossarms and composite crossarms, respectively.

See CO 207 for dead-ending covered conductors.

See CO 211 and CO 212 for dead-ending wood crossarm and composite crossarm construction, respectively.

Dead-ends shall be covered with a Dead End Clamp in covered conductor systems. Covering dead-ends will ensure that stripped portions of the covered conductor at the dead-end will be protected from contact that could lead to phase-to-phase or phase-to-ground faults (see Table DC 535–1 for the Dead End Clamp).

Figure CC 150–2: 4-Wire Covered Conductor Dead-end Construction

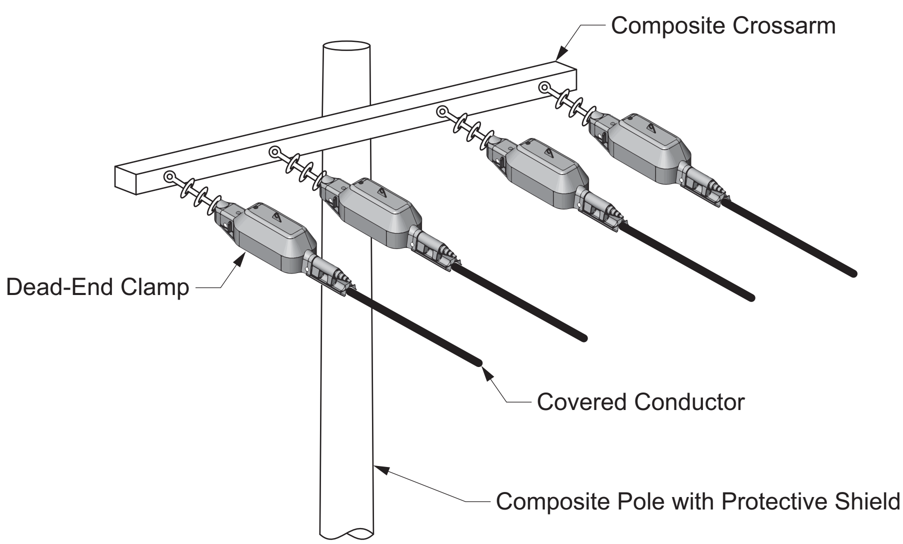
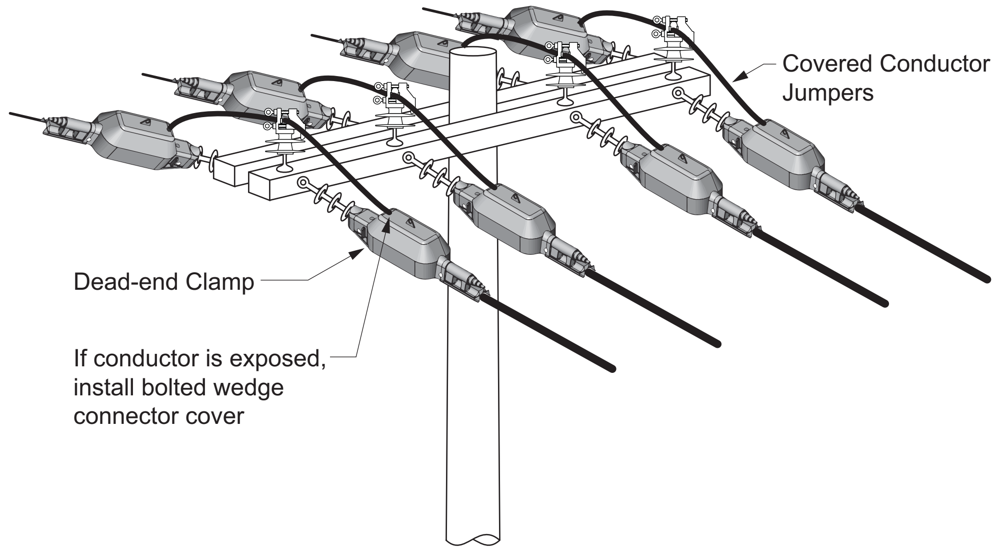


Figure CC 150–3: 4-Wire Covered Conductor Double Dead-end Construction



Scope CC 150.3 Covered Conductor Tap Connections

Bolted wedge connectors shall be used for tap connections in covered conductor systems. This includes overhead line taps, underground risers, and equipment taps.

Parallel grooves and hot line clamps shall not be used in covered conductor systems.

Bolted wedge connects shall be covered with a connector cover. See Table 420–1 for the connector cover appropriate for each size connector.

See CO 420 for Bolted Wedge Connector information.

Figure CC 150–4: Connector Cover Installed at Dead-End Tap

What's Changed? Added new scope detailing the use of the bolted wedge connector ONLY for covered conductor taps. Added new figure depicting connector cover.

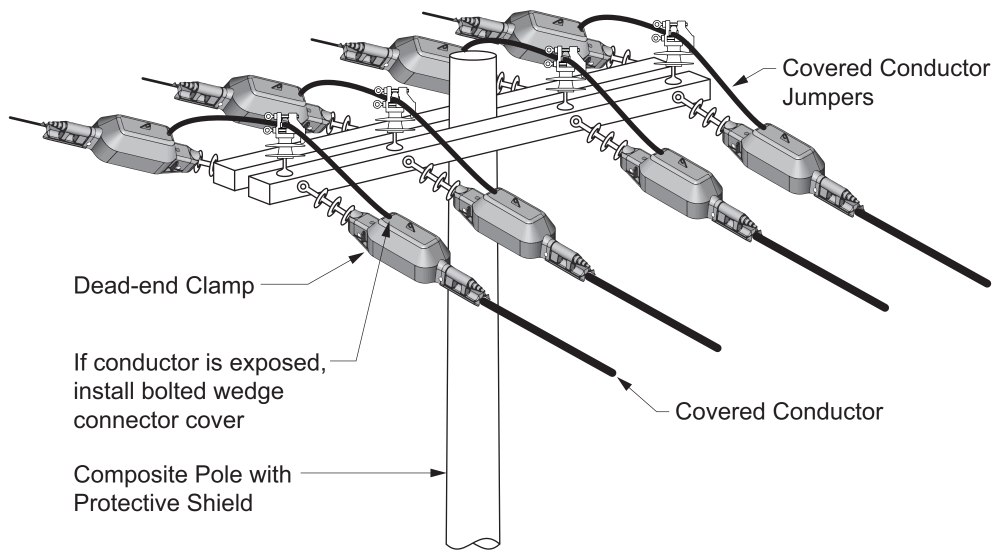
CC 180 Transitioning to Bare Wire

Scope CC 180.1 Transitioning from Covered Conductor to Bare Wire

Covered Conductors must be dead-ended at a dead-end pole when transitioning to bare wire. Splices are not to be used when transitioning from a covered conductor system to bare wire system.

If overhead equipment is located at a pole transition from bare wire to covered conductor, the equipment is considered part of the covered conductor system, therefore, surge arrester requirements for covered conductor systems apply (see CC 130).

Figure CC 180–1: Covered Conductor to Bare Wire Transition



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DOH–CO: Conductors and Splices

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CO 104 Distribution Conductors General Information

Scope CO 104.1 General Information for Copper and Aluminum Overhead Conductors

1.0 Standard Sizes

The following sizes of bare and covered copper and aluminum conductors are in general use by the Company for overhead distribution lines.

Due to the corrosive environment in the beach areas within ONE MILE of the ocean, only bare or covered copper conductor sizes 2/0 and smaller, greased bare ACSR conductor sizes 336.4 and larger should be used for overhead construction. Any specific area that experiences accelerated corrosion because of unique circumstances should contact Field Engineering for review.

1.1 Copper

A. Hard drawn, bare — Material Standard Specification No. 7

1. #6 and #4 solid
2. #4, #2, 2/0, and 4/0 stranded

B. THW Moisture Resistant

1. Soft drawn, #8 solid
2. Soft drawn, #6, #4, and #2 stranded
3. Soft drawn, 2/0 and 4/0 stranded

C. Triplex — Material Standard Specification No. 233

1. #6, #4, and #2

1.2 Aluminum

A. ACSR - Material Standard Specification No. 232

1. #4, 1/0, 336.4 kcmil, and 653.9 kcmil stranded

B. Weather-Resisting - Material Standard Specification No. 234, FOR REFERENCE ONLY

1. #6 solid
2. #2, 1/0, 4/0, 500 kcmil, and 750 kcmil stranded

C. Multiplex - Material Standard Specification No. 233

1. Duplex: #6 and #4 stranded
2. Triplex: #4, #2, 1/0, and 4/0 stranded
3. Quadruplex: #4, 1/0, and 4/0 stranded

D. CLP Insulated Cable - Material Standard Specification No. 238

1. 3-1/C: (2-#2, 1-#4); (2-1/0, 1-#2); (2-4/0, 1-1/0); (2-350, 1-4/0); (2-700, 1-350)
2. 4-1/C: (3-1/0, 1-#2); (3-4/0, 1-1/0); (3-350 kcmil, 1-4/0); (3-700 kcmil,1-350 kcmil)

2.0 Determination of Conductor Size

In order to determine the proper size of conductor to use, the following factors should be known:

1. Line voltage and number of phases
2. Total load to be supplied (including future)
3. Power factor of load
4. Length of line
5. Configuration and spacing of conductors
6. Permissible voltage drop

The proper size of conductor is determined by consideration of the above factors and also the "economic" loading of the conductors. The conductor must be capable of carrying presently-known load currents without excessive voltage drop. Just as important, the conductor should be capable of carrying the anticipated future loads. The recommended conductor size for the best "economic" loading is given in the Distribution Design Standards (DDS-2).

Bare wire shall be used on Primary Voltage circuits wherever practical. Covered wire should normally be used on secondary voltage circuits.

Bare and covered aluminum and copper wire shall not be installed adjacent to each other on the same end of a crossarm, but bare wire may be used on one end of the arm, and covered wire on the other end where the two classifications are separated by 30 inches. The minimum spacing for bare wire is 20 inches for spans up to 205 feet. (Exception: Spacing of less than 20 inches may be used in special cases.)

Note: Where copper and aluminum conductors are used on the same circuit, existing voltage drop tables do not apply.

3.0 Tie Wires

3.1 Aluminum

A. #4 through 336.4 kcmil ACSR aluminum conductors shall be protected by aluminum armor rod where the conductor is attached to pin or post-type insulators. Aluminum conductors shall be tied to insulators with special aluminum tie wire as shown in the CO Section.

Note: On ACSR conductor sizes #4 through 336.4 kcmil #4 aluminum tie wire shall be used.

B. 653.9 kcmil ACSR conductor shall be clamped to post-type insulators as shown in the CO Section, without armor rod.

Note: Exception: Where Universal Clamps and Covered Conductors are used.

3.2 Bare Copper Wire Solid or Stranded

A. On all bare copper conductors, solid or stranded, the tie wires shall be soft drawn copper wire purchased specifically for this purpose. The size and strength of the tie wire shall be #6 AWG soft drawn copper for conductor sizes #6 and #4, and #4 AWG soft drawn copper for conductor sizes #2 AWG and larger.

B. On High Voltage distribution lines, of over 5000 V phase-to-phase, conductors shall be tied to the insulators as shown in the CO Section. (See Index.)

C. On distribution lines of 5000 V or less phase-to-phase, conductors shall be tied to the insulators as shown in the CO Section.

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CO 106 Characteristics of Overhead Aluminum Conductor

Scope CO 106.1 Overhead Aluminum Conductor Physical and Electrical Properties

Standard Sizes and Uses

Table CO 106–1: Aluminum Conductor Steel Reinforced (ACSR)

Size AWG OR kcmil	Current Capacity (A)	Number of Strands	Copper Equivalent AWG OR kcmil	Overall Diameter (in)	Resistance (ohms/1,000 ft)	Ultimate Strength (lb)	Weight (lb/1,000 ft)	
							Ungreased	Greased
#4	160	6/1	6	0.250	0.4240	1,830	57.6	58.0
#2	210	6/1	4	0.316	0.2670	2,790	91.6	62.3
1/0	280	6/1	2	0.398	0.1680	4,280	145.6	146.8
4/0	415	6/1	2/0	0.563	0.0843	8,420	291.1	293.9
336.4	605	18/1	4/0	0.6835	0.0524	8,625	365.2	381.0
653.9	920	18/3	500	0.953	0.0267	14,850	677.0	709.0

Table CO 106–2: All-Aluminum Weather Resistant (WR), High Density (HD), and CLP Insulated Cable

Size AWG or kcmil	Current Capacity (A)	Number of Strands	Type Cover	Copper Equivalent AWG or kcmil	Overall Diameter (in)	Resistance (ohms/1,000 ft)	Ultimate Strength (lb)	Weight (lb/1,000 ft)	Standard Length (ft)
#6 Dupl.	80	1	HD	8	0.450	0.6610	1,170	73	500
#4 Dupl.	110	7	HD	6	0.565	0.4160	1,830	118	500
#6 Tripl.[2.]	80	1	HD	8	0.545	0.6610	1,170	112	500
#4 Tripl.	110	7	HD	6	0.640	0.4160	1,830	180	500
#2 Tripl.	145	7	HD	4	0.760	0.2667	2,790	270	500
1/0 Tripl.	190	7	HD	2	0.980	0.1677	4,280	431	1,000
4/0 Tripl.	300	19	HD	2/0	1.320	0.0836	8,420	812	1,000
#4 Quad.	100	7	HD	6	0.720	0.4160	1,830	238	1,000
1/0 Quad.	180	19	HD	2	1.120	0.1677	4,280	568	1,000
4/0 Quad.	275	19	HD	2/0	1.490	0.0836	8,420	812	1,000
#6[2.]	85	1	WR	8	0.256	0.6610	466	46	2,400
#2[2.]	140	7	WR	4	0.386	0.2667	1,090	105	1,000
1/0[2.]	190	7	WR	2	0.493	0.1677	1,775	171	3,100
4/0[2.]	280	7	WR	2/0	0.647	0.0836	3,475	306	1,800
500[2.]	490	37	WR	314	1.02	0.03468	9,010	684	1,000
750[2.]	640	61	WR	472	1.265	0.02312	13,520	1,002	1,000
4/0	280	19	CLP	2/0	0.684	0.0836	2,500	283	2,000
350	390	37	CLP	220	0.869	0.04955	4,030	452	1,500
700	610	61	CLP	440	1.182	0.2476	7,975	852	1,000

Note(s):

1. CLP cable is packaged 3-1/C for 3Ø and 4-1/C for 3Ø with neutral.
2. Conductor(s) no longer a Customer Service standard.
3. The tables above provide technical data for conductors only. The mention of “copper equivalent” is for ampacity purposes only. Mixed conductors (i.e. copper and ACSR) shall not be used within the same span.

Scope CO 106.2 Overhead Copper Conductor Physical and Electrical Properties

Table CO 106–3: Hard-Drawn Bare Copper Wire and Cable

Conductor Size		Current Capacity (A)	Number of Strands	Wire/Strand Diameter (in)	Overall Diameter (in)	Ultimate Strength (lb)	Conductor Weight (lb)		Feet Per Pound	AC Resistance Per 1,000 ft (ohms)
AWG	kcmil						Per 1,000 ft	Per Mile		
8	16.51	105	1	0.1285	0.1285	826	49.97	263.8	20.01	0.6443
6	26.25	140	1	0.1620	0.1620	1,280	79.46	419.6	12.584	0.4052
4	41.74	190	1	0.2043	0.2043	1,970	126.4	667.1	7.912	0.2548
4	41.74	200	3	0.1180	0.254	1,879	127.6	673.8	7.836	0.2574
4	41.74	195	7	0.0772	0.232	1,938	128.9	680.5	7.757	0.2599
2	66.37	260	7	0.0974	0.292	3,045	204.9	1,082	4.880	0.1635
2/0	133.1	405	7	0.1379	0.414	5,927	410.9	2,169	2.433	0.08166
4/0	211.6	540	7	0.1739	0.522	9,154	653.3	3,450	1.530	0.05149
—	250	600	19	0.1147	0.574	11,360	771.9	4,076	1.295	0.04365
—	350	740	19	0.1357	0.679	15,590	1,081	5,706	0.925	0.03135
—	500	920	37	0.1162	0.813	22,510	1,544	8,151	0.648	0.02219
—	750	1,175	61	0.1109	0.998	34,090	2,316	12,230	.0432	0.01520
—	1,000	1,430	61	0.1280	1.152	45,030	3,088	16,300	0.324	0.01179

Table CO 106–4: #8 to 1000 kcmil Soft-Drawn THW Wire and Cable

Conductor Size		Current Capacity (A)	Number of Strands	Wire/Strand Diameter (in)	Overall Diameter (in)	Ultimate Strength (lb)	Conductor Weight (lb)		Feet Per Pound	AC Resistance Per 1,000 ft (ohms)
AWG	kcmil						Per 1,000 ft	Per Mile		
8	16.51	65	1	0.1285	0.249	456	71	375	14.085	0.6443
6	26.25	95	7	0.0612	0.310	832	111	586	9.009	0.4100
4	41.74	125	7	0.0772	0.360	1,320	164	866	6.098	0.2590
2	66.37	170	7	0.0974	0.410	2,110	248	1,309	4.032	0.1620
2/0	133.1	265	19	0.0837	0.580	4,230	488	2,577	2.049	0.1020
4/0	211.6	360	19	0.1055	0.680	6,453	747	3,944	1.339	0.0509
—	250	405	37	0.0822	0.760	7,940	892	4,710	1.121	0.0433
—	300	445	37	0.0900	0.810	9,520	1,056	5,576	0.947	0.0362
—	500	620	37	0.1162	0.990	15,240	1,707	9,013	0.586	0.0220
—	750	785	61	0.1109	1.210	22,890	2,541	13,416	0.394	0.0150
—	1,000	935	61	0.1280	1.360	30,500	3,345	17,662	0.299	0.01152

Table CO 106–5: Triplex Secondary and Service Drop Wire; Copper Conductor and Copper Neutral

Conductor Size		Current Capacity (A)	Number of Strands	Wire/Strand Diameter (in)	Overall Diameter (in)	Ultimate Strength (lb)	Conductor Weight (lb)		Feet Per Pound	AC Resistance Per 1,000 ft (ohms)
AWG	kcmil						Per 1,000 ft	Per Mile		
6	26.25	95	7	0.0612	0.548	1,280	272	1,436	3.676	0.406
4	41.74	125	7	0.0772	0.646	1,938	427	2,255	2.342	0.254
2	66.37	170	7	0.0974	0.772	3,045	633	3,500	1.508	0.159

CAUTION **In using current capacities as shown above, the full capacity of the wire may be used only where voltage regulation does not require a large size conductor.**

Table CO 106–6: DOH ACSR Conductor Economic Loading — 4 kV, 12 kV, and 16 kV

Conductor Size (AWG or kcmil)	Conductor Economic Loading Range Based on Estimated Annual Peak Demand within Five Years (Amp)	Normal Operating Rating (Amp)	8-Hour Emergency Loading (Amp)
#4	0–55	160	205

= For Reference Only

Note(s):

1. ACSR conductor normal operating rating criteria:
   - Ambient temperature: 40°C
   - Conductor temperature: 90°C
   - Wind speed: 4 ft/s
   - Coefficient of emissivity: 0.5
   - Coefficient of solar absorption: 0.5
   - Latitude: 34°
   - Elevation of conductor above sea level: 0 ft
   - Atmosphere: clear
   - Local sun time: 1:00 p.m.

Table CO 106–7: DOH Copper Conductor Economic Loading — 4 kV, 12 kV, and 16 kV DOH ACSR Conductor Economic Loading — 4 kV, 12 kV, and 16 kV

Conductor Size (AWG or kcmil)	Forecasted Peak Load within 5 Years (Amp)	Normal Operating Rating (Amp)	8-Hour Emergency Loading (Amp)
#4	0–60	195	260

= For Reference Only

Note(s):

1. Stranded copper conductor thermal rating criteria:
   - Ambient temperature: 40°C
   - Conductor temperature: 85°C
   - Wind speed: 4 ft/s
   - Coefficient of emissivity: 0.5
   - Coefficient of solar absorption: 0.5
   - Latitude: 34°
   - Elevation of conductor above sea level: 0 ft
   - Atmosphere: clear
   - Local sun time: 1:00 p.m.

CO 168 Reduce Tension Span Sag Charts — Directions for Use

Scope CO 168.1 Directions for Use of Sag Charts

Unguyed (or Slack) Spans may be considered when the use of downguys or span guys is not feasible. The resultant (bending) moment created by the unguyed strain must be equaled or exceeded by the usable pole strength. A breast block and pole key (PO Section) must be installed on all unguyed dead-end and angle poles.

Reduced tension unguyed spans where the resultant moment exceeds either the usable pole strength or the pole key resisting moment based on the soil condition, the strain should be guyed or the resultant moment reduced. The moment may be reduced by reducing the height of the conductors while maintaining General Order 95 (G.O. 95) clearances.

Reduced tension guyed spans may be considered when a full tension down guy lead is not feasible (that is, easement issue, obstruction).

Three types of tables are presented in this section:

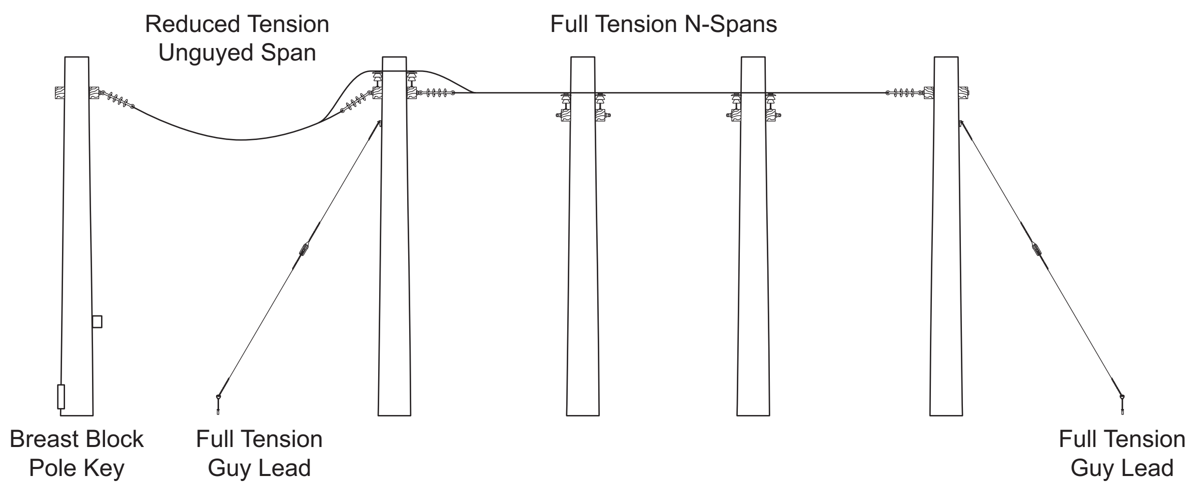
1.0 Sag Charts — These tables provide stringing sags for installation of conductors.

2.0 Stringing Tension Table — These tables provide stringing tensions for dynamometer use during covered conductor installations.

3.0 Span Tension Tables — These tables provide Guyed or Unguyed span tensions to be used for hand calculations. Unguyed span tensions are to be used for breast block and key load calculations. Guyed span tensions are to be used for down guy calculations.

Reduced tension Span Tensions have been determined by engineering in the following Tension Table and Figures. Table CO 168–36 and Table CO 168–40 are used to illustrate and document the values used in SPIDA. Only commonly used conductors and sizes are represented in the tables as examples, though all conductors and sizes are in SPIDA.

Figure CO 168–1: Reduced Tension Unguyed Span Example



What's Changed? Added new paragraph describing the difference between all tables presented in the section.

Figure CO 168–2: Reduced Tension Guyed Span Example

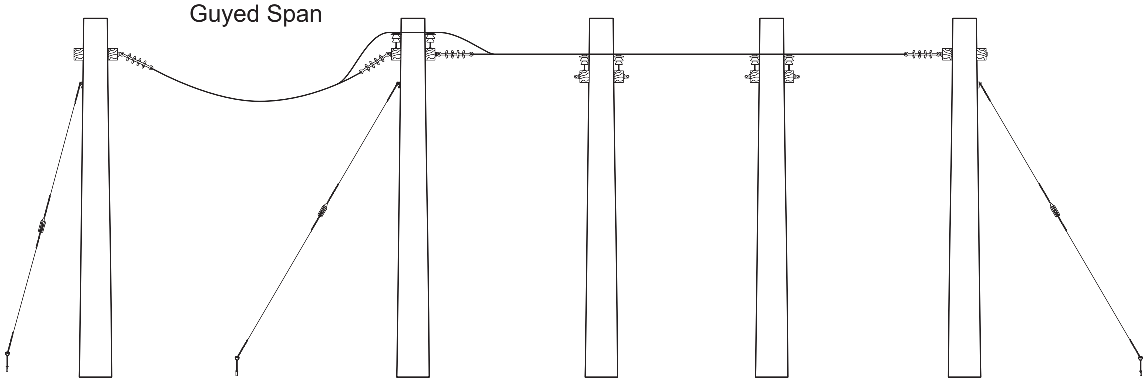


Table CO 168–1: Percent Full Tension of Conductor Light-Loading Areas

Bare ACSR Conductor			
	0–120 feet	121–160 feet	161–200 feet
Guyed new and existing	20%	20%	20%
Unguyed existing[a/]	10%	10%	—[b/]
Unguyed new	10%	N/A	N/A
Bare Copper Conductor			
	0–120 feet	121–160 feet	161–200 feet
Guyed new and existing	15%	30%	30%
Unguyed existing[b/]	15%	30%	—[b/]
Unguyed new	15%	N/A	N/A
ACSR MultiPlex Conductor			
	0–120 feet	121–160 feet	161–200 feet
Guyed new and existing	50%	50%	—[c/]
Unguyed existing[b/]	25%	50%	—[c/]
Unguyed new	25%	N/A	N/A

[a/] This includes existing construction that requires rebuilding or pole replacement. When practicable, consider adding a guy (reduced tension) to the pole or additional poles to reduce span lengths.

[b/] Unguyed existing and rebuild spans for all conductor sizes exceeding 160 feet shall be guyed and considered reduced tension guyed spans.

[c/] All multiplex conductor sizes exceeding 160 feet shall be full tension and guyed.

Note(s):

1. This table applies to reduced tension guyed and reduced tension unguyed spans. See Figure CO 168–1 and Figure CO 168–2, other deign configurations may apply.
2. ACSR and Copper Covered Conductors are not included in Table CO 168–1 because their reduced sags are calculated through a different method, making the information given in Table CO 168–1 not applicable.

Table CO 168–2: Percent Full Tension of Conductor Heavy — Loading Areas

Bare ACSR Conductor			
	Size	0–120 feet	121–160 feet
Guyed new and existing	#4 – 1/0	50%	50%
	336 – 653	25%	25%
Unguyed existing[a/]	#4 – 1/0	50%	50%
	336 – 653	25%	25%
Unguyed new	#4 – 1/0	50%	N/A
	336 – 653	25%	N/A
Bare Copper Conductor			
	Size	0–120 feet	121–160 feet
Guyed new and existing	#6 – #2	70%	70%
	2/0	40%	40%
	4/0	30%	30%
Unguyed existing[a/]	#6 – #2	70%	70%
	2/0	40%	40%
	4/0	30%	30%
Unguyed new	#6 – #2	70%	N/A
	2/0	40%	N/A
	4/0	30%	N/A
Aluminum Duplex (AD) and Aluminum Triplex (AT) Conductor			
	Size	0–120 feet	121–160 feet
Guyed new and existing	#6 AD – #2 AT	75%	75%
	1/0 AT	50%	50%
	4/0 AT	30%	30%
Unguyed existing and rebuild[a/]	#6 AD – #2 AT	75%	75%
	1/0 AT	50%	50%
	4/0 AT	30%	30%
Unguyed new	#6 AD – #2 AT	75%	N/A
	1/0 AT	50%	N/A
	4/0 AT	30%	N/A
Aluminum Quadruplex (AQ) Conductor			
	Size	0–120 feet	121–160 feet
Guyed new and existing	#4	75%	75%
	1/0	50%	50%
	4/0	30%	30%
Unguyed existing[a/]	#4	75%	75%
	1/0	50%	50%
	4/0	30%	30%
Unguyed new	#4	75%	N/A
	1/0	50%	N/A
	4/0	30%	N/A

[a/] This includes existing construction that requires rebuilding or pole replacement. When practicable, consider adding a guy (reduced tension) to the pole or additional poles to reduce span lengths.

Note(s):

1. This table applies to reduced tension guyed and reduced tension unguyed spans. See Figure CO 168–1 and Figure CO 168–2, other deign configurations may apply.
2. ACSR and Copper Covered Conductors are not included in Table CO 168–2 because their reduced sags are calculated through a different method, making the information given in Table CO 168–2 not applicable.

Scope CO 168.2 Sag Chart for New and Existing Reduced Tension Guyed Primary #4 — 653 ACSR for Light-Loading Areas

Table CO 168–3: Sag Chart for New and Existing Reduced Tension Guyed Primary #4 — 653 ACSR for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#4 ACSR[a/]	60	1'-0"	1'-2"
	80	1'-6"	1'-7"
	100	2'-0"	2'-6"
	120	3'-0"	3'-4"
	140	4'-0"	4'-1"
	160	5'-0"	5'-4"
	180	6'-0"	6'-6"
	200	7'-6"	8'-0"
1/0 ACSR	60	1'-0"	1'-2"
	80	1'-6"	1'-7"
	100	2'-0"	2'-6"
	120	2'-6"	2'-8"
	140	3'-0"	3'-6"
	160	3'-6"	4'-3"
	180	4'-6"	5'-4"
	200	5'-6"	6'-4"
336 ACSR	60	1'-0"	1'-2"
	80	1'-6"	1'-7"
	100	2'-0"	2'-6"
	120	2'-6"	2'-8"
	140	3'-0"	3'-6"
	160	3'-6"	4'-3"
	180	4'-6"	5'-4"
	200	5'-6"	6'-4"
653 ACSR	60	1'-0"	1'-2"
	80	1'-6"	2'-0"
	100	2'-0"	2'-6"
	120	3'-0"	3'-6"
	140	4'-0"	4'-6"
	160	5'-0"	5'-6"
	180	6'-0"	6'-8"
	200	7'-6"	8'-4"

[a/] Not approved for new construction.

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 Guyed Span Tensions

1.1 Conductor Tensions for Guying are 20 Percent of Full Tension for 0 to 200 Feet

- Conductor tension for guying #4 ACSR is 120 lb
- Conductor tension for guying 1/0 ACSR is 285 lb
- Conductor tension for guying 336 ACSR is 570 lb
- Conductor tension for guying 653 ACSR is 653 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.3 Sag Chart for New and Existing Reduced Tension Guyed Primary 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Table CO 168–4: Sag Chart for New and Existing Reduced Tension Guyed Primary 17 kV 1/0 — 653 ACSR Covered Conductors for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
1/0 ACSR	50	2'-0"	2'-1"
	75	3'-0"	3'-2"
	100	3'-5"	3'-9"
	125	4'-4"	4'-9"
	150	5'-2"	5'-8"
	175	6'-0"	6'-7"
	200	6'-9"	7'-7"
336 ACSR	50	2'-0"	2'-1"
	75	3'-0"	3'-2"
	100	3'-6"	3'-10"
	125	4'-4"	4'-10"
	150	5'-2"	5'-10"
	175	6'-0"	6'-10"
	200	6'-10"	7'-10"
653 ACSR	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-10"
	125	4'-4"	4'-10"
	150	5'-2"	5'-10"
	175	6'-0"	6'-10"
	200	6'-10"	7'-10"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–5: Stringing Tension Table for New and Existing Reduced Tension Guyed Primary 17 kV 1/0 — 653 ACSR Covered Conductors for Light-Loading Areas

Conductor Type	Span (ft)	Initial Tension 50–110°F	Final Tension (lb) 130°F
1/0 ACSR	50	45	43
	75	68	64
	100	104	95
	125	130	118
	150	156	142
	175	183	165
	200	210	189
336 ACSR	50	91	86
	75	136	127
	100	208	188
	125	261	232
	150	314	277
	175	367	323
	200	420	370
653 ACSR	50	154	144
	75	231	215
	100	353	320
	125	443	397
	150	533	474
	175	624	549
	200	715	626

Table CO 168–6: Sag Chart for New and Existing Reduced Tension Guyed Primary 35 kV 1/0 — 653 ACSR Covered Conductors for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
1/0 ACSR	50	2'-0"	2'-1"
	75	3'-0"	3'-2"
	100	3'-5"	3'-10"
	125	4'-3"	4'-9"
	150	5'-1"	5'-9"
	175	5'-11"	6'-8"
	200	6'-9"	7'-8"
336 ACSR	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-11"
	125	4'-4"	4'-11"
	150	5'-2"	5'-10"
	175	5'-10"	6'-8"
	200	6'-8"	7'-7"
653 ACSR	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-10"
	125	4'-4"	4'-10"
	150	5'-2"	5'-11"
	175	6'-0"	6'-10"
	200	6'-10"	7'-10"

Table CO 168–7: Stringing Tension Table for New and Existing Reduced Tension Guyed Primary 35 kV 1/0 — 653 ACSR Covered Conductors for Light-Loading Areas

Conductor Type	Span (ft)	Initial Tension	Final Tension (lb)
		50–110°F	130°F
1/0 ACSR	50	73	69
	75	110	102
	100	168	152
	125	211	190
	150	255	227
	175	299	265
	200	344	302
336 ACSR	50	127	119
	75	191	177
	100	292	259
	125	367	323
	150	442	388
	175	527	466
	200	605	533
653 ACSR	50	195	183
	75	294	273
	100	450	404
	125	565	501
	150	681	597
	175	798	697
	200	916	797

1.0 Guyed Span Tensions

Table CO 168–8: Guyed Span Tensions: 17 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	94
	75	140
	100	215
	125	267
	150	320
	175	371
	200	423
336 ACSR	50	148
	75	222
	100	342
	125	426
	150	511
	175	594
	200	678
653 ACSR	50	218
	75	326
	100	504
	125	629
	150	754
	175	878
	200	1002

Table CO 168–9: Guyed Span Tensions: 35 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	137
	75	204
	100	312
	125	387
	150	463
	175	537
	200	611
336 ACSR	50	198
	75	296
	100	456
	125	568
	150	680
	175	1506
	200	1708
653 ACSR	50	271
	75	406
	100	626
	125	782
	150	937
	175	1091
	200	1245

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.4 Sag Chart for New and Existing Reduced Tension Guyed Primary #6 — 4/0 Copper for Light-Loading Areas

Table CO 168–10: Sag Chart for New and Existing Reduced Tension Guyed Primary #6 — 4/0 Copper for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
#6 Copper	60	1'-6"	1'-8"
	80	2'-6"	2'-8"
	100	3'-6"	4'-0"
	120	5'-0"	6'-0"
	140	4'-0"	4'-2"
	160	5'-0"	5'-6"
	180	6'-0"	6'-10"
	200	7'-6"	8'-3"
#4 Copper	60	1'-6"	1'-6"
	80	2'-6"	2'-8"
	100	3'-6"	4'-0"
	120	5'-6"	5'-6"
	140	3'-6"	4'-0"
	160	4'-6"	4'-4"
	180	6'-0"	6'-6"
	200	7'-0"	7'-8"
#2 Copper	60	1'-6"	1'-7"
	80	2'-6"	2'-6"
	100	3'-6"	3'-7"
	120	4'-6"	5'-0"
	140	3'-6"	4'-0"
	160	4'-6"	5'-0"
	180	5'-6"	6'-0"
	200	6'-6"	7'-2"
2/0 Copper	60	1'-6"	1'-7"
	80	2'-0"	2'-1"
	100	3'-0"	3'-1"
	120	4'-6"	4'-7"
	140	3'-6"	3'-8"
	160	4'-0"	4'-6"
	180	5'-0"	5'-6"
	200	6'-0"	6'-6"
4/0 Copper	60	1'-6"	1'-6"
	80	2'-0"	2'-0"
	100	3'-0"	3'-1"
	120	4'-6"	4'-7"
	140	3'-6"	3'-8"
	160	4'-0"	4'-6"
	180	4'-6"	5'-6"
	200	6'-0"	6'-6"

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 Guyed Span Tensions

1.1 Conductor Tensions for Guying are 15 Percent of Full Tension for 60 to 120 Feet

- Conductor tension for guying #6 Copper is 45 lb
- Conductor tension for guying #4 Copper is 73 lb
- Conductor tension for guying #2 Copper is 115 lb
- Conductor tension for guying 2/0 Copper is 223 lb
- Conductor tension for guying 4/0 Copper is 345 lb

1.2 Conductor Tensions for Guying are 30 Percent of Full Tension for 121 to 200 Feet

- Conductor tension for guying #6 Copper is 90 lb
- Conductor tension for guying #4 Copper is 145 lb
- Conductor tension for guying #2 Copper is 228 lb
- Conductor tension for guying 2/0 Copper is 445 lb
- Conductor tension for guying 4/0 Copper is 685 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.5 Sag Chart for New and Existing Reduced Tension Guyed Primary #2 — 4/0 Copper Covered Conductor for Light Loading Areas

Table CO 168–11: Sag Chart for New and Existing Reduced Tension Guyed Primary 17 kV #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
#2 Copper	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-10"
	125	4'-4"	4'-9"
	150	5'-2"	5'-9"
	175	6'-0"	6'-8"
	200	6'-11"	7'-8"
2/0 Copper	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-10"
	125	4'-4"	4'-9"
	150	5'-3"	5'-9"
	175	6'-1"	6'-8"
	200	6'-11"	7'-8"
4/0 Copper	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-10"
	125	4'-4"	4'-9"
	150	5'-3"	5'-9"
	175	6'-1"	6'-8"
	200	6'-11"	7'-8"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–12: Stringing Tension Table for New and Existing Reduced Tension Guyed Primary 17 kV #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Tension (lb)	Final Tension (lb)
		50–110°F	130°F
#2 Copper	50	50	46
	75	75	70
	100	115	104
	125	144	130
	150	173	156
	175	202	182
	200	232	208
2/0 Copper	50	88	81
	75	132	122
	100	201	182
	125	251	228
	150	302	274
	175	352	319
	200	403	365
4/0 Copper	50	131	121
	75	196	182
	100	299	272
	125	374	340
	150	449	408
	175	524	476
	200	599	544

1.0 Guyed Span Tensions

Table CO 168–13: Guyed Span Tensions: 17 kV #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
#2 Copper	50	87
	75	130
	100	198
	125	247
	150	295
	175	343
	200	391
2/0 Copper	50	123
	75	184
	100	283
	125	353
	150	423
	175	492
	200	562
4/0 Copper	50	165
	75	248
	100	381
	125	476
	150	570
	175	665
	200	759

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.6 Sag Chart for New and Existing Reduced Tension Guyed #6 — 1/0 Aluminum Duplex and Triplex for Light-Loading Areas

Table CO 168–14: Sag Chart for New and Existing Reduced Tension Guyed #6 — 1/0 Aluminum Duplex and Triplex for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
#6 Aluminum Duplex	60	8"	1'-0"
	80	1'-2"	1'-7"
	100	1'-10"	2'-4"
	120	2'-9"	3'-4"
	140	3'-9"	4'-4"
	160	5'-0"	5'-6"
#4 Aluminum Duplex	60	6"-0"	1'-0"
	80	1'-0"	1'-6"
	100	1'-6"	2'-2"
	120	2'-4"	2'-10"
	140	3'-2"	3'-10"
	160	4'-0"	4'-10"
#4 Aluminum Triplex	60	8"-0"	1'-1"
	80	1'-2"	1'-9"
	100	1'-10"	2'-6"
	120	2'-9"	3'-4"
	140	3'-9"	4'-4"
	160	4'-10"	5'-6"
#2 Aluminum Triplex	60	10"-0"	1'-1"
	80	1'-4"	1'-10"
	100	2'-0"	2'-6"
	120	2'-10"	3'-6"
	140	3'-10"	4'-6"
	160	5'-0"	5'-6"
1/0 Aluminum Triplex	60	7"-0"	1'-0"
	80	1'-0"	1'-6"
	100	1'-6"	2'-2"
	120	2'-0"	2'-10"
	140	2'-10"	3'-8"
	160	3'-6"	4'-7"

1.0 Guyed Span Tensions

1.1 Conductor Tensions for Guying are 50 Percent of Full Tension for 0 to 160 Feet

- Conductor tension for guying #6 Aluminum Duplex is 193 lb
- Conductor tension for guying #4 Aluminum Duplex is 302 lb
- Conductor tension for guying #4 Aluminum Triplex is 302 lb
- Conductor tension for guying #2 Aluminum Triplex is 380 lb
- Conductor tension for guying 1/0 Aluminum Triplex is 707 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.7 Sag Chart for New and Existing Reduced Tension Guyed #4 — 4/0 Aluminum Quadruplex for Light-Loading Areas

Table CO 168–15: Sag Chart for New and Existing Reduced Tension Guyed #4 — 4/0 Aluminum Quadruplex for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#4 Aluminum Quadruplex	60	10"-0"	1'-3"
	80	1'-6"	2'-0"
	100	2'-3"	2'-10"
	120	3'-3"	3'-10"
	140	4'-4"	5'-0"
	160	5'-9"	6'-4"
#1/0 Aluminum Quadruplex	60	8"-0"	1'-4"
	80	1'-2"	1'-9"
	100	1'-9"	2'-6"
	120	2'-6"	3'-10"
	140	3'-6"	4'-2"
	160	4'-6"	5'-2"
#4/0 Aluminum Quadruplex	60	7"-0"	1'-0"
	80	1'-0"	1'-7"
	100	1'-6"	2'-3"
	120	2'-2"	3'-0"
	140	2'-10"	3'-9"
	160	3'-8"	4'-7"

1.0 Guying Span Tensions

1.1 Conductor Tensions for Guying are 50 Percent of Full Tension for 0 to 160 Feet

- Conductor tension for guying #4 Aluminum Quadruplex is 302 lb
- Conductor tension for guying 1/0 Aluminum Quadruplex is 707 lb
- Conductor tension for guying 4/0 Aluminum Quadruplex is 1,390 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.8 Sag Chart for New Reduced Tension Unguyed #4 — 653 ACSR for Light-Loading Areas

Table CO 168–16: Sag Chart for New Reduced Tension Unguyed #4 — 653 ACSR for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#4 ACSR[a/]	60	1'-6"	1'-8"
	80	2'-6"	2'-9"
	100	4'-0"	4'-1"
	120	5'-6"	5'-8"
1/0 ACSR	60	1'-6"	1'-7"
	80	2'-0"	2'-3"
	100	3'-0"	3'-3"
	120	4'-0"	4'-5"
336 ACSR	60	1'-6"	1'-7"
	80	2'-0"	2'-3"
	100	3'-0"	3'-3"
	120	4'-0"	4'-5"
653 ACSR	60	1'-6"	1'-9"
	80	2'-6"	2'-9"
	100	4'-0"	4'-1"
	120	5'-6"	5'-8"

[a/] Not approved for new construction.

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 New Unguyed Span Tensions

1.1 Conductor Tensions are 10 Percent of Full Tension for 0 to 120 Feet

- Conductor tension for #4 ACSR is 60 lb
- Conductor tension for 1/0 ACSR is 142 lb
- Conductor tension for 336 ACSR is 285 lb
- Conductor tension for 653 ACSR is 327 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.9 Sag Chart for New Reduced Tension Unguyed 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Table CO 168–17: Sag Chart for New Reduced Tension Unguyed 17 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
1/0 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-7"
	125	9'-4"	9'-6"
336 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
653 ACSR	50	3'-9"	3'-10"
	75	5'-8"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–18: Stringing Tension Table for New Reduced Tension Unguyed 17 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Tension	Final Tension
		50–110°F	130°F
1/0 ACSR	50	24	24
	75	36	36
	100	49	48
	125	61	60
336 ACSR	50	49	48
	75	74	72
	100	98	96
	125	123	120
653 ACSR	50	83	82
	75	125	123
	100	167	163
	125	208	204

Table CO 168–19: Sag Chart for New Reduced Tension Unguyed 35 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
1/0 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-7"
	125	9'-4"	9'-6"
336 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
653 ACSR	50	3'-9"	3'-10"
	75	5'-8"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"

Table CO 168–20: Stringing Tension Table for New Reduced Tension Unguyed 35 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Tension 50–110°F	Final Tension 130°F
1/0 ACSR	50	39	39
	75	59	58
	100	79	77
	125	98	96
336 ACSR	50	69	68
	75	103	101
	100	137	135
	125	172	168
653 ACSR	50	106	104
	75	159	156
	100	212	207
	125	265	259

1.0 New Unguyed Span Tensions

Table CO 168–21: New Unguyed Span Tensions: 17 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	49
	75	74
	100	99
	125	124
336 ACSR	50	77
	75	116
	100	155
	125	194
653 ACSR	50	114
	75	171
	100	227
	125	284

Table CO 168–22: New Unguyed Span Tensions: 35 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	72
	75	108
	100	144
	125	180
336 ACSR	50	104
	75	155
	100	207
	125	259
653 ACSR	50	142
	75	212
	100	283
	125	354

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.10 Sag Chart for New Reduced Tension Unguyed #6 — 4/0 Copper for Light-Loading Areas

Table CO 168–23: Sag Chart for New Reduced Tension Unguyed #6 — 4/0 Copper for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
#6 Copper	60	1'-6"	1'-8"
	80	2'-6"	2'-8"
	100	3'-6"	4'-0"
	120	5'-0"	6'-0"
#4 Copper	60	1'-6"	1'-6"
	80	2'-6"	2'-8"
	100	3'-6"	4'-0"
	120	5'-6"	5'-6"
#2 Copper	60	1'-6"	1'-7"
	80	2'-6"	2'-6"
	100	3'-6"	3'-7"
	120	4'-6"	5'-0"
2/0 Copper	60	1'-6"	1'-7"
	80	2'-0"	2'-1"
	100	3'-0"	3'-1"
	120	4'-6"	4'-7"
4/0 Copper	60	1'-6"	1'-6"
	80	2'-0"	2'-0"
	100	3'-0"	3'-1"
	120	4'-6"	4'-7"

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 New Unguyed Span Tensions

1.1 Conductor Tensions are 15 Percent of Full Tension for 0 to 120 Feet

- Conductor tension for #6 Copper is 45 lb
- Conductor tension for #4 Copper is 73 lb
- Conductor tension for #2 Copper is 115 lb
- Conductor tension for 2/0 Copper is 223 lb
- Conductor tension for 4/0 Copper is 345 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.11 Sag Chart for New Reduced Tension Unguyed #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Table CO 168–24: Sag Chart for New Reduced Tension Unguyed 17 kV #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#2 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
2/0 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
2/0 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–25: Stringing Tension Table for New Reduced Tension Unguyed 17 kV #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Tension	Final Tension
		50–110°F	130°F
#2 Copper	50	27	26
	75	41	40
	100	54	53
	125	68	66
2/0 Copper	50	47	46
	75	71	70
	100	95	93
	125	119	116
2/0 Copper	50	71	69
	75	106	104
	100	141	138
	125	177	173

1.0 New Unguyed Span Tensions

Table CO 168–26: New Unguyed Span Tensions: 17 kV #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
#2 Copper	50	46
	75	69
	100	92
	125	114
2/0 Copper	50	65
	75	97
	100	130
	125	162
4/0 Copper	50	87
	75	131
	100	174
	125	218

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.12 Sag Chart for New Reduced Tension Unguyed #6 — 1/0 Aluminum Duplex and Triplex for Light-Loading Areas

Table CO 168–27: Sag Chart for New Reduced Tension Unguyed #6 — 1/0 Aluminum Duplex and Triplex for Light- Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#6 Aluminum Duplex	60	1'-6"	1'-8"
	80	2'-6"	2'-10"
	100	4'-0"	4'-6"
	120	5'-6"	6'-0"
#4 Aluminum Duplex	60	1'-6"	1'-7"
	80	2'-6"	2'-6"
	100	3'-6"	3'-7"
	120	4'-6"	5'-0"
#4 Aluminum Triplex	60	1'-6"	1'-8"
	80	2'-6"	2'-7"
	100	4'-0"	4'-2"
	120	5'-6"	6'-0"
#2 Aluminum Triplex	60	1'-6"	1'-8"
	80	2'-6"	4'-0"
	100	4'-0"	4'-2"
	120	5'-6"	6'-0"
1/0 Aluminum Triplex	60	1'-6"	1'-7"
	80	2'-0"	2'-2"
	100	3'-0"	3'-3"
	120	4'-0"	4'-6"

1.0 New Unguyed Span Tensions

1.1 Conductor Tensions are 25 Percent of Full Tension for 0 to 120 Feet

- Conductor tension for #6 Aluminum Duplex is 97 lb
- Conductor tension for #4 Aluminum Duplex is 150 lb
- Conductor tension for #4 Aluminum Triplex is 150 lb
- Conductor tension for #2 Aluminum Triplex is 355 lb
- Conductor tension for 1/0 Aluminum Triplex is 695 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.13 Sag Chart for New Reduced Tension Unguyed #4 — 4/0 Aluminum Quadruplex for Light-Loading Areas

Table CO 168–28: Sag Chart for New Reduced Tension Unguyed #4 — 4/0 Aluminum Quadruplex for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#4 Aluminum Quadruplex	60	1'-6"	1'-10"
	80	3'-0"	3'-2"
	100	4'-6"	4'-8"
	120	6'-6"	6'-10"
#1/0 Aluminum Quadruplex	60	1'-0"	1'-7"
	80	2'-6"	2'-7"
	100	3'-5"	3'-9"
	120	5'-0"	5'-3"
#4/0 Aluminum Quadruplex	60	1'-6"	1'-7"
	80	2'-0"	2'-3"
	100	3'-0"	3'-3"
	120	4'-0"	4'-5"

1.0 New Unguyed Span Tensions

1.1 Conductor Tensions are 25 Percent of Full Tension for 0 to 120 Feet

- Conductor tension for #4 Aluminum Quadruplex is 150 lb
- Conductor tension for 1/0 Aluminum Quadruplex is 355 lb
- Conductor tension for 4/0 Aluminum Quadruplex is 695 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.14 Sag Chart for Existing and Rebuild Reduced Tension Unguyed #4 — 653 ACSR for Light-Loading Areas

Table CO 168–29: Sag Chart for Existing and Rebuild Reduced Tension Unguyed #4 — 653 ACSR for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#4 ACSR[a/]	60	1'-6"	1'-8"
	80	2'-6"	2'-9"
	100	4'-0"	4'-1"
	120	5'-6"	5'-8"
	140	7'-6"	7'-7"
	160	9'-6"	9'-7"
1/0 ACSR	60	1'-6"	1'-7"
	80	2'-0"	2'-3"
	100	3'-0"	3'-3"
	120	4'-0"	4'-5"
	140	5'-6"	5'-8"
	160	7'-0"	7'-2"
336 ACSR	60	1'-6"	1'-7"
	80	2'-0"	2'-3"
	100	3'-0"	3'-3"
	120	4'-0"	4'-5"
	140	5'-6"	5'-7"
	160	7'-0"	7'-2"
653 ACSR	60	1'-6"	1'-9"
	80	2'-6"	2'-9"
	100	4'-0"	4'-1"
	120	5'-6"	5'-8"
	140	7'-0"	7'-2"
	160	9'-6"	9'-8"

[a/] Not approved for new construction.

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 Existing and Rebuild Unguyed Span Tensions

1.1 Conductor Tensions are 10 Percent of Full Tension for 0 to 160 Feet

- Conductor tension for #4 ACSR is 60 lb
- Conductor tension for 1/0 ACSR is 142 lb
- Conductor tension for 336 ACSR is 285 lb
- Conductor tension for 653 ACSR is 327 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.15 Sag Chart for Existing and Rebuild Reduced Tension Unguyed 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Table CO 168–30: Sag Chart for Existing and Rebuild Reduced Tension Unguyed 17 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
1/0 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-7"
	125	9'-4"	9'-6"
	150	10'-10"	11'-1"
	175	12'-2"	12'-6"
336 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-1"
	175	12'-3"	12'-7"
653 ACSR	50	3'-9"	3'-10"
	75	5'-8"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-7"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–31: Stringing Tension Table for Existing and Rebuild Reduced Tension Unguyed 17 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Tension (lb)	Final Tension (lb)
		50–110°F	130°F
1/0 ACSR	50	24	24
	75	36	36
	100	49	48
	125	61	60
	150	75	74
	175	91	89
336 ACSR	50	49	48
	75	74	72
	100	98	96
	125	123	120
	150	152	149
	175	184	179
653 ACSR	50	83	82
	75	125	123
	100	167	163
	125	208	204
	150	258	252
	175	312	304

Table CO 168–32: Sag Chart for Existing and Rebuild Reduced Tension Unguyed 35 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
1/0 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-7"
	125	9'-4"	9'-6"
	150	10'-10"	11'-1"
	175	12'-2"	12'-6"
336 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-8"
653 ACSR	50	3'-9"	3'-10"
	75	5'-8"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-7"

What's Changed? Added "Stringing" in table title for clarity.

Table CO 168–33: Stringing Tension Table for Existing and Rebuild Reduced Tension Unguyed 35 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Tension (lb)	Final Tension (lb)
		50–110°F	130°F
1/0 ACSR	50	39	39
	75	59	58
	100	79	77
	125	98	96
	150	122	119
	175	147	144
336 ACSR	50	103	101
	75	137	135
	100	172	168
	125	213	207
	150	257	249
	175	103	101
653 ACSR	50	106	104
	75	159	156
	100	212	207
	125	265	259
	150	328	320
	175	397	385

What's Changed? Added "Stringing" in table title for clarity.

1.0 Existing and Rebuild Unguyed Span Tension

Table CO 168–34: Existing and Rebuild Unguyed Span Tensions: 17 kV 1/0 — 653 ACSR Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	49
	75	74
	100	99
	125	124
	150	153
	175	185
336 ACSR	50	77
	75	116
	100	155
	125	194
	150	240
	175	290
653 ACSR	50	114
	75	171
	100	227
	125	284
	150	353
	175	426

Table CO 168–35: Existing and Rebuild Unguyed Span Tensions: 35 kV 1/0 Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	72
	75	108
	100	144
	125	180
	150	223
	175	269
336 ACSR	50	104
	75	155
	100	207
	125	259
	150	321
	175	387
653 ACSR	50	142
	75	212
	100	283
	125	354
	150	439
	175	530

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.16 Sag Chart for Existing and Rebuild Reduced Tension Unguyed #6 — 4/0 Copper for Light-Loading Areas

Table CO 168–36: Sag Chart for Existing and Rebuild Reduced Tension Unguyed #6 — 4/0 Copper for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#6 Copper	60	1'-6"	1'-8"
	80	2'-6"	2'-8"
	100	3'-6"	4'-0"
	120	5'-0"	6'-0"
	140	4'-0"	4'-2"
	160	5'-0"	5'-6"
#4 Copper	60	1'-6"	1'-6"
	80	2'-6"	2'-8"
	100	3'-6"	4'-0"
	120	5'-6"	5'-6"
	140	3'-6"	4'-0"
	160	4'-6"	5'-4"
#2 Copper	60	1'-6"	1'-7"
	80	2'-6"	2'-6"
	100	3'-6"	3'-7"
	120	4'-6"	5'-0"
	140	3'-6"	4'-0"
	160	4'-6"	5'-0"
2/0 Copper	60	1'-6"	1'-7"
	80	2'-0"	2'-1"
	100	3'-0"	3'-1"
	120	4'-6"	4'-7"
	140	3'-6"	3'-8"
	160	4'-0"	4'-6"
4/0 Copper	60	1'-6"	1'-6"
	80	2'-0"	2'-0"
	100	3'-0"	3'-1"
	120	4'-6"	4'-7"
	140	3'-6"	3'-8"
	160	4'-0"	4'-6"

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 Existing and Rebuild Unguyed Span Tensions

1.1 Conductor Tensions are 15 Percent of Full Tension for 60 to 120 Feet

- Conductor tension for #6 Copper is 45 lb
- Conductor tension for #4 Copper is 73 lb
- Conductor tension for #2 Copper is 115 lb
- Conductor tension for 2/0 Copper is 223 lb
- Conductor tension for 4/0 Copper is 345 lb

1.2 Conductor Tensions are 30 Percent of Full Tension for 121 to 200 Feet

- Conductor tension for #6 Copper is 90 lb
- Conductor tension for #4 Copper is 145 lb
- Conductor tension for #2 Copper is 228 lb
- Conductor tension for 2/0 Copper is 445 lb
- Conductor tension for 4/0 Copper is 685 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.17 Sag Chart for Existing and Rebuild Reduced Tension Unguyed #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Table CO 168–37: Sag Chart for Existing and Rebuild Reduced Tension Unguyed 17 kV #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	**130°F**
#2 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-7"
2/0 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-7"
4/0 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-7"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–38: Stringing Tension Table for Existing and Rebuild Reduced Tension Unguyed 17 kV #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Initial Tension (lb)	Final Tension (lb)
		50–110°F	130°F
#2 Copper	50	27	26
	75	41	40
	100	54	53
	125	68	66
	150	84	82
	175	101	99
2/0 Copper	50	47	46
	75	71	70
	100	95	93
	125	119	116
	150	147	144
	175	177	173
4/0 Copper	50	71	69
	75	106	104
	100	141	138
	125	177	173
	150	219	214
	175	264	258

What's Changed? Added "Stringing" in table title for clarity.

1.0 Existing and Rebuild Unguyed Span Tension

Table CO 168–39: Sag Chart for Existing and Rebuild Reduced Tension Unguyed 17 kV #2 — 4/0 Copper Covered Conductor for Light-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
#2 Copper	50	46
	75	69
	100	92
	125	114
	150	142
	175	171
2/0 Copper	50	65
	75	97
	100	130
	125	162
	150	201
	175	243
4/0 Copper	50	87
	75	131
	100	174
	125	218
	150	270
	175	326

2.0 Ground Clearances

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.18 Sag Chart for Existing and Rebuild Reduced Tension Unguyed #6 — 4/0 Aluminum Duplex and Triplex for Light-Loading Areas

Table CO 168–40: Sag Chart for Existing and Rebuild Reduced Tension Unguyed #6 — 4/0 Aluminum Duplex and Triplex for Light-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
#6 Aluminum Duplex	60	1'-6"	1'-8"
	80	2'-6"	2'-10"
	100	4'-0"	4'-6"
	120	5'-6"	6'-0"
	140	3'-10"	4'-4"
	160	5'-0"	5'-7"
#4 Aluminum Duplex	60	1'-6"	1'-7"
	80	2'-6"	2'-6"
	100	3'-6"	3'-7"
	120	4'-6"	5'-0"
	140	3'-0"	3'-10"
	160	4'-0"	4'-10"
#4 Aluminum Triplex	60	1'-6"	1'-8"
	80	2'-6"	2'-7"
	100	4'-0"	4'-2"
	120	5'-6"	6'-0"
	140	3'-8"	4'-4"
	160	4'-10"	5'-6"
#2 Aluminum Triplex	60	1'-6"	1'-8"
	80	2'-6"	4'-0"
	100	4'-0"	4'-2"
	120	5'-6"	6'-0"
	140	3'-10"	4'-2"
	160	5'-0"	5'-7"
1/0 Aluminum Triplex	60	7"-0"	1'-0"
	80	1'-0"	1'-6"
	100	1'-6"	2'-2"
	120	2'-0"	2'-10"
	140	2'-10"	3'-8"
	160	3'-6"	4'-7"
1/0 Aluminum Duplex	60	1'-6"	1'-7"
	80	2'-0"	2'-2"
	100	3'-0"	3'-3
	120	4'-0"	4'-6"
	140	2'-10"	3'-8"
	160	3'-7"	4'-7"
4/0 Aluminum Duplex	60	1'-0"	1'-3"
	80	1'-6"	2'-0"
	100	2'-6"	2'-9"
	120	3'-6"	3'-8"
	140	2'-3"	3'-4"
	160	3'-0"	4'-0"

1.0 Existing and Rebuild Unguyed Span Tensions

1.1 Conductor Tensions are 25 Percent of Full Tension for 0 to 120 Feet

- Conductor tension for #6 Aluminum Duplex is 97 lb
- Conductor tension for #4 Aluminum Duplex is 150 lb
- Conductor tension for #4 Aluminum Triplex is 150 lb
- Conductor tension for #2 Aluminum Triplex is 190 lb
- Conductor tension for 1/0 Aluminum Triplex is 355 lb
- Conductor tension for 4/0 Aluminum Triplex is 695 lb

1.2 Conductor Tensions are 50 Percent of Full Tension for 121 to 160 Feet

- Conductor tension for #6 Aluminum Duplex is 193 lb
- Conductor tension for #4 Aluminum Duplex is 302 lb
- Conductor tension for #4 Aluminum Triplex is 302 lb
- Conductor tension for #2 Aluminum Triplex is 380 lb
- Conductor tension for 1/0 Aluminum Triplex is 707 lb
- Conductor tension for 4/0 Aluminum Triplex is 1,390 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.19 Sag Chart for New and Existing Reduced Tension Guyed #4 — 653 ACSR for Heavy-Loading Areas

Table CO 168–41: Sag Chart for New and Existing Reduced Tension Guyed #4 — 653 ACSR for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
#4 ACSR[a/]	60	1'-3"	1'-6"
	80	2'-2"	2'-6"
	100	3'-6"	3'-7"
	120	4'-10"	5'-2"
	140	6'-10"	7'-0"
	160	8'-9"	9'-0"
#2 ACSR[a/]	60	1'-3"	1'-6"
	80	2'-0"	2'-4"
	100	3'-0"	3'-4"
	120	4'-5"	4'-7"
	140	5'-10"	6'-2"
	160	7'-8"	8'-0"
1/0 ACSR	60	1'-0"	1'-1"
	80	1'-2"	1'-6"
	100	1'-10"	2'-4"
	120	2'-7"	3'-0"
	140	3'-6"	4'-0"
	160	4'-7"	5'-0"
336 ACSR	60	1'-3"	1'-6"
	80	2'-0"	2'-4"
	100	2'-10"	3'-3"
	120	4'-0"	4'-5"
	140	5'-4"	5'-8"
	160	6'-8"	7'-2"
653 ACSR	60	1'-6"	1'-9"
	80	2'-3"	2'-6"
	100	3'-4"	3'-7"
	120	5'-6"	5'-8"
	140	6'-0"	6'-5"
	160	7'-0"	8'-2"

[a/] Not approved for new construction.

Note(s):

1. a/Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 Guyed Span Tensions

1.1 Conductor Tensions for Guying are 50 Percent of Full Tension for 0 to 160 Feet
- Conductor tension for guying #4 ACSR is 302 lb
- Conductor tension for guying #2 ACSR is 380 lb
- Conductor tension for guying 1/0 ACSR is 707 lb

1.2 Conductor Tensions for Guying are 25 Percent of Full Tension for 0 to 160 Feet
- Conductor tension for guying 336 ACSR is 710 lb
- Conductor tension for guying 653 ACSR is 815 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.20 Sag Chart for New and Existing Reduced Tension Guyed 1/0— 653 ACSR Covered Conductor for Heavy-Loading Areas

Table CO 168–42: Sag Chart for New and Existing Reduced Tension Guyed 17 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
1/0 ACSR	50	2'-0"	2'-1"
	75	3'-0"	3'-2"
	100	3'-5"	3'-9"
	125	4'-4"	4'-9"
	150	5'-2"	5'-8"
	175	6'-0"	6'-7"
336 ACSR	50	2'-0"	2'-1"
	75	3'-0"	3'-2"
	100	3'-6"	3'-10"
	125	4'-4"	4'-10"
	150	5'-2"	5'-10"
	175	6'-0"	6'-10"
653 ACSR	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-10"
	125	4'-4"	4'-10"
	150	5'-2"	5'-10"
	175	6'-0"	6'-10"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–43: Stringing Tension Table for New and Existing Reduced Tension Guyed 17 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Tension (lb)	Final Tension (lb)
		50–110°F	130°F
1/0 ACSR	50	45	43
	75	68	64
	100	104	95
	125	130	118
	150	156	142
	175	183	165
336 ACSR	50	91	86
	75	136	127
	100	208	188
	125	261	232
	150	314	277
	175	367	323
653 ACSR	50	154	144
	75	231	215
	100	353	320
	125	443	397
	150	533	474
	175	624	549

Table CO 168–44: Sag Chart for New and Existing Reduced Tension Guyed 35 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
1/0 ACSR	50	2'-0"	2'-1"
	75	3'-0"	3'-2"
	100	3'-5"	3'-10"
	125	4'-3"	4'-9"
	150	5'-1"	5'-9"
	175	5'-11"	6'-8"
336 ACSR	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-11"
	125	4'-4"	4'-11"
	150	5'-2"	5'-10"
	175	5'-10"	6'-8"
653 ACSR	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-10"
	125	4'-4"	4'-10"
	150	5'-2"	5'-11"
	175	6'-0"	6'-10"

Table CO 168–45: Stringing Tension Table for New and Existing Reduced Tension Guyed 35 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Tension (lb)	Final Tension (lb)
		50–110°F	130°F
1/0 ACSR	50	73	69
	75	110	102
	100	168	152
	125	211	190
	150	255	227
	175	299	265
336 ACSR	50	127	119
	75	191	177
	100	292	259
	125	367	323
	150	442	388
	175	527	466
653 ACSR	50	195	183
	75	294	273
	100	450	404
	125	565	501
	150	681	597
	175	798	697

What's Changed? Added "Stringing" in table title for clarity.

1.0 Guyed Span Tensions

Table CO 168–46: Guyed Span Tensions: 17 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	229
	75	340
	100	514
	125	633
	150	750
	175	864
336 ACSR	50	313
	75	467
	100	719
	125	892
	150	1062
	175	1230
653 ACSR	50	414
	75	617
	100	958
	125	1191
	150	1422
	175	1651

Table CO 168–47: Guyed Span Tensions: 35 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	291
	75	431
	100	648
	125	798
	150	943
	175	1086
336 ACSR	50	386
	75	575
	100	883
	125	1094
	150	1302
	175	1506
653 ACSR	50	491
	75	732
	100	1135
	125	1410
	150	1683
	175	1952

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.21 Sag Chart for New and Existing Reduced Tension Guyed #6 — 4/0 Copper for Heavy-Loading Areas

Table CO 168–48: Sag Chart for New and Existing Reduced Tension Guyed #6 — 4/0 Copper for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#6 Copper[a/]	60	1'-6"	1'-10"
	80	2'-10"	3'-0"
	100	4'-4"	4'-6"
	120	6'-0"	6'-6"
	140	N/A[b/]	N/A[b/]
	160	N/A[b/]	N/A[b/]
#4 Copper[a/]	60	1'-3"	1'-6"
	80	2'-0"	2'-5"
	100	3'-2"	3'-6"
	120	4'-6"	5'-0"
	140	6'-3"	6'-7"
	160	N/A	N/A[b/]
#2 Copper[a/]	60	1'-0"	1'-7"
	80	1'-6"	2'-0"
	100	2'-4"	2'-9"
	120	3'-4"	3'-9"
	140	4'-6"	5'-0"
	160	5'-10"	6'-4"
2/0 Copper	60	1'-2"	1'-6"
	80	2'-0"	2'-3"
	100	2'-10"	3'-3"
	120	4'-0"	4'-6"
	140	5'-4"	5'-9"
	160	6'-10"	7'-4"
4/0 Copper	60	1'-2"	1'-6"
	80	1'-8"	2'-0"
	100	2'-5"	2'-10"
	120	3'-4"	3'-10"
	140	4'-6"	4'-10"
	160	5'-8"	6'-3"

[a/] Not approved for new construction.
[b/] Excessive sagging, use full tension.

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 Guyed Span Tensions

1.1 Conductor Tensions for Guying are 70 Percent of Full Tension for 60 to 160 Feet

- Conductor tension for guying #6 Copper is 225 lb
- Conductor tension for guying #4 Copper is 340 lb
- Conductor tension for guying #2 Copper is 533 lb

1.2 Conductor Tensions for Guying are 40 Percent of Full Tension for 60 to 160 Feet

- Conductor tension for guying 2/0 Copper is 593 lb

1.3 Conductor Tensions for Guying are 30 Percent of Full Tension for 60 to 160 Feet

- Conductor tension for guying 4/0 Copper is 915 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.22 Sag Chart for New and Existing Reduced Tension Guyed #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Table CO 168–49: Sag Chart for New and Existing Reduced Tension Guyed 17 kV #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#2 Copper	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-10"
	125	4'-4"	4'-9"
	150	5'-2"	5'-9"
	175	6'-0"	6'-8"
2/0 Copper	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-10"
	125	4'-4"	4'-9"
	150	5'-3"	5'-9"
	175	6'-1"	6'-8"
4/0 Copper	50	2'-0"	2'-2"
	75	3'-0"	3'-3"
	100	3'-6"	3'-10"
	125	4'-4"	4'-9"
	150	5'-3"	5'-9"
	175	6'-1"	6'-8"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–50: Stringing Tension Table for New and Existing Reduced Tension Guyed 17 kV #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Tension (lb)	Final Tension (lb)
		50–110°F	130°F
#2 Copper	50	50	46
	75	75	70
	100	115	104
	125	144	130
	150	173	156
	175	202	182
2/0 Copper	50	88	81
	75	132	122
	100	201	182
	125	251	228
	150	302	274
	175	352	319
4/0 Copper	50	131	121
	75	196	182
	100	299	272
	125	374	340
	150	449	408
	175	524	476

What's Changed? Added "Stringing" in table title for clarity.

1.0 Guyed Span Tensions

Table CO 168–51: Guyed Span Tensions: 17 kV #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
#2 Copper	50	216
	75	321
	100	483
	125	594
	150	703
	175	810
2/0 Copper	50	267
	75	398
	100	608
	125	753
	150	896
	175	1036
4/0 Copper	50	322
	75	481
	100	738
	125	917
	150	1093
	175	1268

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.23 Sag Chart for New and Existing Reduced Tension Guyed #6 — 1/0 Aluminum Duplex and Triplex for Heavy-Loading Areas

Table CO 168–52: Sag Chart for New and Existing Reduced Tension Guyed #6 — 1/0 Aluminum Duplex and Triplex for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
#6 Aluminum Duplex	60	1'-6"	1'-8"
	80	2'-6"	2'-10"
	100	4'-0"	4'-6"
	120	6'-0"	6'-3"
	140	8'-3"	8'-6"
	160	11'-0"	11'-1"
#4 Aluminum Duplex	60	1'-0"	1'-3"
	80	1'-8"	2'-2"
	100	2'-9"	3'-3"
	120	4'-4"	4'-6"
	140	5'-10"	6'-3"
	160	7'-6"	8'-0"
#4 Aluminum Triplex	60	1'-0"	1'-3"
	80	2'-0"	2'-4"
	100	3'-0"	3'-6"
	120	4'-6"	4'-7"
	140	6'-5"	6'-8"
	160	8'-6"	8'-9"
#2 Aluminum Triplex	60	1'-0"	1'-5"
	80	2'-0"	2'-3"
	100	3'-0"	3'-6"
	120	4'-5"	4'-9"
	140	6'-0"	6'-4"
	160	7'-10"	8'-3"
1/0 Aluminum Triplex	60	1'-3"	1'-5"
	80	2'-0"	2'-4"
	100	3'-0"	3'-6"
	120	4'-6"	4'-8"
	140	6'-10"	6'-4"
	160	7'-9"	8'-3"
4/0 Aluminum Triplex	60	1'-6"	1'-8"
	80	2'-5"	2'-8"
	100	3'-8"	3'-10"
	120	5'-3"	5'-6"
	140	7'-0"	7'-4"
	160	9'-0"	9'-6"

1.0 Guyed Span Tensions

1.1 Conductor Tensions for Guying are 75 Percent of Full Tension for 0 to 160 Feet
- Conductor tension for guying #6 Aluminum Duplex is 290 lb
- Conductor tension for guying #4 Aluminum Duplex is 453 lb
- Conductor tension for guying #4 Aluminum Triplex is 453 lb
- Conductor tension for guying #2 Aluminum Triplex is 570 lb

1.2 Conductor Tensions for Guying are 50 Percent of Full Tension for 0 to 160 Feet
- Conductor tension for guying 1/0 Aluminum Triplex is 707 lb

1.3 Conductor Tensions for Guying are 30 Percent of Full Tension for 0 to 160 Feet
- Conductor tension for guying 4/0 Aluminum Triplex is 835 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.24 Sag Chart for New and Existing Reduced Tension Guyed #4 — 4/0 Aluminum Quadruplex for Heavy-Loading Area

Table CO 168–53: Sag Chart for New and Existing Reduced Tension Guyed #4 — 4/0 Aluminum Quadruplex for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#4 Aluminum Quadruplex	60	1'-2"	1'-6"
	80	2'-3"	2'-6"
	100	3'-6"	3'-10"
	120	5'-3"	5'-6"
	140	7'-0"	7'-5"
	160	9'-4"	9'-8"
#1/0 Aluminum Quadruplex	60	1'-4"	1'-7"
	80	2'-2"	2'-7"
	100	3'-5"	3'-10"
	120	5'-0"	5'-5"
	140	6'-9"	7'-0"
	160	8'-9"	9'-2"
#4/0 Aluminum Quadruplex	60	1'-7"	1'-10"
	80	2'-0"	3'-0"
	100	4'-3"	4'-6"
	120	6'-0"	6'-3"
	140	8'-0"	8'-4"
	160	10'-5"	10'-9"

1.0 Guyed Span Tensions

1.1 Conductor Tensions for Guying are 75 Percent of Full Tension for 0 to 160 Feet

- Conductor tension for guying #4 Aluminum Quadruplex is 453 lb

1.2 Conductor Tensions for Guying are 50 Percent of Full Tension for 0 to 160 Feet

- Conductor tension for guying 1/0 Aluminum Quadruplex is 707 lb

1.3 Conductor Tensions for Guying are 39 Percent of Full Tension for 0 to 160 Feet

- Conductor tension for guying 4/0 Aluminum Quadruplex is 835 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.25 Sag Chart for New Reduced Tension Unguyed #4 — 653 ACSR for Heavy-Loading Areas

Table CO 168–54: Sag Chart for New Reduced Tension Unguyed #4 — 653 ACSR for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#4 ACSR[a/]	60	1'-3"	1'-6"
	80	2'-2"	2'-6"
	100	3'-6"	3'-7"
	120	4'-10"	5'-2"
#2 ACSR[a/]	60	1'-3"	1'-6"
	80	2'-0"	2'-4"
	100	3'-0"	3'-4"
	120	4'-5"	4'-7"
1/0 ACSR	60	1'-0"	1'-1"
	80	1'-2"	1'-6"
	100	1'-10"	2'-4"
	120	2'-7"	3'-0"
336 ACSR	60	1'-3"	1'-6"
	80	2'-0"	2'-4"
	100	2'-10"	3'-3"
	120	4'-0"	4'-5"
653 ACSR	60	1'-6"	1'-9"
	80	2'-3"	2'-6"
	100	3'-4"	3'-7"
	120	5'-6"	5'-8"

[a/] Not approved for new construction.

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 New Unguyed Span Tensions

1.1 Conductor Tensions are 50 Percent of Full Tension for 0 to 120 Feet

- Conductor tension for #4 ACSR is 302 lb
- Conductor tension for #2 ACSR is 380 lb
- Conductor tension for 1/0 ACSR is 707 lb

1.2 Conductor Tensions are 25 Percent of Full Tension for 0 to 120 Feet

- Conductor tension for 336 ACSR is 710 lb
- Conductor tension for 653 ACSR is 815 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.26 Sag Chart for New Reduced Tension Unguyed 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Table CO 168–55: Sag Chart for New Reduced Tension Unguyed 17 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
1/0 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-7"
	125	9'-4"	9'-6"
336 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-7"
	125	9'-4"	9'-7"
653 ACSR	50	3'-9"	3'-10"
	75	5'-8"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–56: Stringing Tension Table for New Reduced Tension Unguyed 17 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Tension	Final Tension
		50–110°F	130°F
1/0 ACSR	50	24	24
	75	36	36
	100	49	48
	125	61	60
336 ACSR	50	49	48
	75	74	72
	100	98	96
	125	123	120
653 ACSR	50	83	82
	75	125	123
	100	167	163
	125	208	204

Table CO 168–57: Sag Chart for New Reduced Tension Unguyed 35 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
1/0 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-7"
	125	9'-4"	9'-6"
336 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
653 ACSR	50	3'-9"	3'-10"
	75	5'-8"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"

Table CO 168–58: Stringing Tension Table for New Reduced Tension Unguyed 35 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Tension	Final Tension
		50–110°F	130°F
1/0 ACSR	50	39	39
	75	59	58
	100	79	77
	125	98	96
336 ACSR	50	69	68
	75	103	101
	100	137	135
	125	172	168
653 ACSR	50	106	104
	75	159	156
	100	212	207
	125	265	259

1.0 New Unguyed Span Tensions

Table CO 168–59: New Unguyed Span Tensions: 17 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	119
	75	179
	100	238
	125	297
336 ACSR	50	160
	75	240
	100	320
	125	399
653 ACSR	50	210
	75	315
	100	420
	125	525

Table CO 168–60: New Unguyed Span Tensions: 35 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	152
	75	228
	100	303
	125	378
336 ACSR	50	198
	75	296
	100	395
	125	493
653 ACSR	50	250
	75	375
	100	499
	125	623

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.27 Sag Chart for New Reduced Tension Unguyed #6 — 4/0 Copper for Heavy-Loading Areas

Table CO 168–61: Sag Chart for New Reduced Tension Unguyed #6 — 4/0 Copper for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
#6 Copper[a/]	60	1'-6"	1'-10"
	80	2'-10"	3'-0"
	100	4'-4"	4'-6"
	120	6'-0"	6'-6"
#4 Copper[a/]	60	1'-3"	1'-6"
	80	2'-0"	2'-5"
	100	3'-2"	3'-6"
	120	4'-6"	5'-0"
#2 Copper[a/]	60	1'-0"	1'-7"
	80	1'-6"	2'-0"
	100	2'-4"	2'-9"
	120	3'-4"	3'-9"
2/0 Copper	60	1'-2"	1'-6"
	80	2'-0"	2'-3"
	100	2'-10"	3'-3"
	120	4'-0"	4'-6"
4/0 Copper	60	1'-2"	1'-6"
	80	1'-8"	2'-0"
	100	2'-5"	2'-10"
	120	3'-4"	3'-10"

[a/] Not approved for new construction.

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 New Unguyed Span Tensions

1.1 Conductor Tensions are 70 Percent of Full Tension for 60 to 120 Feet
- Conductor tension for #6 Copper is 225 lb
- Conductor tension for #4 Copper is 340 lb
- Conductor tension for #2 Copper is 533 lb

1.2 Conductor Tensions are 40 Percent of Full Tension for 60 to 120 Feet
- Conductor tension for 2/0 Copper is 593 lb

1.3 Conductor Tensions are 30 Percent of Full Tension for 60 to 120 Feet
- Conductor tension for 4/0 Copper is 915 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.28 Sag Chart for New Reduced Tension Unguyed #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Table CO 168–62: Sag Chart for New Reduced Tension Unguyed 17 kV #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#2 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
2/0 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
2/0 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–63: Stringing Tension Table for New Reduced Tension Unguyed 17 kV #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Tension	Final Tension
		50–110°F	130°F
#2 Copper	50	27	26
	75	41	40
	100	54	53
	125	68	66
2/0 Copper	50	47	46
	75	71	70
	100	95	93
	125	119	116
2/0 Copper	50	71	69
	75	106	104
	100	141	138
	125	177	173

1.0 New Unguyed Span Tensions

Table CO 168–64: New Unguyed Span Tensions: 17 kV #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
#2 Copper	50	114
	75	170
	100	227
	125	283
2/0 Copper	50	139
	75	209
	100	278
	125	347
4/0 Copper	50	167
	75	250
	100	333
	125	417

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.29 Sag Chart for New Reduced Tension Unguyed #6 — 1/0 Aluminum Duplex and Triplex for Heavy-Loading Areas

Table CO 168–65: Sag Chart for New Reduced Tension Unguyed #6 — 1/0 Aluminum Duplex and Triplex for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#6 Aluminum Duplex	60	1'-6"	1'-8"
	80	2'-6"	2'-10"
	100	4'-0"	4'-6"
	120	6'-0"	6'-3"
#4 Aluminum Duplex	60	1'-0"	1'-3"
	80	1'-8"	2'-2"
	100	2'-9"	3'-3"
	120	4'-4"	4'-6"
#4 Aluminum Triplex	60	1'-0"	1'-3"
	80	2'-0"	2'-4"
	100	3'-0"	3'-6"
	120	4'-6"	4'-7"
#2 Aluminum Triplex	60	1'-0"	1'-5"
	80	2'-0"	2'-3"
	100	3'-0"	3'-6"
	120	4'-5"	4'-9"
1/0 Aluminum Triplex	60	1'-3"	1'-5"
	80	2'-0"	2'-4"
	100	3'-0"	3'-6"
	120	4'-6"	4'-8"
1/0 Aluminum Triplex	60	1'-6"	1'-8"
	80	2'-5"	2'-8"
	100	3'-8"	3'-10"
	120	5'-3"	5'-6"
4/0 Aluminum Triplex	60	1'-6"	1'-8"
	80	2'-5"	2'-8"
	100	3'-8"	3'-10"
	120	5'-3"	5'-6"

1.0 New Unguyed Span Tensions

1.1 Conductor Tensions are 75 Percent of Full Tension for 0 to 120 Feet

- Conductor tension for #6 Aluminum Duplex is 290 lb
- Conductor tension for #4 Aluminum Duplex is 453 lb
- Conductor tension for #4 Aluminum Triplex is 453 lb
- Conductor tension for #2 Aluminum Triplex is 570 lb

1.2 Conductor Tensions are 50 Percent of Full Tension for 0 to 120 Feet

- Conductor tension for 1/0 Aluminum Triplex is 707 lb

1.3 Conductor Tensions are 30 Percent of Full Tension for 0 to 120 Feet

- Conductor tension for 4/0 Aluminum Triplex is 835 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.30 Sag Chart for New Reduced Tension Unguyed #4 — 4/0 Aluminum Quadruplex for Heavy-Loading Areas

Table CO 168–66: Sag Chart for New Reduced Tension Unguyed #4 — 4/0 Aluminum Quadruplex for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#4 Aluminum Quadruplex	60	1'-2"	1'-6"
	80	2'-3"	2'-6"
	100	3'-6"	3'-10"
	120	5'-3"	5'-6"
#1/0 Aluminum Quadruplex	60	1'4"	1'-7"
	80	2'-2"	2'-7"
	100	3'-5"	3'-10"
	120	5'-0"	5'-5"
#4/0 Aluminum Quadruplex	60	1'-7"	1'-10"
	80	2'-0"	3'-0"
	100	4'-3"	4'-6"
	120	6'-0"	6'-3"

1.0 New Unguyed Span Tensions

1.1 Conductor Tensions are 75 Percent of Full Tension for 0 to 120 Feet
- Conductor tension for #4 Aluminum Quadruplex is 453 lb

1.2 Conductor Tensions are 50 Percent of Full Tension for 0 to 120 Feet
- Conductor tension for 1/0 Aluminum Quadruplex is 707 lb

1.3 Conductor Tensions are 30 Percent of Full Tension for 0 to 120 Feet
- Conductor tension for 4/0 Aluminum Quadruplex is 835 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.31 Sag Chart for Existing and Rebuild Reduced Tension Unguyed #4 — 653 ACSR for Heavy-Loading Areas

Table CO 168–67: Sag Chart for Existing and Rebuild Reduced Tension Unguyed #4 — 653 ACSR for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#4 ACSR[a/]	60	1'-3"	1'-6"
	80	2'-2"	2'-6"
	100	3'-6"	3'-7"
	120	4'-10"	5'-2"
	140	6'-10"	7'-0"
	160	8'-9"	9'-0"
#2 ACSR[a/]	60	1'-3"	1'-6"
	80	2'-0"	2'-4"
	100	3'-0"	3'-4"
	120	4'-5"	4'-7"
	140	5'-10"	6'-2"
	160	7'-8"	8'-0"
1/0 ACSR	60	1'-0"	1'-1"
	80	1'-2"	1'-6"
	100	1'-10"	2'-4"
	120	2'-7"	3'-0"
	140	3'-6"	4'-0"
	160	4'-7"	5'-0"
336 ACSR	60	1'-3"	1'-6"
	80	2'-0"	2'-4"
	100	2'-10"	3'-3"
	120	4'-0"	4'-5"
	140	5'-4"	5'-8"
	160	6'-8"	7'-2"
653 ACSR	60	1'-6"	1'-9"
	80	2'-3"	2'-6"
	100	3'-4"	3'-7"
	120	5'-6"	5'-8"
	140	6'-0"	6'-5"
	160	7'-10"	8'-2"

[a/] Not approved for new construction.

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 Existing and Rebuild Unguyed Span Tensions

1.1 Conductor Tensions are 50 Percent of Full Tension for 0 to 160 Feet

- Conductor tension for #4 ACSR is 302 lb
- Conductor tension for #2 ACSR is 380 lb
- Conductor tension for 1/0 ACSR is 707 lb

1.2 Conductor Tensions are 25 Percent of Full Tension for 0 to 160 Feet

- Conductor tension for 336 ACSR is 710 lb
- Conductor tension for 653 ACSR is 815 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.32 Sag Chart for Existing and Rebuild Reduced Tension Unguyed 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Table CO 168–68: Sag Chart for Existing and Rebuild Reduced Tension Unguyed 17 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
1/0 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-7"
	125	9'-4"	9'-6"
	150	10'-10"	11'-1"
	175	12'-2"	12'-6"
336 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-1"
	175	12'-3"	12'-7"
653 ACSR	50	3'-9"	3'-10"
	75	5'-8"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-7"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–69: Stringing Tension Table for Existing and Rebuild Reduced Tension Unguyed 17 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Tension (lb)	Final Tension (lb)
		50–110°F	130°F
1/0 ACSR	50	24	24
	75	36	36
	100	49	48
	125	61	60
	150	75	74
	175	91	89
336 ACSR	50	49	48
	75	74	72
	100	98	96
	125	123	120
	150	152	149
	175	184	179
653 ACSR	50	83	82
	75	125	123
	100	167	163
	125	208	204
	150	258	252
	175	312	304

Table CO 168–70: Sag Chart for Existing and Rebuild Reduced Tension Unguyed 35 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
1/0 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-7"
	125	9'-4"	9'-6"
	150	10'-10"	11'-1"
	175	12'-2"	12'-6"
336 ACSR	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-8"
653 ACSR	50	3'-9"	3'-10"
	75	5'-8"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-7"

Table CO 168–71: Stringing Tension Table for Existing and Rebuild Reduced Tension Unguyed 35 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Tension (lb)	Final Tension (lb)
		50–110°F	130°F
1/0 ACSR	50	39	39
	75	59	58
	100	79	77
	125	98	96
	150	122	119
	175	147	144
336 ACSR	50	103	101
	75	137	135
	100	172	168
	125	213	207
	150	257	249
	175	103	101
653 ACSR	50	106	104
	75	159	156
	100	212	207
	125	265	259
	150	328	320
	175	397	385

1.0 Existing and Rebuild Unguyed Span Tensions

Table CO 168–72: Existing and Rebuild Unguyed Span Tensions: 17 kV 1/0 — 653 ACSR Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	119
	75	179
	100	238
	125	297
	150	368
	175	443
336 ACSR	50	160
	75	240
	100	320
	125	399
	150	495
	175	598
653 ACSR	50	210
	75	315
	100	420
	125	525
	150	651
	175	787

Table CO 168–73: Existing and Rebuild Unguyed Span Tensions: 35 kV 1/0 Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
1/0 ACSR	50	152
	75	228
	100	303
	125	378
	150	468
	175	564
336 ACSR	50	198
	75	296
	100	395
	125	493
	150	611
	175	738
653 ACSR	50	250
	75	375
	100	499
	125	623
	150	773
	175	934

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.33 Sag Chart for Existing and Rebuild Reduced Tension Unguyed #6 — 4/0 Copper for Heavy-Loading Areas

Table CO 168–74: Sag Chart for Existing and Rebuild Reduced Tension Unguyed #6 — 4/0 Copper for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#6 Copper[a/]	60	1'-6"	1'-10"
	80	2'-10"	3'-0"
	100	4'-4"	4'-6"
	120	6'-0"	6'-6"
	140	N/A[b/]	N/A[b/]
	160	N/A[b/]	N/A[b/]
#4 Copper[a/]	60	1'-3"	1'-6"
	80	2'-0"	2'-5"
	100	3'-2"	3'-6"
	120	4'-6"	5'-0"
	140	6'-3"	6'-7"
	160	N/A[b/]	N/A[b/]
#2 Copper[a/]	60	1'-0"	1'-7"
	80	1'-6"	2'-0"
	100	2'-4"	2'-9"
	120	3'-4"	3'-9"
	140	4'-6"	5'-0"
	160	5'-10"	6'-4"
2/0 Copper	60	1'-2"	1'-6"
	80	2'-0"	2'-3"
	100	2'-10"	3'-3"
	120	4'-0"	4'-6"
	140	5'-4"	5'-9"
	160	6'-10"	7'-4"
4/0 Copper	60	1'-2"	1'-6"
	80	1'-8"	2'-0"
	100	2'-5"	2'-10"
	120	3'-4"	3'-10"
	140	4'-6"	4'-10"
	160	5'-8"	6'-3"

[a/] Not approved for new construction.
[b/] Excessive sagging, use full tension.

Note(s):

1. Use on all 2.4 kV through 33 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

1.0 Existing and Rebuild Unguyed Span Tensions

1.1 Conductor Tensions are 70 Percent of Full Tension for 60 to 160 Feet

- Conductor tension for #6 Copper is 225 lb
- Conductor tension for #4 Copper is 340 lb
- Conductor tension for #2 Copper is 533 lb

1.2 Conductor Tensions are 40 Percent of Full Tension for 60 to 160 Feet

- Conductor tension for 2/0 Copper is 593 lb

1.3 Conductor Tensions are 30 Percent of Full Tension for 60 to 160 Feet

- Conductor tension for 4/0 Copper is 915 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.34 Sag Chart for Existing and Rebuild Reduced Tension Unguyed #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Table CO 168–75: Sag Chart for Existing and Rebuild Reduced Tension Unguyed 17 kV #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag 50–110°F	Final Sag 130°F
#2 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-7"
2/0 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-7"
4/0 Copper	50	3'-9"	3'-10"
	75	5'-7"	5'-9"
	100	7'-6"	7'-8"
	125	9'-4"	9'-7"
	150	10'-10"	11'-2"
	175	12'-3"	12'-7"

Note(s):

1. Use on all 2.4 kV through 17 kV systems. 36-inch minimum mid span conductor spacing depending on deviation angle may require more than 36-inch pin spacing to achieve 36-inch conductor spacing.

Table CO 168–76: Stringing Tension Table for Existing and Rebuild Reduced Tension Unguyed 17 kV #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Tension (lb)	Final Tension (lb)
		50–110°F	130°F
#2 Copper	50	27	26
	75	41	40
	100	54	53
	125	68	66
	150	84	82
	175	101	99
2/0 Copper	50	47	46
	75	71	70
	100	95	93
	125	119	116
	150	147	144
	175	177	173
4/0 Copper	50	71	69
	75	106	104
	100	141	138
	125	177	173
	150	219	214
	175	264	258

What's Changed? Added "Stringing" in table title for clarity.

1.0 Existing and Rebuild Unguyed Span Tensions

Table CO 168–77: Existing and Rebuild Unguyed Span Tensions: 17 kV #2 — 4/0 Copper Covered Conductor for Heavy-Loading Areas

Conductor Type	Span (ft)	Tension (lb)
#2 Copper	50	114
	75	170
	100	227
	125	283
	150	350
	175	422
2/0 Copper	50	139
	75	209
	100	278
	125	347
	150	430
	175	519
4/0 Copper	50	167
	75	250
	100	333
	125	417
	150	517
	175	624

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

Scope CO 168.35 Sag Chart for Existing and Rebuild Reduced Tension Unguyed #6 — 4/0 Aluminum Duplex and Triplex for Heavy-Loading Areas

Table CO 168–78: Sag Chart for Existing and Rebuild Reduced Tension Unguyed #6 — 4/0 Aluminum Duplex and Triplex for Heavy-Loading Areas

Conductor Type	Span (ft)	Initial Sag	Final Sag
		50–110°F	130°F
#6 Aluminum Duplex	60	1'-6"	1'-8"
	80	2'-6"	2'-10"
	100	4'-0"	4'-6"
	120	6'-0"	6'-3"
	140	8'-3"	8'-6"
	160	11'-0"	11'-1"
#4 Aluminum Duplex	60	1'-0"	1'-3"
	80	1'-8"	2'-2"
	100	2'-9"	3'-3"
	120	4'-4"	4'-6"
	140	5'-10"	6'-3"
	160	7'-6"	8'-0"
#4 Aluminum Triplex	60	1'-0"	1'-3"
	80	2'-0"	2'-4"
	100	3'-0"	3'-6"
	120	4'-6"	4'-7"
	140	6'-5"	6'-8"
	160	8'-6"	8'-9"
#2 Aluminum Triplex	60	1'-0"	1'-5"
	80	2'-0"	2'-3"
	100	3'-0"	3'-6"
	120	4'-5"	4'-9"
	140	6'-0"	6'-4"
	160	7'-10"	8'-3"
1/0 Aluminum Triplex	60	1'-3"	1'-5"
	80	2'-0"	2'-4"
	100	3'-0"	3'-6"
	120	4'-6"	4'-8"
	140	6'-10"	6'-4"
	160	7'-9"	8'-3"
4/0 Aluminum Triplex	60	1'-6"	1'-8"
	80	2'-5"	2'-8"
	100	3'-8"	3'-10"
	120	5'-3"	5'-6"
	140	7'-0"	7'-4"
	160	9'-0"	9'-6"

1.0 Existing and Rebuild Unguyed Span Tensions

1.1 Conductor Tensions are 75 Percent of Full Tension for 0 to 160 Feet
- Conductor tension for #6 Aluminum Duplex is 290 lb
- Conductor tension for #4 Aluminum Duplex is 453 lb
- Conductor tension for #4 Aluminum Triplex is 453 lb
- Conductor tension for #2 Aluminum Triplex is 570 lb

1.2 Conductor Tensions are 50 Percent of Full Tension for 0 to 160 Feet
- Conductor tension for 1/0 Aluminum Triplex is 707 lb

1.3 Conductor Tensions are 30 Percent of Full Tension for 0 to 160 Feet
- Conductor tension for 4/0 Aluminum Triplex is 835 lb

2.0 Ground Clearance

Per G.O. 95, use 130°F sags when calculating conductor-to-ground clearances.

CO 212 Dead-Ending — Composite Crossarm Construction

Scope CO 212.1 Composite Crossarm Construction Requirements for Dead-Ending Conductors

Figure CO 212–1: Composite Crossarm Construction Requirements for Dead-Ending Conductors

Figure CO 212–1.1: 8 ft Single

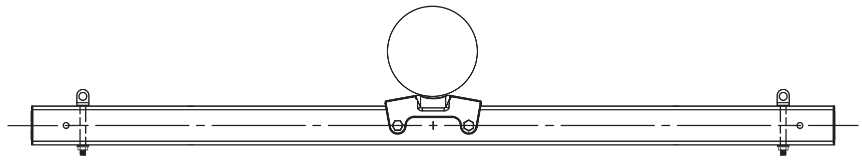


Figure CO 212–1.2: 8 ft Double

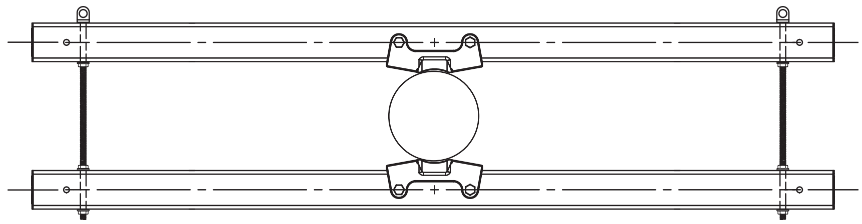


Figure CO 212–1.3: 10 & 12 ft Single

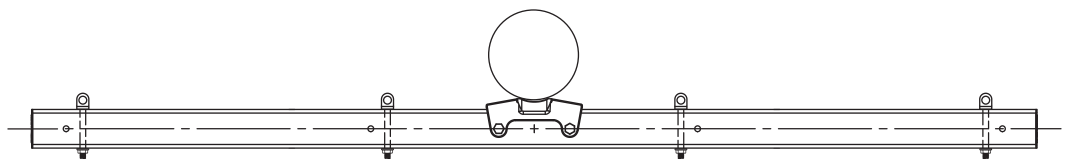
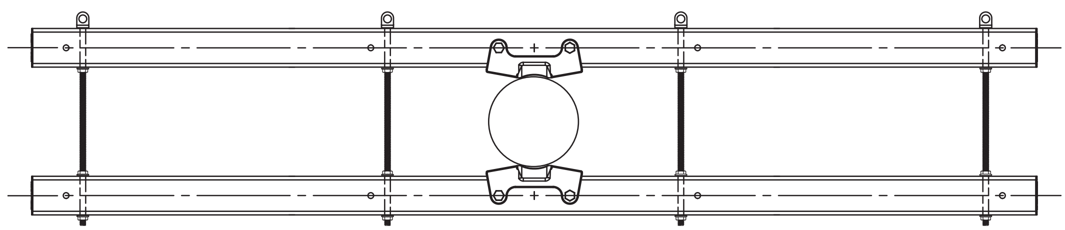


Figure CO 212–1.4: 10 & 12 ft Double



Note(s):

1. Mount arm bracket to pole with 3/4" bolts and spring washers.
2. Use 4 × 4 × 1/4" 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 ft. lbs). Do not over tighten.
4. Triple arm construction is not required when using composite crossarms.
5. Double arming brackets shall not be used on composite crossarms.

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CO 410 Compression Splices

Scope CO 410.1 Tool and Die List for Full Tension Compression Splices

1.0 Tool and Die List for Copper Full Tension Compression Splice

Figure CO 410–1: Copper Full Tension Compression Splice

1.1 Application

To be used on copper conductors of all distribution voltages.

Table CO 410–1: Copper Full Tension Compression Splice

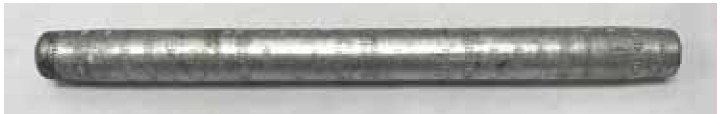
Wire Size	Splice SAP	MD-6 Die Number and SAP	Y34A Die Number and SAP	Y35-Y39-12HA Die Number and SAP	UT-15 Die Number and SAP	Number of Crimps per End
#8 SOL	10110772	W-161 10148858	N/A	N/A	N/A	1
#6 SOL	10110773	W-161 10148858	N/A	N/A	N/A	2
#4 SOL	10110774	W-162 10148861	N/A	N/A	N/A	5
#2 SOL	10110775	W-163 10148862	N/A	N/A	N/A	5
#4-7 Str.	10110776	W-162 10148861	N/A	N/A	N/A	5
#2-7 Str.	10110778	W-163 10148862	N/A	N/A	N/A	5
2/0 Str.	10110779	W-166 10148863	A166/A26YD 10148874	U-166 10148878	U-166 10148878	MD6=12 Others=6
4/0 Str.	10110781	N/A	A168/A28YD 10148875	U-168 10148880	U-168 10148880	9

Note(s):

1. Use adapter die SAP 10148852 to fit Y35, Y39, or 12HA dies in UT-15 tool.
2. Use adapter die SAP 10148851 to fit Y34A dies in UT-15 tool.

2.0 Tool and Die List for All Aluminum Full Tension Compression Splice

Figure CO 410–2: All Aluminum Full Tension Compression Splice



2.1 Application

Full tension splicing.

Table CO 410–2: All Aluminum Full Tension Compression Splice

Wire Size	Splice SAP	MD-6 Die Number and SAP	Y34A Die Number and SAP	Y35-Y39-12HA Die Number and SAP	UT-15 Die Number and SAP	Number of Crimps per End
#6 SOL	10112143	W-161 10148858	N/A	N/A	N/A	2
#6-7 Str.	10112144	W-161 10148858	N/A	N/A	N/A	2
#4-7 Str.	10112145	W-162 10148861	N/A	N/A	N/A	4
#2-7 Str.	10112146	W-163 10148862	N/A	N/A	N/A	5
#1/0-7 Str.	10112147	BG 10148818	N/A	N/A	N/A	8
4/0 7 Str.	10112148	N/A	A249 10148887	U-249 10148909	See Note 1 See Note 2	6
477 kcmil	10111998	N/A	N/A	15CA106H 10148853	See Note 1	Overlap

Note(s):

1. Use adapter die SAP 10148852 to fit Y35, Y39, or 12HA dies in UT-15 tool.
2. Use adapter die SAP 10148851 to fit Y34A dies in UT-15 tool.

Scope CO 410.2 Tool and Die List for Full and Partial Tension Compression and Repair Splices

1.0 Tool and Die List for ACSR Full and Partial Tension Compression and Repair Splices (Single Sleeve)

Figure CO 410–3: ACSR Full Tension Compression and Repair Splices (Single Sleeve)

1.1 Application

May be used on distribution voltages.

Table CO 410–3: ACSR Full and Partial Tension Compression and Repair Splices (Single Sleeve)

Wire Size	Splice SAP	Repair Splice SAP	MD-6 Die Number and SAP	Y35-Y39-12HA Die Number and SAP	UT-15 Die Number and SAP	Number of Crimps per End
#4 (6/1)	10112090	10212509	W-687 10148864	U-243 10148908	See Note 1	MD6=12 Others=6
#2 (6/1)	10112091	10212510	W-687 10148864	U-243 10148908	See Note 1	MD6=14 Others=7
1/0 (6/1)	10112092	10212511	W-702 10148865	U-247 10148910	See Note 1	MD6=14 Others=7
2/0 (6/1)	10112093	10212512	N/A	U-659 10148911	See Note 1	Overlap
4/0 (6/1)	10112094	10212513	N/A	U-654 10148912	See Note 1	Overlap
336.4 kcmil (18/1)	10112095	10212514	N/A	U-655 10148913	See Note 1	Overlap
653.9 kcmi l (18/3)	10112096	N/A	N/A	N/A	15C140R 10148896 See Note 2	22

Note(s):

1. Use adapter die SAP 10148852 to fit Y35, Y39, or 12HA dies in UT-15 tool.
2. Partial Tension Splice, 93 percent Rated Breaking Strength, (RBS), or 13,800 lb.

2.0 Tool and Die List for All Aluminum Partial Tension Compression Splice for Use on Aluminum or ACSR (Services/Jumpers)

Figure CO 410–4: All Aluminum Compression Splice for Use on Aluminum or ACSR-Partial Tension (Services/Jumpers)

2.1 Application

May be used on all distribution voltages.

Table CO 410–4: All Aluminum Partial Tension Compression Splice for Use on Aluminum or ACSR (Services/Jumpers)

Wire Size	Splice SAP	MD-6 Die Number and SAP	Y34A Die Number and SAP	Y35-Y39-12HA Die Number and SAP	UT-15 Die Number and SAP	Number of Crimps per End
#6 (6/1)	10112129	W-162 10148861	N/A	N/A	N/A	2
#4 (6/1)	10112130	W-162 10148861	N/A	N/A	N/A	4
#4 (6/1)	10112005	W-687 10148864	N/A	U-243 10148908	See Note 1	3
1/0 (6/1)	10112007	W-702 10148865	N/A	U-247 10148910	See Note 1	MD6=4 Others=3

Note(s):

1. Use adapter die SAP 10148852 to fit Y35, Y39, or 12HA dies in UT-15 tool.

Scope CO 410.3 Instructions for Installing Full Tension, Double-Sleeve, Compression Splices for ACSR Conductors

1.0 Instructions for Installing Full Tension, Double-Sleeve, Compression Splices for ACSR Conductors

Figure CO 410–5: Instructions for Installing Full Tension, Double-Sleeve, Compression Splices for ACSR Conductors

To be installed on de-energized conductors only.

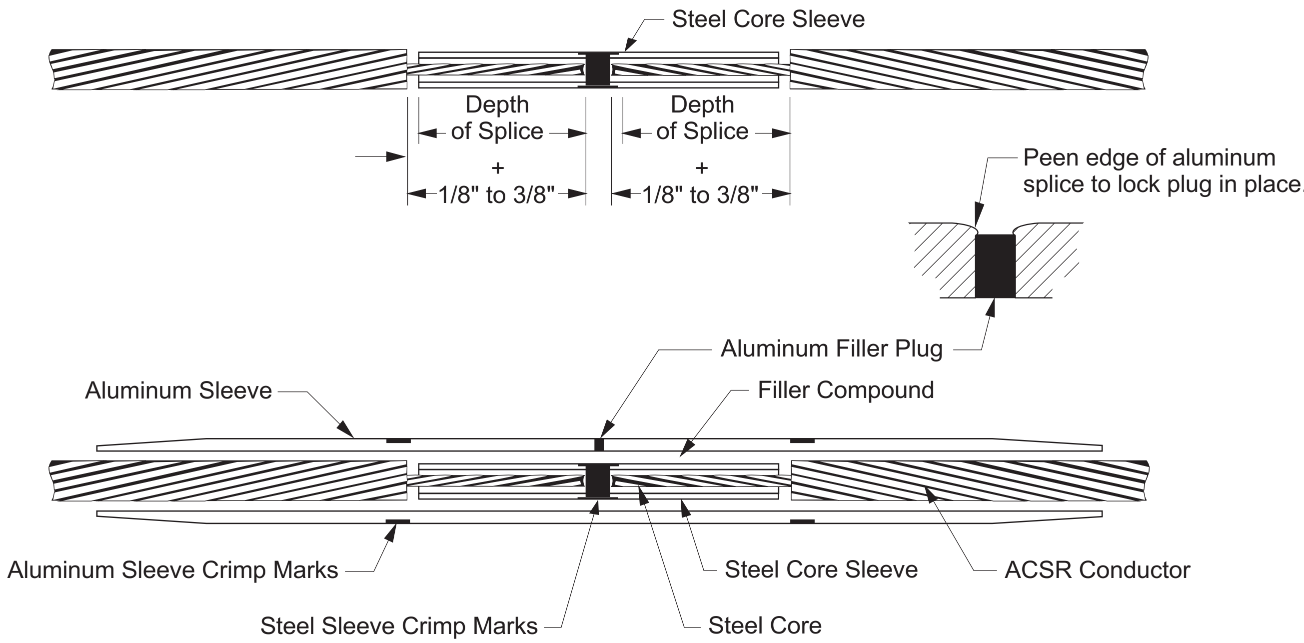


Table CO 410–5: Instructions for Installing Full Tension, Double-Sleeve, Compression Splices for ACSR Conductors

Conductor Size	SAP	Sleeve	Die SAP	UT-15	Y35-39
336.4-30x7	10112041	Aluminum Sleeve	10148918 10148917	B20AH-14AH[a/] B105H[a/]	B20AH-14AH B10SH

[a/] May be used in UT-15 with adapter die SAP 10148852.

Note(s):

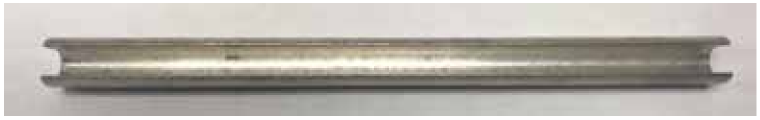
1. Surfaces of the conductor shall be cleaned of all foreign matter before splicing. Use a wire brush before applying a coat of filler compound (SAP 10064145).
2. The ends of conductor strands shall be examined for defects (burrs, nicks, and so forth) and the strands shall be counted to verify that they have the correct number for the subject conductor. The conductor ends shall be cut beyond any damaged or missing strands; The aluminum sleeve shall be thoroughly cleaned inside and out before it is slipped over the conductor ends.

3. Loose strands shall be tightened by having the outer layer twisted in the direction of the lay, and shall be bound with binding wire along the entire length over which strands have been tightened so as to prevent unravelling.
4. To allow for elongation of the steel sleeve during crimping, the aluminum strands shall be removed to a point not more than 3/8 inch nor less than 1/8 inch beyond the ends of the steel core sleeve.
5. The outer layers of aluminum strands shall be cut using a hack saw or an approved cable cutting tool. The inner layer shall be nicked only, with cutting completed by breaking the strands. The saw shall not touch the steel core. All cuts shall be square when finished.
6. The ends of the steel core shall be centered in the steel core sleeve with all binding removed from the steel core.
7. On Alcoa and Fargo steel core splices, pressing shall start adjacent to the center mark on each sleeve and continue to the ends leaving no space between presses.
8. The correct die shall be selected each time by matching the index numbers stamped on both the sleeve and die set.
9. After the wire binding has been removed from the aluminum strands, the aluminum sleeve shall be centered over the steel sleeve. Any looseness in the strands shall be worked into the sleeve and the conductor tightly bound with wire just outside each sleeve end. A double check shall be made of the correct position of the aluminum sleeve over the core splice by marking with tape the points where the ends of the sleeve should fall.
10. Before pressing, the space between the steel and aluminum sleeves shall be filled with filler compound using a caulking gun. Grease shall be forced into the filling hole until it comes out at each end of the sleeve. Using a hammer and punch, the aluminum plug shall then be driven into the fill hole and locked in place by peening the edge of the hole opening over it.
11. On Alcoa and Fargo splices, pressing of the aluminum sleeve shall start at the ends of the steel core (at the marks on sleeve) and continue toward the ends. Pressing shall be continuous, leaving no space between presses.
12. Should there be any indication of the splice bending during pressing operations, the press shall be reversed in direction for each compression.
13. At the completion of pressing operations, all wrapping, binding, and excess grease shall be removed.
14. The conductor strands shall be snugly seated after the splice is completed. Slight bends in the splice can be removed with a hammer, by using a hardwood block above and below the splice to protect the splice from direct blows of the hammer.
15. A parallel groove clamp may be substituted wherever wire binding is specified.

Scope CO 410.4 ACSR Repair Splice for #4, 1/0, and 336.4 ACSR

1.0 ACSR Repair Splice for #4, 1/0, and 336.4 ACSR

Figure CO 410–6: ACSR Repair Splice for #4, 1/0, and 336.4 ACSR



1.1 Application

Used to repair damaged #4, 1/0, and 336.4 ACSR conductors. The U-shaped splice completely encloses all strands and restores full load rating to Al/ACSR conductors with burned or mechanically damaged strands. The splice is not to be used on conductors where the steel core of an ACSR conductor has been damaged, or where more than 1/3 of the conductor strands have been damaged.

The splice is designed to be applied without cutting the conductor (requiring bypasses, wire grips or hot hoists).

1.2 Installation

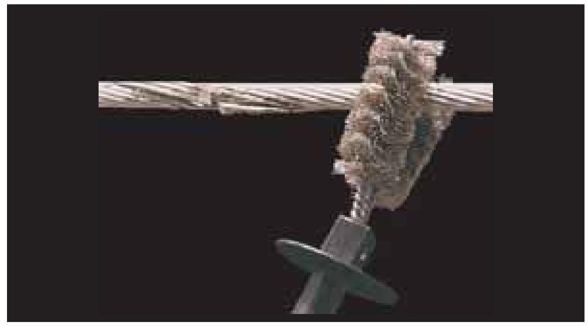
A. Inspect the damaged conductor. The steel core must be undamaged and no more than 1/3 of the conductor strands damaged.

B. Select the splice, correct die, and the crimping tool from the table.

Conductor Size	SAP	Length (in)	Die	
			MD-6	12HA, UT-15, Y-35
#4 ACSR	10111822	7	W-163	U-163
1/0 ACSR	10111823	8	W-165, W-166	U-165, U-166
336.4 ACSR	10111824	12	—	U-655

C. Reseat the damaged strands to the line. This may take a little time and may involve trimming a few strands. Damage to the conductor (including any necessary trimming) must not exceed 1 inch in length.

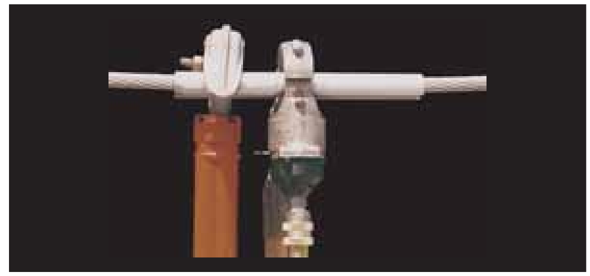
D. Properly clean and grease conductor. This step is very important to ensure a good electrical splice.

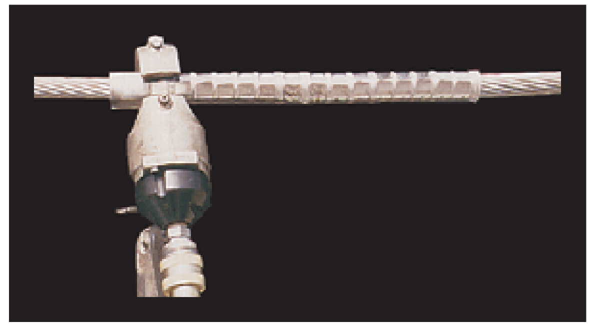


E. Install splice — generally install the U-shaped splice on top of the conductor and center on the damaged area, so that the open side of the splice is pointed down. A duckbill ground clamp is used to install the splice onto the conductor.

F. Position the splice so that the opened side of the splice is pointing towards the upper or lower die. Do not install the splice so that the opened side of the splice is pointing towards the seam between the upper and lower die.

G. Start crimps at center of splice, working towards each end. Space each crimp approximately 1/16 inch–1/8 inch apart. It is not necessary to rotate crimps around the splice while crimping.





H. Finished splice.

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CO 420 Bolted Wedge Connector

Scope CO 420.1 ACSR - ACSR, ACSR - CU and CU - CU Bolted Wedge Connectors

Figure CO 420–1: ACSR - ACSR

Figure CO 420–2: ACSR - CU

Figure CO 420–3: CU - CU

1.0 General Information — Bolted Wedge Connector

The bolted wedge connector consists of two parts: the “C” member and the “interface”.

1.1 “C” Member

A heat treated spring-like “C” member exerts continuous pressure on the conductors once the shear bolt is tightened. The bolted wedge connector can be removed by loosening the bolt without damaging the conductors.

Figure CO 420–4: “C” Member

1.2 Interface

The interface is stamped with the corresponding conductor sizes for each side.

Figure CO 420–5: Interface

Figure CO 420–6: Stamped Interface

2.0 Application

Bolted Wedge Connectors are for primary distribution tap connections on overhead line taps, underground risers and equipment taps. Applications may include fire hazard areas as clearing around the structures is not required (that is, exempt by California Department of Forestry).

2.1 Typical Applications

- Overhead main line to main line
- Overhead main line to UG main line risers
- Transformers and Transformer Banks (CU)
- Voltage Regulators (CU)
- Capacitor Banks (CU)
- OH Switches

Various sizes of bolted wedge connector are available for use on SCE's ACSR and Copper conductors and are all installed in the same manner per Table 420–1.

For detailed installation of connectors (see CO 100). When the main conductor is ACSR and tap conductor is CU, ACSR shall always be placed on top of CU.

Figure CO 420–7: ACSR on Top of CU

2.2 Covers

Bolted Wedge Connectors installed on covered conductors (see CC 150), shall have covers installed per Table 420–1.

Figure CO 420–8: Large Cover

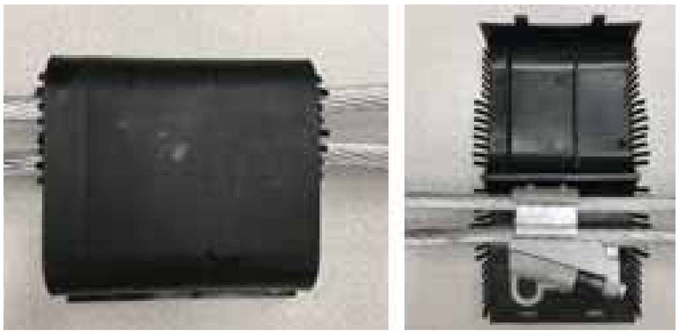


Figure CO 420–9: Small Cover

Bolted wedge connectors require no special tools for installation and can be installed with standard hot-stick tools or rubber gloves.

Table 420–1: Bolted Wedge Connectors

Conductor Range				Connector SAP	Connector Cover SAP
Run		Tap			
ACSR Size	CU Size	ACSR Size	CU Size		
300–397	—	266.8—397 ACSR	350	10211096	10212441
300–336	—	4/0–266.8	4/0	10211200	10212441
300–397	—	1/0–3/0	2/0	10211097	10212441
300–336	—	#4–#2	#2–#6 Sol	10211098	10212441
300–336[a/]	—	#4–#2	#2–#2	10211619	10212441
3/0–4/0	—	3/0–4/0	4/0	10211201	10212442
3/0–4/0	—	#2–1/0	1/0–2/0	10211202	10212442
4/0	—	#6–#4	#6–#2	10211203	10212442
#1–1/0	—	1/0	1/0–2/0	10211099	10212442
#1–1/0	—	#6–#4	#2–#6 Sol	10211100	10212442
—	4/0	1/0	—	10211202	10212442
—	2/0	#4	—	10211100	10212442
—	4/0	—	4/0	10211101	10212442
—	4/0	—	1/0–2/0	10211102	10212442
—	4/0	—	#2–#6 Sol	10211103	10212442
—	1/0–2/0	—	1/0–2/0	10211104	10212442
—	2/0	—	#2–#6 Sol	10211105	10212442
—	#6–#4	—	#4–#6 Sol	10211106	10212442
—	#2	—	#2–#6 Sol	10212440	10212442

[a/] Use in Heavy-Loading areas per Table DC 520–1.

Note(s):

1. All conductors in Table 420–1 are stranded unless notes as solid (Sol).

What's Changed? Updated Table CO 420-1 to include #6 Cu Sol and covers.

CO 450 Insulated Overhead Wire Spacers

Scope CO 450.1 Insulated Overhead Wire Spacers for 4 kV, 12 kV, 16 kV, and 34.5 kV Systems

1.0 Application

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

1.1 Horizontal Configuration:

Any span, including reduced tension spans, that meet both of the following criteria shall have line spacers installed.

- ☐ Three feet or more of conductor sag
- ☐ Conductor separation of 36 inches or less

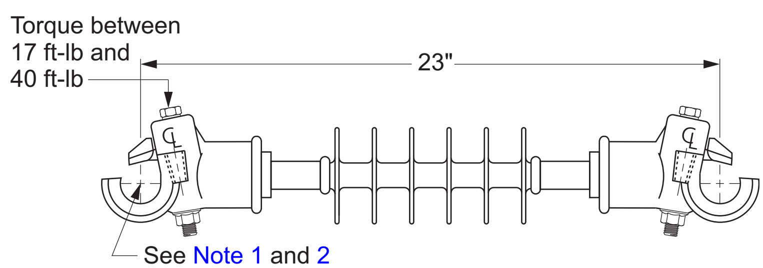
1.2 Vertical Configuration:

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

- ☐ Ice formation (heavy loading areas) that can result in traveling waves or line galloping
- ☐ Extreme changes in terrain (pole line on apex of ridge) that can result in traveling waves or line galloping

NOTE Overhead wire spacers are not required on covered conductor.

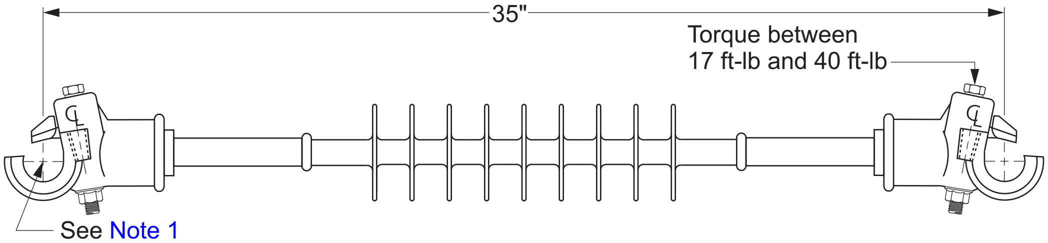
Figure CO 450–1: 23-Inch Insulated Spacer



Note(s):

1. 23-inch spacer not applicable for 34.5 kV.
2. Conductor Range: #4 ACSR to 653 ACSR and #4 SOL to 500 AWG Cu.

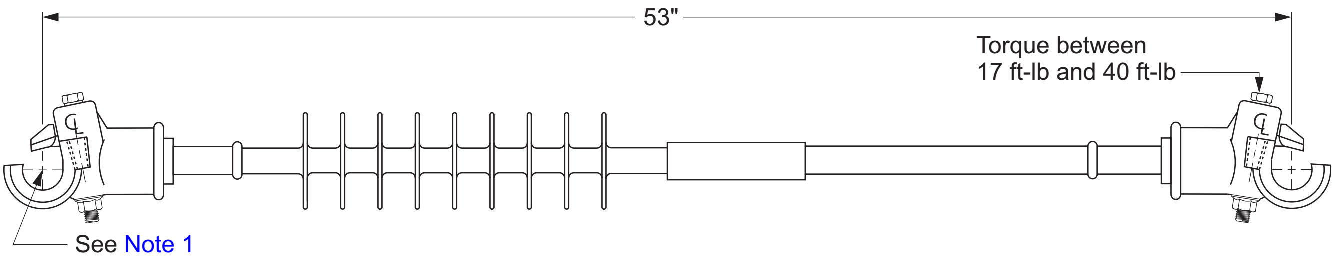
Figure CO 450–2: 35-Inch Insulated Spacer



Note(s):

1. Conductor Range: #4 ACSR to 653 ACSR and #4 SOL to 500 AWG Cu.

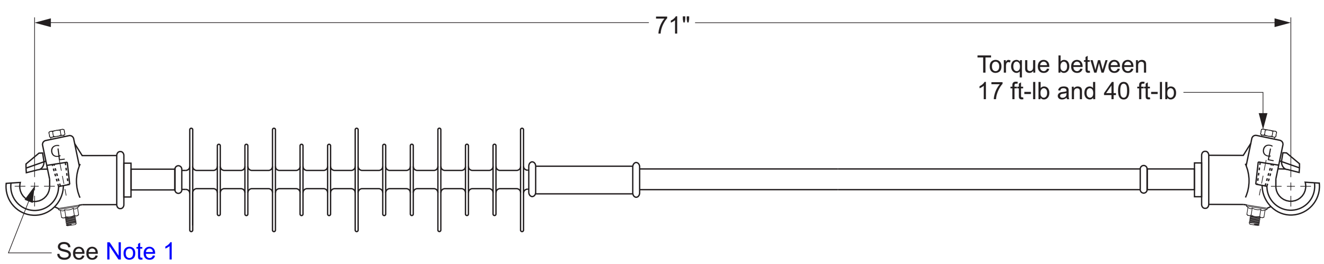
Figure CO 450–3: 53-Inch Insulated Spacer



Note(s):

1. Conductor Range: #4 ACSR to 653 ACSR and #4 SOL to 500 AWG Cu.

Figure CO 450–4: 71-Inch Insulated Spacer



Note(s):

1. Conductor Range: #4 ACSR to 653 ACSR and #4 SOL to 500 AWG Cu.

Table CO 450–1: Insulated Spacer SAP Numbers

Spacer Length (inches)	SAP
23	10116357
35	10116358
53	10116359
71	10116360

Note(s):

1. The distance between two phases will dictate the length of spacer used.
2. Select spacer that slightly pulls the conductors together rather than pushing them apart.

2.0 Installation

2.1 Line guard or armor rod protection shall be installed on all conductors that the wire spacers are to be attached to per Table CO 450–2 and Table CO 450–3. Maximum conductor sizes for wire spacers is 653 ACSR. More than one spacer can fit on a line guard or armor rod.

Table CO 450–2: Line Guard SAP Numbers

Conductor Size	SAP	Required w/Line Spacers
#6 Sol, Cu	10212369	Yes
#4 Sol, Cu	10212370	Yes
#4 ACSR-6/1	10068425	Yes
#2 ACSR-6/1	10068380	Optional
1/0 ACSR-6/1	10068426	Optional
4/0 ACSR-6/1	10068427	Optional
336.4 ACSR-18/1	10068428	Optional
336.4 ACSR-30/7	10068419	Optional
653.9 ACSR-18/3	10068420	Optional

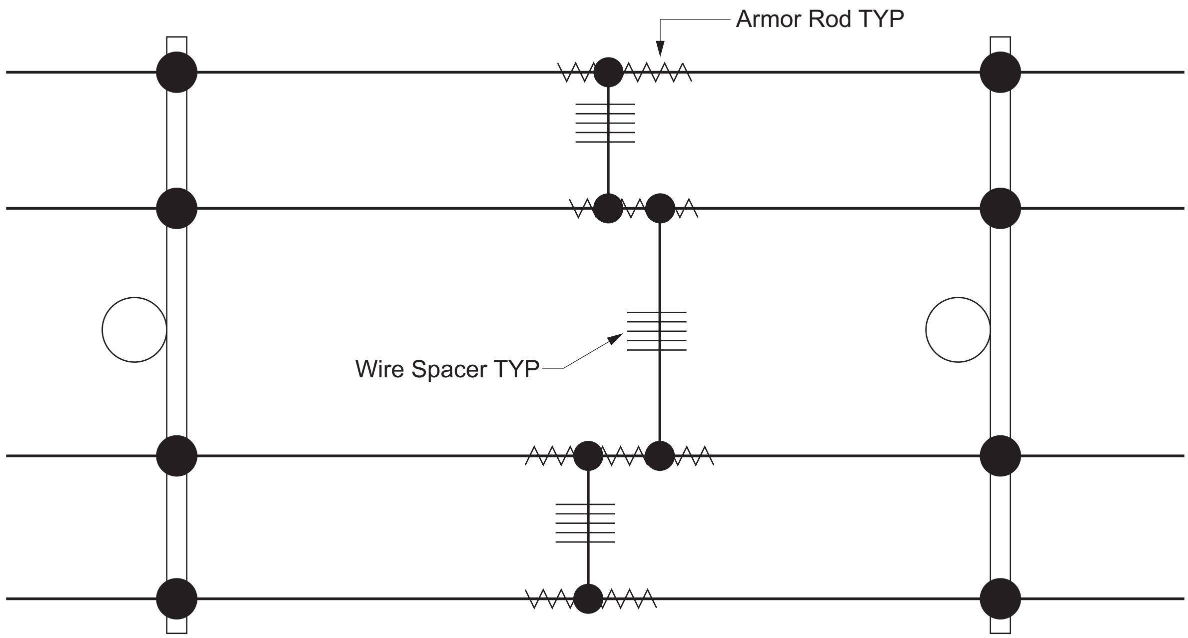
Table CO 450–3: Armor Rod SAP Numbers

Conductor size	SAP Numbers	Required w/Line Spacers
#4 Cu	10068381	Yes
#2 Cu	10068382	Yes
2/0 Cu	10068383	Optional
4/0 Cu	10068384	Optional
500 Cu	10068385	Optional

2.2 Spacers are not required on covered conductor. One set of spacers installed on a line span in horizontal configuration should be applied at the lowest point of sag, typically in the middle of the span.

NOTE The lowest point of sag in an incline span will be closer to the lower pole.

Figure CO 450–5: Wire Spacers for Horizontal Configuration



Note(s):

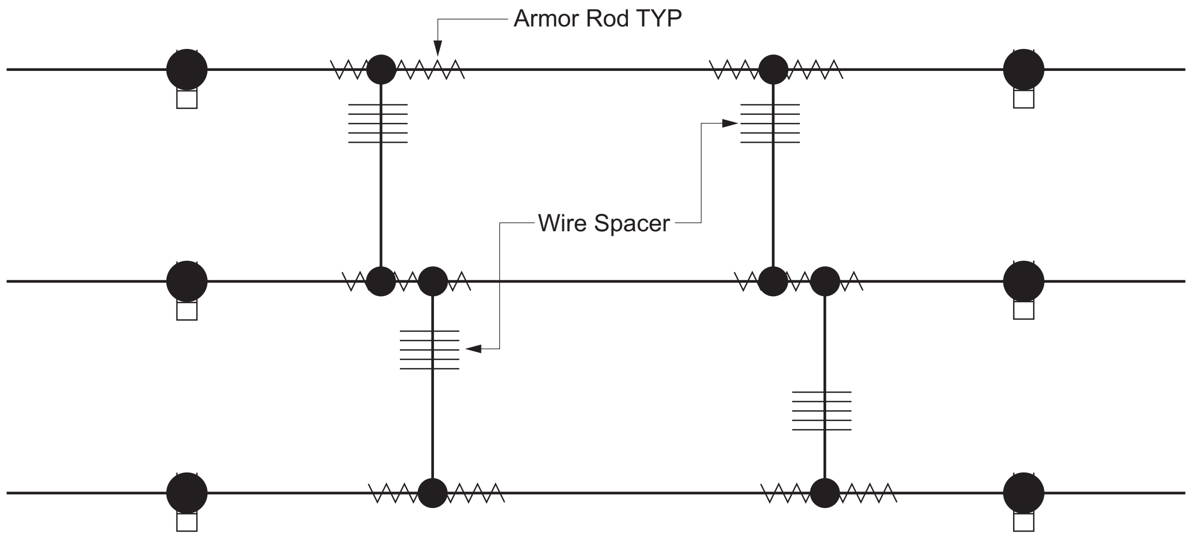
1. Install one set of spacers in middle of span for spans up to 400 feet. Longer spans may require additional spacers.

2.3 Spacers can only be installed with bucket access. If there is no bucket access, reconfigure circuit with 3 wire ridge pin (see Figure DC 535–5), or two levels of crossarms (box type, see Figure DC 535–3) construction.

2.4 Spacers installed on a line span in vertical configuration must be applied according to the following rules to prevent traveling wave/galloping problems (see Figure CO 450–1).

- Maximum distance between spacers must be less than 240 feet.
- Maximum distance from the pole to the first spacer must be less than or equal to 100 feet.
- Adjacent subspans (for example, distance between adjacent spacers) must differ in length by at least 10 feet.
- No more than two subspans in a given span can have the same length.

Figure CO 450–6: Vertical Configuration Line Guard or Armor Rod Installation



2.5 The number of spacers required for a given span length that meet the criteria in Subsection 1.2 are:

Table CO 450–4: Number of Spacers for Given Span Length

Span Length	No. of Spacers Required
190–400[a/]	2
410–590	3

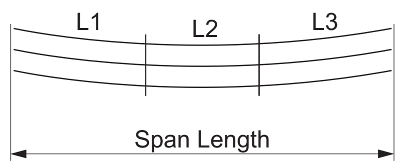
a/ For span lengths greater than 590 feet, contact Distribution Apparatus Engineering.

Note(s):

1. See Subsection 1.2 for application to mitigate conductor galloping.

Table CO 450–5: Span Lengths from 190 ft to 400 ft (Vertical Configuration)

Two Spacers

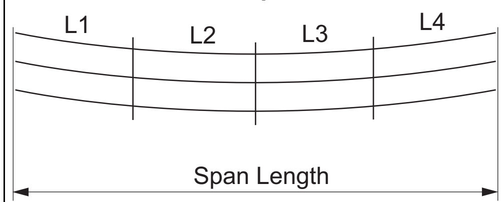


Span Length	L1	L2	L3
190	60	90	40
200	60	90	50
210	60	90	60
220	65	90	65
230	70	90	70
240	75	90	75
250	75	95	80
260	80	100	80
270	85	100	85
280	85	105	90
290	90	110	90
300	90	115	95
310	95	120	95
320	95	130	95
330	95	140	95
340	95	145	100
350	95	155	100
360	100	160	100
370	100	170	100
380	100	180	100
390	100	190	100
400	100	200	100

What's Changed? Revised figure in table to show vertically configured lines.

Table CO 450–6: Span Lengths from 410 ft to 590 ft (Vertical Configuration)

Three Spacers



Span Length	L1	L2	L3	L4
410	80	110	140	80
420	80	120	140	80
430	85	120	140	85
440	90	120	140	90
450	95	120	140	95
460	100	120	140	100
470	100	120	150	100
480	100	130	150	100
490	100	130	160	100
500	100	140	160	100
510	100	140	170	100
520	100	150	170	100
530	100	150	180	100
540	100	160	180	100
550	100	160	190	100
560	100	170	190	100
570	100	170	200	100
580	100	180	200	100
590	100	190	200	100

DOH–DC: Distribution Construction

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STANDARD **TITLE**

DC 535 Wildlife-Safe Power Line Construction

Scope DC 535.1 Wildlife-Safe Power Line Construction

1.0 General Information

These standards are intended to protect lines from wildlife by constructing sufficient phase-to-phase and phase-to-ground clearances and by installing approved protective materials on high voltage lines and equipment. In addition, installing wildlife protection on all phases will mitigate other contact-related faults, such as incidental contact of trees and metallic balloons at the pole. Should it be determined at the time of design or construction that undertaking such efforts would compromise public or worker safety, reasonable efforts will be made to construct with the best possible clearances and/or protective materials.

Wildlife protection material is for incidental wildlife contact only. They are not rated for personal protection and should be treated as bare wires.

1.1 New poles, bare and covered conductor lines, equipment, apparatus, and pole replacements shall be constructed per this standard.

A. Standard Construction

- Horizontal phase-to-phase/ground separation of 36 inches and vertical phase-to-phase/ground separation of 36 inches (Measured center of pin to center of pin on a wood/composite arm) (see Figure DC 535–1).

  In the absence of sufficient separation, wildlife protection material shall be used (for example, Wildlife Hoods, Wildlife Hood Extenders, and Protective Tubing).
- In covered conductor systems, wildlife protection material 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 on all four wires.
- Covered Conductor systems do not require use of wildlife hoods, wildlife hood extenders, and/or protective tubing.
- Dead-ends in covered conductor systems shall be covered with wildlife protection.
- Overhead equipment shall have bushing covers
- Overhead equipment shall be connected with covered conductors
- Overhead arresters shall utilize vendor supplied covers
- All overhead taps, leads, and jumper wires shall utilize covered conductors
- On all riser poles, potheads shall utilize covers and all phase jumpers shall be covered
- All new overhead switches shall be inverted

B. Eagle Zone Construction

Portions of the SCE service territory are designated as Eagle Zones (see Section 5.0):

- In addition to areas defined in Section 5.0, all Public Lands (for example, 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:

- Horizontal phase-to-phase/ground separation of 60 inches (Measured center of pin to center of pin on a wood/composite arm, see Figure DC 535–1) and vertical phase-to-phase/ground separation of 40 inches
- In the absence of sufficient separation, wildlife protection material shall be used (for example, Wildlife Hoods, Wildlife Hood Extenders, and Protective Tubing)
- Covered Conductor systems do not require the use of Wildlife Hoods, Wildlife Hood Extenders, and Protective Tubing.

1.2 Any SCE power line structure involved in the mortality of a protected wildlife species will be evaluated by CES to determine if the SCE power line structure is wildlife safe. As appropriate, poles, lines, equipment, and apparatus involved in avian mortalities will be retrofitted with wildlife protection materials.

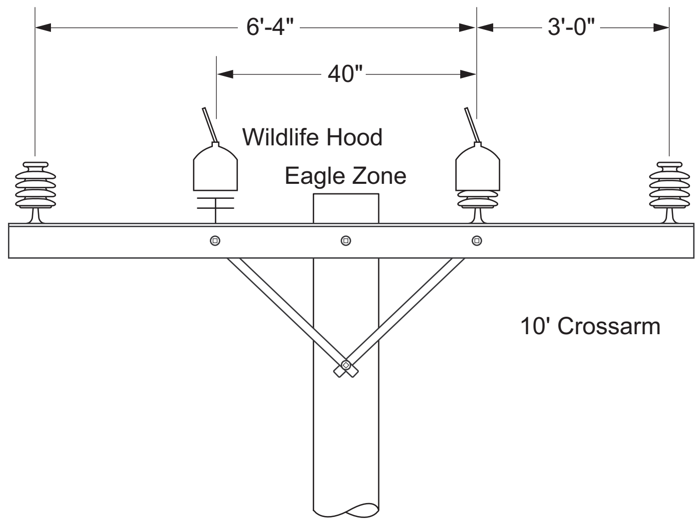
1.3 For the purposes of this standard, wood poles/crossarms and composite poles/crossarms are not considered “grounded”.

1.4 In areas where secondary/service drop conductors have been damaged (chewed or gnawed) by rodents and damage to the conductor has been observed, copper secondary’s shall be utilized in replacement. Aluminum secondary’s/service drops shall be replaced with copper to deter animals from re-visiting the effected line. In areas where high vegetation and rodent population exists, preventative measures like using secondary copper conductors shall be employed during the replacement of aluminum conductors. Refer to CO 108 for requirements.

2.0 Wildlife-Safe Construction for Standard Construction and Eagle Zones

2.1 4/12/16/33 kV, 3-Wire or 4-Wire, Straight-Line Construction

Figure DC 535–1: 4/12/16/33 kV, 3-Wire or 4-Wire, Straight-Line Construction

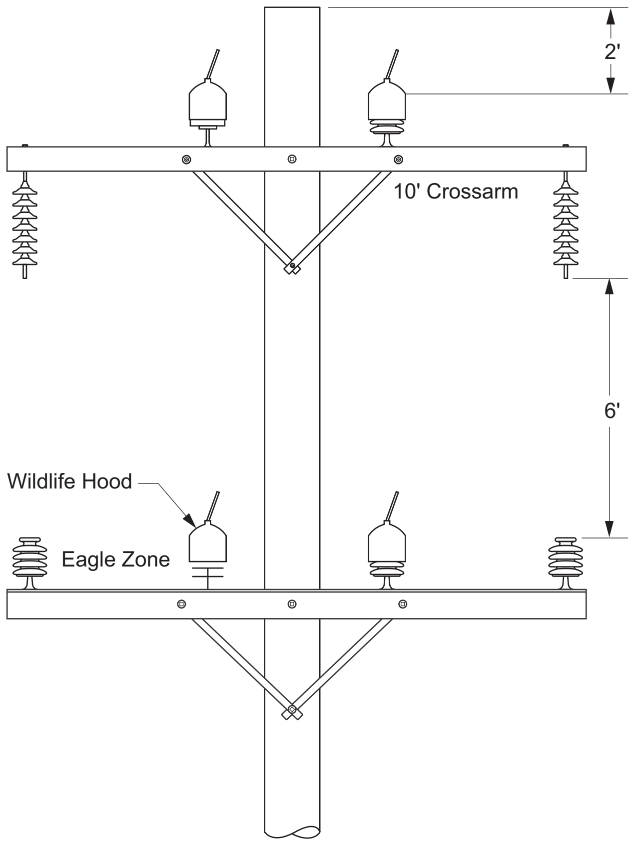


Note(s):

1. Wildlife Hoods shall be trimmed to properly fit double pin insulator application.
2. Wildlife Hoods may be installed on single pin-type insulators with a maximum of six degrees deviation angle. For double pin-type insulators the maximum deviation angle is 12 degrees with wildlife hoods trimmed to fit properly. See DC 585 for determination of deviation angles.
3. In Eagle Zones, a 12 foot crossarm will require wildlife protection material or modifications to the pre-drilled holes for insulator spacing.
4. See DC 510 for construction details.

2.2 4/12/16/33 kV, 3-Wire or 4-Wire, Straight Line Post-Suspension Construction

Figure DC 535–2: 4/12/16/33 kV, 3-Wire or 4-Wire, Straight Line Pin/Post-Suspension Construction

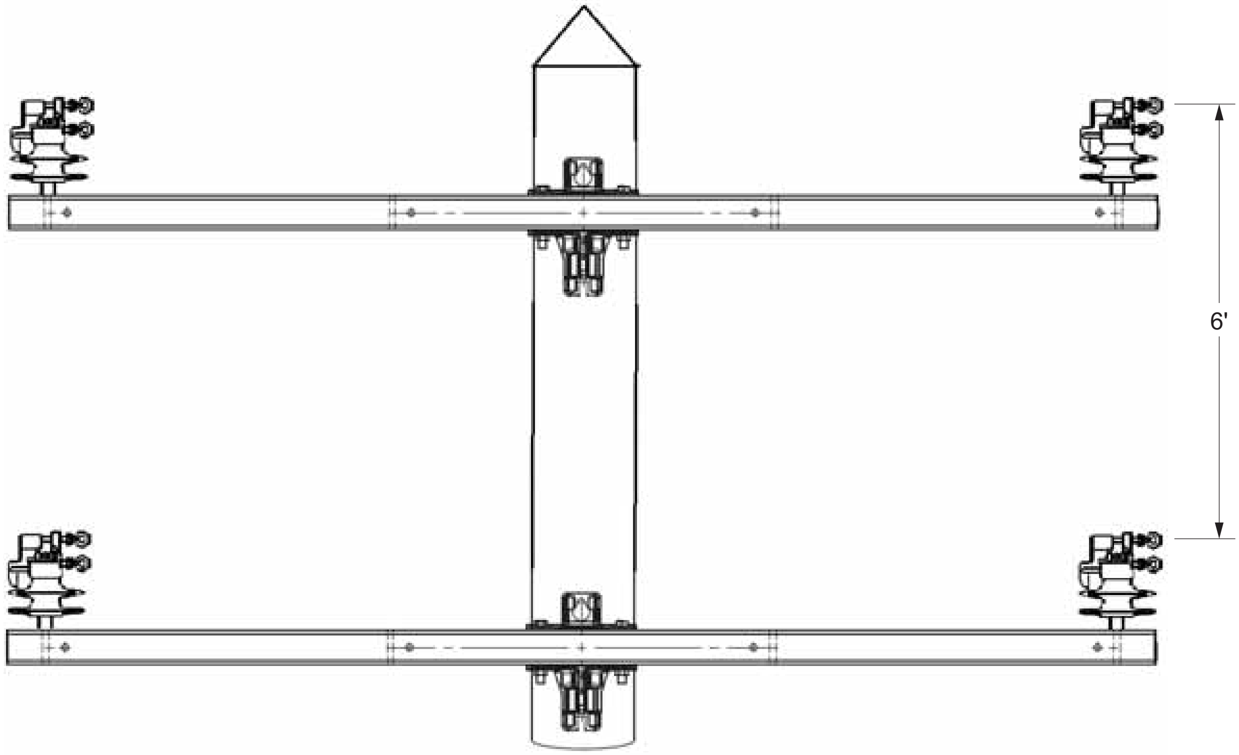


Note(s):

1. See DC 530 for suspension-type construction clearances.
2. In Eagle Zones, a 12 foot crossarm will require wildlife protection material or modifications to the pre-drilled holes for insulator spacing. See CO 700 for conductor spacing on 12 foot crossarms.

2.3 4/12/16/33 kV 3-Wire or 4-Wire, Two Level (Box) Construction

Figure DC 535–3: 4/12/16/33 kV, 3-Wire or 4-Wire, Two Level (Box) Construction

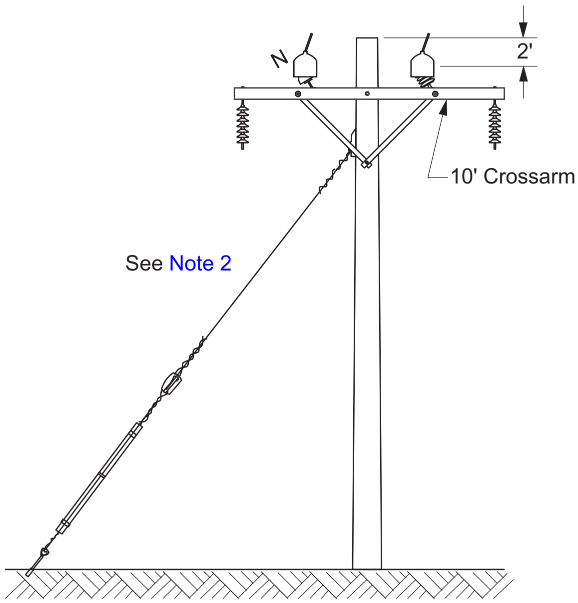


Note(s):

1. In Eagle Zones, a 12 foot crossarm will require wildlife protection material or modifications to the predrilled holes for insulator spacing. See CO 700 for conductor spacing on 12 foot crossarms.
2. Insulators shown are 25 kV polymer vise-top. For 16/25 kV, use 35 kV polymer vise-top insulators (see GR Section).

2.4 4/12/16/33 kV, 3-Wire or 4-Wire, Angle Suspension Construction

Figure DC 535–4: 4/12/16/33 kV, 3-Wire or 4-Wire, Angle Suspension Construction

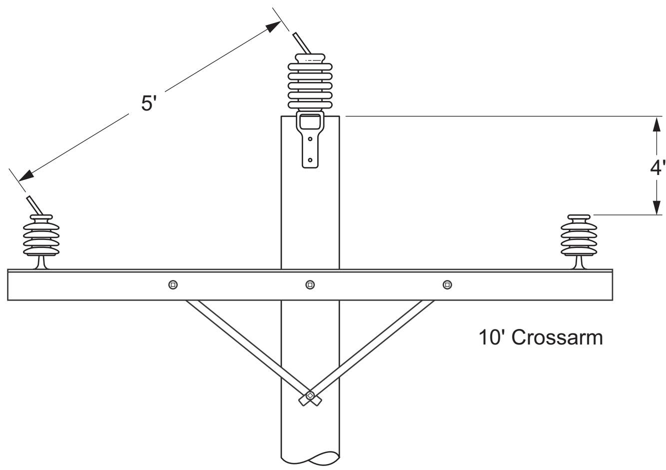


Note(s):

1. For angle deviation limits, refer to the Pole Loading Manual (PLM), Chapter PLM-4.
2. See PO 300 for guying requirements.
3. In Eagle Zones, a 12 foot crossarm will require wildlife protection material or modifications to the pre-drilled holes for insulator spacing. See CO 700 for conductor spacing on 12 foot crossarms.

2.5 12/16/33 kV, 3-Wire, Ridge Pin Construction

Figure DC 535–5: 12/16/33 kV, 3-Wire, Ridge Pin Construction

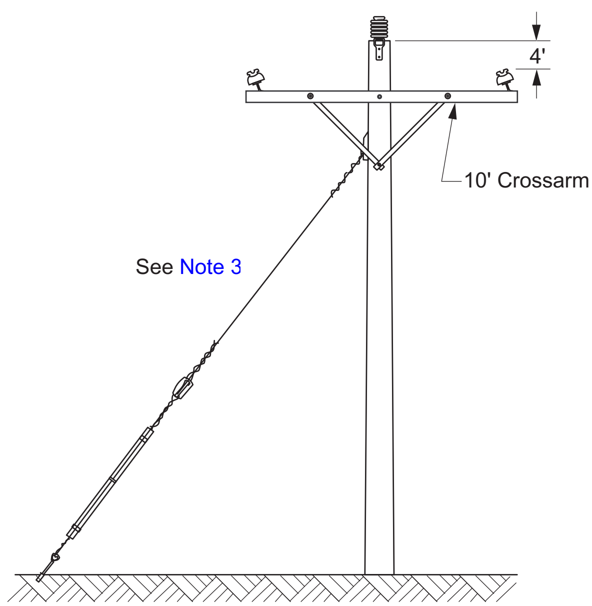


Note(s):

1. 3-Wire, Ridge Pin Construction may also be used for 12/16 kV pole replacements.
2. See DC 500 for construction details.

2.6 12/16/33 kV, 3-Wire, Angled Ridge Pin Construction

Figure DC 535–6: 12/16/33 kV, 3-Wire, Angled Ridge Pin Construction

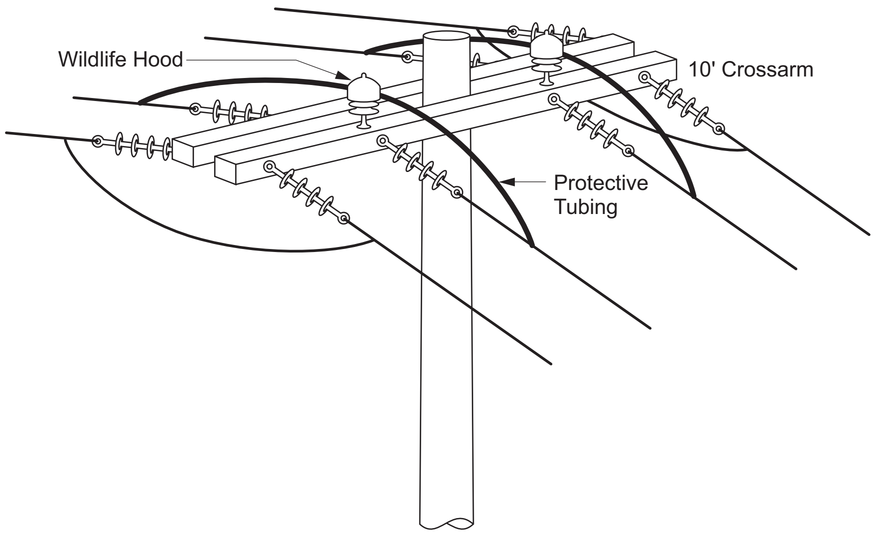


Note(s):

1. 3-Wire, Angled Ridge Pin Construction may also be used for 12/16 kV pole replacements.
2. For angle deviation limits, refer to the Pole Loading Manual (PLM), Chapter PLM-4.
3. See PO 300 for guying requirements.

2.7 3-Wire or 4-Wire, Double Dead-End Construction

Figure DC 535–7: 3-Wire or 4-Wire, Double Dead-End Construction

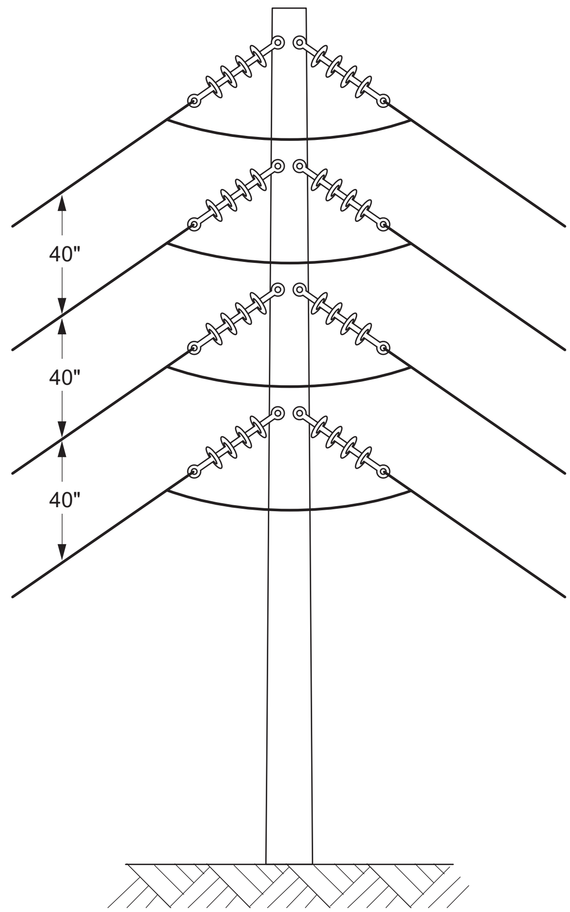


Note(s):

1. Inside phase jumper(s) shall be covered with protective tubing when installed over the crossarms.
2. In Eagle Zones, a 12 foot crossarm will require wildlife protection material or modifications to the pre-drilled holes for insulator spacing.

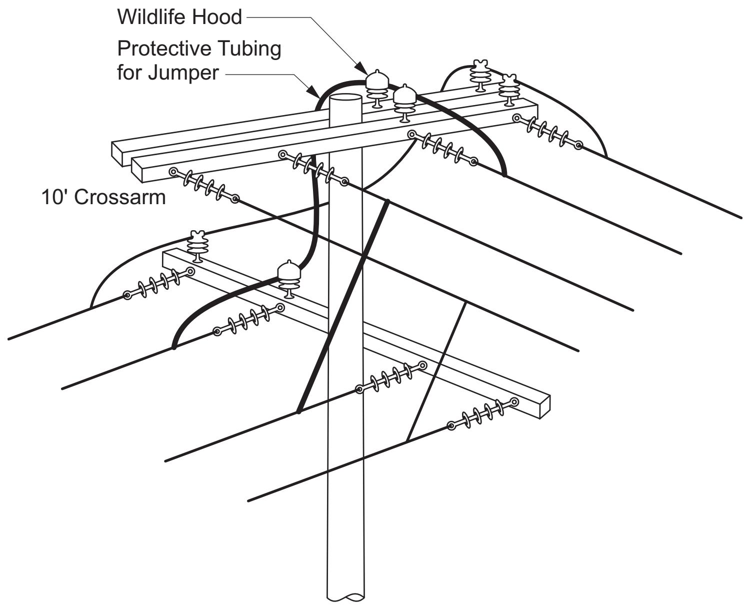
2.8 3-Wire or 4-Wire, Corner Pole, Vertical Construction

Figure DC 535–8: 3-Wire or 4-Wire, Corner Pole, Vertical Construction



2.9 3-Wire or 4-Wire, Corner Pole, Horizontal Construction

Figure DC 535–9: 3-Wire or 4-Wire, Corner Pole, Horizontal Construction



Note(s):

1. Wildlife Hoods shall be trimmed to properly fit double pin insulator application.
2. See DC 110 and DC 120 for proper clearances.
3. In Eagle Zones, a 12 foot crossarm will require wildlife protection material or modifications to the pre-drilled holes for insulator spacing.

2.10 12/16/25/33 kV 3/4-Wire, Transmission Underbuild

Follow DC 530 for suspension construction. If suspension construction is not possible, construct to Figure DC 535–4.

For steel poles utilizing crossarms to support primary conductors with less than 60 inches of horizontal phase-to-phase clearance (Measured center of pin to center of pin, see Figure DC 535–1) or 36 inches of horizontal phase-to-pole clearance (measured to the surface of the pole), all phases shall be covered.

Per GR 111.1, the neutral to pole connection shall be made using a conductor with at least the same ampacity as the primary and/or secondary neutral conductor of the circuit and shall be covered with appropriate protective tubing.

3.0 Wildlife Protection for Apparatus

3.1 Connectors

Connectors shall be installed at a minimum of 40 inches above mounting brackets (for example, cable terminations, arresters, or fuse holders) or wildlife protection materials shall be installed.

3.2 Transformers

Transformers shall have bushing covers for primary transformer bushings (including neutrals) and covered tubing for jumpers between fuse holders. New lightning arresters come from the manufacturer with required protective covering and all high side taps on fuse holders require covered tubing and the wire shall be connected at the top of the fuse holder. Protected Ground Wire (PGW) can be used in these situations. When working on a pole with existing arresters that do not have covers, replace them with new ones that have the required covers.

3.3 Cable Terminations (Potheads)

Cable terminations shall have protective covers over the energized, upper part of the termination, and covered tubing for the termination taps. The jumper or tap area immediately adjacent to the grounded metal termination bracket and crossarm must also be adequately covered. New lightning arresters come from the manufacturer with required protective covering. When working on a pole with existing arresters that do not have covers, replace them with new ones that have the required covers.

3.4 Capacitor Banks

Capacitor banks shall have protective covering. When vendor supplied capacitor units do not include protective covers over energized parts, the exposed areas shall be covered by Field Personnel. Bushing covers and current limiting fuse covers shall be installed on potential transformers and current limiting fuses in the area closest to the high voltage transformer bushings.

3.5 Automatic Reclosers (AR), Remote Control Switches (RCS) and Regulators

ARs and regulators shall have protective covers over exposed bushings. A minimum of three feet of covered tubing shall be installed over the line taps. Bushing covers and current limiting fuse covers shall be installed on potential transformers and current limiting fuses in the area closest to the high voltage transformer bushings.

3.6 Overhead Switches

A. Horizontal Construction

New installations requiring an overhead distribution switch (up to 17 kV class) shall be an inverted Omni-Rupter wildlife-safe switch (see AP 336). Center phase leads of the switch shall have protective covering.

38 kV class applications requiring an overhead distribution switch shall be an inverted Alduti-Rupter wildlife-safe switch. For Eagle Zones only, center phase leads of the switch shall have protective covering (see AP 338).

B. Vertical Construction

Installations requiring an overhead distribution switch (up to 17 kV class) shall be an inverted Omni-Rupter wildlife-safe switch (see AP 336).

4.0 Wildlife Protection Materials

Wildlife protection material is for incidental wildlife contact only. They are not rated for personal protection and should be treated as bare wires.

Bushing covers shall only cover top skirt of the bushing.

Table DC 535–1: Wildlife Protection Material

SAP	Description	Photo
10067758	Cover, Wildlife, Bushing, to be Used on Transformer Bushing, 3.25" to 4.25" Skirt Diameter, HDPE Material, Grey Color.	
10067783	Cover, Wildlife, Bushing, to be Used on Transformer Bushing, 4.5" Maximum Skirt Diameter, HDPE Material, Grey Color.	
10067753	Cover, Wildlife, Bushing, to be Used on Recloser and Voltage Regulator Bushing, 5.00" to 6.25" Skirt Diameter, HDPE Material, Grey Color.	
10211487	Cover, Wildlife, Dead End Clamp, HDPE Material, Grey Color	

Table DC 535–1: Wildlife Protection Material *(Continued)*

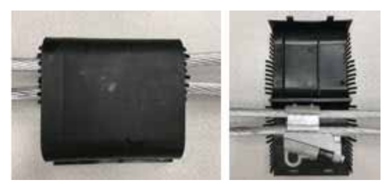
SAP	Description	Photo
10067793	Cover, Wildlife, Bushing, to be Used on Current Limiting Device, (CLD), Install Either Horizontal or Vertical Position, HDPE Material, Red Color.	
10200065	Cover, Wildlife, to be Used on Terminators/Potheads, can also be used on Bolted Wedge Connectors, 4-1/2" × 8" Outside Dimensions, HDPE Material, Grey Color.	
10211426	Cover, Wildlife, to be Used on Terminators/Potheads, 350–1500 kcmil, 4-1/2" × 16" Outside Dimensions, HDPE Material, Grey Color.	
10212441	Cover, Large, Wildlife, Bolted Wedge Connector, to be used on 336 ACSR and larger conductors.	
10212442	Cover, Small, Wildlife, Bolted Wedge Connector, to be used on 4/0 and smaller conductors.	
10200066	Cover, Wildlife, Brace Bolt, to be Used on Crossarms with V-braces on Steel Poles, HDPE Material, Grey Color.	

Table DC 535–1: Wildlife Protection Material *(Continued)*

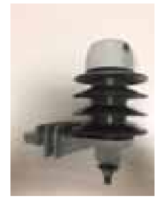
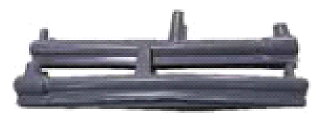
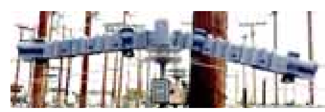
SAP	Description	Photo
10109289	Cover, Wildlife, Stud, to be Used on Distribution Lightning Arresters, PVC Material, Grey Color.	
10184084	Cover, Wildlife, Body, Insulator, Post Type, to be Used with SAP 10067847 Extenders, Grey Color.	
10067846	Cover, Wildlife, Body, Insulator, Post and Vice-top Type, Body, to be Used with SAP 10067847 Extenders, Grey Color.	
10067847	Cover, Wildlife, Extenders for 60" Coverage, Set of 2, to be Used with SAP 10184084 or SAP 10067846 Body, Grey Color.	
10184091	Cover, Wildlife, 1-piece, 60", to be Used with Post and Vice-top Insulators, Grey Color.	
10184097	Cover, Wildlife, Cutout, Large, HDPE Material, Grey Color.	
10184093	Cover, Wildlife, Cutout — 4 kV, HDPE Material, Grey Color.	

Table DC 535–1: Wildlife Protection Material *(Continued)*

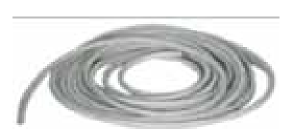
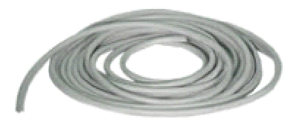
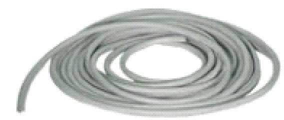
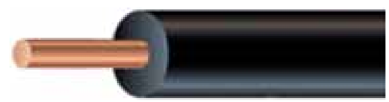
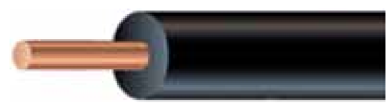
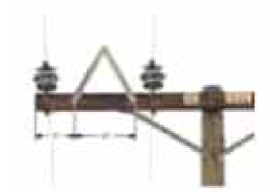
SAP	Description	Photo
10184094	Cover, Wildlife, Cutout — 12/16 kV, HDPE Material, Grey Color.	
10117060	Tubing, Wildlife, Non-split, to be Used on Capacitor Banks, 5/16" ID × 2' Long, 5/32" Wall Thickness, for #6 AWG Bare Cu — #2 AWG Str., PVC Material, Grey Color.	
10117061	Tubing, Wildlife, Non-split, 0.45" ID × 2' Long, 5/32" Wall Thickness, for #2/0 AWG Bare Cu — 1/0 AWG ACSR, PVC Material, Grey Color.	
10117062	Tubing, Wildlife, Non-split, 3/4" ID × 2' Long, 5/32" Wall Thickness, for 336.4 kcmil ACSR, PVC Material, Grey Color.	
10147890	Cover, Wildlife, Stinger, Split, to be Used to Cover Primary Wire, 3/8" ID × 2' Long, (25) Per Box, for #6 AWG — 1/0 ACSR, Ozone Resistant Rubber Material, Grey Color.	
10200336	Cover, Wildlife, Stinger, Split, to be Used to Cover Primary Wire, 3/8" ID × 50' Long Coil, for #6 AWG — 1/0 ACSR, Ozone Resistant Rubber Material, Grey Color.	

Table DC 535–1: Wildlife Protection Material *(Continued)*

SAP	Description	Photo
10180176	Cover, Wildlife, Stinger, Split, to be Used to Cover Primary Wire, 5/8" ID × 50' Long Coil, for 2/0 — 336.4 kcmil, Ozone Resistant Rubber Material, Grey Color.	
10180177	Cover, Wildlife, Stinger, Split, to be Used to Cover Primary Wire, 3/4" ID × 25' Long Coil, (2) Coils Per Box, for 653 kcmil–750 kcmil, Ozone Resistant Rubber Material, Grey Color.	
10109302	Protected Ground Wire (PGW), LDPE, #6 AWG CU to be used over taps (when applicable), high-side bushing on transformer banks and capacitor banks.	
10109304	Protected Ground Wire (PGW), LDPE, #4 AWG CU to be used over taps (when applicable), high-side bushing on transformer banks and capacitor banks.	
10067816	Guard, Wildlife, Triangular, Adjustable, 2-1/4" × 24-1/4", Polyethylene Material, to be Mounted on Crossarms Between Phases. Note(s): Contact Environmental Services for approval.	

5.0 Eagle Zones

Table DC 535–2 summarizes whether a District contains Eagle Zones, which require additional conductor clearances or covers. In many Districts, both Standard Construction and Eagle Zones are identified; in these cases, the Eagle Zone Maps should be used to identify requirements for a specific area.

The Eagle Zone map designations are a collaboration between T&D and CES and are subject to change. The most recent publications and maps should always be referenced prior to Planning or Construction.

Eagle Zone maps are broken down by districts and may be found at the link below:

Eagle Zone Maps

Table DC 535–2: Districts and Eagle Zone

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
Catalina	61	Catalina	X	X	Entire island except the portion of the city of Avalon within a line beginning at Crescent Ave. and Claressa Ave.; going south on Claressa Ave. to Tremont St. West on Tremont to Country Club Dr., North on Country Club and Las Lomas to Crescent Ave.; and East to point of origin.
Desert	30	Foothill	X	X	Areas of Foothill district on north of the 210 FWY and West of the 15 FWY.
Desert	31	Redlands	X	X	Outside a boundary starting on: 1. N/E of 215 FWY and Devore Rd. going S/E on Kendall Dr. to Campus Pkwy. 2. Going N/E on Campus Pkwy to W Northpark Blvd. 3. South/East on W Northpark Blvd. to Electric Ave. 4. South on Electric Ave. to 40th St. 5. East on 40th St. to Mountain Ave. 6. South on Mountain Ave. to 39th St. 7. East on 39th St. to Del Rosa Ave. 8. South on Del Rosa Ave. to Foothill Dr. 9. East on Foothill Dr. to Sterling Ave. 10. South on Sterling Ave. to Lynwood Dr. 11. East on Lynwood Dr. to Victoria Ave. 12. South on Victoria Ave. to Highland Ave. 13. East on Highland Ave. to Church St. 14. South on Church St. to side of the Santa Ana River. 15. Santa Ana River East to Crafton 16. South on Crafton to Sand Canyon. 17. East on Sand Canyon to Chapman Heights Rd. 18. West on Chapman heights Rd. to Oak Glen Rd. 19. East on Oak Glen Rd. to Bryant St.

Table DC 535–2: Districts and Eagle Zone *(Continued)*

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
Desert (cont'd)	31	Redlands	X	X	Outside a boundary starting on: 20. South on Bryant St. to Ave. F. 21. East on Ave. F to Mesa Grande Dr. 22. South Mesa Grande Dr. to County Line Rd. 23. West on County Line Rd. to Fremont St. 24. South on Fremont to Ave L. 25. West on Ave. L to California St. 26. South on California St. to Myrtlewood Dr. 27. West on Myrtlewood Dr. to Calimesa Blvd. 28. South on Calimesa Blvd. to the 10 FWY. 29. West on 10 FWY to Highland Ave. 30. West on Highland Ave. to Smiley Heights Dr. 31. West on Smiley Heights Dr. to Terracina Blvd. 32. North on Terracina Blvd. to Barton Rd. 33. West on Barton Rd. to the district boundary. 34. East of Mt. Vernon Ave. and Washington St. 35. South on Mt. Vernon Ave. to Palmyrita Ave. 36. Undeveloped areas South/East of the intersection of the 215 FWY and 10 FWY.
Desert	73	Victorville (aka High Desert)	X	X	Outside a boundary beginning on the intersection of 15 FWY and Ranchero Rd. 1. North on 15 FWY to 395. 2. North on 395 to Rancho Rd. 3. East on Rancho Rd. to 18 HWY. 4. S/E on 18 HWY to Navajo Rd. 5. South on Navajo Rd. to Bear Valley Rd. 6. West on Bear Valley Rd. to Deep Creek Rd.

Table DC 535–2: Districts and Eagle Zone *(Continued)*

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
Desert (cont'd)	73	Victorville (aka High Desert)	X	X	Outside a boundary beginning on the intersection of 15 FWY and Ranchero Rd. 7. South of Deep 8 Creep Rd. to Juniper Rd. 8. West on Juniper Rd. to Ranchero Rd. 9. West on Ranchero Rd. to 15 FWY.
Desert	79	Palm Springs	X	X	Outside the boundaries between the 10 FWY and HWY 111.
Metro East	22	Montebello	X	—	—
Metro East	26	Covina	X	X	All areas North of a line beginning at intersection of HWY 39 and Foothill Blvd., proceeding East along Foothill Blvd. to Valley Center, South on Valley Center to Route 66, East on Route 66 to Baseline Rd, East on Baseline Rd. to 210 FWY.
Metro East	27	Monrovia	X	X	All the area North of a line beginning on Encanto Pkwy and Huntington Dr. 1. West on Huntington Dr. to Mountain Ave. 2. North on Mountain Ave. to Foothill Blvd. 3. West on Foothill Blvd. to Michillinda Ave. 4. North on Michillinda Ave. to Park Vista Dr. 5. All Area of Sierra Madre, Altadena, La Canada Flintridge, and La Cresenta.
Metro East	34	Ontario	X	—	All district areas North of the 210 FWY. "Eagle zone with Exceptions" 1. Within the boundaries of Ontario district on South of 60 FWY and West of 71 FWY.

Table DC 535–2: Districts and Eagle Zone *(Continued)*

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
Metro East (cont'd)	34	Ontario	X	X	Within a boundary beginning on intersection of 71 FWY and Edison. 1. East on Edison Ave. to 15 FWY. 2. South on 15 FWY to Limonite Ave. 3. East on Limonite Ave. to Van Buren Blvd. 4. South on Van Buren Blvd. to Santa Ana River. 5. West on Santa Ana River trail to North Dr. 6. West on North Dr. to California Ave. 7. South on California Ave. to Sixth St. 8. West on Sixth St/Norco Dr./ Corydon Ave. to River Rd. 9. S/E on River Rd. to Lincoln Ave. 10. South on Lincoln Ave. to Foothill Pkwy. 11. East on Foothill Pkwy to 15 FWY. 12. North on 15 FWY to Magnolia Ave. 13. N/E on Magnolia Ave. to Pierce St. 14. South on Pierce St. to Indiana Ave. 15. All undeveloped areas North and West of Lake Matthews.
Metro West	32	Dominguez Hills	X	—	—
Metro West	42	Santa Monica	X	—	—
Metro West	44	South Bay	X	—	—
Metro West	46	Long Beach	X	—	—
Metro West	47	Whittier	X	—	—
North Coast	35	Thousand Oaks	X	X	North of the 101 FWY, and undeveloped areas outside cities of Moorpark, Simi Valley, and Thousand Oaks.

Table DC 535–2: Districts and Eagle Zone *(Continued)*

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
North Coast	36	Antelope Valley	X	X	Outside a boundary beginning on intersection of Ave. I and 60th St. W. 1. South to 60th St. to W Ave. N. 2. East on W Ave. N to 30th St. 3. South on 30th St. to Rancho Vista Blvd. 4. East on Rancho Vista Blvd. to 20th St. 5. South on 20th St. to Elizabeth Lake Rd. 6. East on Elizabeth Lake Rd. to Tierra Subida Ave. 7. South on Tierra Subida Ave. to Ave. S 8. East on Ave. S to 40th St. 9. North on 40th St. to Ave. I. 10. West on Ave. I to 60th St. Outside a boundary beginning on intersection of 150th St. and Palmdale Blvd. 1. East on Palmdale Blvd to 180th St. 2. North on 180th St. to Ave M 8. 3. West on Ave M 8 to 150th St. 4. South on 150th to Palmdale Blvd.
North Coast	39	Ventura	X	X	North of a line beginning on 33 FWY and Main St. 1. S/E on Main to Telegraph Rd. 2. East on Telegraph Rd. to 118 (Wells Rd.) 3. South on 118 (Wells Rd.) to Railroad 4. South/West on Railroad to 101 FWY 5. S/E on 101 FWY to Beardsley Rd. All undeveloped areas North of City of Camarillo.
North Coast	49	Santa Barbara	X	X	North of a boundary beginning from HWY 192 and HWY 150. 1. West on 192/Cathedral Oaks to 1 FWY.

Table DC 535–2: Districts and Eagle Zone *(Continued)*

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
North Coast	59	Valencia	X	X	All Area outside the boundaries beginning from intersection of 5 FWY and HWY 14. 1. N/E on 14 to Soledad Canyon Rd. 2. West on Soledad Canyon Rd. to Whites Canyon Rd. 3. North on Whites Canyon Rd./ Plum Canyon Rd. to bouquet Canyon Rd. 4. North on Bouquet Canyon Rd. to Copper Hill Dr. 5. West on Copper Hill Dr. to Newhall Ranch Rd. 6. West on Newhall Ranch Rd. to 5 FWY. 7. Undeveloped areas west of the 5 FWY to HWY 14.
Orange	29	Santa Ana	X	—	—
Orange	33	Huntington Beach	X	—	—
Orange	43	Saddleback	X	X	East of the 241 FWY within the district boundaries. Starting on 241 FWY and Santiago Canyon Rd.
Orange	48	Fullerton	X	—	
Rurals North	50	Shaver Lake	—	X	
Rurals North	52	Tehachapi	X	X	Outside the boundaries beginning from 58 HWY and Tucker Rd. 1. South on Tucker Rd. to Highline Dr. 2. East on Highline Dr. to Dennison Rd. 3. North on Dennison Rd. to 58 HWY. 4. West on 58 HWY to Tucker.
Rurals North	53	Kernville	—	X	All district
Rurals North	85	Bishop/Mammoth	—	X	All district

Table DC 535–2: Districts and Eagle Zone *(Continued)*

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
Rurals North	86	Ridgecrest	X	X	Outside the boundaries beginning from intersection of Inyokern Rd. and Mahan St. 1. South on Mahan St. to Dolphin Ave. 2. East on Dolphin Ave. to College Heights Blvd. 3. North on College Height Blvd. to Bowman Rd. 4. East on Bowman Rd. to Gateway Blvd. 5. North on Gateway Blvd. to Ridgecrest Blvd. 6. West on Ridgecrest Blvd. to China Lake Blvd. 7. North on China Lake Blvd. to Inyokern Rd. 8. West on Inyokern Rd. to Mahan St.
Rurals South	40	Arrowhead	—	X	All district
Rurals South	72	Barstow	X	X	Outside the boundaries beginning on intersection of Main St. and P St. 1. South on P St. to Linda Vista Ave. 2. East on Linda Vista Ave. to H St. 3. North on H St. to Rimrock Rd. 4. East on Rimrock Rd. to Montana Rd. 5. North on Montana Rd. to Main St. 6. West on Main St. to P St.
Rurals South	84	29 Palms (aka Yucca Valley)	X	X	Outside the boundaries of 29 Palms. 1. Boundary beginning on Intersection of HWY 62 and Encila Ave. 2. North on Encila Ave. to Samarkan Dr. 3. East on Samarkan Dr. to Morongo Rd. 4. South on Morongo Rd. to 2 mile Rd. 5. East on 2 mile Rd. to Utah Trail 6. South on Utah Trail to HWY 62 7. West on Hwy 62 to Encila Ave.

Table DC 535–2: Districts and Eagle Zone ***(Continued)***

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
Rurals South (cont'd)	84	29 Palms (aka Yucca Valley)	X	X	Outside the boundaries of Yucca Valley. 1. Boundary beginning on Intersection of HWY 62 Kickapoo Trail. 2. South on Kickapoo Trail to Golden Bee Dr. 3. East on Golden Bee Dr. to Sage Ave. 4. South on Sage Ave. to San Andreas Rd. 5. East on San Andreas Rd. to Palomar Ave. 6. North on Palomar Ave. to HWY 62. 7. East on HWY 62 to Kickappo trail
Rurals South	87	Blythe	X	X	Outside the boundaries Blythe beginning on: 1. Intersection of Defrain Blvd. and of 10th Ave. 2. South on Defrain Blvd to Seeley Ave. 3. East on Seeley to Intake Blvd. 4. North on Intake Blvd. to 10th Ave. 5. West on 10th Ave to Defrain Blvd.
San Jacinto	77	Menifee (formerly San Jacinto)	X	X	All district under Eagle Zone with exceptions
San Jacinto	88	Wildomar (formerly San Jacinto)	X	X	All district under Eagle Zone with exceptions
San Joaquin	51	San Joaquin	X	X	Outside Boundaries city of Tulare. 1. Intersection of Cartmill Ave. and West St. 2. South on West St. to Bardsley Ave. 3. East on Bardsley Ave. to Mooney Rd. 4. North on Mooney Rd. to Cartmill Ave. 5. West on Cartmill Ave. to West St.

Table DC 535–2: Districts and Eagle Zone *(Continued)*

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
San Joaquin (cont'd)	51	San Joaquin	X	X	Outside Boundaries city of Visalia. 1. Intersection of Riggin Ave. and Akers St. 2. South on Akers St. to Caldwell Ave. 3. East on Caldwell Ave/Ave 280 to Rd. 140. 4. North on Rd. 140 to Johns Pkwy. 5. West on Johns Pkwy to Riggin Ave. 6. West on Riggin Ave. to Akers St. Outside the Boundaries of city of Hanford. 1. Intersection of Fargo Ave. and 12th Ave. 2. South on 12th Ave. to Hanford Armona Ave. 3. East on Hanford Armona Ave. to 9-1/2 Ave. 4. North on 9-1/2 Ave. to Fargo Ave. 5. West on Fargo Ave. to 12th St. Outside boundaries city of Delano: 1. Intersection of County HWY 44 and Stradley Ave. 2. South on Stradley Ave. to Kernell Ave. 3. East on Kernell Ave. to Browning Rd. 4. North on Browning Rd. to County HWY 44. 5. West on County HWY 44 to Stradley Ave.

Table DC 535–2: Districts and Eagle Zone *(Continued)*

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
San Joaquin (cont'd)	51	San Joaquin	X	X	Outside boundaries city of Porterville. 1. Intersection of Westfield Ave. and Rd. 224 2. South on Rd. 224 to Poplar Ave. 3. East on Poplar Ave. to Plano St. 4. North on Plano St. to Westfield Ave. 5. West on Westfield Ave. to Rd. 224. Outside boundaries city of Exeter. 1. Intersection of Vine St. and Belmont Rd. 2. South on Belmont Rd. to Glaze Ave. 3. East on Glaze Ave. to 65 HWY. 4. North on 65 HWY to Ave. 276. 5. East on Ave. 275 to Gill Rd. 6. North on Gill Rd. to Palm Dr. 7. West on Palm Dr. to Valencia Dr. 8. North on Valencia Dr. to Sequoia Dr. 9. West on Sequoia Dr. to Rd. 192 10. South on Rd. 192 to Vine St. 11. West on Vine St. to Belmont Rd. Outside boundaries city of Lindsay. 1. Intersection of Tulare Rd. and Westwood Ave. 2. South on Westwood Ave. to Apia St/ Valencia St. 3. East on Apia/Valencia St. to Foothill Ave. 4. North on Foothill Ave. to Fir St. 5. West on Fir St. to Sequoia Ave. 6. South on Sequoia Ave. to Tulare Rd. 7. West on Tulare Rd. to Westwood Ave.

Table DC 535–2: Districts and Eagle Zone *(Continued)*

Region	District #	District Name	Standard Construction	Eagle Zone	Eagle Construction Zone
San Joaquin (cont'd)	51	San Joaquin	X	X	Outside boundaries city of Farmsville. 1. Intersection of Tulare St. and Virginia Ave. 2. North on Virginia Ave. to Ave. 228. 3. East on Ave. 228 to Farmsville Blvd. 4. South on Farmsville Blvd. to Railroad. 5. East on Railroad to Brundage Ave. 6. South on Brundage Ave. to HWY J20. 7. West on HWY J20 to Edge of Orchards. 8. South on Orchards to Tulare St. 9. West on Tulare St. to Virginia Ave.

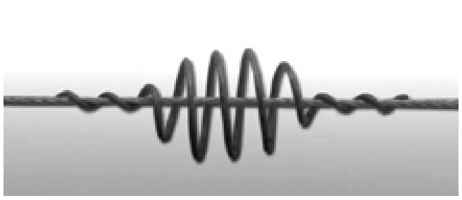
Note(s): Eagle Zones with Exception Rules

1. Standard Construction
   a. Development on both sides of the street or pole line
   b. Less than approximately 40 acres of open space on either side of a street or pole line
   c. Open space such as groomed parkland or golf courses
2. Eagle Construction
   a. Greater than approximately 40 acres of open space on either side of a street or pole line
   b. In situations that aren't clearly defined above as Standard Construction (when in doubt)

6.0 Swan Diverter

Swan Diverters are designed for use on bare conductors to create greater visibility for avian flight paths on overhead lines. Swan Diverters may be used to mark conductors where previous Avian collisions have occurred, where it is determined there is a high risk of Avian collisions with the conductor, or when required by an Agency or Land Manager. Swan Diverters may be installed on covered conductor when required. Consult SCE's Avian Protection Specialist for assistance.

Figure DC 535–10: Swan Diverter



If required, Swan Diverters shall be installed starting 15 feet from the pole, at 15 foot intervals, per Figure DC 535–11.

Figure DC 535–11: Swan Diverter Installation

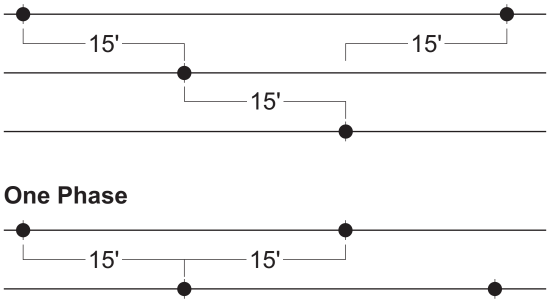


Table DC 535–3: Swan Diverters for Bare Conductor Application

SAP	Conductor Size
10211410	0.175"–0.249"
10211411	0.250"–0.349"
10211412	0.350"–0.449"
10211413	0.450"–0.599"
10211414	0.600"–0.770"
10211415	0.771"–0.858"
10211416	0.859"–0.970"
10211417	0.971"–1.121"
10211418	1.122"–1.306"
10211419	1.307"–1.530"

Note(s):

1. May be installed on covered conductor when required.

DOH–GR: Grounding Bonds and Insulators

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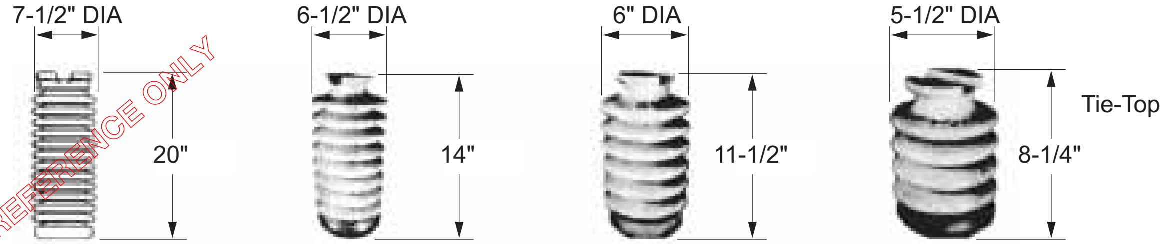
GR 205 Post-Type Line Insulators

Scope GR 205.1 Porcelain Post-Type Line Insulators — Tie-Top

Figure GR 205–1: Porcelain Post-Type Insulators — Tie-Top



N-Neck (6" DIA) (SAP 10116400) Brown

F-Neck (2-7/8" DIA) (SAP 10116399) Gray or Brown

F-Neck (2-7/8" DIA) (SAP 10116397) Gray or Brown

F-Neck (2-7/8" DIA) (SAP 10116395) Gray or Brown

Note(s):

1. For Porcelain Post-Type installation details refer to Scope GR 205.5.
2. New units purchased will be gray; however, brown units may be supplied by the re-use of returned units.

Table GR 205–1: Porcelain Post-Type Insulators — Tie Top

Line Voltage (kV)	Insul. Area[a]	Conductor	Nom. kV Rating	SAP[b]	Insulator Studs[c] Short (1-3/4") SAP	Insulator Studs[c] Long (7-1/2" to 8") SAP
33	A	Phase	66	10116400	10116404	10116405
	A	Phase	45	10116399[d]	10116404	10116398
	B, C	Phase	45	10116399	10116404	10116398
16	A, B, C	Phase	35	10116397	10116404	10116398
	A, B, C	Neutral	25[e]	10116326	10116404	10116398
12	A	Phase	35	10116397	10116404	10116398
	B, C	Phase	25	10116326	10116404	10116398
	A, B, C	Neutral	25[e]	10116326	10116404	10116398
4 or Less	A, B, C	Phase	15	Key 6 - See Polymer Table	—	—
	A, B, C	Neutral	15	Key 6 - See Polymer Table	—	—

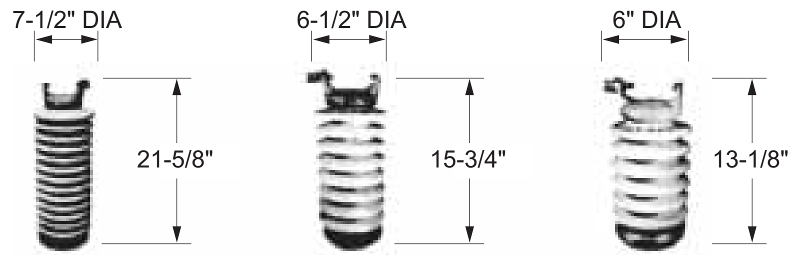
[a] See GR 215, insulation area map.
[b] For angle construction, use angle base SAP 10068619.
[c] New gray horizontal clamp-top post insulators are automatically supplied with short studs.
[d] This insulator is recommended for use in insulation area "A" only when it is mounted horizontally (for example, wood upsweep arm).
[e] The same nominal kV rated insulator can be used on all conductors provided that the Neutral is identified (SAP 10135124).

Note(s):

1. See CO 510 for clamp SAP numbers.
2. Not used with horizontal clamp-top post insulators.
3. See DC 535 for Wildlife Protection standards.
4. Not for use with covered conductors.

Scope GR 205.2 Porcelain Post-Type Line Insulators — Trunnion-Top

Figure GR 205–2: Porcelain Post-Type Insulators — Trunnion-Top



(SAP 10116415)
Gray

(SAP 10116425)
Gray or Brown

(SAP 10116424)
Gray or Brown

Note(s):

1. For Porcelain Post-Type installation details refer to Scope GR 205.5.
2. New units purchased will be gray; however, brown units may be supplied by the re-use of returned units.

Table GR 205–2: Porcelain Post-Type Insulators — Trunnion Top

Line Voltage (kV)	Insul. Area[a/]	Conductor	Nom. kV Rating	SAP[b/c/]	Insulator Studs[d/] Short (1-3/4") SAP	Insulator Studs[d/] Long[e/] (7-1/2" to 8") SAP
33	A	Phase	66	10116425	10116404	10116405
	B, C	Phase	45	10116425	10116404	10116398
16	A, B, C	Phase	35	10116424	10116404	10116398
	A, B, C	Neutral	25[f/]	10116424	10116404	10116398
12	A	Phase	35	10116424	10116404	10116398
	B, C	Phase	25	10116424	10116404	10116398
	A, B, C	Neutral	25[f/]	10116424	10116404	10116398
4 or Less	A, B, C	Phase	15	Key 6 - See Polymer Table	—	—
	A, B, C	Neutral	15	Key 6 - See Polymer Table	—	—

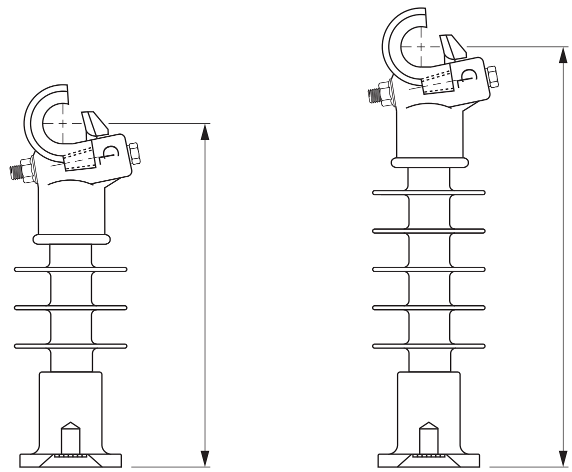
[a/] See GR 215, insulation area map.
[b/] For angle construction, use angle base SAP 10068619.
[c/] See CO 510 for clamp SAP numbers.
[d/] New gray horizontal clamp-top post insulators are automatically supplied with short studs.
[e/] Not used with horizontal clamp-top post insulators.
[f/] The same nominal kV rated insulator can be used on all conductors provided that the Neutral is identified (SAP 10135124)

Note(s):

1. See DC 535 for Wildlife Protection standards.
2. Not for use with covered conductors.

Scope GR 205.3 Polymer Post-Type Line Insulators — Clamp-Top

Figure GR 205–3: Polymer Post-Type Insulators — Clamp-Top



28 kV Class
(SAP 10116350)

35 kV Class
(SAP 10116351)

Note(s):

1. For Porcelain Post-Type installation details refer to Scope GR 205.5.

Table GR 205–3: Polymer Post-Type Insulators — Clamp-Top

Line Voltage (kV)	Insul. Area	Nom. kV Rating	SAP	Insulator Studs	
				Short Stud SAP[a/]	Long Stud SAP
33	A, B, C	35	10116351	10116404	10116398
16	A, B, C	35	10116351	10116404	10116398
	Neutral	28[b/]	10116350	10116404	10116398
4 and 12	A, B, C	28	10116350	10116404	10116398
	Neutral	28[b/]	10116350	10116404	10116398

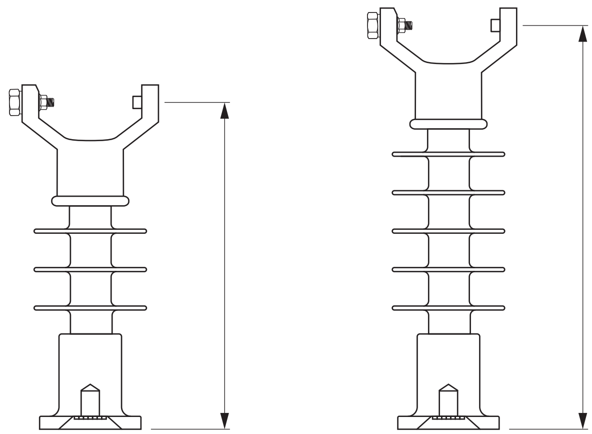
[a/] Short Insulator Stud and Angle Base (SAP 10068619) should be used for angle applications.
[b/] The same nominal kV rated insulator can be used on all conductors provided that the Neutral is identified (SAP 10135124).

Note(s):

1. See DC 535 for Wildlife Protection standards.
2. Clamp Top insulators are rated for #4 through 653 ACSR.
3. Not for use with covered conductors.

Scope GR 205.4 Polymer Post-Type Line Insulators — Trunnion-Top

Figure GR 205–4: Polymer Post-Type Insulators — Trunnion-Top



28 kV Class
(SAP 10116327)

35 kV Class
(SAP 10116325)

Note(s):

1. For Porcelain Post-Type installation details refer to Scope GR 205.5.

Table GR 205–4: Polymer Post-Type Insulators — Trunnion-Top

Line Voltage (kV)	Insul. Area	Nom. kV Rating	SAP	Insulator Studs	
				Short Stud SAP[a/]	Long Stud SAP
33	A, B, C	35	10116325	10116404	10116398
16	A, B, C	35	10116325	10116404	10116398
	Neutral	28[b/]	10116327	10116404	10116398
4 and 12	A, B, C	28	10116327	10116404	10116398
	Neutral	28[b/]	10116327	10116404	10116398

a/ Short Insulator Stud and Angle Base (SAP 10068619) should be used for angle applications.
b/ The same nominal kV rated insulator can be used on all conductors provided that the Neutral is identified (SAP 10135124).

Note(s):

1. See DC 535 for Wildlife Protection standards.
2. Trunnion top insulators may be used on un-guyed spans.
3. Not for use with covered conductors.

Scope GR 205.5 Porcelain and Polymer Post-Type Insulator Installation Instructions

1.0 Porcelain and Polymer Post-Type Insulator Installation Instructions

1.1 Install insulator onto the appropriate stud
- Long Stud for Cross-Arm mounting
- Short Stud for Angle Base mounting

1.2 For Tie-top insulators:
- Place conductor in the saddle and tie securely.

1.3 For Trunnion-Top Insulators:
- Place clamp into trunnion and conductor into clamp and tighten.

1.4 For Clamp-top insulators:
- Place conductor in the clamp and tighten.

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DOH–PO: Poles and Guying

Table of Contents

PO 300 Guying — General Information

Scope PO 300.1 Guying — General Information

1.0 Guying Requirements for Distribution and Transmission Lines

1.1 When the mechanical loads to be imposed upon the poles are greater than can be safely supported by the poles, use guys to provide additional strength. This applies particularly to angles and dead-ends when the conductor stresses are sufficiently unbalanced to make guying necessary.

1.2 No guys shall be attached to trees or other private property (except in special cases when permission to do so must be obtained in writing from the owner).

1.3 Guys attached to anchors must be protected with standard guards. Where more than one guy is attached to an anchor rod, only the outermost guy must be protected (see PO 350).

1.4 When required by the rules of General Order (G.O.) 95, use porcelain-strain insulators of the interlocking type in all guys attached to poles.

1.5 All guys shall be attached to poles with special hardware designed for this purpose. Preformed guy grips will be used to make up guy heads at the anchor end of guys and over strain insulators (johnny balls).

1.6 When two or more guy wires are installed in close proximity to each other, the attachment of one guy shall not overlap that of another, but each shall be entirely independent of the other and at least 12 inches apart at the point of attachment to the pole.

1.7 Guys should be installed and adjusted before the conductors are strung so that the pole or crossarm will stand in its proper position when the entire unbalanced stress is taken by the guy.

1.8 The point of attachment of the guy to the pole should be as near the level of the crossarms supporting the conductors as is practical to avoid undue bending stresses in the pole. Wherever possible down guy leads (distance from pole to eye of anchor rod) should be equal to or greater than the height of the guy attachment above ground. If it is impractical to install a satisfactory anchor guy at the dead-end pole, the stress may be carried by means of a span guy to an adjacent pole that can be properly guyed.

2.0 Guy Wires

2.1 For guy wire SAP numbers (see Table PO 315–5).

2.2 A corrosion-resistant Bezinal guy wire is available for use in coastal areas and other locations where standard galvanized steel guy wire has been susceptible to severe corrosion damage.

Scope PO 300.2 Anchors for Guys

1.0 Plate Anchors

A sheet steel cross plate shall be buried in the ground to a depth such that the entire eye of the anchor rod will extend a minimum of 6 inches and a maximum of 18 inches above finished grade measured along the rod. A trench/slot is cut so that the rod will be in alignment with the guys. The face of the plate shall be at right angles to the direction of the guy, and shall bear against undisturbed soil. Anchor holes shall be backfilled in the same manner as the holes for line poles. When a backhoe is used to dig holes for anchors, each anchor shall be limited to a working load of 11,500 pounds. Cross plate anchors shall not be used with 7-foot screw anchor rods.

1.1 For multiple anchor installations, it is necessary for the plate anchors to be properly spaced to prevent failure. 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.

Cross plate anchors shall have separations of:

- 4 feet for installations up to 10,000 lb
- 5 feet for installations up to 15,000 lb
- 6 feet for installations up to 18,000 lb
- 7 feet for installations greater than 18,000 lb

2.0 Joint Anchors

Anchor and rod installations for joint use with other utilities shall be made as specified under “Anchors for Guys,” and as may be agreed upon under joint pole routine.

3.0 Anchors, Removal or Abandonment

When an anchor location is abandoned, the rod and plate shall be removed if in a hazardous or potentially dangerous location.

Otherwise, cut the rods off at least 12 inches below the ground line and abandon the remaining anchorage. Screw anchor rods may be either unscrewed or cut off. Under no conditions should the rod be bent over or left exposed.

To avoid risk of liability, it is important that all personnel be instructed to follow these requirements.

Scope PO 300.3 Pole Bands for Guying Composite Poles

1.0 Application

1.1 Pole bands (Figure PO 300–1) shall be used on down guys of composite poles. Pole band selection will be based on the diameter of the composite pole. Pole bands for octagon poles are available in 10-inch diameter (Table PO 300–1).

Table PO 300–1: Pole Band SAP Numbers for Round Poles

Composite Pole Diameter (in)	Pole Band SAP
7–10	10067325
11–12	10067326
13–15	10067337

Figure PO 300–1: Pole Band for Round Poles

Table PO 300–2: Pole Band SAP Numbers for Octagon Poles

Composite Pole Diameters (in)	Pole Band SAP
10	10067324

Figure PO 300–2: Pole Band for Octagon Poles

1.2 A 5/8-inch or 3/4-inch thimbleye bolt will be used in conjunction with the pole band for guying. Thimbleye bolt selection will be based on the loading area. For thimbleye bolt SAP numbers (see PO 370).

1.3 Pole band placement shall maintain standard hardware clearance.

1.4 See the guying section of PO 310 for allowable working strength of guying components.

PO 310 Power-Installed Screw Anchors

Scope PO 310.1 Heavy-Duty Power-Installed Screw Anchors (PISA)

The standard for anchoring is "Heavy-Duty Power Installed Screw Anchors." These anchors have 1-1/2-inch hubs compared to the old type screw anchor with 1-3/8-inch hubs. The 1-1/2-inch hub anchor will withstand considerably more installation torque and can, therefore, be used in more areas of the company. Plate anchors will continue to be used in extremely loose soil, inaccessible areas, or rock bed areas.

1.0 Tooling

A line truck should be equipped with a heavy-duty PISA wrench (SAP 10148222 or SAP 10148223, and SAP 10148225), and a new drive end assembly (SAP 10148716) (used for 1-1/2-inch hub anchors). Torque indicator (SAP 10144863) should be used for installing the new heavy duty anchors for predicting the anchor performance (see Table PO 310–2).

2.0 Anchor Ordering Information

Table PO 310–1: Power Installed Screw Anchors

	Size Helix (in)	Torque Rating (lb)	SAP	Hub (in)
Light Duty	8 single[a/]	4,000	10067284	1-3/8
	8 double[a/]	4,000	10067286	1-3/8
Heavy Duty	10 double[a/]	4,000	Pending	1-3/8
	8 single	7,000	10200593	1-1/2
	8 double	7,000	10067290	1-1/2
	10 double	5,000	Pending	1-1/2
Granite Anchor	4 single	7,000	10067287	1-1/2
	4 double	7,000	Pending	1-1/2

[a/] All 1-3/8-inch hub PISA are Key 06 (not to be repurchased)

3.0 Torque Indicator Operating Instructions

3.1 Install the torque indicator between the appropriate flanged kelly bar adapter and the locking dog assembly (see Figure PO 310–1).

3.2 Install indicator so that the plate with built-in nut assembly will be toward the kelly bar.

3.3 Check freedom of unit by rotating bottom plate with respect to top plate.

3.4 The edge of each plate has an indented mark accented with a painted line. Rotate plate to bring these index marks into alignment with each other. These marks must be aligned before each loading for proper operation (see Figure PO 310–1).

3.5 Determine the minimum torque value needed for anchor installation. See examples for calculating holding strength PO 310.2 (Sheet 5).

3.6 Load the unit with the correct number of pins for the torque value wanted. Place approximately equal number of pins in opposing sectors of torque indicator (see Figure PO 310–1).

3.7 Eye of rod shall be 9 inches minimum and 18 inches maximum above finished grade measured along rod (with new installation).

Note:* *Do not install more pins exceeding torque value of anchor or equipment driving anchor than is necessary. Fourteen pins maximum for 7,000 lb anchor (1-1/2 inch hub).

3.8 Install anchor until pins shear. Reload unit with the original number of pins plus two (not to exceed maximum torque recommendation for anchor) and drive anchor at least two additional feet into soil. Also drive the anchor so that the end is approximately the correct distance out of the ground.

3.9 Reload the unit with original number of pins. If anchor is still in the same type of soil or better, the pins will shear and anchor is installed to the minimum torque value required. If a single helix is driven past a strata of hard soil into soft soil, the pins may not shear and it will be necessary to remove the anchor and install a double helix anchor. The correct amount of pins or more should shear.

3.10 Install anchor so that the rod is in alignment with the guys.

3.11 For multiple anchor installations, it is necessary for the anchors to be properly spaced to prevent failure. The minimum distance that the anchors shall be spaced apart from each other is four times the helix diameter. For example, two-8 inch anchors, the minimum spacing between the two shall be 32 inches.

Table PO 310–2: Installing Torque Versus Holding Strengths

Table Note: The torque indicator enables anchors to be installed to a predetermined torque value which gives a positive indication of the holding strength of the anchor in any type of soil. The torque indicator will prevent excessive torque on the anchor during installation, thus preventing fracture and loss of the anchor.

Type of Anchors	Torque (in Minimum Pins Sheared)			Anchor Assembly Load Rating (lbs)	Guideline for Guys[a/]
Power Installed Screw Anchors (PISA)	8-Inch Single	8-Inch Double	10-Inch Double	Allowable New (S.F. = 2)	
1-3/8" or 1-1/2" Anchor Hub	3	2	2	5,000	1-9/32"
	7	5	4	10,000	2-9/32", or 1-3/8", or 1-7/16"
1-1/2" Anchor Hub Only	9	8	7	15,000	3-9/32", or 1-9/32" & 1-3/8", or 1-9/32" & 1-7/16"
	12	10	9	18,000	2-3/8" & 1-7/32", or 1-3/8" & 2-9/32", or 1-3/8" & 1-7/16"
4" Granite Anchors		4-Inch Single	4-Inch Double		
		9		10,000	2-9/32", or 1-3/8", or 1-7/16"
		10		15,000	3-9/32", or 1-9/32" & 1-3/8", or 1-9/32" & 1-7/16"
		12	12	18,000	2-3/8" & 1-7/32", or 1-3/8" & 2-9/32", or 1-3/8" & 1-7/16"
Cross-Plate Anchors	**Anchor Rod and Plate**				
	5/8" × 6' Single Eye[b/]			8,000	1-3/8"
	3/4" × 8' Double Eye[b/]			11,500	2-9/32" or 1-3/8" or 1-7/16"
	1" × 10' Triple Eye[b/]			18,000	2-3/8" or 3-9/32" or 1-7/16" and 1-3/8"
	1-1/4" × 10' Triple Eye[b/]			29,000	2-7/16" or 3-3/8" or 2-3/8" and 1-9/32"
Expanding Rock	3/4" × 15" Double Eye			11,500	2-9/32' or 1-3/8" or 1-7/16"

[a/] Guy recommendations are guidelines to insure that the anchor can support the full strength capability of the guys.

[b/] Where a backhoe is used to dig holes for plate anchor, each anchor shall be limited to a working load of 11,500 lb.

Note(s):

1. Anchors shall have the same safety factor requirements as the guys they support (2.0 for new).
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 lb new
   — 5 feet for installations up to 15,000 lb new
   — 6 feet for installations greater than 15,000 lb new
4. See PO 320, Table 8 for placement of anchor plate relative to anchor eye rod.
5. For multiple backhoe installations, trenches should be perpendicular to guy wire.

4.0 Loading Pins

Each individual pin has a shearing value of 500 foot-pounds. As the above chart indicates, a predetermined amount of pins sheared will predict the holding strength of the anchor. Pins may be ordered by boxes of 1,800 (SAP 10148739).

Scope PO 310.2 Holding Strength Calculations for PISA Anchors

The necessary holding strength shall be determined by the number and size of down guys to be attached to the anchor.

Example:

1. One 3/8-inch and one 9/32-inch E.H.S. guys are to be attached to an anchor. What holding strength should the anchor have?

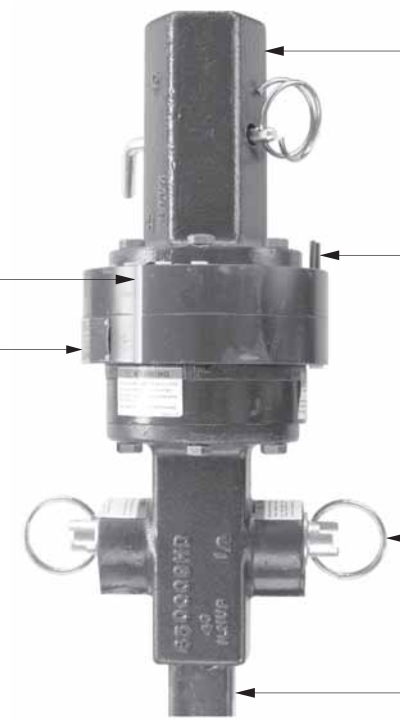
   Ans. See PO 320 — The total conductor pull at a level angle is the rated guy strength with a safety factor of 2 (working tension), so that 1-3/8-inch E.H.S. guy has a working tension of 7,700 lb, and 1-9/32-inch guy has a working tension of 4,475 lb. The total holding strength for the anchor should be the sum of the rated working tensions of both guys, or 7,000 lb + 4,475 lb = 12,175 lb. A screw anchor installed with a holding strength above 12,175 lb should be used (see Table PO 310–2).

2. One 3/8-inch and two 9/32-inch E.H.S. guys are to be installed on an anchor. (The maximum amount allowed on a triple eye rod per PO 320.) What holding strength should the anchor have?

   Ans. Per PO 320, the full rated working tension for guys with a safety factor of two is found under level angle. 1-3/8-inch E.H.S. = 7,700 lb and two 9/32-inch E.H.S. — 4,475 lb × 2 = 8,950 lb. The total pull will be 7,700 lb + 8,950 lb = 16,650 lb.

In accordance with Table PO 310–2, an anchor with a holding strength above 16,650 lb should be used. Therefore, a single 8-inch PISA should shear 12 loading pins, a double 8-inch PISA should shear 10 loading pins, or a double 10-inch PISA should shear 9 loading pins upon installation.

Figure PO 310–1: Power Installed Screw Anchors



See Note 1

See Note 2

See Note 3

Index Torque Indicator (SAP 10144863)

Wrench Locking Dog Assembly (SAP 10148225)

1-1/2" Drive End Assembly (SAP 10148716)

Double Helix Anchor

Single Helix Anchor

Note(s):

1. Kelly bar adapter 2" hex shaft (SAP 10148222) 2-5/8" hex shaft (SAP 10148223) (See Note 3.1 [Sheet 1].)
2. Loading pins (SAP 10148739) (See Note 3.6 [Sheet 2].)
3. Index marks on torque indicator (See Note 3.4 [Sheet 1].)

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PO 315 Guying Components

Scope PO 315.1 Guying Components

Table PO 315–1: Anchors and Rods for Guys

Guys	Heavy-Duty Power-Installed Screw Anchors (PISA)				
	Screw Anchor		Rod and Eye		Allowable Working Strength (lb)
MAX Size and Number	SAP	Helix	Size	SAP	
See PO 310	10067288	1—8" H.D.	1" × 7' Triple Eye	10067303	See PO 310 for PISA
	10067290	2—8" H.D.			
	10067291	2—10" H.D.			
	10067287	1—4" GR.[a/]			
	10067289	2—4" GR.			

[a/] Denotes “granite anchor”

Table PO 315–2: Optional Methods of Anchoring Where Power Installed Screw Anchor Cannot Be Used

Guys	Anchor	Rod		
MAX Size and Number	SAP	SAP	Size	Allowable Working Strength (lb)
1-3/8"	20" Cross Plate[a/] 10067304	10067296	5/8" × 6' Single Eye	8,000
2-9/32" or 1-3/8" or 1-7/16"		10067297	3/4" × 8' Double Eye[a/]	11,500
2-3/8"		10185604	1" × 10' Triple Eye[a/]	18,000
2-7/16" or 3-3/8" or 2-3/8" and 1-9/32"	24" Cross Plate 10210268	10210269	1-1/4" × 10' Triple Eye	29,000
2-9/32" or 1-3/8" or 1-7/16"	Expanding Rock Anchor 10067281	—	3/4" × 15" Double Eye	11,500

[a/] In corrosion areas use:
1-inch copper-clad anchor rod — SAP 10067254
3/4-inch copper-clad anchor rod — SAP 10067255
Concrete anchor plate — SAP 10067305

Note(s):

1. Minimum size guy strand for anchor guys is 9/32 inch.
2. 5/16 inch and 7/16 inch high-strength guy strand may be substituted for 9/32 inch and 3/8 inch extra-high-strength guy strand, respectively.
3. An anchor shall have allowable working strength equal to or greater than the working strength of a guy or guys attached to it. See PO 320 for the working tensions for guys, as shown for overhead guys in a level tension.
4. PISA anchors shall be installed with a minimum spacing of 4 times the largest Helix.
5. Cross plate anchor spacing shall be:
   - 4 feet for installations up to 10,000 lb
   - 5 feet for installations up to 15,000 lb
   - 6 feet for installations up to 18,000 lb
   - 7 feet for installations greater than 18,000 lb

Table PO 315–3: Guying Components — Automatic Dead-Ends

Wire Size	Short Bail SAP	Long Bail SAP
5/16" or 9/32" E.H.S.	10067504	10211779
7/16" E.H.S.	10067507	10184970
3/8" E.H.S.	10067506	10067405

Table PO 315–4: Guying Components — Automatic Dead-Ends (Fits Over Guy Strain Insulator)

Wire Size	SAP
3/8" E.H.S.	10067689
7/16" E.H.S.	10204169

= For Reference Only

Table PO 315–5: Guying Components — Preformed Dead-Ends and Guy Wire

Wire SAP	Wire Size	Color Code	Dead-End SAP
10110468	7/32" E.H.S.	Green	10067957
10110471	9/32" E.H.S.	Blue	10067958
10110475	7/16" E.H.S.	Green	10067961
10110473	3/8" E.H.S.	Orange	10067959
10110453	3/8" E.H.S.[a/]	Orange	10067845

[a/] For high corrosion, coastal areas.

PO 340 Types of Guying

Scope PO 340.1 Types of Guying

Figure PO 340–1: Overhead Guy across Streets and Roadways

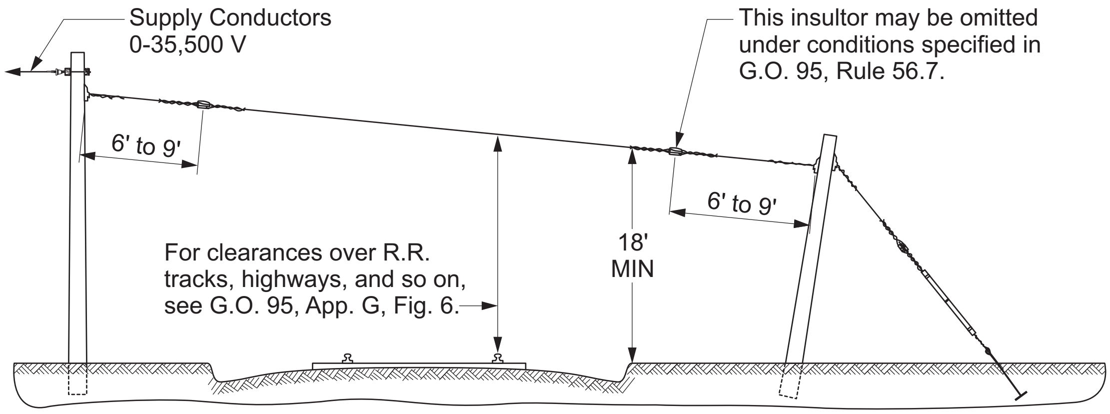


Figure PO 340–2: Overhead Span Guy Parallel to Streets and Roadways

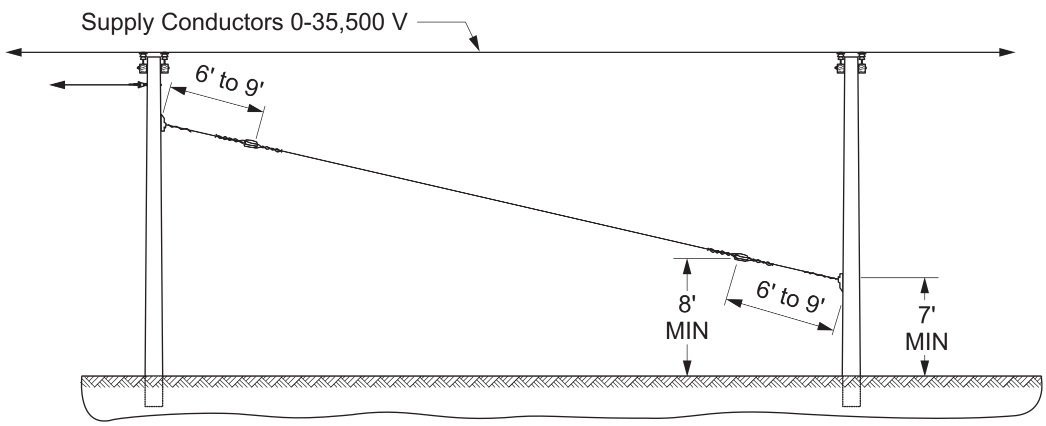
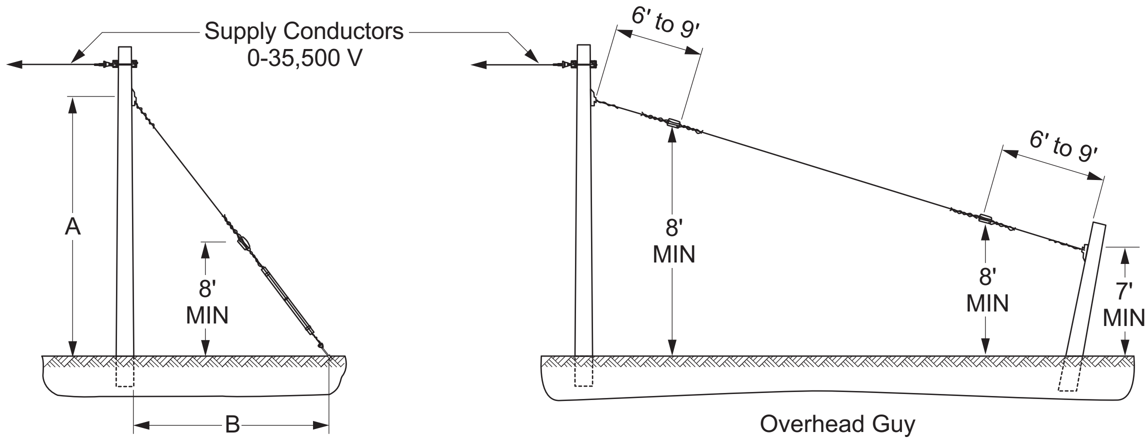


Figure PO 340–3: Anchor Guy and Overhead Guy Parallel to Streets and Roadways



Anchor Guy

Overhead Guy
Parallel to Streets and Roadways

Distance “B” should equal “A” approx.
Where possible, “B” should not be less than one half of “A”.

Note(s):

1. No insulators are required in guys for metal poles or structures permanently grounded, except as required by G.O. 95, Rule 56.6E. When two guys are installed, they shall be at least 12 inches apart. See Note 2 (Sheet 3).
2. Guying shall maintain a minimum safety factor required for grade of construction.

Figure PO 340–4: Types of Guying

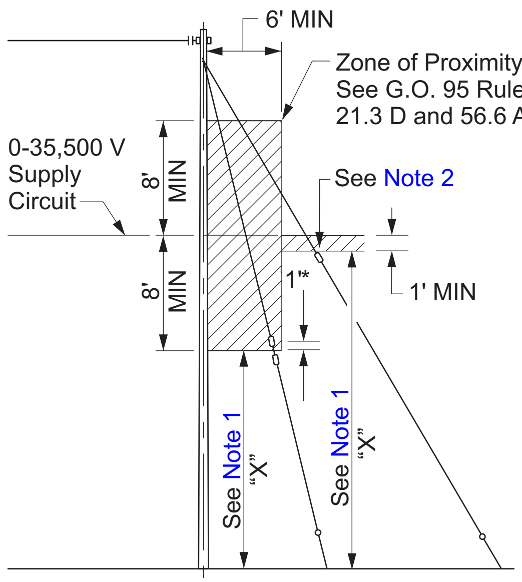


Figure PO 340–4.1

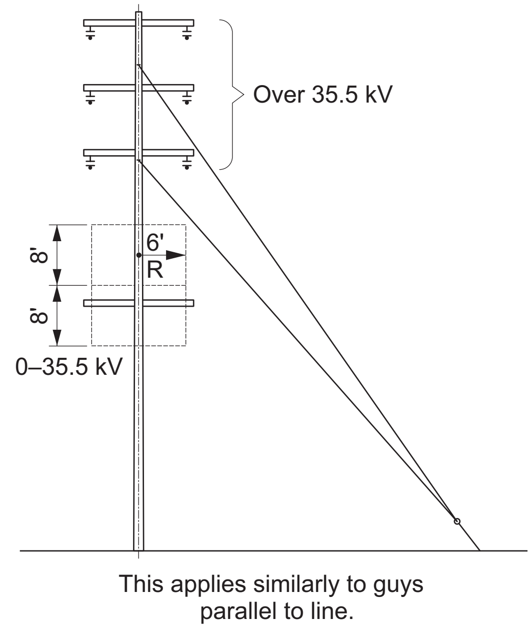


Figure PO 340–4.2

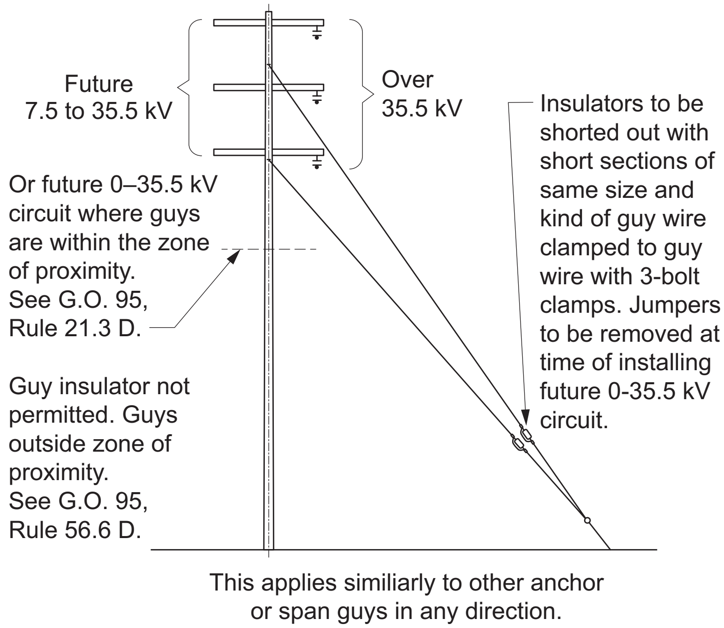


Figure PO 340–4.3

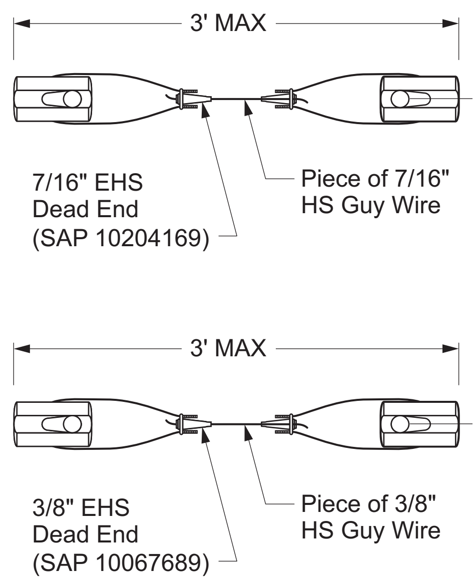


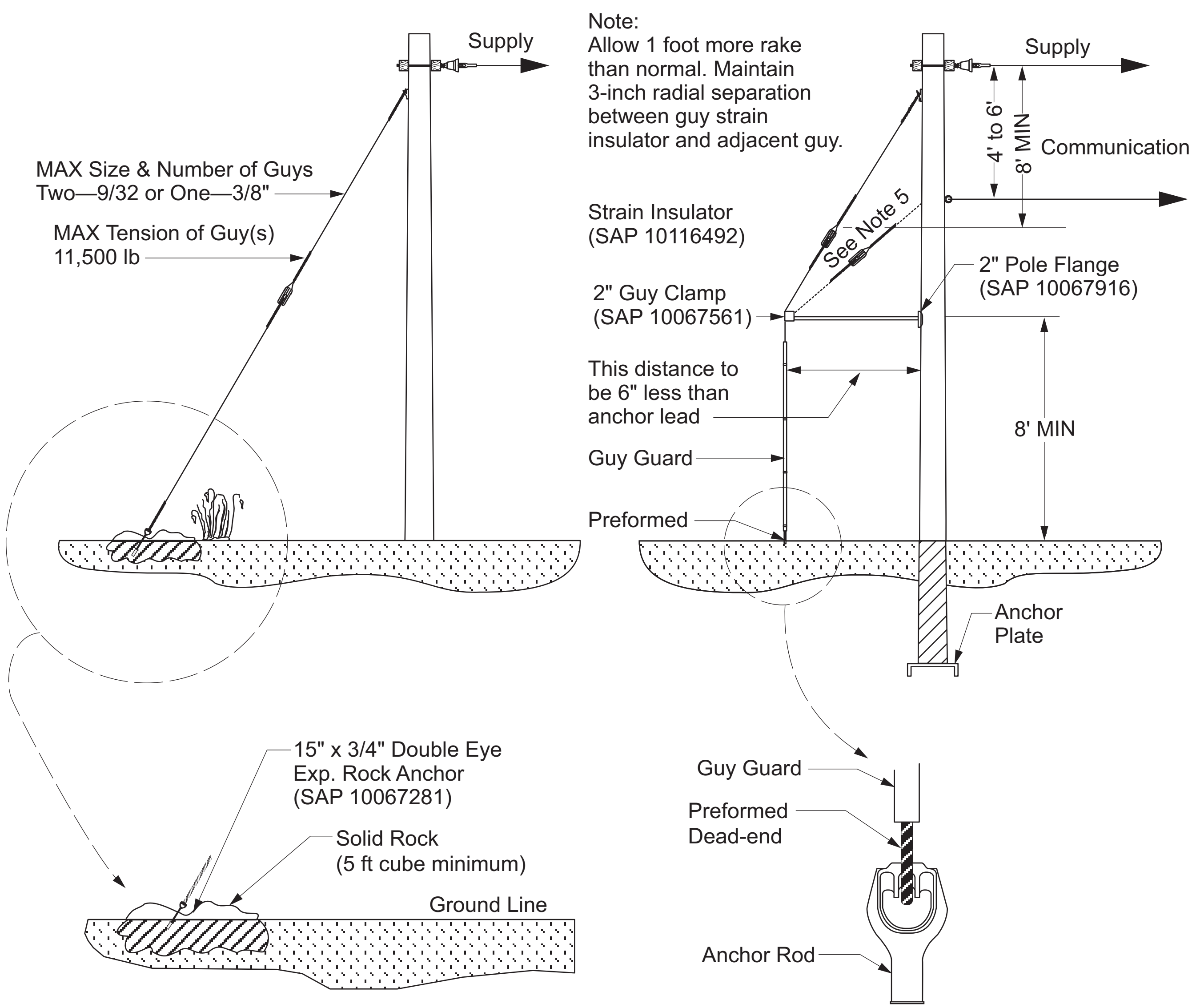
Figure PO 340–4.4

Note(s):

1. If dimension "X" is less than 8 feet, a second insulator located at a minimum of 8 feet vertically above ground is required.
2. One guy insulator required on circuits from 0 to 22.5 kV. Two insulators in series required from 22.5 kV to 35.5 kV, G.O. 95, Rules 56.8 and 86.8.

Scope PO 340.2 Typical Installation of Rock Anchor Guying and Sidewalk Anchor Guying

Figure PO 340–5: Rock Anchor and Sidewalk Anchor

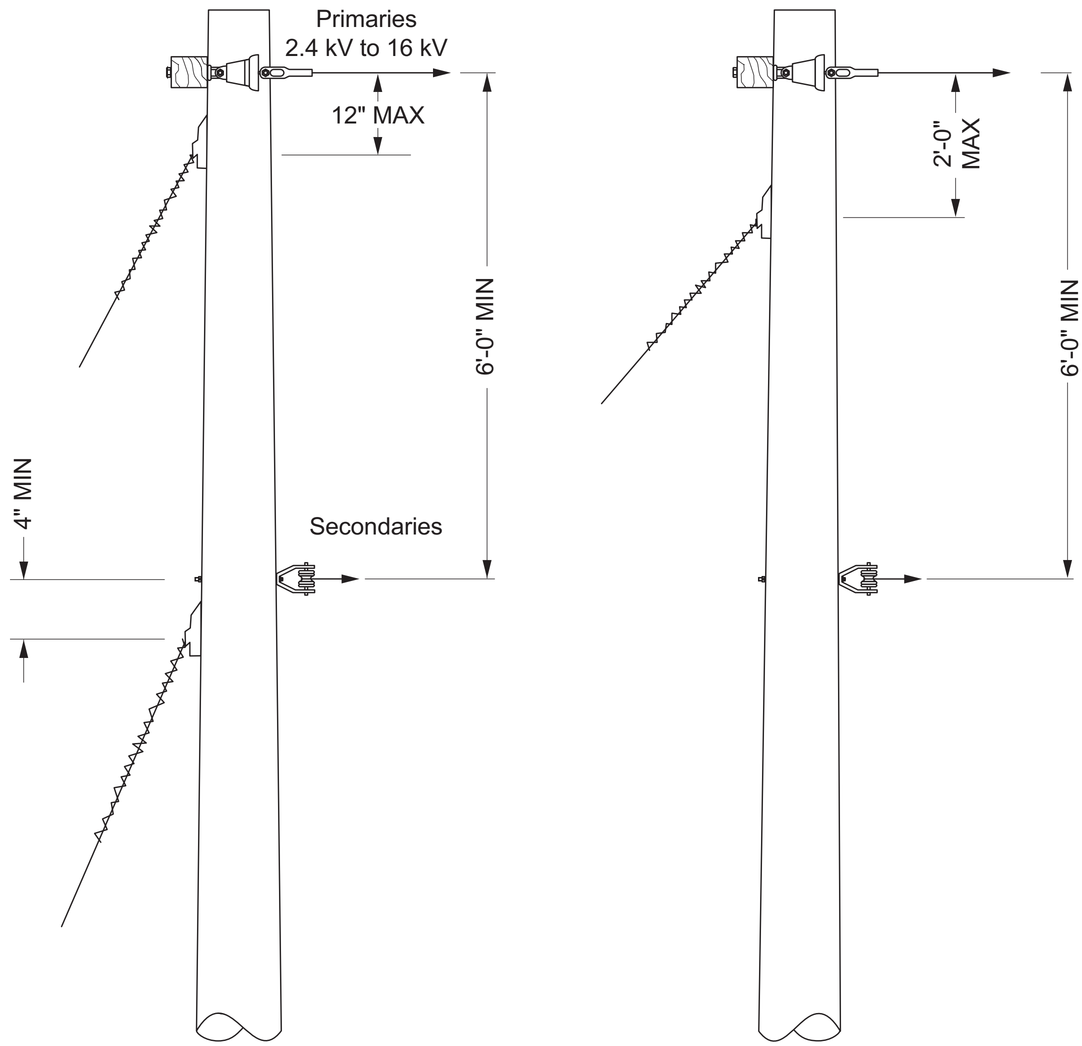


Note(s):

1. Rock anchors should only be installed in solid rock: never in decomposed or crumbly rock.
2. Anchor should be placed in a hole having a minimum depth of 12 inches and bored so that guy tension will be applied in line with the longitudinal axis of the rod.
3. Expand wedge by inserting an 18-inch minimum lever into eye and rotating the rod until cinched tight.
4. Tamp dirt around rod after cinching.
5. Maximum of two guys per sidewalk anchor.

Scope PO 340.3 Typical Guying for Grades A and B Construction

Figure PO 340–6: Typical Guying for Grades A and B Construction



Note(s):

1. Guying shall take into consideration the maximum bending moment that may be applied to a pole (due to pole loading and conductor strain) for a given wind area without exceeding the safety factor for the specified grade of construction.
2. Refer to Chapter PLM-2 of the Pole Loading Manual (PLM) for safety factors of new and in-service Grade A or Grade B construction.
3. Down guys shall not contact crossarms or hardware.

Scope PO 340.4 Maximum Conductor Tension for Guy Wires — Grade B Construction

Table PO 340–1: Maximum Conductor Tension for Guy Wires — Grade B Construction

Maximum Safe Conductor Tension (lb) for One Guy Wire [a/]			
Angle of (Guy-to-Pole) (Degrees)	Guy Size		
	9/32"	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	2,692
20	1,531	2,634	3,557
25	1,891	3,254	4,395
30	2,238	3,850	5,200
35	2,567	4,417	5,965
40	2,876	4,949	6,685
45	3,164	5,445	7,354
50	3,428	5,899	7,967
55	3,666	6,307	8,519
60	3,875	6,668	9,007
Level (Overhead Guy)	4475	7,700	10,400

[a/] Ultimate conductor tension divided by safety factor (from Table 24, G.O. 95). The 1/4", 5/16", and 7/16" entries are listed for reference only. The Maximum number of guys for a sidewalk anchor is two.

EXAMPLE:

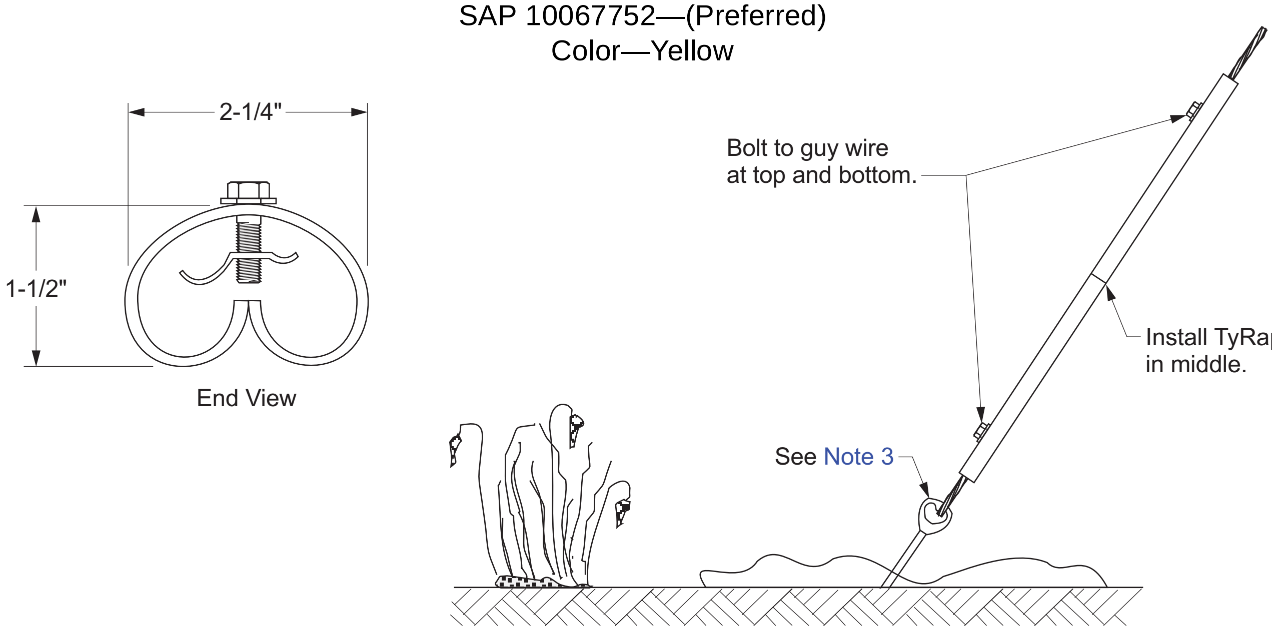
A single 3/8" guy wire installed at a 40 degree angle, between the pole and guy, is capable of supporting a conductor tension of 4,949 pounds in Grade B construction.

PO 350 Guy Guards

Scope PO 350.1 Approved Guy Guards, Application, and Installation Information

Figure PO 350–1: Plastic "Snapper" Guy Guard

SAP 10067752—(Preferred)
Color—Yellow

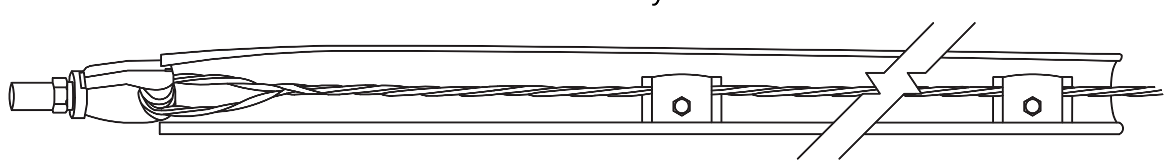


Application

1. All new and rebuild construction (except in Fire Clearing Area).
2. Use Steel Guy Guard in areas requiring Fire Clearings.

Figure PO 350–2: Half Round Plastic Guy Guard

SAP 10067972—(Alternate)
Color—Gray

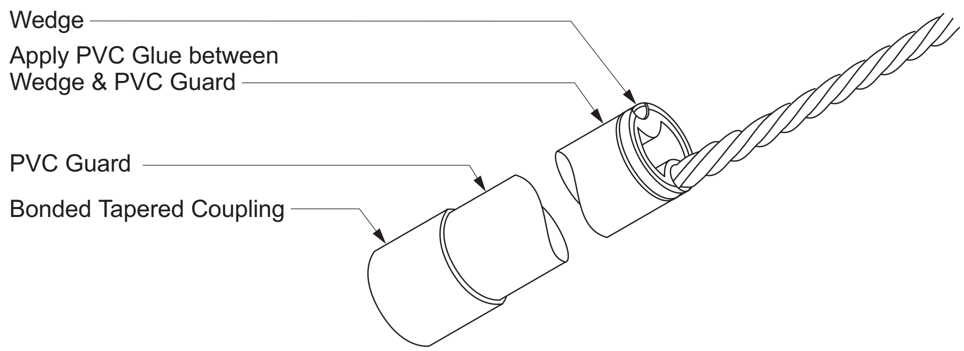


Application

1. New sidewalk anchor guys and replacement of damaged Guy Guards.
2. Use Steel Guy Guard in areas requiring Fire Clearings.
3. Entire eye of the rod shall be a minimum of 9 inches and a maximum of 18 inches above finished grade measured along the rod.

Figure PO 350–3: Tubular PVC Guy Guard

SAP 10067970—Assembly includes Guard and Wedge (Alternate)
Color—Gray



Application

On all new and rebuild construction it is necessary to place the guard on the guy wire prior to tensioning.

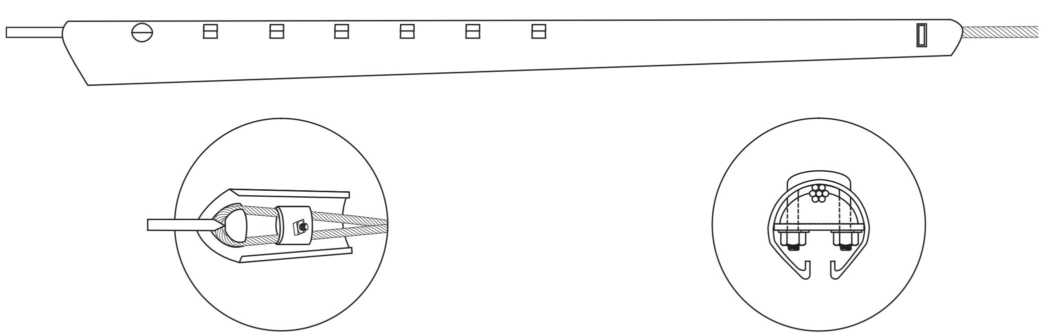
Install PVC wedge after guard is in place.

Note(s):

1. A parallel groove connector shall be installed above the wedge where a preformed dead-end is used at the bottom of the guy.
2. One-inch sch 40 PVC may be substituted for the tubular PVC guard. A parallel groove connector shall be installed on the guy above the end of PVC conduit.
3. Use steel guy guard in areas requiring fire clearings.

Figure PO 350–4: Half Round Steel Guy Guard

SAP 10067971



Bottom Clamp Detail   Top Clamp Detail

Application

Steel guy guards shall be used in areas requiring fire clearings.

PO 370 Composite Pole Hardware

Scope PO 370.1 Composite Pole Hardware

1.0 Composite Crossarms

1.1 Composite crossarms (see Figure PO 370–1) are available in sizes ranging from 5 feet to 20 feet for either heavy tangent and dead-end types for use on composite poles (see Table PO 370–1).

Composite crossarms shall be used on composite poles.

Figure PO 370–1: Heavy Duty Crossarms

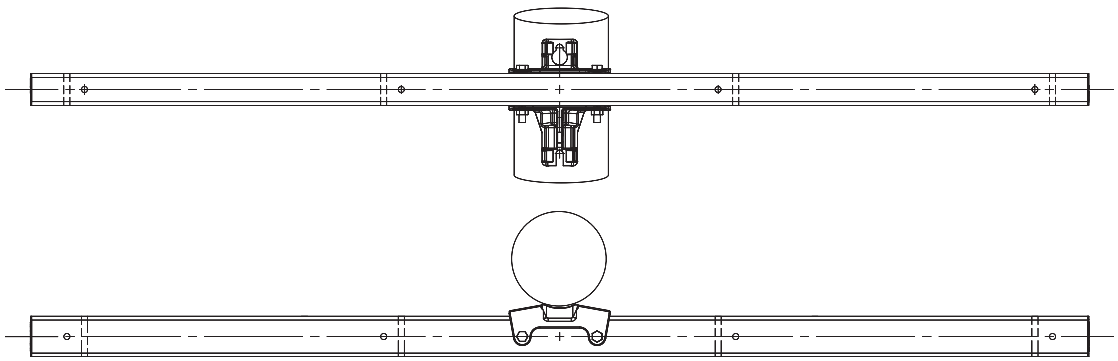


Table PO 370–1: Heavy Duty Crossarm SAP Numbers

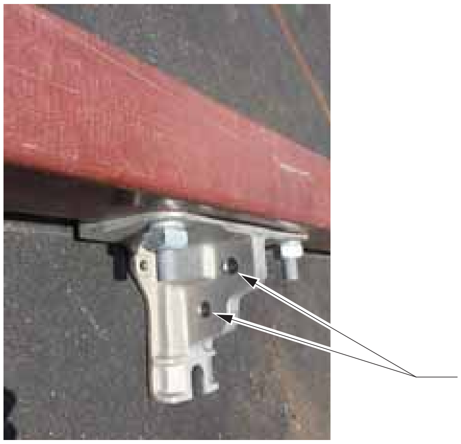
Type	Size (ft)	SAP
Tangent	5	10211425
Tangent	8	10060793
Tangent	10	10060794
Tangent	12	10060795
Tangent	20	10208033
Dead-End	8	10060796
Dead-End	10	10060797
Dead-End	12	10060798
Dead-End	20	10208513
Tangent Alley Arm	10	10211423
Tangent Alley Arm	12	10211424

Note(s):

1. For installation, application or, assembly details, see PO 112.
2. 8 foot and 10 foot composite crossarms dimensions are 3-5/8" × 4-5/8". 12 foot composite crossarms dimensions are 4" × 6".
3. Composite crossarms include mounting assembly bracket. 3/4" bolts shall be used on mounting assembly bracket. V-braces and back braces are not required, except on 5 foot crossarms.
4. Field drilling is permissible; drilled holes shall be 2 inches MIN apart (center-to-center), 4 inches MIN from end of arm, and 15 inches MIN from center of arm except holes for vertical braces on capacitor banks and transformers. Use carbide drill bit.
5. Tangent alley arms do not include mounting assembly bracket, use bracket SAP 10067345.

1.2 Crossarm Mounting Bracket with Guy Attachment Holes

Figure PO 370–2: Composite Crossarm Mounting Bracket with Guy Attachment Holes



Guy Attachment Holes
Working Load Capacity
10,000 lb either hole

2.0 Riser Support

Figure PO 370–3: Riser Support

Table PO 370–2: Riser Support

Table Note: Attach risers as described in PO 112, and refer to the Distribution Underground Construction Standards (DUG) Section CR 110.

Size	SAP
24" Extended	10073393

3.0 Pole Hole Plug

3.1 Pole hole plugs (Figure PO 370–4 and Figure PO 370–5), shall be installed in open composite pole holes per Table PO 370–3 Table PO 370–4 to prevent bugs and moisture intrusion. Only use stainless steel plugs in Bulletin 322 and/or high fire areas.

Figure PO 370–4: Plastic Pole Hole Plug

Table PO 370–3: Plastic Pole Hole Plug

Plug Size (in)	SAP
5/8	10068598
3/4	10068599
7/8	10068601
1	10068602
1-1/2	10068603

Figure PO 370–5: Stainless Steel Pole Hole Plugs

Table PO 370–4: Stainless Steel Pole Hole Plug

Plug Size (in)	SAP
11/16	10211092
13/16	10211093
1	10211094
1-1/8	10211095
1-3/8	10211194

4.0 Insulated Clamp for Ground Wire

For use on composite poles, use (2) #10 × 2" self-drilling screws (SAP 10071503).

Figure PO 370–6: Insulated Clamp and (2) Self-drilling Screws

Table PO 370–5: Insulated Clamp and (2) Self-drilling Screws

Description	Quantity	Size	SAP
Insulated Clamp (Grey)	1	#4-PGW	10209485
Insulated Clamp (Black)	1	#6-PGW	10209484
Self-drilling Screw	2	#10 × 2"	10071503

5.0 Bonding Clip

Figure PO 370–7: Bonding Clip

Table PO 370–6: Bonding Clip

Description	Quantity	Size	SAP
Bonding Clip	1	1/8"	10113253
Self-drilling Screw	1	#10 × 1"	10072230

6.0 Thimble Eyelet

Figure PO 370–8: Thimble Eyelet

Table PO 370–7: Thimble Eyelet

Type	Application	Size	SAP
Standard	Span Guys	5/8"	10068524
		3/4"	10068525

7.0 Pole-Top Cap

Pole-top caps (see Figure PO 370–10 and Figure PO 370–11) come in various sizes and fit directly on top of the pole module. Pole caps for octagon poles are available in 10 inches.

Figure PO 370–9: Pole Top and Base Section Cap for 45-Foot Round Composite Sectional Poles

Cone Type (Top Section)

Flat Type
(Top Section for Use with Ridge Pin)
(Bottom Section — Temporary)

Table PO 370–8: Pole Top and Base Section Cap for 45-Foot Round Composite Sectional Poles

Pole Manufacturer	Description	Cap Size	SAP
Highland	Base Section Temporary Cap	14" Flat Type	10207279
	Top Section Cap	9.5" Cone Type	10207280
	Top Section Cap	9.5" Flat Type (for use with ridge pin)	10207281
RS	Base Section Temporary Cap	14" Flat Type	10207279
	Top Section Cap	10" Cone Type	10207282
	Top Section Cap	10" Flat Type (for use with ridge pin)	10207283

Note(s):

1. Top and Base Covers are included with RS poles.

8.0 Spring Washer

Hardware for composite poles shall be tightened until the spring washer has been compressed to where the springs just touch.

Figure PO 370–10: Spring Washer

Table PO 370–9: Spring Washer

Size	SAP
3/8"	10072344
1/2"	10072345
5/8"	10072346
3/4"	10072347

9.0 Composite Pole Guying Tee

The composite pole guying tee shall be used when attaching all down guys, regardless of size, directly to composite and LWS poles. Pole guying tee shall be used when attaching 7/16th inch down guys directly to wood, composite, and LWS poles. See PO 320 (Sheet 8, Note 1). Two 3/4-inch through bolts shall be used to attach the tee to the pole. Must be used in conjunction with 4-inch curved square washers.

Figure PO 370–11: Composite Pole Guying Tee

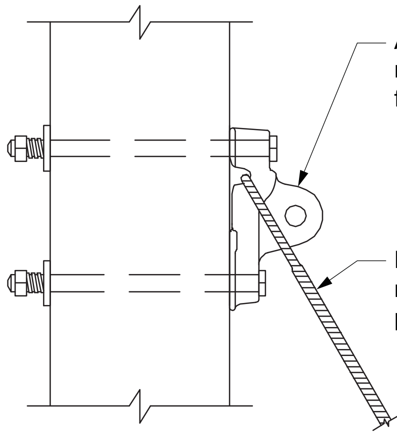


Table PO 370–10: Composite Pole Guying Tee

Maximum Working Load (lb)	SAP
10,400	10181650

10.0 Pole Plate for Sidewalk Guy

The sidewalk guy pole plate (SAP 10211422), shall be used on composite poles. Mount pole plate to pole with a 5/8 inch through bolt and spring washer. A 3 inch curved washer shall be used on the opposite side of the pole (see Figure PO 340–5 for details).

Figure PO 370–12: Pole Plate

11.0 Thimble Eye Bolt

Straight thimble eye bolts are to be used for span guys.

Figure PO 370–13: Thimble Eye Bolt, Straight Type

Table PO 370–11: Thimble Eye Bolt, Straight Type

Size	SAP	Strength (lb)
5/8" × 10"	10068513	13,550
5/8" × 12"	10068514	13,550
5/8" × 14"	10068512	13,550
5/8" × 16"	10068516	13,550
3/4" × 12"	10068520	20,050
3/4" × 14"	10068647	20,050

12.0 Pole Band

Figure PO 370–14: Stainless Steel Pole Band

Table PO 370–12: Stainless Steel Pole Band

Size (in)	SAP
1-1/4	10209449

13.0 Flat Square Washer

Figure PO 370–15: Flat Square Washer

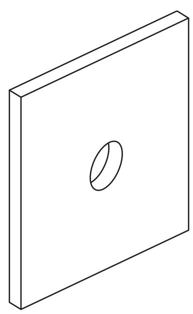


Table PO 370–13: Flat Square Washer

Size	Bolt Hole	SAP
4" × 4" × 1/4"	13/16"	10071859

14.0 Curved Square Washer

Figure PO 370–16: Curved Square Washer

Table PO 370–14: Curved Square Washer

Size	Bolt Hole	SAP
3" × 3" × 1/4"	5/8"	10071941
3" × 3" × 1/4"	3/4"	10071853
4" × 4" × 1/4"	3/4"	10071863
4" × 4" × 1/4"	7/8"	10071946

15.0 Permanent/Temporary Climbing Step

Figure PO 370–17: Permanent/Temporary Climbing Steps

Table PO 370–15: Permanent/Temporary Climbing Steps

Table Note: For installation, application or, assembly details, see PO 112.

Pole	SAP
Round	10068660

16.0 Temporary Pole Step Plate

Figure PO 370–18: Temporary Pole Step Mounting Assembly

Table PO 370–16: Temporary Pole Step Mounting Assembly

Table Note: For installation, application or, assembly details see PO 112.

Pole	Washer	SAP
Round	Curved	10068609

17.0 Detachable Temporary Pole Step

Figure PO 370–19: Detachable Temporary Pole Step

Table PO 370–17: Detachable Temporary Pole Step

Table Note: For installation, application or, assembly details, see PO 112.

Size	SAP
5-1/2"	10068470

= FOR REFERENCE ONLY

18.0 Mast Arm

Figure PO 370–20: Mast Arm

Table PO 370–18: Mast Arm

Size	SAP
6'	10118507
8'	10118508
16'	10118511

19.0 Insulator Pin

Figure PO 370–21: Insulator Pin

Table PO 370–19: Insulator Pin

Pin Length (in)	Shank Length (in)	SAP	Application
7	8-1/2	10068281	12' Tangent Only
7	7 to 7-1/2	10068306	8'/10' Tangent 8'/10'/12' Dead-end
7	1-3/4	10068309	Angle or Ridge Pin

20.0 Ridge Pin Bracket

Figure PO 370–22: Ridge Pin Bracket

Table PO 370–20: Ridge Pin Bracket

Size	SAP
Universal	10067373

21.0 Protected Ground Wire

Figure PO 370–23: Protected Ground Wire

Table PO 370–21: Protected Ground Wire

Size	SAP
4 AWG	10109304
6 AWG	10109302

22.0 No Drill Zone Decal for Intelli-Pole

Figure PO 370–24: No Drill Zone Decal

Table PO 370–22: No Drill Zone Decal

Type	SAP
Arrow Up	10204661
Arrow Down	10204660

Note(s):

1. For RS Composite Poles, No Drill Zone Tag is already installed.

23.0 Visibility Strip

Figure PO 370–25: Visibility Strip

Table PO 370–23: Visibility Strip

Description	Quantity	Size	SAP
Visibility Strip	1	2" × 12"	10068488
Self-drilling Screw	2	#10 × 1"	10072230

DOH–SL: Street Lighting

TABLE OF CONTENTS

STANDARD	TITLE

SL 318 Light Emitting Diode (LED) Cobra Head Style Luminaires

Scope SL 318.1 Light Emitting Diode (LED) Cobra Head Style Luminaires

Figure SL 318–1: Cobra Head Style LED Luminaires

Table SL 318–1: Cobra Head Style LED Luminaires

LED Wattage	HPSV[a/] Equivalent Lumen Wattage	SAP
25[b/]	50	10205807
32[b/]	70	10205808
41[b/]	100	10205809
88[b/]	150	10205810
90[c/]	200	10205811
157[c/]	310	10205813
161[c/]	250	10205812
193[c/]	400	10205814

[a/] High Pressure Sodium Vapor (HPSV)
[b/] 1-Bar Luminaire
[c/] 2-Bar Luminaire

Note(s):

1. All Cobra Head style LED Luminaires are outfitted with ‘Cut Off’ style Optics which will help eliminate glare or ‘sky glow’ conditions.

Table SL 318–2: Cobra Head Style LED Luminaires

LED Wattage	HPSV[a/] Equivalent Lumen Wattage	SAP
28[b/]	50	10183629
43[b/]	70	10183631
54[b/]	100	10183633
90[b/]	150	14083634
130[c/]	200	10183635
196[d/]	250	10183636
258[e/]	400	10183637

a/ High Pressure Sodium Vapor (HPSV)
b/ 1-Bar Luminaire
c/ 2-Bar Luminaire
d/ 3-Bar Luminaire
e/ 4-Bar Luminaire

Note(s):

1. All Cobra Head style LED Luminaires are outfitted with ‘Cut Off’ style Optics which will help eliminate glare or ‘sky glow’ conditions.

Figure SL 318–2: Cobra Head Style LED Luminaires

1-Bar

2-Bar

Table SL 318–3: Cobra Head Style LED Luminaires 3000K Light Temp — HPSV Equivalents

LED Wattage	HPSV[a/] Equivalent Lumen Wattage	SAP
22[b/]	50	10210241
31[b/]	70	10210242
39[b/]	100	10210243
71[b/]	150	10210244
82[c/]	200	10210246
136[c/]	250	10210247
137[c/]	310	10210249
174[c/]	400	10210250

a/ High Pressure Sodium Vapor (HPSV)
b/ 1-Bar Luminaire
c/ 2-Bar Luminaire

Note(s):

1. All Cobra Head style LED Luminaires are outfitted with ‘Cut Off’ style Optics which will help eliminate glare or ‘sky glow’ conditions.

Table SL 318–4: Cobra Head Style LED Luminaires 4000K Light Temp — Equivalent for HPSV

LED Wattage	HPSV[a/] Equivalent Lumen Wattage	SAP
22[b/]	50	10210230
31[b/]	70	10210231
39[b/]	100	10210233
71[b/]	150	10210234
82[c/]	200	10210239
136[c/]	250	10210236
137[c/]	310	10210237
174[c/]	400	10210238

a/ High Pressure Sodium Vapor (HPSV)
b/ 1-Bar Luminaire
c/ 2-Bar Luminaire

Note(s):

1. All Cobra Head style LED Luminaires are outfitted with ‘Cut Off’ style Optics which will help eliminate glare or ‘sky glow’ conditions.

Table SL 318–5: 480 V Cobra Head Style LED Luminaires 3000K Light Temp — HPSV Equivalents

LED Wattage	HPSV[a/] Equivalent Lumen Wattage	SAP
39[b/]	100	10210298
71[b/]	150	10210300
82[c/]	200	10210299
136[c/]	250	10210301
174[c/]	400	10210302

a/ High Pressure Sodium Vapor (HPSV)
b/ 1-Bar Luminaire
c/ 2-Bar Luminaire

Note(s):

1. All Cobra Head style LED Luminaires are outfitted with ‘Cut Off’ style Optics which will help eliminate glare or ‘sky glow’ conditions.

Table SL 318–6: 480 V Cobra Head Style LED Luminaires 4000K Light Temp — Equivalent for HPSV

LED Wattage	HPSV[a/] Equivalent Lumen Wattage	SAP
39[b/]	100	10210293
71[b/]	150	10210294
82[c/]	200	10210295
136[c/]	250	10210297
174[c/]	400	10210296

[a/] High Pressure Sodium Vapor (HPSV)
[b/] 1-Bar Luminaire
[c/] 2-Bar Luminaire

Note(s):

1. All Cobra Head style LED Luminaires are outfitted with 'Cut Off' style Optics which will help eliminate glare or 'sky glow' conditions.

Table SL 318–7: Cobra Head Style LED Luminaires 3000K Light Temp — LPSV Equivalents

LED Wattage	LPSV[a/] Equivalent Lumen Wattage	SAP
22[b/]	100	10210283
31[b/]	150	10210284
71[b/]	200	10210285
96[c/]	250	10210282

[a/] Low Pressure Sodium Vapor (LPSV)
[b/] 1-Bar Luminaire
[c/] 2-Bar Luminaire

Note(s):

1. All Cobra Head style LED Luminaires are outfitted with 'Cut Off' style Optics which will help eliminate glare or 'sky glow' conditions.

Table SL 318–8: Cobra Head Style LED Luminaires 3000K Light Temp — MH Equivalents

LED Wattage	MH[a/] Equivalent Lumen Wattage	SAP
31[b/]	100	10210290
39[b/]	150	10210291
39[c/]	175	10210291
71	250	10210292
111[c/]	400	10210303

a/ Metal Halide (MH)
b/ 1-Bar Luminaire
c/ 2-Bar Luminaire

Note(s):

1. All Cobra Head style LED Luminaires are outfitted with ‘Cut Off’ style Optics which will help eliminate glare or ‘sky glow’ conditions.

Table SL 318–9: Cobra Head Style LED Luminaires 4000K Light Temp — MH Equivalents

LED Wattage	MH[a/] Equivalent Lumen Wattage	SAP
31[b/]	100	10210286
39[b/]	150	10210287
39[c/]	175	10210287
71[c/]	250	10210288
111[c/]	400	10210289

a/ Metal Halide (MH)
b/ 1-Bar Luminaire
c/ 2-Bar Luminaire

Note(s):

1. All Cobra Head style LED Luminaires are outfitted with ‘Cut Off’ style Optics which will help eliminate glare or ‘sky glow’ conditions.

What’s Changed? Added Table SL 318–8 and Table SL 318–9.