LIGHTNING PROTECTION & GROUNDING 12

This section outlines standard ratings of lightning protective equipment, methods of installation, equipment to be grounded, and methods of grounding.

1. Lightning Protection

A. Overhead Static Wire

This is a grounded overhead wire installed above the circuit to be protected to shield it from lightning. It is located at an elevation such that a line passing through the static wire and the outermost conductor below it is at a 30° maximum angle with a vertical line. This continuous overhead static wire is grounded by means of a formed copper wire grounding electrode at each pole.

a. Installation of Static Wire

The preferred method of lightning protection of overhead sub-transmission circuits is through use of an overhead static wire. The static wire shall be grounded at every pole except manually operated group air break switch poles. The best protection is afforded by low pole ground resistance (less than 15 ohms).

B. Lightning Arresters

Metal Oxide Varistor (MOV) arresters are normally used for protection of overhead distribution circuits or equipment where conditions warrant (e.g. high ground resistance or retrofitting shielded circuits with a poor history of lightning performance). These arresters (mostly zinc oxide) are solid state and are direct connected from line to ground. MOV arresters are sensitive to temporary system overvoltage such as may occur due to ferroresonance or to single phase switching of ungrounded wye-delta transformer banks. In such instances contact Standards Engineering for recommendations. Higher voltage arresters may be required.

There are many silicon carbide internally and externally gaped arresters still on the system. These allow a higher discharge voltage than MOV arresters, reducing the surge protective margin. When these are found during work on a pole they should be replaced with a polymer housed metal oxide (MOV) arrester (especially at riser poles).

a. Installation of Lightning Arresters

When installed to protect equipment, arresters shall be installed as near as practical to the equipment to be protected. See Table 2 for equipment to be protected.

Arresters are also installed on sub-transmission for general line protection. In this application, arresters should be installed on the top phase of every pole where a 30° shield angle exists. Skipping spans severely reduces the ability of the arresters to protect against direct stroke flashovers. Where lines run through wooded areas or close (within 1-1/2 pole heights) to any type of structure at least as tall as the top phase, induce flashovers may be experienced. If outages are experienced in this circumstance, arresters should be installed on the remaining phases of the circuit(s) at roughly 300' intervals. Where a shield angle greater than 30° exists, arresters should be placed on all three phases of every pole in open territory. Where the line runs through areas shielded by trees or other structures, arresters should be installed on all three phases at roughly 300' intervals.

Distribuition underbuild, particularly when built with all three phases on one crossarm, will many times experience flashovers from the ground lead of either static construction or arresters on the sub-transmission circuit(s). If experience indicates this to be the case, arresters should be installed on the B phase (closest to the pole).

In all cases the primary connection lead as well as the ground lead should be as short as possible and free of any sharp bends. Under no circumstances should "pigtail" coils be made in the arrester connecting leads.

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CONSTRUCTION NOTE(s):

1. Connect the arrester ground lead before connecting the arrester to the line.
2. Install wildlife guards on line terminals of all line arresters.
3. Do not reconnect arresters with a blown ground lead disconnector.
4. Arresters removed for any reason shall not be re-installed.

Table 1 - Standard Lightning Arrester Ratings

App	Note(s)	Type Circuit	Rating	*MCOV	Stock Number
OVERHEAD	5	2400 V Delta	3 kV	2.55 kV	10 01 133
	5	4160 Gnd Y/2400V	3 kV	2.55 kV	10 01 133
	5	4160 Gnd Y/2400 V Trf. Mnt	3 kV	2.55 kV	10 01 122
	5	4160 Gnd Y/2400 V Terminal Pole	3 kV	2.55 kV	10 01 133
	5	4160/2400 V with Isolated Neut	3 kV	2.55 kV	10 01 133
	5	4160 V without Neutral Extended	6 kV	5.10 kV	10 01 184
	5	4800 V Delta	6 kV	5.10 kV	10 01 184
	6	**12470 Gnd Y/7200 V**	**10 kV**	**8.4 kV**	**10 01 144**
		12470 Gnd Y/7200 V Trf Mnt	10 kV	8.4 kV	10 01 145
	6	**12470 Gnd Y/7200 V Terminal Pole**	**9 kV**	**7.65 kV**	**10 01 129**
	8	12470 Gnd Y/7200 V Terminal Pole	10 kV	8.4 kV	10 01 146
		12470 Delta or 14,400 Un-Grounded, Gapped	15 kV	12.7 kV	10 01 188
		13200 Gnd Y/7620 V	10 kV	8.4 kV	10 01 144
		13800 Gnd Y/7970 V	12 kV	10.2 kV	10 01 008
		13800 V Uni-Grounded	15 kV	12.7 kV	10 01 188
		13800 or 14400 Delta	18 kV	15.3 kV	10 01 143
		13800 Gnd Y/7970 V Terminal Pole	10 kV	8.4 kV	10 01 146
		24900 Gnd Y/14400 V (Solidly Grounded)	18 kV	15.3 kV	10 01 143
		34500 Gnd Y/19.9 kV (Solidly Grounded)(Transformer)	27 kV	22 kV	10 01 234
	6	**34500 Gnd Y/19920 V (Solidly Grounded)**	**36 kV**	**30 kV**	**10 01 252**
	6	**34500 Gnd Y/19920 V Terminal Pole**	**27 kV**	**22 kV**	**10 01 137**
	10	34500 Gnd Y/19920 V Terminal Pole, Gapped	27 kV	22 kV	10 01 199
	9	34500 Gnd Y/19920 V Suspended with Side Post Insulator	30 kV	24.4 kV	10 01 239
	10,18	34500 V Un-grounded Delta/Suspended with Side Post Insulator	36 kV	29 kV	10 01 249
		34500 Gnd Y/19920 Suspended with DE Insulator	30 kV	24.4 kV	10 01 237
	6,18	**34500 V Un-grounded Delta/Suspended with DE Insulator**	**36 kV**	**29 kV**	**10 01 248**
	15	34500 Gnd Y/19920 V (Solidly Grounded) - Intermediate Class	30 kV	24.4 kV	10 01 240
	12	34500 Gnd Y/19920 V (Solidly Grounded) - Intermediate Class	30 kV	24.4 kV	10 01 241
	12,18	34500 V Un-grounded Delta - Intermediate Class	36 kV	29 kV	10 01 243
	13,18	34500 V Un-grounded Delta - Intermediate Class	36 kV	29 kV	10 01 242
	15	69000 V Gnd Y - Intermediate Class	60 kV	48 kV	10 01 245
		69000 V Gnd Y Suspended with Side Post Insulator	60 kV	48 kV	10 01 158
		69000 V Gnd Y Susspended with DE Insulator	60 kV	48 kV	10 01 236
UNDERGROUND	6	**12470 V URD**	**10 kV**	**8.4 kV**	**10 01 138**
		12470 V URD (Parking Stand Arrester)	10 kV	8.4 kV	10 01 151
		25000 V URD	18 kV	15.3 kV	10 01 267
	6,16	**34000 V URD (Small Interface)**	**27 kV**	**22 kV**	**10 01 163**
	17	34000 V URD (Large Interface)	27 kV	22 kV	10 01 177
	16,18	34000 V URD (Small Interface)	36 kV	29 kV	10 01 255
	17,18	34000 V URD (Large Interface)	36 kV	29 kV	10 01 154
SEC		1 Phase 120 or 120/240 V	175 kV		10 01 032

* Maximum Continuous Operating Voltage (MCOV)

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DESIGN NOTE(s):

5. Use 3kV arrester only on structures built to old 5kV specs, or for replacement on 5kV rated equipment and cable. Use 10kV and 9kV arresters when built to 15kV specs.

6. Bold indicates common arresters for 4kV, 12kV, and 34kV lines, terminal poles, and URD applications.

7. Crossarm or pole mounting bracket required.

8. Use when problems occur with 9kV arresters (Stock #10 01 129) or where voltage may be high, such as right outside substation. Also use on 13.2kV terminal poles.

9. The suspended arrester is special application only on 34kV.

10. Use on un-grounded delta system.

11. Base mount for use on primary metering structure

12. Crossarm mount for use on primary metering structure.

13. Base mount for use on un-grounded delta primary metering structure.

14. Crossarm mount for use on un-grounded delta primary metering structure.

15. Base mount for use on primary metering structure.

16. Small interface is to mount on radial feed.

17. Large interface is to mount on loop feed.

18. For un-grounded delta 34kV system.

Table 2 - Equipment To Be Protected by Lightning Arresters

Equipment	**Arrester Location**
Distribution Transformers	Primary Side
Voltage Regulators - Pole Installations	Primary & Secondary Sides
Constant Current Regulators - Pole Installations	Primary & Secondary Sides
Terminal Poles - Lead and Non-Lead Cables	On terminal pole and on same phase on strucures each side of riser poles
Line Switches - Normally Closed	Arresters not required
Line Switches - Normally Open	Install both sets of arresters on adjacent poles. If adjacent pole cannot accomodate arresters, install arresters on a separate bracket arm below the switches, and install additional set of arresters on adjacent pole of unprotected side.
Airbreak Switches - Normally Open - 35 & 69 kV	Install both sets of arresters on adjacent poles.
Capacitors	On capacitor rack
Meters only on approval of Engineering)	On service entrance equipment
Unshielded Distribution Lines	On crossarm, pole face or primary apparatus. Minimum of 4 arresters per phase per mile (counting apparatus arresters if separated by 600ft or more)
Deadend Poles (Unshielded Circuits)	Top Phase (Vert): All Phases (Flat)

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2. Grounding Practices

A. Grounds in Soil

Ground rods will continue to be used for grounding pad mounted equipment and existing pole ground installations. For new pole ground installations, a formed #2 soft-drawn copper electrode shall be used. This electrode is to be placed at the bottom of the pole and covered with at least twelve inches of native soil. The vertical lead of the electrode should be trained to the side of the pole hole so that it will not be covered by the crushed rock backfill. If the desired resistance is not obtained, additional ground rods can be driven in parallel with the formed electrode, but a minimum separation distance of six feet shall be maintained.

B. The Common Neutral System

Either a 2400/4160 Y volt or a 7200/12470 volt common neutral distribution system is normally used at Ameren. These systems use a continuous metallic conductor which serves as both the primary and secondary neutral conductor. This neutral conductor must be attached to grounds at various points throughout its length to ensure adequate grounding of the circuit. These grounds (Table 3) will consist of customers' grounds, lightning arrester grounds, and static wire grounds and occasionally a ground installed solely to provide adequate grounding of the common neutral. Where a common neutral is present, all grounds installed for any purpose shall be bonded to it.

C. Number of Grounds - Common Neutral

At least four grounds are required, (counting equipment grounds but not counting customers' grounds), in each mile of common neutral circuit for both overhead and underground circuits (maximum 1320 feet spacing).

D. Size of Ground Wire

The size of the ground wire will be 7-#10 CW or #2 Cu. Equipment must it connected to the ground wire or the system neutral with wire shown in Table 3.

E. Multiple Ground Leads on Same Pole

Where both Ameren and communication systems are grounded on a joint use structure, NESC Rule 97G requires that either a single pole ground lead shall be used for both systems or the Ameren and communication worker safety zone (40" below lowest Ameren attachment if made by Communication Company or at the neutral if connection is made by Ameren). Where Ameren is maintaining isolation* between primary and secondary neutrals, the communication system ground shall be connected only to the primary neutral ground lead.

The same requirement for bonding of separate ground leads at the neutral level applies for all instances where multiple ground leads are installed. (i.e., static/shield wire and system neutral ground leads; Ameren and other electrical utility system neutral ground leads).

*See DCS **13 00 06 06**, **13 00 06 08**, and the delta primary connection diagrams in **13 00 07 02** thru **13 00 07 12** for situations requiring isolation of Ameren primary and secondary neutrals.

F. Multiple Ground Rods on Same Pole

Where separate ground rods are used for separate pole grounds, NESC Rule 99C requires a bond wire not smaller than #6 copper or equivalent to be placed between the two ground rods. This bond should be visible at the pole base. All separate ground rods shall be bonded together except where Ameren is maintaining isolation between primary and secondary neutrals.

*See DCS **13 00 06 06**, **13 00 06 08**, and the delta primary connection diagrams in **13 00 07 02** thru **13 00 07 12** for situations requiring isolation of Ameren primary and secondary neutrals.

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G. Equipment to be Grounded

Table 3 - Equipment to be Connected to Ground (Pole Ground, System Neutral, or Ground Bus) and Size of Connecting Wire

Pole Mounted Equipment	**Wires**	**Pad Mounted Equipment**	**Wires**
Transformer - tank	#4 Cu. Poly Cov.	Transformer - tank	#2 Cu. Bare
Transformer - H2 Bushing	#4 Cu. Poly Cov.	Transformer - X0 Bushing	#2 Cu. Bare
Transformer - X2 Bushing	#4 Cu. Poly Cov.	Capacitor Bank - cabinet	#2 Cu. Bare
Voltage Regulator - tank and SL Bushing	#4 Cu. Poly Cov.	Switchgear - cabinet	#2 Cu. Bare
Voltage Regulator - control cabinet	#6 Cu. Poly Cov.	Primary Pedestal - cabinet	#2 Cu. Bare
Capacitor Bank - frame or rack	#4 Cu. Poly Cov.	Secondary Pedestal - cabinet	#2 Cu. Bare
Capacitor Bank - cell ground bus	#4 Cu. Poly Cov.	Cable Concentric Neutral (at elbow, terminator or splice)	#2 Cu. Bare
Capacitor Bank - control	#6 Cu. Poly Cov.	Elbow (static drain wire)	#14 Cu. Bare
Capacitor Bank - junction box	#6 Cu. Poly Cov.	Elbow Lightning Arrester (static drain wire)	#14 Cu. Bare
Capacitor Bank - disconnect box	#6 Cu. Poly Cov.	Insulating Cap (static drain wire)	#14 Cu. Bare
Recloser (oil filled) - tank	#4 Cu. Poly Cov.	Feed Through Bushing (static drain wire)	#14 Cu. Bare
Recloser (S&C Intellirupter) - frame	#2 Cu. Poly Cov.		
Recloser (G&W Viper) - frame	#2 Cu. Poly Cov.		
Recloser (G&W Viper) - disconnect box	#6 Cu. Poly Cov.		
Recloser (G&W Viper) - control	#6 Cu. Poly Cov.		
Cable Concentric Neutral (terminator)	#2 Cu. Poly Cov.		
Metal Guards (protecting cable risers)	#6 Cu. Poly Cov.		
Lightning Arrester - ground terminal	#6 Cu. Poly Cov.		

CONSTRUCTION NOTE(s):

19. Pole line hardware (including cluster bracket and streetlight brackets) must not be grounded except with engineering approval.

20. Where a lightning arrester is installed on a secondary or service the arrester ground lead shall be solidly connected to any one or combination of the following grounds:

    A. The neutral or grounded service wire.

    B. Customer's common grounding conductor.

    C. Customer's equipment grounding conductor.

    D. A separate grounding conductor such as a driven rod.

H. Ground Wire Attachment and Covering

The ground wire shall be run in a straight line or a smooth curve and shall clear hardware by at least 2 inches. The static ground wire from 34kV circuits shall be routed on the opposite side of the pole away from the closest phase of any underbuilt circuit. Avoid making sharp bends in ground wires. Take care when driving staples to avoid damaging the wire.

Where the ground wire passes over a messenger or guy wire, a loop shall be formed to clear the messenger or guy wire. If necessary, a bridge shall be made from a 6" length of plastic molding, placing the half round of the molding against the pole and taping the ground wire in place in the groove.

Where guarding is not required, grounds shall be protected by being substantially attached closely to the surface of the pole or other structure in areas of exposure to mechanical damage and, where practical, on the portion of the structure having least exposure.

A 4'0" section of molding may be placed over the ground wire in the working area on badly congested poles. The purpose of the molding is to keep linemen's climbers from damaging the ground wire when working on primary circuits.

Ground wire molding is required for installation with no common neutral and separate arrester/equipment tank and secondary neutral grounds. These separate grounds shall be made with 600 volt insulated conductor (Stock #18 53 011) and shall be covered with plastic molding for a distance of 8 feet from the ground. The arrester/tank ground and secondary ground can be connected using an isolation arrester (Stock #10 01 019). One ground rod at least 20 feet from the base of the pole and connected with #2 SD bare copper conductor.

I. Static Wire at Substation

1/0 AAAC or 110.8 ACSR static wire shall be electrically continuous and tied into the bulk substation ground grid. Where the connection into the substation cannot be made overhead, direct bury a 4/0 bare copper conductor from the last pole with static termination to the substation ground grid. The 4/0 size conductor allows some safety margin for corrosion. The downlead from the static wire to the 4/0 conductor shall be #2 copper.

J. Static Wire Personal Protective Grounds

a. Wire Common Neutral

1/0 AAAC or 110.8 (12/7) ACSR (or other shield wires having current capacity of 250 amps or greater) may be used for direct connection of protective grounds on 35 and 69kV circuits if there is a common neutral and #2 copper pole grounds (or other pole grounds with current capacity of at least 50 amps) connected to the shield wire for at least two poles in each direction. The common neutral must also be connected to the down leads at each pole.

b. Without Common Neutral

1/0 AAAC or 110.8 (12/7) ACSR (or other shield wires having current capacity of 250 amps or greater) may be used for direct connection of protective grounds on 35 and 69kV circuits with no common neutral present if #2 copper down leads are grounded at every 4th pole (no more than 1200 feet apart); a supplementary grounded rod must be driven at least 6 feet from the closest ground rod. This extra ground rod shall be connected with #2 copper to the #2 copper down lead.

c. Alumoweld Static Wire

Alumoweld static wires have been installed in the past. Do not connect protective grounds to Alumoweld. It may fuse if a fault occurs. To improve protective grounding on 35kV lines with Alumoweld static and poor ground resistance, #2 copper downleads may be installed at intervals of 4 spans (no more than 1200 feet). Protective grounds can then be connected to the #2 Cu. A supplemental ground is required from #2 copper downlead to a second driven ground.

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K. Static Wire/Common Neutral Wire

1/0 AAAC or 110.8 (12/7) ACSR (or other static wires having current capacity of 250 amps or greater) may be used as the common neutral for lower voltage underbuilt circuits where the run is 3000 feet or more. In such cases the static wire must be continuous and connected to the source transformer neutral with #2 SD poly covered wire.

The static wire shall not be used in place of the secondary neutral. Where secondary is present the secondary neutral shall be paralleled with the static wire neutral and interconnected at every static wire ground downlead. However, where this would result in short discontinuous sections of neutral a continuous neutral shall be installed from the source transformer.

To equalize ground potential static wire ground leads, arrester ground leads, neutral ground leads and equipment case ground leads shall be bonded together with the only exceptions noted in the transformer section of the standards.

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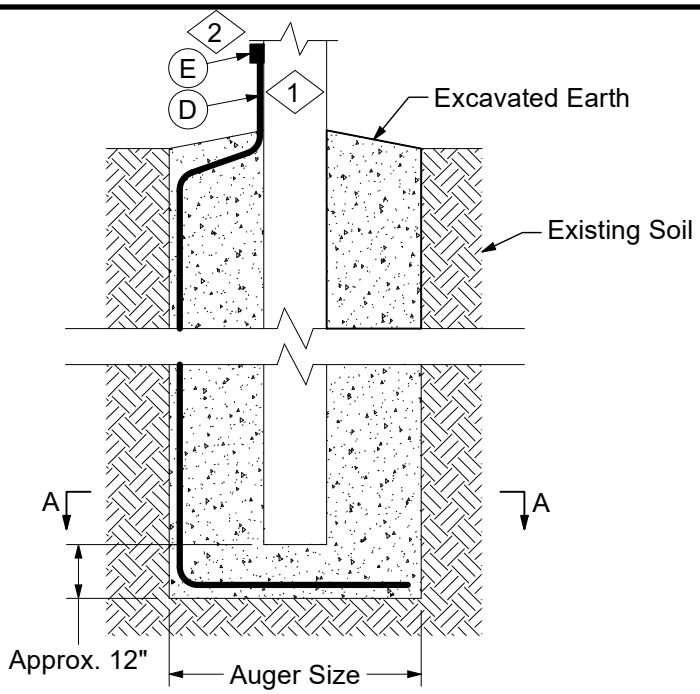
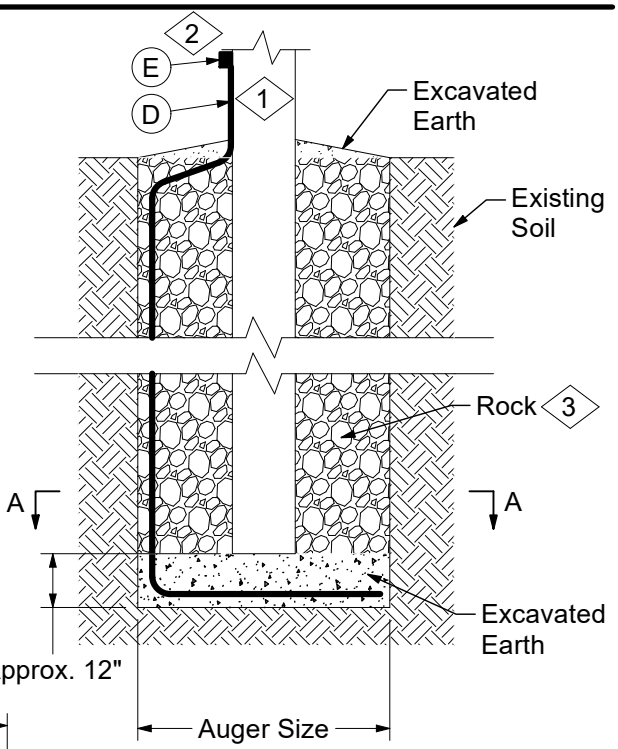
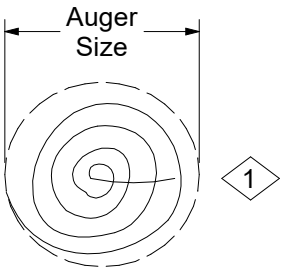


New Pole
Excavated Earth Backfill



New Pole
Rock Backfill



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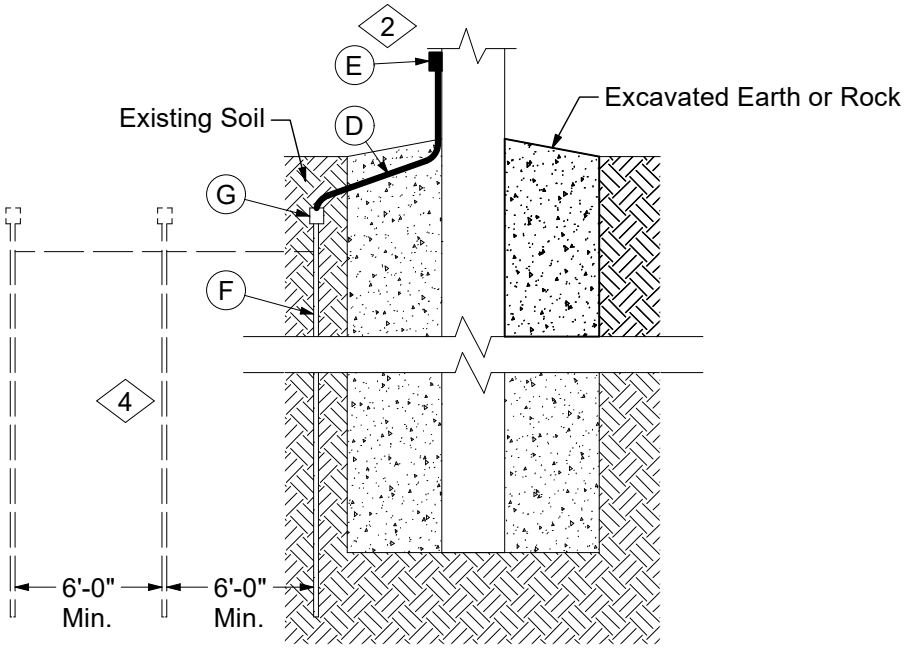

Existing Pole
Adding Ground(s)

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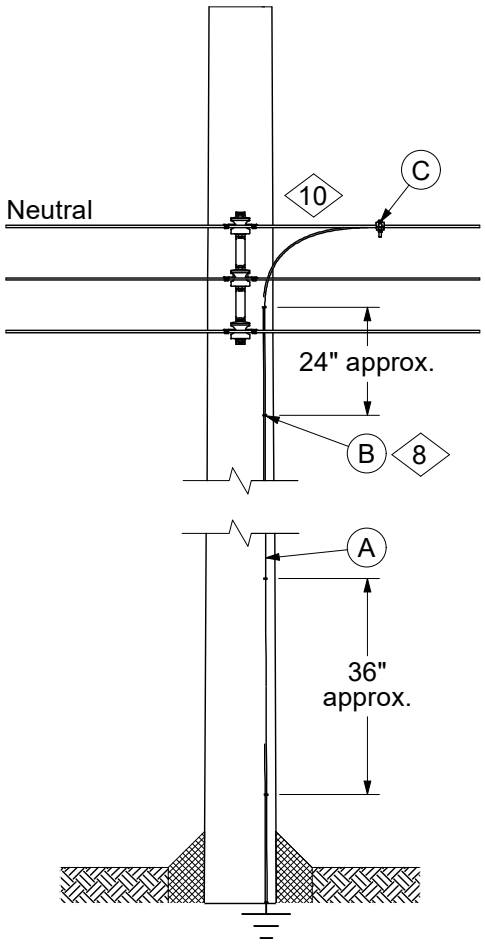
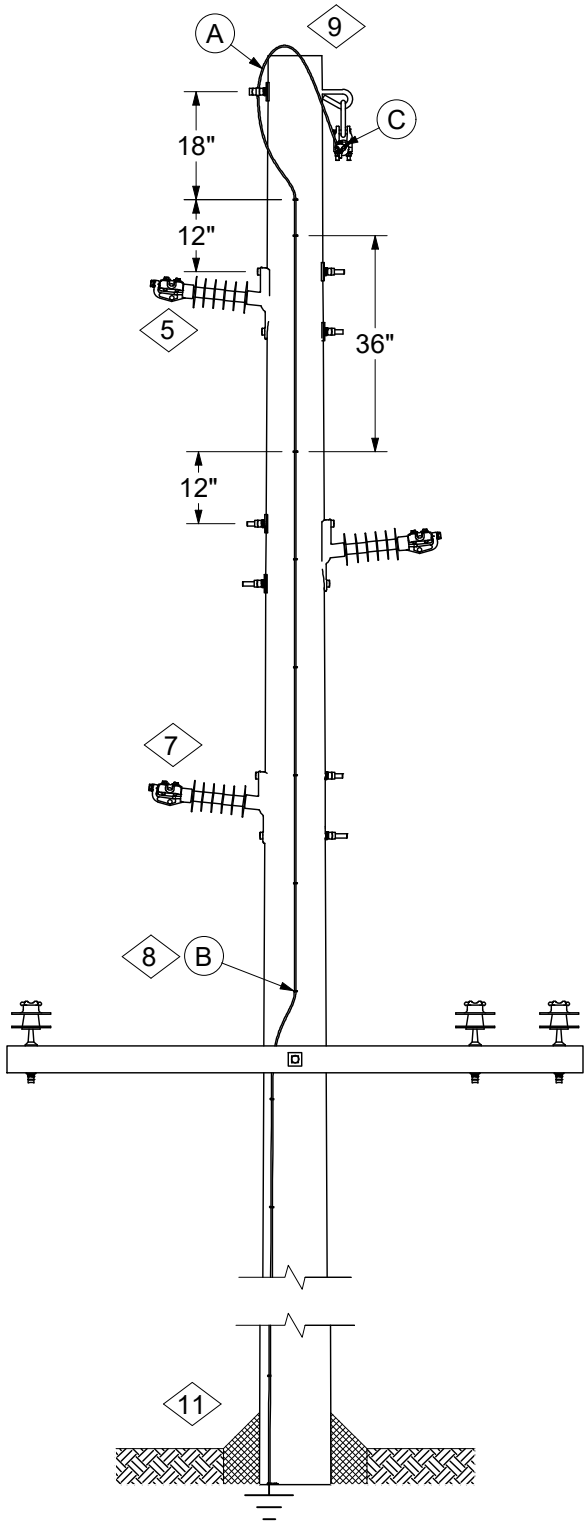


Wood Pole Ground - 15kV



Wood Pole Ground - 34kV & 69kV

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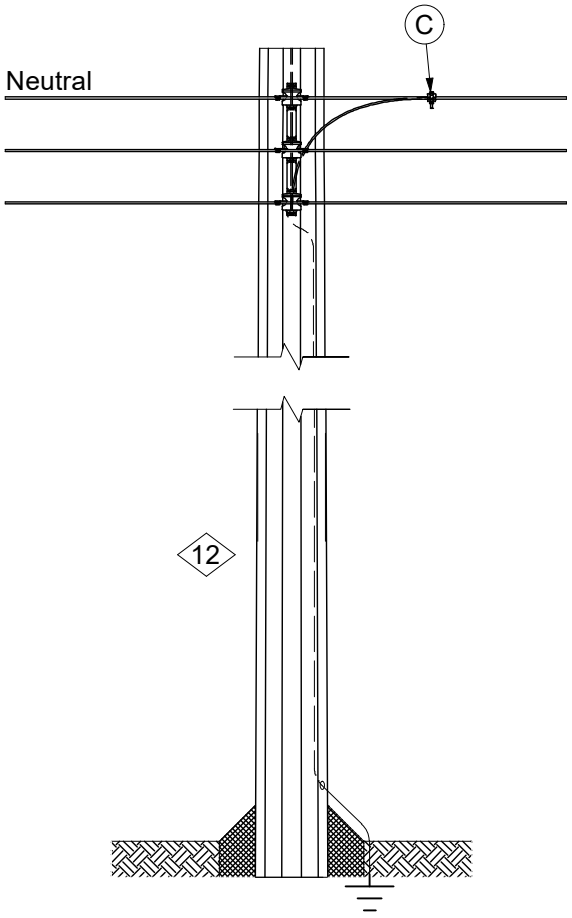
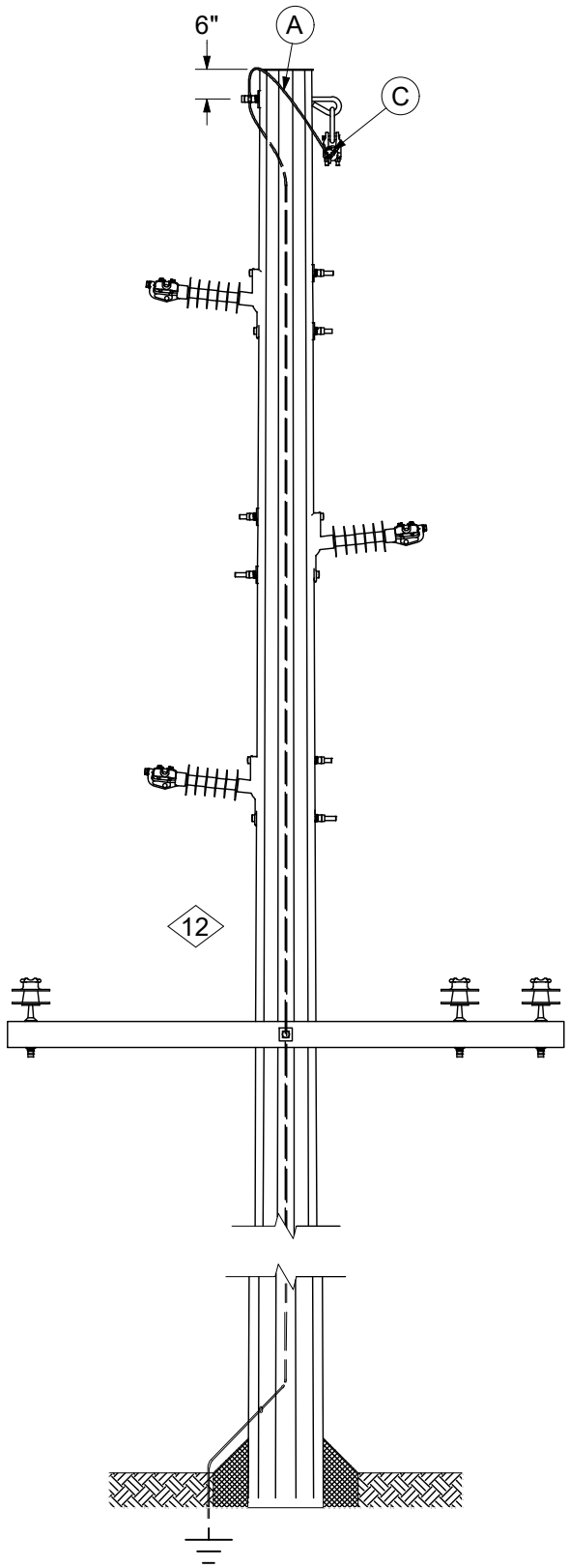


Composite Pole Ground - 15kV



Composite Pole Ground - 34kV & 69kV

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CONSTRUCTION NOTE(s):

1. Train below grade ground wire approximately 8" above ground line to line up with pole ground wire above grade. Avoid making sharp bends. Make the ground coil to the same diameter as the pole hole using at least 12' of bare #2 copper wire.

2. Connectors shall be positioned above grade with a staple above and below the connector.

3. Pole foam may be used in extenuating circumstances. With rock or foam backfill, make sure ground coil wire is pushed against dirt and not encapsulated in rock or foam.

4. Ground resistance will normally be less than 25 ohms with one coil or one rod. In rocky or sandy soil where experience indicates ground resistance may exceed 25 ohms, install additional coil or rods spaced not less than 6' apart. Doubling the number of rods or coils or doubling the length of the rod reduces ground resistance by 40%.

   If additional grounding is needed:

   A. terminal poles - a #2 bare Cu. counterpoise wire 100'-150' long may be placed in the cable trench and connected to the ground lead.

   B. in rocky soil where driving a rod is difficult - a counterpoise, as stated in A., may be placed in a trench at least 18" deep.

5. The ground wire shall be run in as straight a line down the pole without making sharp bends in such a manner as to clear hardware by at least 2 inches. Avoid damaging ground wire when installing staples.

6. According to an NESC subcommittee's interpretation, metal brackets and straps used to support non-conductive conduits do not need to be grounded. However, conductive material conduits that enclose electrical supply lines or are exposed to contact with open supply conductors must be effectively grounded.

7. Refer to DCS Section 03 for proper grounding position on different structure configuration.

8. Staples are to be spaced 3' on pole ground wire and 18" from top of the pole on 34kV and 69kV line.

9. See DCS **06 00 11 ** ** for static support assembly and DCS **12 34 01 ** ** and **12 34 02 ** ** for lightning arrester connection.

10. When the ground wire is run up the pole and past the neutral, a jumper must connect the pole ground to the system neutral. For #2 Cu. pole ground wire, use a #2 Cu. poly covered jumper. For 7-#10 CW pole ground wire, use a #4 Cu. poly covered jumper. Use a bronze connector to connect the Cu. jumper wire to the Cu. or CW pole ground wire.

11. If pole ground wire cannot be connected to system neutral or static wire, cover ground wire at base of pole with plastic molding Stock #41 56 041 using 10 staples Stock #23 64 028.

12. Factory installed #2 Cu. pole ground located inside pole.

13. Use appropriate connector for the ground wire size being replaced. Non-tension sleeve (Stock #17 60 730) can be used 7#10 CW connections, reducing non-tension sleeve (Stock #17 60 749) can be used for #2 solid Cu. to 7-#10 CW or #2 stranded Cu. connections, and split-bolt (Stock #17 54 373) can be used for most other connections.

14. If a distribution circuit is added to subtransmission pole with 7-#10 Copperweld or #6 Cu. pole ground wire and the static wire is used for the distribution system neutral, the pole ground wire must be changed to #2 Cu or larger.

Table 1 - Grounding System for Wood Poles			
APPLICATION		**WIRE**	**DCS #**
New Pole	System Neutral	7 #10 CW	12 00 10 01
		#2 Cu.	12 00 10 04
	Static Wire	7 #10 CW	12 00 10 05
		#2 Cu.	12 00 10 09
Existing Pole	System Neutral	7 #10 CW	12 00 10 02
		#2 Cu.	12 00 10 03
	Static Wire	7 #10 CW	12 00 10 06
		#2 Cu.	12 00 10 10

Table 2 - Grounding System for Composite Poles			
APPLICATION		**WIRE**	**DCS #**
New Pole	System Neutral	#2 Cu.	12 00 10 11
	Static Wire	#2 Cu.	12 00 10 12

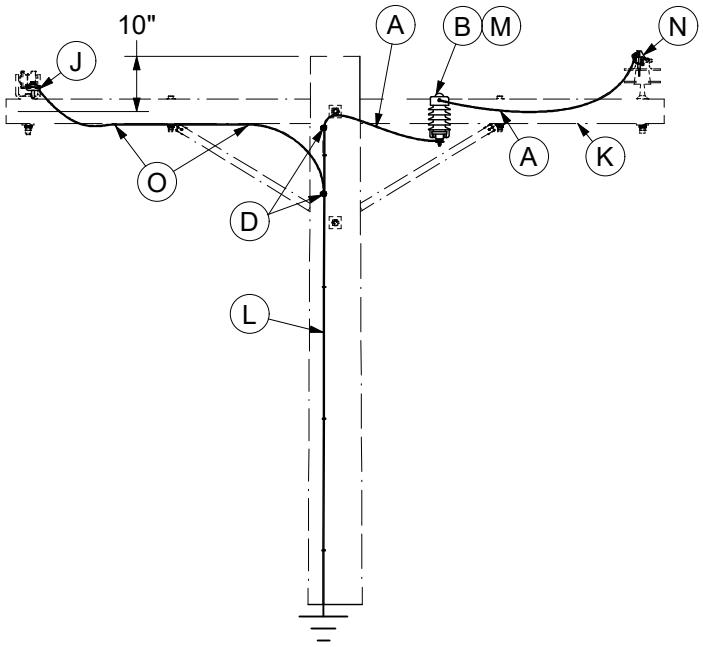
	ITEM	STK / DCS #	DESCRIPTION 12 00 10 **	01	02	03	04	05	06	10	09	11	12
8	A	27 09 215	Wire, 7#10, CW Poly Covered	40	40	-	-	70	70	-	-	-	-
		18 51 019	Wire, #2 Cu. Poly Covered, 7 Strand	-	-	40	40	-	-	70	70	5	10
	B	23 64 001	Staple, Ground Wire, Serrated, Cu Clad	15	15	15	15	25	25	25	25	-	-
	C	17 51 032	Clamp, Parallel Groove, #6 - 1/0	1	1	1	1	1	1	1	1	1	2
	D	18 52 025	Wire, #2 Cu. Bare, Solid	20	2	2	20	20	2	2	20	20	20
	E	17 60 749	Sleeve, Non-tension, Reducer, #2 Cu Solid to 7#10 CW or #2 Cu 7 Strand	1	1	1	1	1	1	1	1	1	1
	F	23 13 069	Rod, Ground, 5/8" x 8' Cu Bonded	-	1	1	-	-	1	1	-	-	-
	G	17 52 032	Clamp, Ground Rod, 5/8" dia Rod	-	1	1	-	-	1	1	-	-	-
		301	Op Code Install Ground Coil	1	-	-	1	1	-	-	1	1	1
		401	Op Code Install Ground Rod	-	1	1	-	-	1	1	-	-	-
		302	Op Code Install Ground Wire on Pole	1	1	1	1	1	1	1	1	-	-

DESIGN NOTE(s):

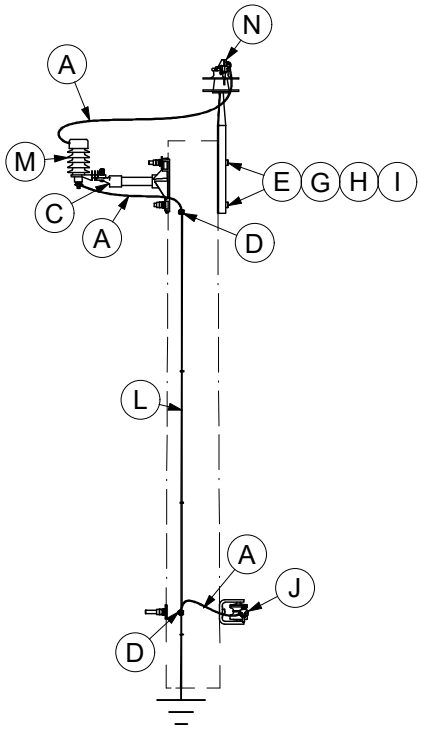
15. 7-#10 CW shall be the pole ground conductor on poles with transformers, capacitors, regulators and lightning arresters - unless other equipment on the pole requires #2 Cu. 7 strand. #2 Cu. 7 strand may also be substituted in areas where copper theft is unexpected.

16. #2 Cu. 7 strand shall be the pole ground conductor on terminal poles, poles with reclosers, and poles with static wire. The pole ground conductor for the static may be 7#10 CW in areas with high copper theft, but not if the static is the system neutral.

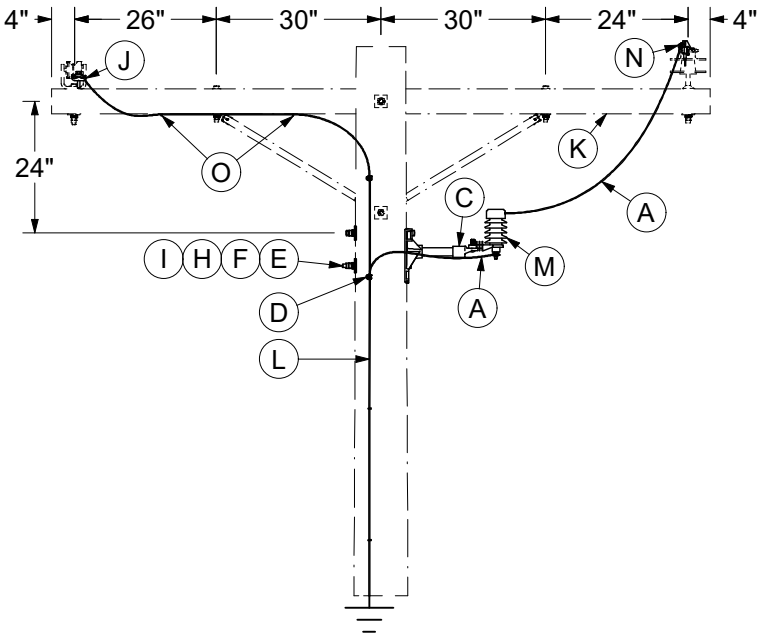
REV	DATE	ENG	DESCRIPTION
22	10/01/23	JMW	Converted to new format
21	02/01/18	JMW	



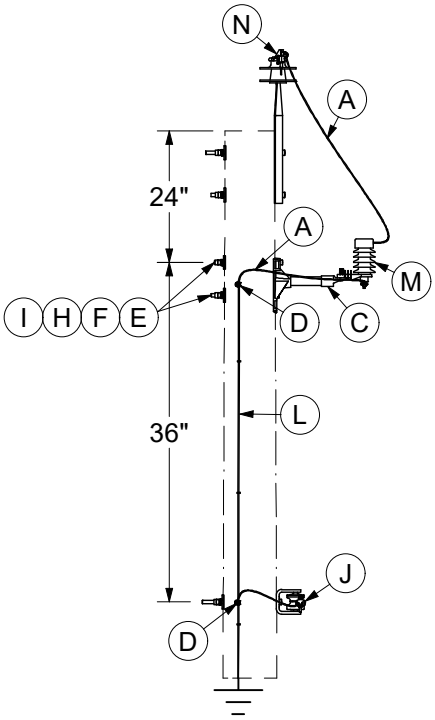
12 12 01 01



12 12 01 03

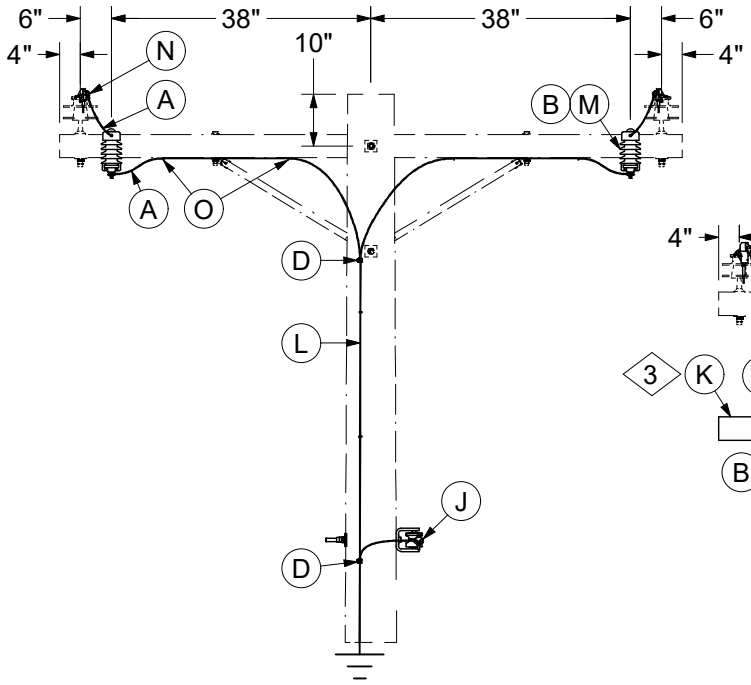


12 12 01 02

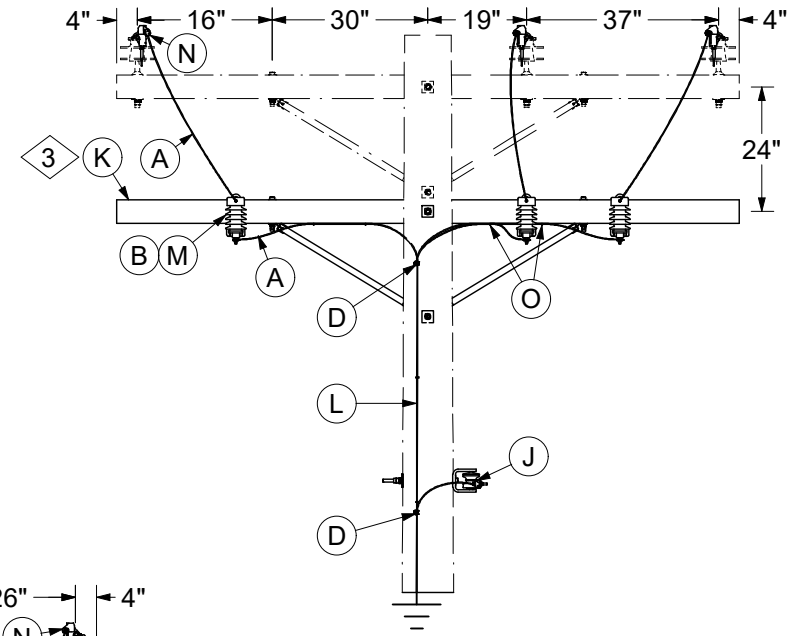


12 12 01 04

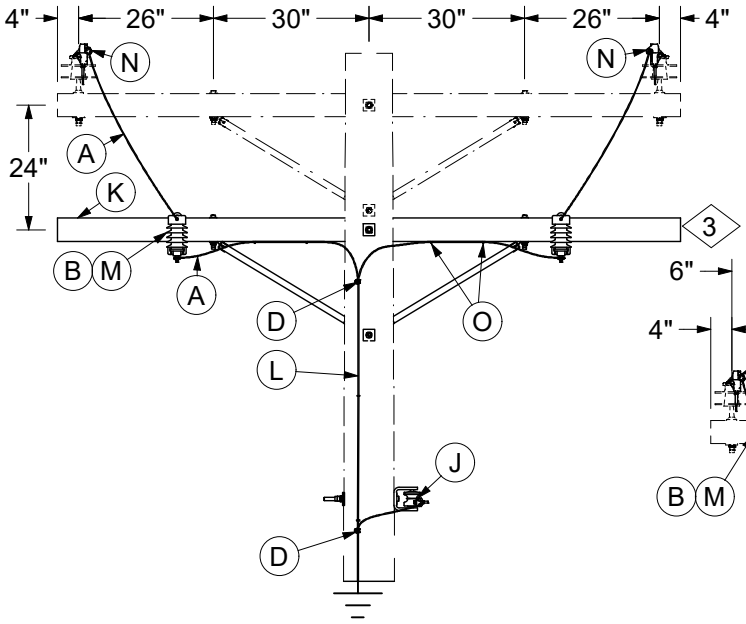
REV	DATE	ENG	DESCRIPTION
12	10/01/23	JMW	Converted to new format
11	06/15/15	WYW	



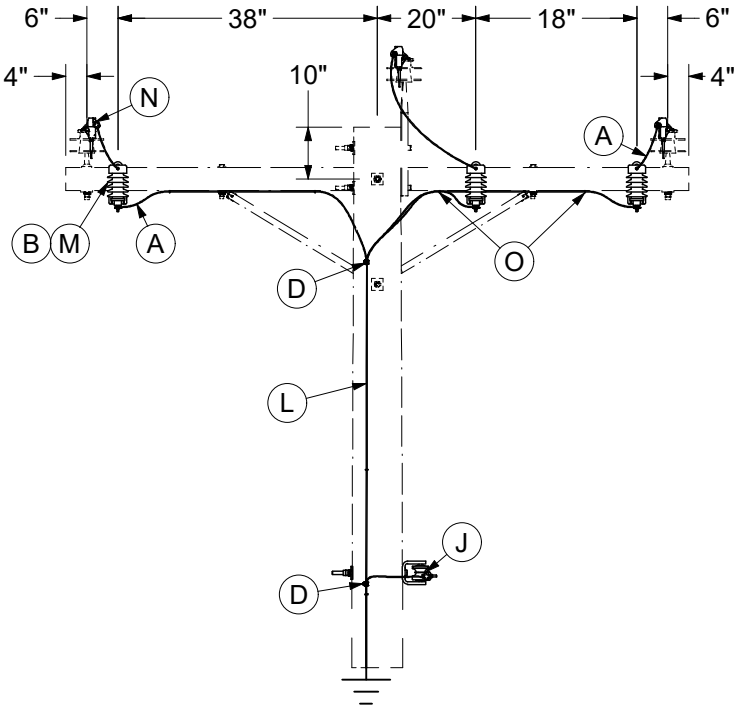
12 12 01 05



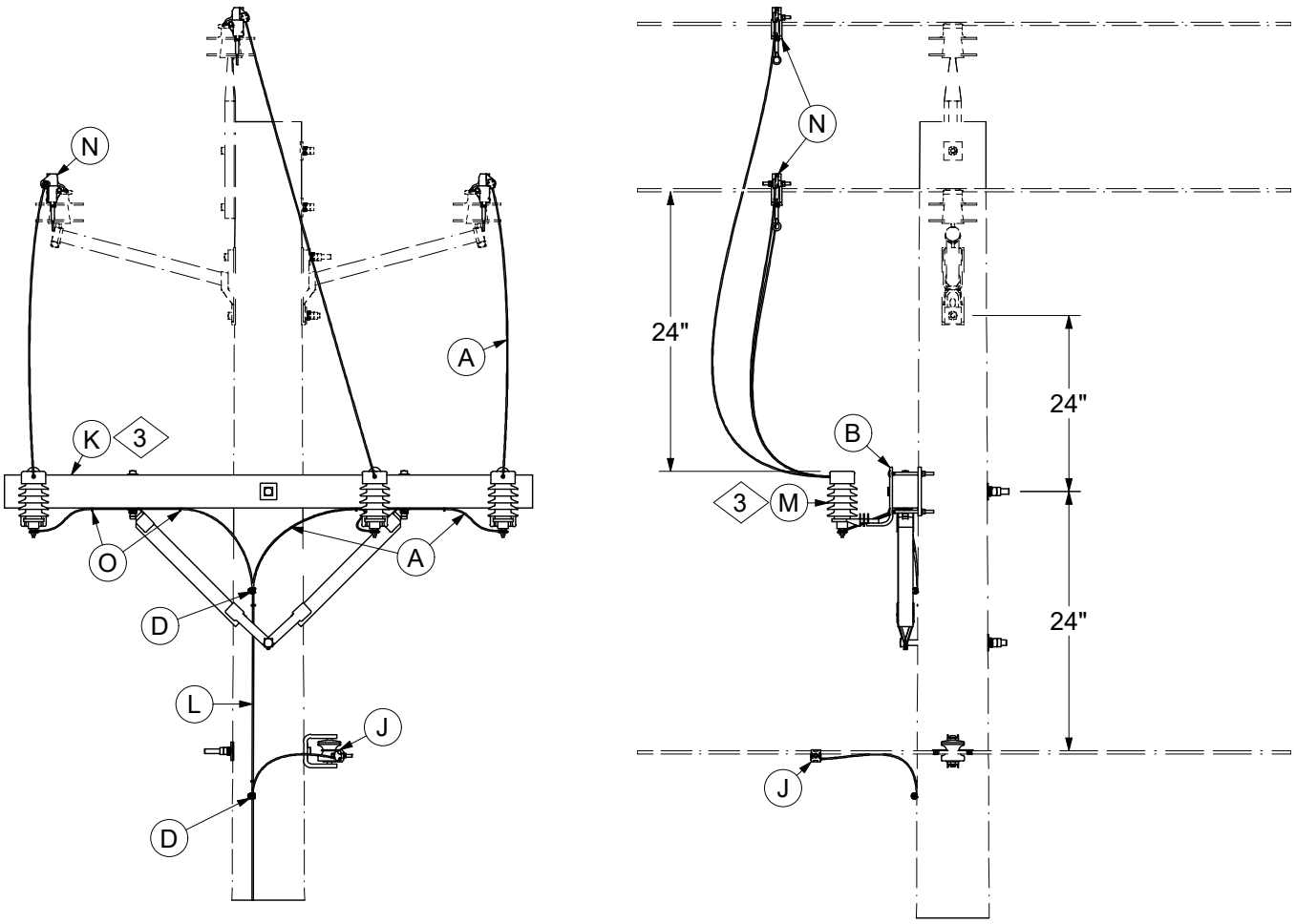
12 12 01 07



12 12 01 06



12 12 01 08



12 12 01 09 - 10 ft Crossarm
12 12 01 10 - 6 ft Crossarm

REV	DATE	ENG	DESCRIPTION
12	10/01/23	JMW	Converted to new format
11	06/15/15	WYW	

CONSTRUCTION NOTE(s):

1. Route the ground wires in a straight line or a smooth curve. Avoid making sharp bends in ground wires.
2. Take care when driving the staples onto the ground wires to avoid damaging the wire.
3. If fiberglass crossarm is used, secure ground wire to bottom of arm with clips, Stock #23 67 746. 12 clips per bag.

	ITEM	STK / DCS #	DESCRIPTION 12 12 01 **	01	02	03	04	05
				1 Ph	1 Ph	1 Ph	1 Ph	2 Ph
	A	18 51 021	Wire, Copper, #6 SD Poly Covered (ft)	10	10	6	6	12
	B	17 58 054	Bracket, Arrester/Cutout Mounting	1	-	-	-	2
	C	23 06 127	Bracket - Standoff, 12" FG	-	1	1	1	-
	D	17 54 373	Connector - Split Bolt	2	2	2	2	2
	E	23 52 065	Bolt, Mach., 5/8" x 12" w/ square nut	-	2	2	2	-
		23 52 066	Bolt, Mach., 5/8" x 14" w/ square nut	-	2	2	2	-
	F	23 66 207	Washer, Curved, Square, 5/8"	-	2	-	2	-
	G	23 66 027	Washer, Flat, Square 5/8"	-	-	2	-	-
	H	23 66 134	Lock Washer - 5/8" Double Coil	-	2	2	2	-
	I	23 65 043	Lock Nut - 5/8" Square	-	2	2	2	-
	J	07 00 25 00	Clamp, Parallel Groove PG**	1	1	1	1	1
@	K	04 00 20 01	6' Crossarm	-	-	-	-	-
		04 00 20 03	10' Crossarm	-	-	-	-	-
@	L	12 00 10 **	Grounding Unit	1	1	1	1	1
	M	10 01 144	Arrester, 10kV, 8.4kV MCOV	1	1	1	1	2
5,@		10 01 008	Arrester, 12kV, 10.2kV MCOV	1	1	1	1	2
		10 01 188	Arrester, 15kV, 12.7kV MCOV	1	1	1	1	2
@	N	07 00 21 00	Clamp, Hotline HLC*W	1	1	1	1	2
@	O	23 64 001	Staple 3/8" x 2"	4	2	-	-	4

REV	DATE	ENG	DESCRIPTION
12	10/01/23	JMW	Converted to new format
11	06/15/15	WYW	

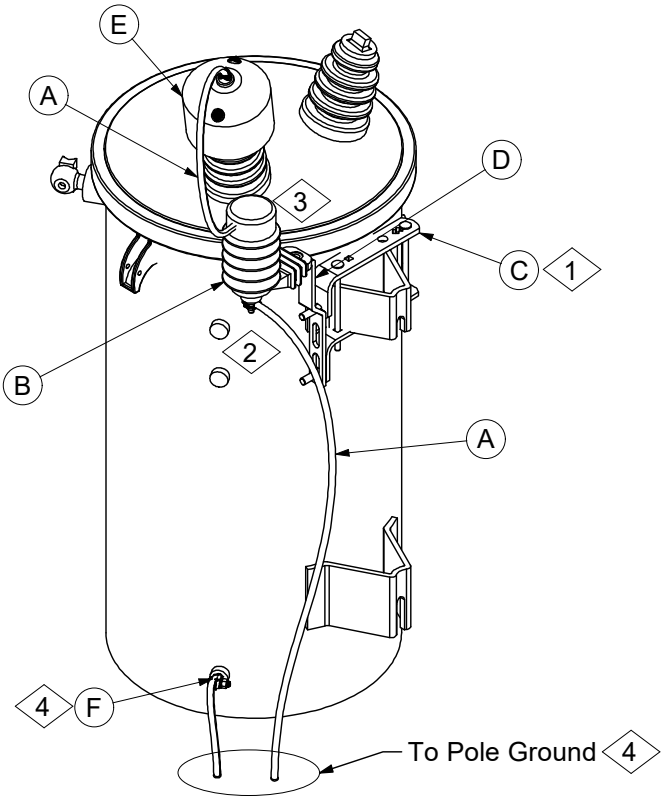
	ITEM	STK / DCS #	DESCRIPTION 12 12 01 **	06	07	08	09	10
				2 Ph	3 Ph	3 Ph	3 Ph	3 Ph
	A	18 51 021	Wire, Copper, #6 SD Poly Covered (ft)	16	24	20	23	23
	B	17 58 054	Bracket, Arrester/Cutout Mounting	2	3	3	3	3
	C	23 06 127	Bracket - Standoff, 12" FG	-	-	-	-	-
	D	17 54 373	Connector - Split Bolt	2	2	2	2	2
	E	23 52 065	Bolt, Mach., 5/8" x 12" w/ square nut	-	-	-	-	-
		23 52 066	Bolt, Mach., 5/8" x 14" w/ square nut	-	-	-	-	-
	F	23 66 207	Washer, Curved, Square, 5/8"	-	-	-	-	-
	G	23 66 027	Washer, Flat, Square 5/8"	-	-	-	-	-
	H	23 66 134	Lock Washer - 5/8" Double Coil	-	-	-	-	-
	I	23 65 043	Lock Nut - 5/8" Square	-	-	-	-	-
	J	07 00 25 00	Clamp, Parallel Groove - PG**	1	1	1	1	1
@	K	04 00 20 01	6' Crossarm - 3-1/2" x 4-1/2"	1	1	-	-	1
		04 00 20 03	10' Crossarm - 3-1/2" x 4-1/2"	1	1	-	1	-
@	L	12 00 10 **	Grounding Unit	1	1	1	1	1
	M	10 01 144	Arrester, 10kV, 8.4kV MCOV	2	3	3	3	3
5,@		10 01 008	Arrester, 12kV, 10.2V MCOV	2	3	3	3	3
		10 01 188	Arrester, 15kV, 12.7kV MCOV	2	3	3	3	3
@	N	07 00 21 00	Clamp, Hot line - HLC*W	2	3	3	3	3
@	O	23 64 001	Staple 3/8" x 2"	4	6	6	6	6

DESIGN NOTE(s):

4. In IL - the arresters must be installed on 10' crossarm below the line arm. In MO - the arresters should be installed on a crossarm below the line arm, but if space is not available, the arresters may be placed on the line arm. Note that an additional crew person will be required to replace the arresters on the line arm.

5. Arresters selection, Refer to DCS **12 00 01 01** - Table 1.

REV	DATE	ENG	DESCRIPTION
12	10/01/23	JMW	Converted to new format
11	06/15/15	WYW	



12 12 05 01 - 7.2 kV thru 7.97 kV
12 12 05 02 - 2.4kV

CONSTRUCTION NOTE(s):

1. For transformer with cover mounted primary bushings, install the cutout/arrester crossarm mounting bracket oriented as shown on the top hanger of the transformer.

2. Stock #23 06 122 comes with a copper strap that is to be removed and returned to the storeroom for recycling.

3. Make sure the wire opening in the arrester cap is oriented away from the mounting bracket.

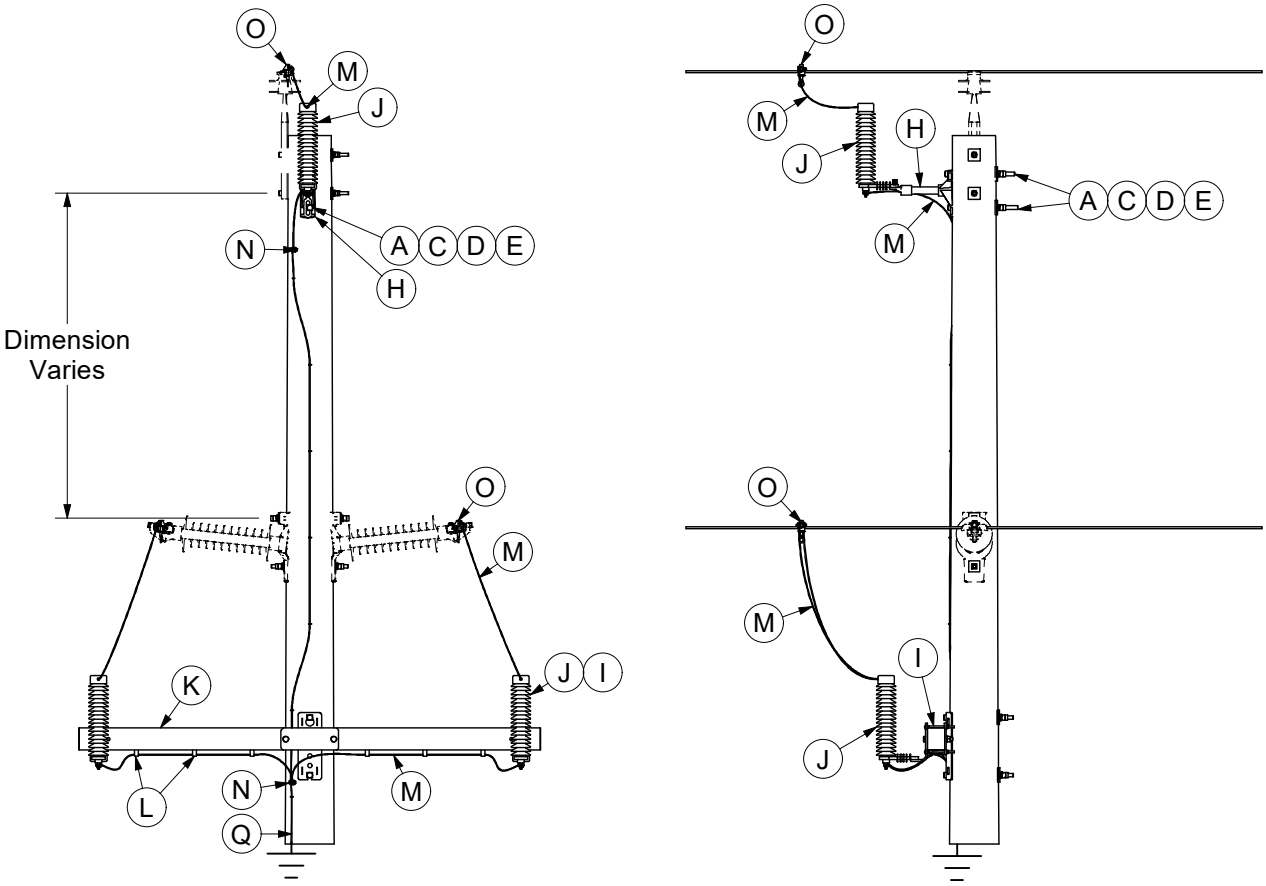
4. Bond the arrester ground directly to the pole ground and use the ground lug to separately bond the tank to the pole ground.

	ITEM	STK / DCS #	DESCRIPTION 12 12 05 **	01	02
2	A	18 51 021	Wire, Ground, #6, S.D. Poly Covered (ft.)	7	7
	B	10 01 133	Arrester, 3kV, 2.55kV MCOV	-	1
		10 01 144	Arrester, 10kV, 8.4kV MCOV	1	-
	C	23 56 088	Backet - Crossarm Double Sided NEMA	1	1
	D	23 06 122	Arrester L Bracket - Packaged with Arrester Kit	1	1
	E	69 58 296	Wildlife Guard - Transformer Bushing Cover	1	1
	F	69 58 121	Ground, Transformer Tank, #8 Sol. to #2 Str. Cu.	1	1

DESIGN NOTE(s):

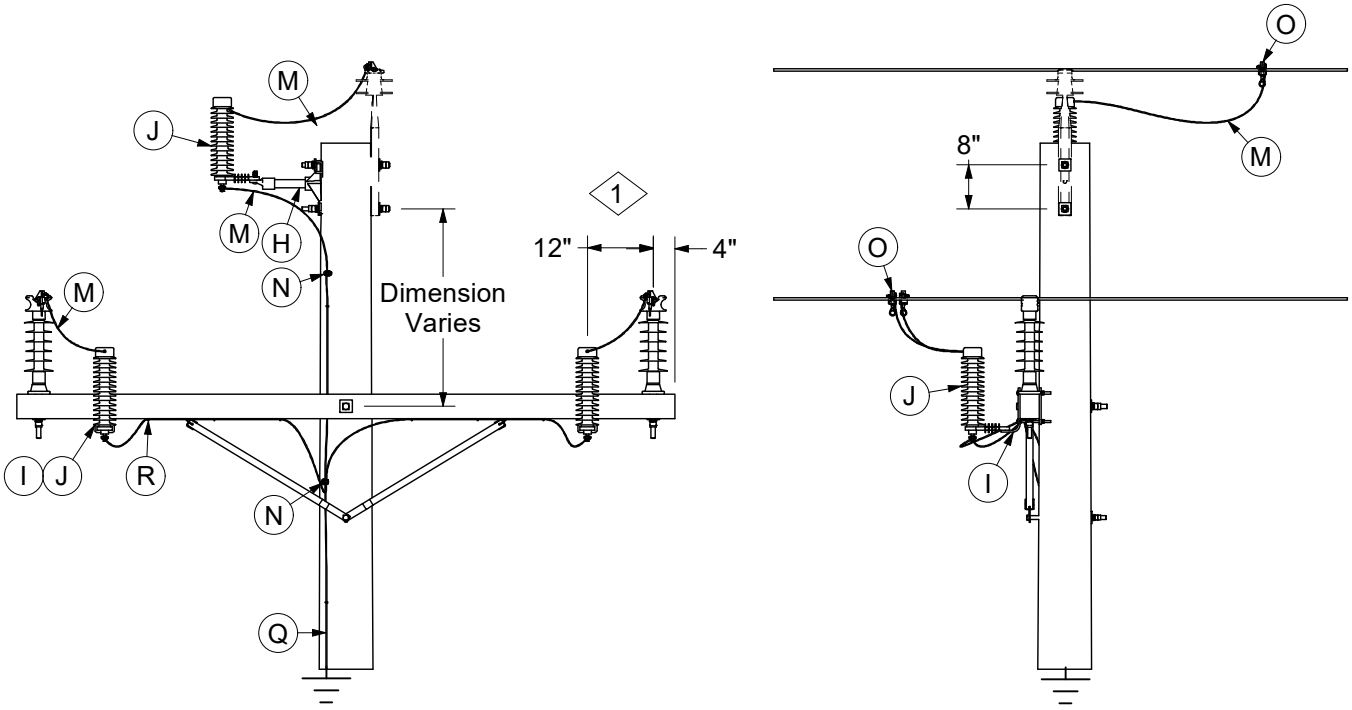
5. This DCS is for mounting arresters adjacent to the H1 bushing on a transformer that does NOT have existing lugs for tank mounting of the arrester. Use when arrester is being moved from Engergized Zone to transformer level on existing/older transformer installations.

REV	DATE	ENG	DESCRIPTION
1	10/01/23	JMW	Converted to new format
0	05/21/18	DG	



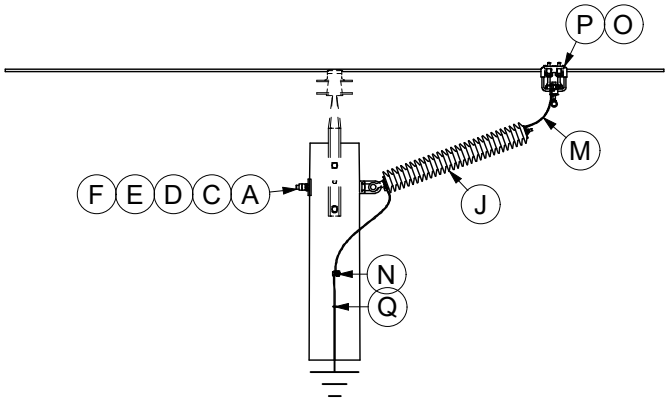
12 34 01 01 - 34kV Top Phase
12 34 01 02 - 34kV Three Phase

REV	DATE	ENG	DESCRIPTION
15	10/01/23	JMW	Converted to new format
14	12/16/16	WYW	

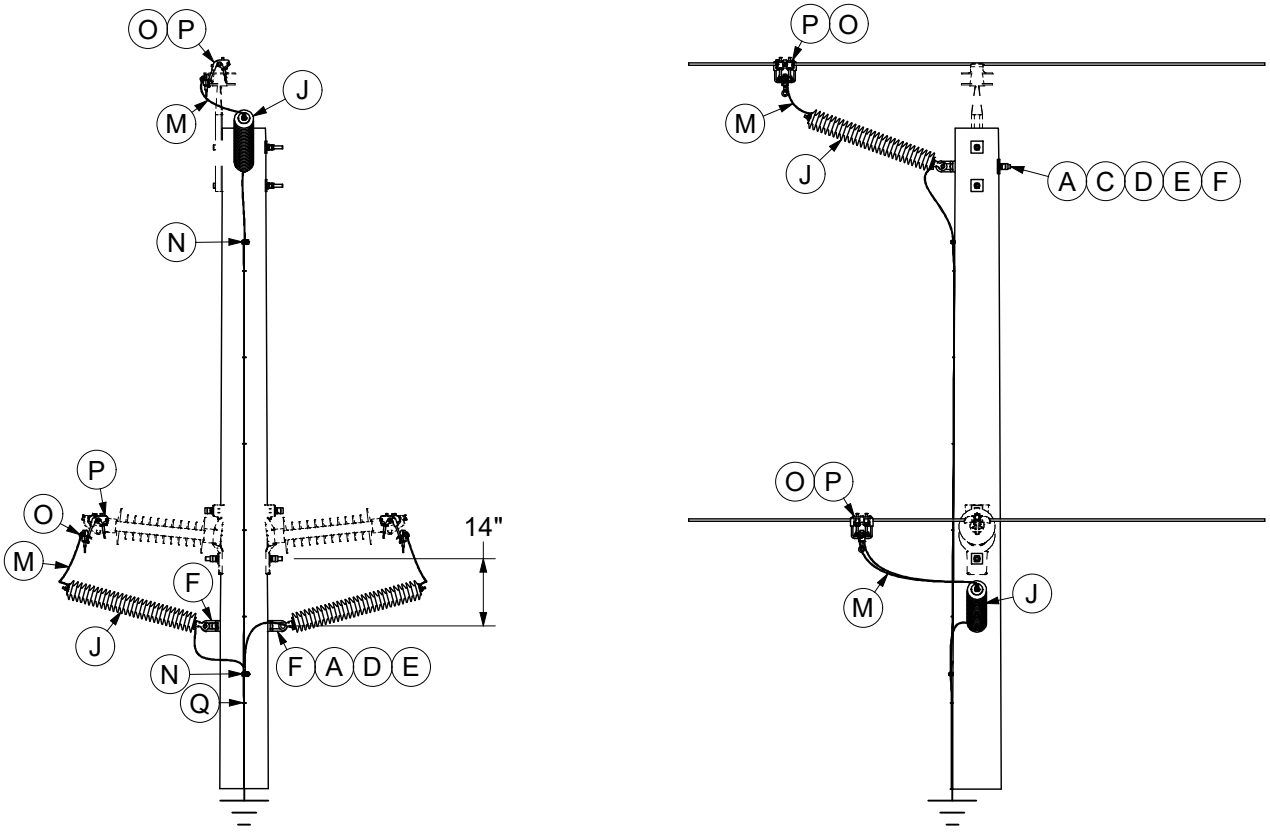


12 34 01 03 - 34kV Three Phase

REV	DATE	ENG	DESCRIPTION
15	10/01/23	JMW	Converted to new format
14	12/16/16	WYW	



12 34 01 04 - 69kV Top Phase



12 34 01 05 - 69kV Three Phase

REV	DATE	ENG	DESCRIPTION
15	10/01/23	JMW	Converted to new format
14	12/16/16	WYW	

CONSTRUCTION NOTE(s):

1. Use double staples to hold ground wire in the event the ground lead isolator blows off. Distance from the double staples to the ground lead isolator should be 6" minimum.

2. Route the ground wires in a straight line or a smooth curve. Avoid making sharp bends in ground wires.

3. Take care when driving the staples onto the ground wires to avoid damaging the wire.

	ITEM	STK / DCS #	DESCRIPTION 12 34 01 **	01	02	03	04	05
	A	23 52 097	Bolt, Mach., 3/4" x 12" w/ square nut	2	2	-	1	2
	B	23 53 058	Bolt, DA, 3/4" Dia x 16" w/ 4 square nuts	-	-	2	-	-
	C	23 66 031	Washer, Curved, Square, 3/4"	2	2	-	1	1
		23 66 131	Washer, Square, 3/4"	-	-	4	-	-
	D	23 66 135	Lock Washer - 3/4" Double Coil	2	2	4	1	2
	E	23 65 042	Lock Nut - 3/4" Square	2	2	4	1	2
	F	23 59 095	Eyelet, 3/4" Bolt	-	-	-	1	3
	G	23 65 018	Eyenut, 3/4" Bolt	-	-	-	-	-
	H	23 06 127	Bracket - Standoff, 12" FG	1	1	1	-	-
	I	17 58 054	Bracket, Arrester/Cutout Mounting	-	2	2	-	-
	J	10 01 252	Arrester, 36kV, 29kV MCOV	1	3	-	-	-
		10 01 158	Arrester, 60kV, 48kV MCOV W/Clevis, Susp	-	-	-	1	3
	K	04 00 42 01	Crossarm - Tangent, F/G 8'	-	1	-	-	-
	L	23 68 746	Grounding Clip	-	1	-	-	-
	M	18 51 021	Wire - Copper, Poly Covered, #6 S.D.	8	20	20	8	20
@	N	17 54 373	Connector - Split Bolt, #14 AWG Str. to #2 AWG Str.	1	2	2	1	2
@	O	07 00 21 00	Clamp - Hotline HLC*W	1	3	3	1	3
@	P	07 00 21 00	Clamp - Stirrup STC*W	-	-	-	1	3
@	Q	12 00 10 **	Grounding Unit	1	1	1	1	1
1,@	R	23 64 001	Staple 3/8" x 2"	-	-	6	-	-

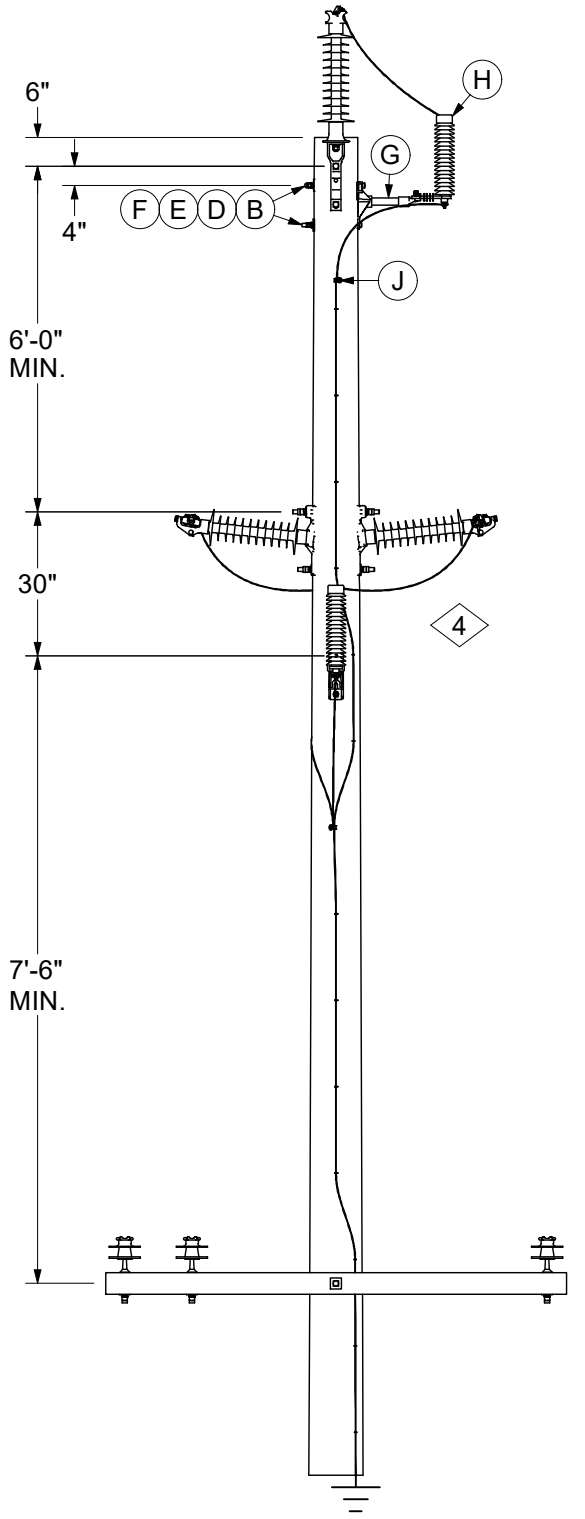
DESIGN NOTE(s):

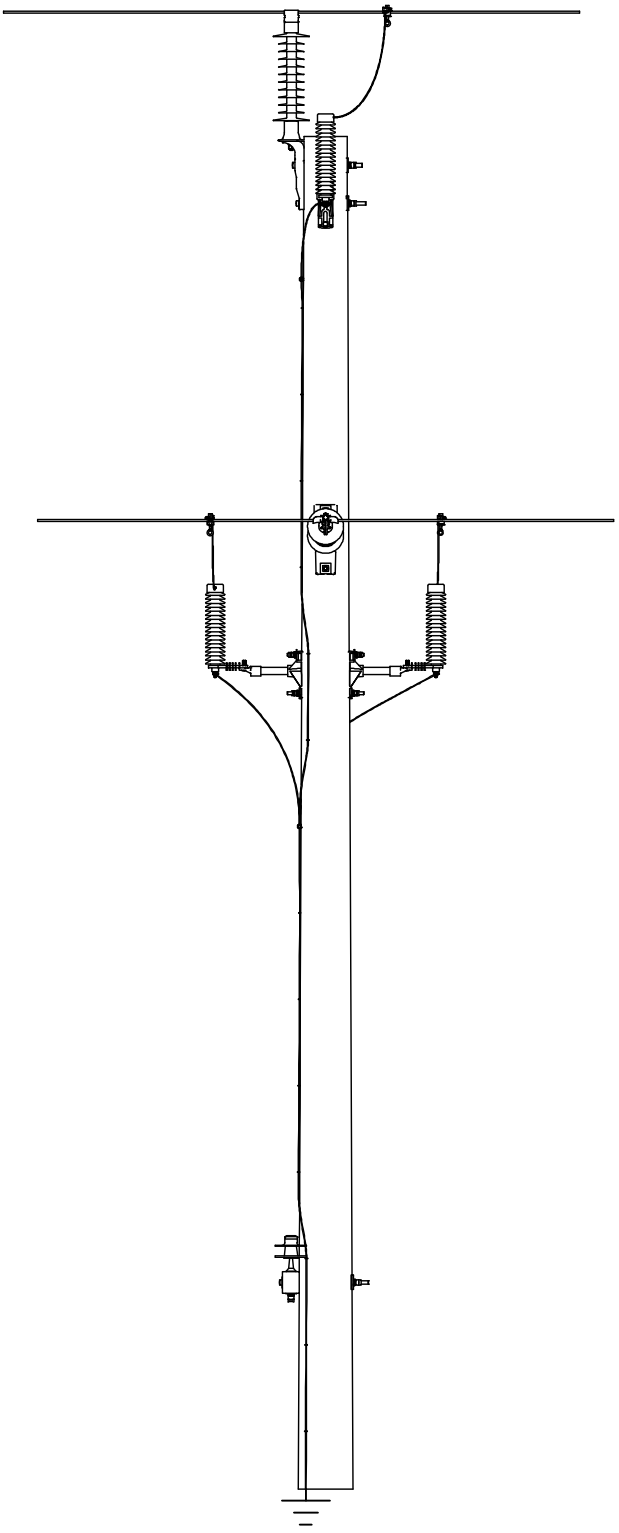
4. Not for use in new construction. This standard is only for lightning protection of existing subtransmission configurations.

5. Arresters should be installed on the top phase of every pole. If the line runs through wooded areas where trees are as tall as the top phase, induced flashover may be experienced and additional arresters are needed. In these cases, install arresters on the lower phases at roughly 300' intervals.

6. If the shield formed by the pole top insulator and the outside crossarm insulator is less than 30 deg., install arresters on the top phase only. If the angle exceeds 30 deg., install arresters on all three phases.

REV	DATE	ENG	DESCRIPTION
15	10/01/23	JMW	Converted to new format
14	12/16/16	WYW	

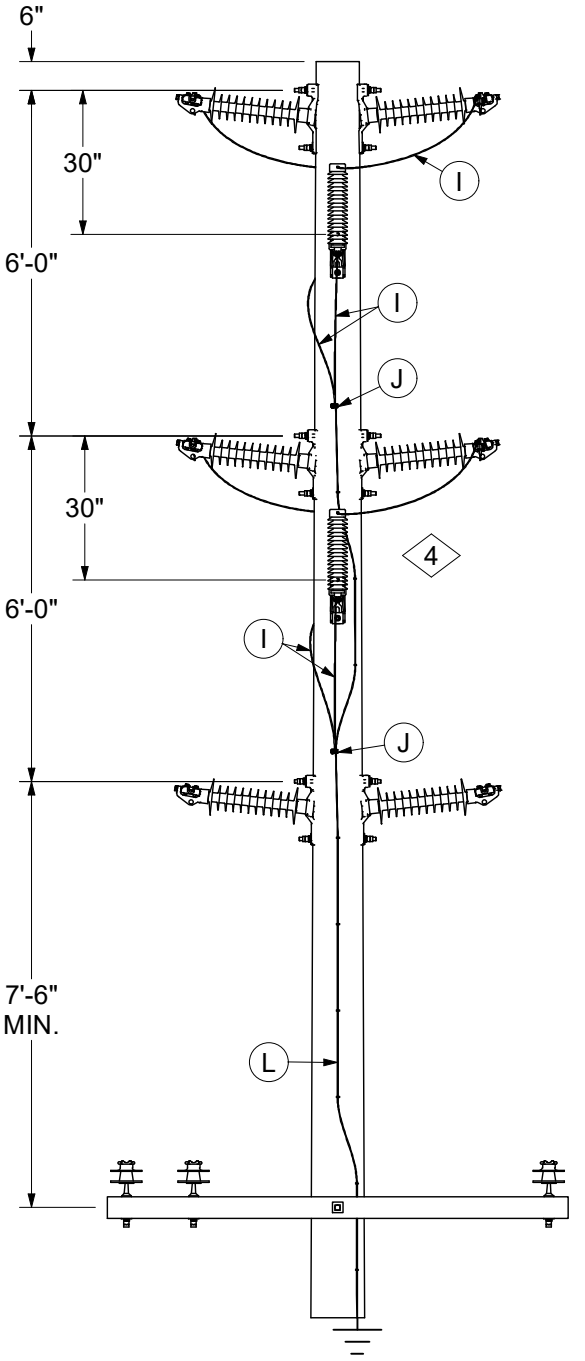


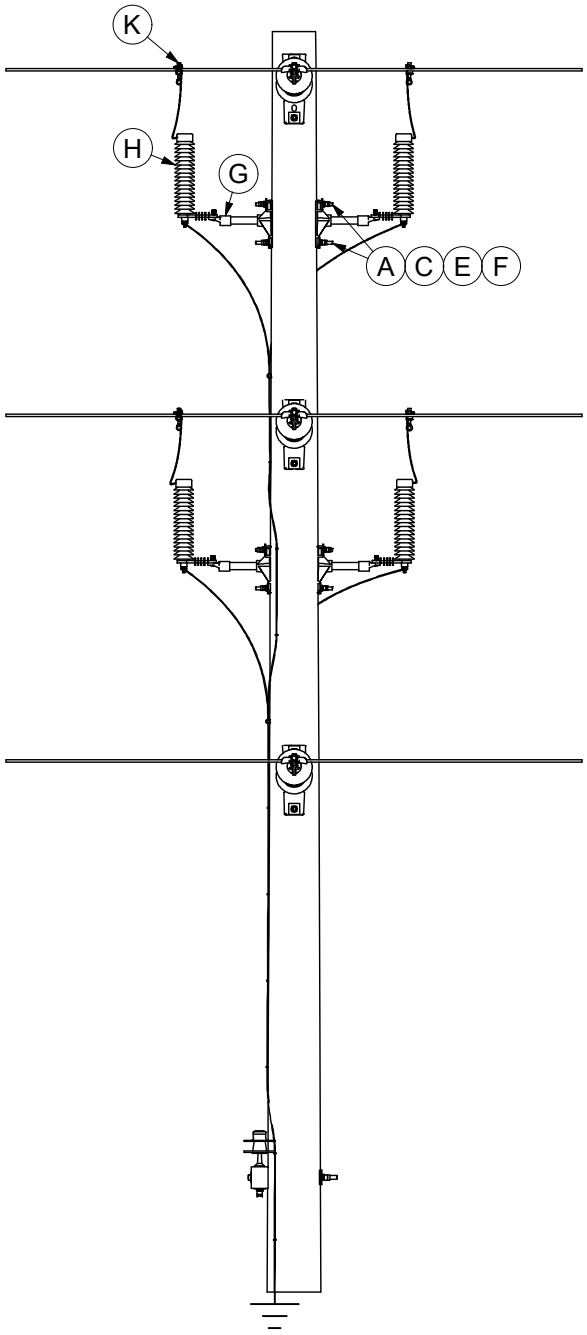


12 34 02 01 - Single Circuit - Arrester Top Phase
12 34 02 02 - Single Circuit - Arrester Three Phase

4

REV	DATE	ENG	DESCRIPTION
8	10/01/23	JMW	Converted to new format
7	09/08/14	WYW	





12 34 02 03 - Double Circuit - Arrester Top Phase
12 34 02 04 - Double Circuit - Arrester Top Two Phases ◇4

REV	DATE	ENG	DESCRIPTION
8	10/01/23	JMW	Converted to new format
7	09/08/14	WYW	

CONSTRUCTION NOTE(s):

1. Route the ground wires in a straight line or a smooth curve. Avoid making sharp bends in ground wires.

2. Use double staples to hold ground wire in case the ground lead isolator blows off. Distance from the double staples to the ground lead isolator should be 6" maximum.

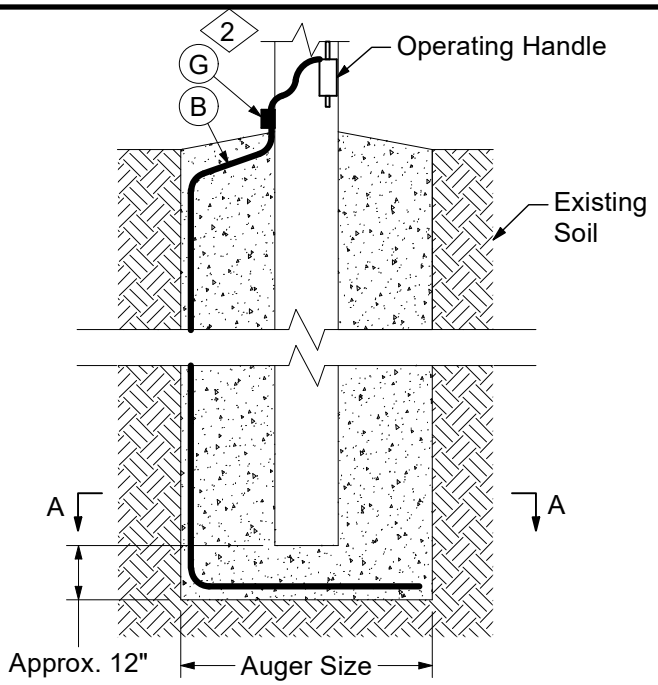
3. Use care when driving staples onto covered pole ground wire to avoid damaging the wire.

	ITEM	STK / DCS #	DESCRIPTION 12 34 02 **	01	02	03	04
	A	23 53 002	Bolt, DA, 5/8" Dia x 16" w/ 4 square nuts	-	2	4	4
	B	23 52 066	Bolt, Mach., 5/8" x 14" w/ square nut	2	2	0	0
	C	23 66 027	Washer, Flat, Square 5/8"	-	4	8	8
	D	23 66 207	Washer, Curved, Square, 5/8"	2	2	-	-
	E	23 66 134	Lock Washer - 5/8" Double Coil	2	6	4	8
	F	23 65 043	Lock Nut - 5/8" Square	2	6	4	8
	G	23 06 127	Bracket - Standoff, 12" FG	1	3	2	4
	H	10 01 252	Arrester, 36kV, 29kV MCOV	1	3	2	4
	I	18 51 021	Wire, Copper, Poly Covered, #6 S.D.	10	15	20	25
@	J	17 54 373	Connector - Split Bolt, #14 AWG Str. to #2 AWG Str.	1	2	1	2
@	K	07 00 21 00	Hotline Clamp	1	3	2	4
@	L	12 00 10 **	Grounding Unit	1	1	1	1

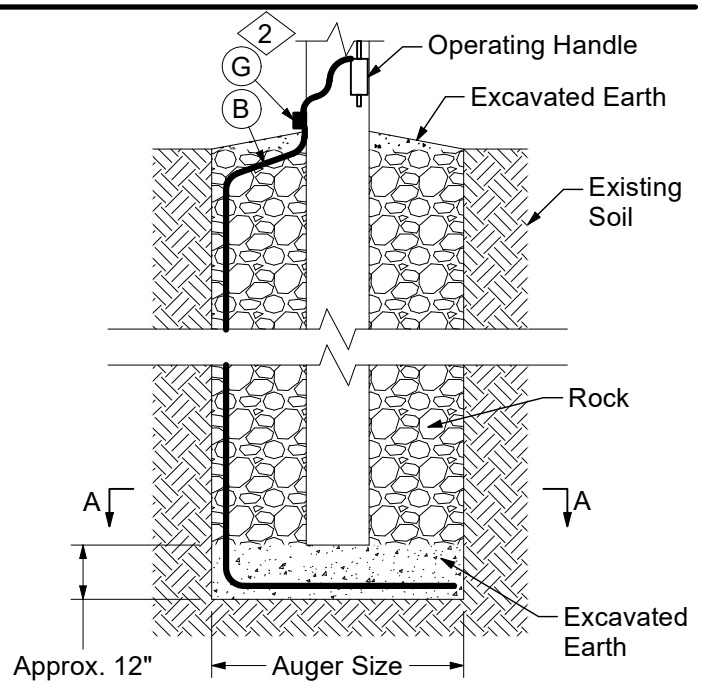
DESIGN NOTE(s):

◇4. Arresters should be installed on the top phase(s) of every pole. This provides approximately the same level of protection as a static wire system. If the line runs through wooded areas where nearby trees are as tall as the top phase, induced flashovers may be experienced and additional arresters are needed. In these cases, install additional arresters on the lower phases at roughly 300' intervals. On poles with a single circuit, install extra arresters on both lower phases. On poles with a double circuit, install extra arresters on both middle phases.

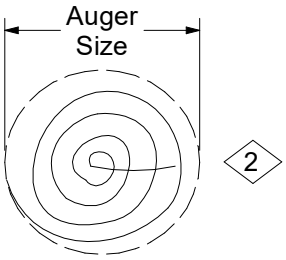
REV	DATE	ENG	DESCRIPTION
8	10/01/23	JMW	Converted to new format
7	09/08/14	WYW	



Ground Coil with Excavated Earth Backfill

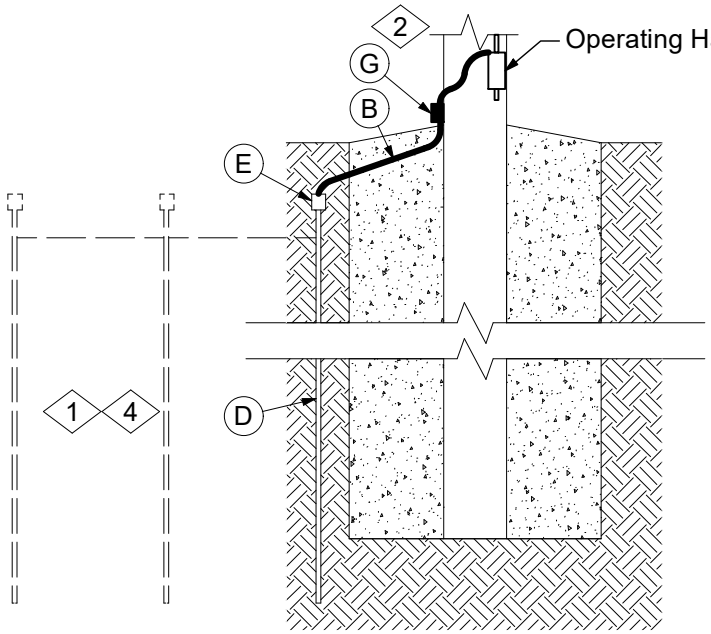


Ground Coil with Rock Backfill



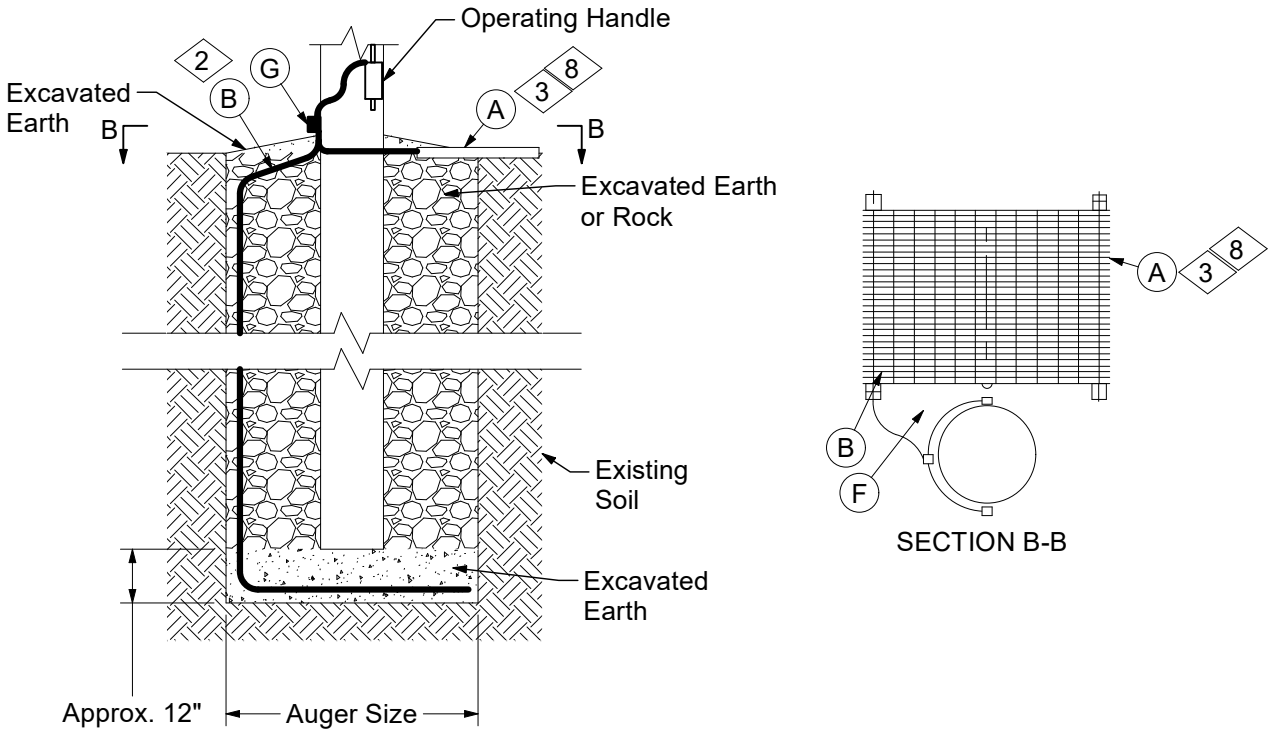
Section A-A

12 69 11 01 Ground Coil for New Pole Installation

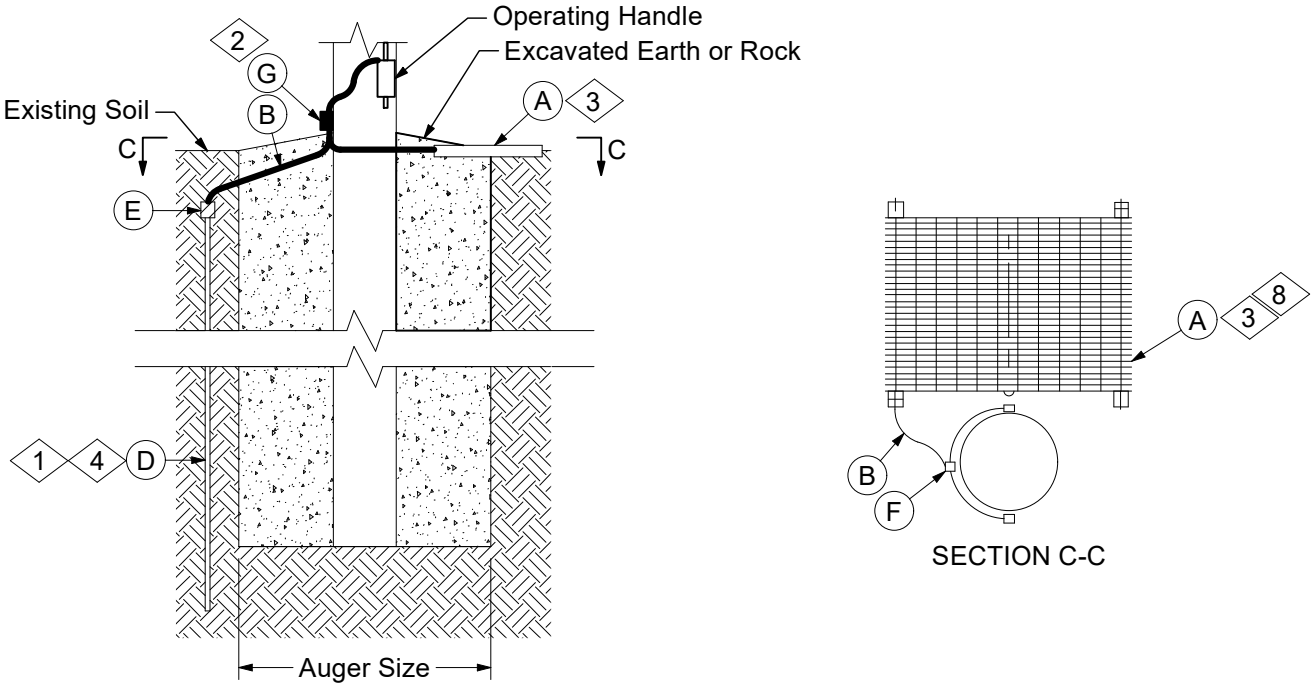


12 69 11 02 Ground Rod(s) with Existing Pole

REV	DATE	ENG	DESCRIPTION
9	10/01/23	JMW	Converted to new format
8	11/04/16	WYW	



12 69 11 03 - Ground Mat with Ground Coil



12 69 11 04 - Ground Mat with Ground Rod

REV	DATE	ENG	DESCRIPTION
9	10/01/23	JMW	Converted to new format
8	11/04/16	WYW	

CONSTRUCTION NOTE(s):

1. Ground resistance will normally be less than 25 ohms with one rod. In rocky or sandy soil where experience indicates ground resistance may exceed 25 ohms, install additional rods spaced 6' apart. Doubling the number or length of the rod reduces the ground resistance by 40%.

   A. If additional grounding is needed and this is a terminal pole, a #2 bare copper counterpoise wire 100'-150' long may be placed in the conduit trench and connected to the ground lead.

   B. In rocky soil where driving a rod is difficult - a counterpoise, as stated in A., may be placed in a trench at least 18" deep.

2. Train below grade ground wire approximately 8" above ground line to line up with ground lead from switch handle. Staple wire to pole above and below connector. Make the ground coil to the same diameter as the pole hole and use at least 12' of bare #2 copper wire.

3. Ground mat to be installed under operating handle. Always place some crushed rock on top of ground mat to add better ground support for operating the switch.

4. Ground rods to be installed along conductor center-line if more than one rod is required.

5. Switches come with connectors to join braided cable to ground wire. If extra are needed, use Stock #17 52 140 for SEECO switch and Stock #17 54 373 for Turner switch.

6. The ground wire is normally connected to only the switch handle. However, on some 34kV terminal poles, the ground wire must extend up the pole and connect to the cable concentric or arrester. See 34kV terminal pole and switch DCS's for guidance.

	ITEM	STK / DCS #	DESCRIPTION 12 69 11 **	01	02	03	04
8	A	23 17 405	Ground Platform 4' x 3', Galv. Steel	-	-	1	1
2	B	18 52 025	Wire - #2 Cu. Bare, Solid	20	4	25	8
	C	23 64 001	Staple, Ground Wire, Serrated, Cu. Clad	5	5	5	5
1	D	23 13 069	Rod, Ground, 5/8" x 8' Cu. Bonded	-	1	-	1
1	E	17 52 032	Clamp, Ground Rod, 5/8" dia Rod	-	1	-	1
	F	17 54 373	Connector - Wire, #2 Cu. Split Bolt	-	-	1	1
5,@	G	17 52 140	Clamp, Grounding, Cable to Flat, 4-300 kcmil, Cu.	-	-	-	-
6,8,@	H	18 51 019	Wire, #2 Cu. Poly Covered, 7 Strand	50	50	50	50
		303	Op Code, Install Ground Rod	-	1	-	1
		306	Op Code, Pole Ground	0.5	-	0.5	-
		307	Op Code, Grounding Connection	0.5	0.5	0.5	0.5

DESIGN NOTE(s):

7. All group operated switch handles will be connected to a ground rod/coil.

8. Ground mat is required if the switch is motor operated or if the switch is mounted on a steel pole. Ground mat is also required on 34kV switch poles where the cable concentrics or arresters must connect to the ground rod/coil because the static or neutral is not present. Use #2 Cu. poly wire for this ground wire. See 34kV terminal pole and switch DCS's for guidance.

REV	DATE	ENG	DESCRIPTION
9	10/01/23	JMW	Converted to new format
8	11/04/16	WYW	

NOTES