

Issued 30-May-02	CONSTRUCTION STANDARD ELECTRIC OPERATIONS ORGANIZATION	C5000
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C5000

******This Standard Supersedes BECo CS2.13-2.3 & ComElectric OH Construction Manual, System Grounding Section, drawings CGND, GRDSUM, and C2******

GROUNDING AND BONDING POLE-MOUNTED EQUIPMENT

1.0 Bill of Materials

Item	Description	Stock Symbol
1	Wire, ground #4 copper covered	120
2	5/8" x 8' sectional ground rod, threaded at both ends.	9229
3	Molding, ground wire	833
4	Staple, ground wire molding	9332
5	Ground rod coupling, 5/8" x 2"	10234
6	Copper Pole Butt Plate, 7" diam.	9200
7	Staples (fence) to secure wire to pole	6341
8	Ground rod driver, fits 5/8" and 3/4" ground rods. Use in conjunction with Cat ID # 15295	15450
9	Ground rod driving cap, fits 5/8" and 3/4" ground rods. Use in conjunction with Cat ID # 15450	15295
10	Ground rod connector, range #8 solid – 1/0 stranded copper.	9009
11	Wire, tinned # 4 solid copper	114
12	1/0 AWG polyethylene covered stranded copper wire	123
13	Ground resistance tester (if needed)	15892

2.0 Procedure

- 2.1 Use this procedure for updated bonding and grounding requirements for distribution equipment, to comply with the National Electric Safety Code. Low resistance earth grounding is essential to provide the level of protection required to protect personnel, equipment, and the public from shock hazards. Proper grounding will provide a more stable system with a minimum of transient over voltage and electrical noise. Proper grounding will also provide a path to ground in fault conditions and protection from large electrical disturbances (such as lightning) by creating a low resistance path to earth.

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2.2 Grounding Pole-Mounted Equipment on Grounded-Wye System.

- A. All equipment cabinets, tanks, frames, and mounting brackets shall be grounded to the system neutral.
- B. Surge or lightning arrester ground terminals should be connected with the shortest, most direct path to earth/ground.
- C. Transformer mounted arresters are connected directly to the grounded tank.
- D. Any new or upgraded pole-mounted equipment, except for streetlights, will be connected to the existing system neutral. A new ground rod will be installed if one does not already exist at the pole.
- E. All new equipment poles require a butt plate and a ground rod. Switch handles, streetlight fixtures, down guys, and transformer secondaries must be properly grounded.
- F. The system neutral shall be connected to any grounding that exists on a distribution pole.
- G. Grounding equipment will protect people from energized wires that are no longer properly insulated for their voltage.

2.3 Pole Grounding Butt Plate Requirements.

- A. All new poles that will support electrical wire or cable shall have a minimum #4 copper wire pole down ground installed. Before the pole is set in the ground, that wire shall be connected to a copper pole butt plate with a mechanical connector. That wire shall be stapled along the pole to a point just above ground level, where it will be secured as a small coil. After the pole is set, the wire shall be uncoiled and connected up to the system neutral, and any messenger cable, if present.
- B. The pole butt plate is not a substitute for a driven ground rod. If a new pole is to have any equipment requiring a ground rod, then one or more shall be installed as required elsewhere in this document.

2.4 Ground Rod Requirements.

- A. Drive ground rods four (4) inches below the finished surface. Ground rods must be driven into undisturbed soil at a minimum distance of twelve to eighteen inches from the pole. **If the pole setting foam is used, the ground rod must not be encased in this foam** Be sure dig safe markings are clearly visible in the area. Where rocky soil or other field conditions prohibit driving ground rods to a depth of eight (8) feet, install additional ground rods at adjacent poles.

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- B. Where practicable, a reading of 25 ohms or less between the underground and the earth is desired. If you are in an area where the soil conditions are highly resistive, (sandy, dry, less than ideal soil conditions...) install an additional ground rod above the first, resulting in a 16-foot driven ground. When rocky soil or other conditions prohibit driving ground rods to 16 feet, install the additional rod adjacent to the first no closer than six (6) feet to any existing rod, and connect rods with a bare #4 copper wire. See Figure 2.
- C. For both open wire and spacer cable overhead installations, install ground rods at all pole locations having transformers, switching devices, disconnects, sectionalizers, reclosers, voltage regulating devices and/or lighting arrestors, at all dead-ends, and at all riser poles. For spacer cable construction, install ground rods at every pole.
- D. Bonding Requirements
 - 1) Bonding conductors shall be bare tinned copper wire or covered copper wire.
 - 2) Minimize joints in bond wires. If joints are unavoidable, use compression or solder connectors.
 - 3) Use bonds as a permanent connection between otherwise isolated circuits and/or equipment to equalize potentials. When bonding conductors are in direct contact with the earth, the wire MUST be covered.

2.5 Pole Installations.

- A. Attach #4 pole down grounds to driven ground rods in accordance with Figures 2 and 3 when a continuous metallic underground system is not available.
- B. Terminate the down grounds from pole mounted equipment to the common neutral as shown in Figure 3, providing a disconnect point to safely remove grounds when required to perform work on the pole.
- C. Power risers – Pole grounds shall be upgraded to 1/0 copper size from the ground rod to the system neutral and up to the primary area grounds.

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3.0 Intercompany Bonding

Intercompany grounding/bonding requirements as defined in the National Electric Safety Code (NESC), the Joint Ownership (JO) agreements, and the Intercompany Operating Procedures (IOP's) between the company and communication companies follow. Communication lines and communication company messengers include (by NESC definition) all lines used for public or private signal or communication service. Included are telephone, telegraph, railroad signal, fire and police alarms, cable television, and various other non-electrical supply lines.

- 3.1 Electric supply and communication systems shall be bonded together in accordance with NESC requirements. The purpose of bonding is to reduce the possibility of electric shock and minimize plant damage in the event of accidental contact.
- 3.2 Overhead NESC Rule 097G defines the required bonding between communication systems and electric supply systems on joint use poles.
 - a) If a single pole ground is used, it must be connected to both the supply neutral and the communication messengers.
 - b) If separate pole grounds are run to the supply neutral and the communication messengers, the pole grounds must be bonded together.
 - c) If isolation is being maintained between the primary and the secondary neutrals, such as for stray voltage, the communication messengers shall be connected only to the primary grounding conductor.
- 3.3 Underground NESC Rule 384C requires that above ground metallic power and communication apparatus such as pedestals or transformer cases that are six feet or less apart be bonded together. A bond is not required if the separation is greater than six feet. See Figure 1.

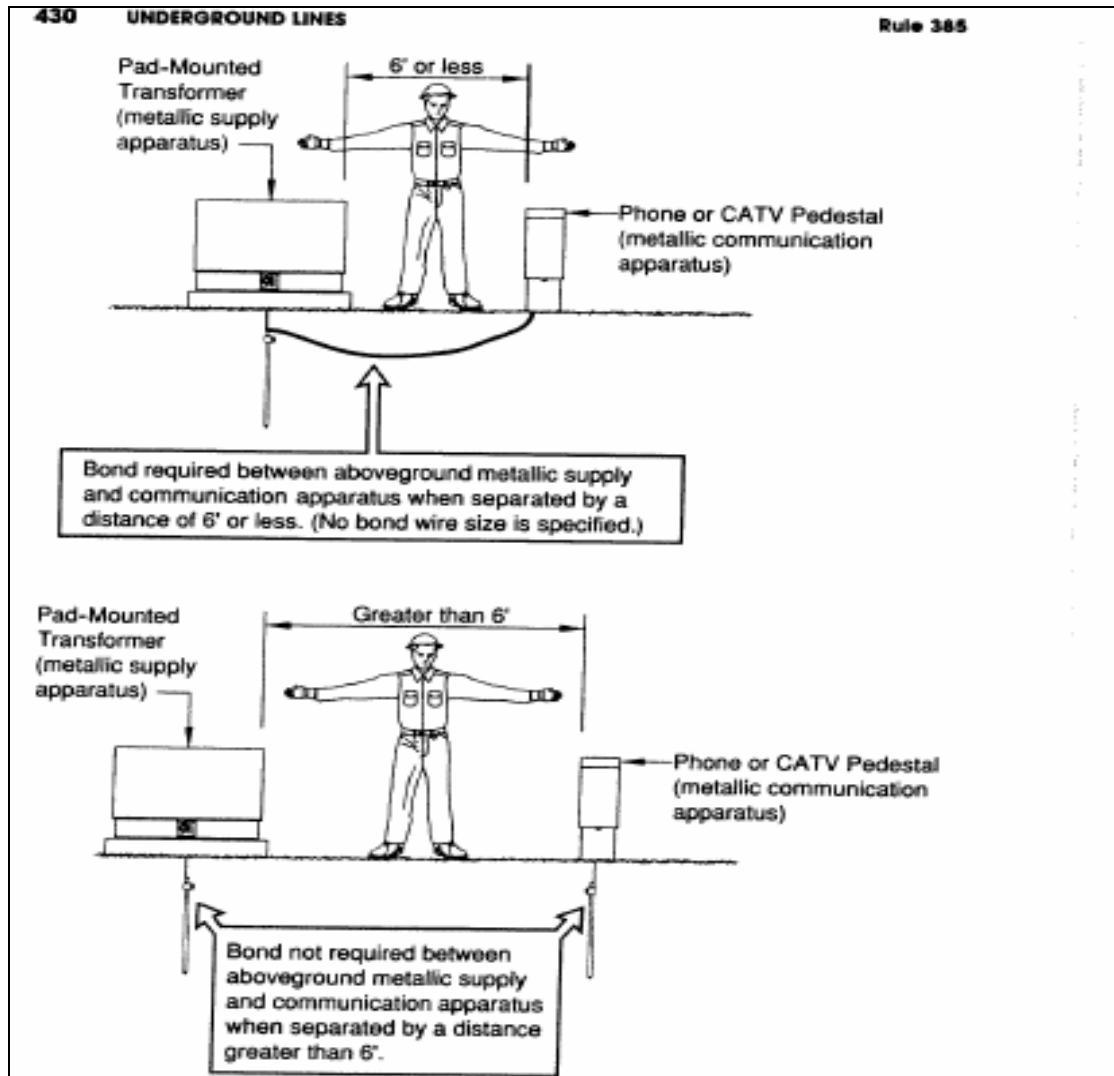


Figure 1

NESC reference Rule 97G refers to bonding of communication systems to electric supply systems where all systems on the pole are grounded on a joint use structure. A single grounding conductor shall be used for all systems or the electric and communication grounding conductors shall be bonded together. An exception to this rule is where separation is required by Rule 97A. This rule requires the electric supply utility to maintain isolation between primary and secondary neutrals; the communication system ground shall be connected only to the primary grounding conductor. Typical installations are outlined in Figure 4.

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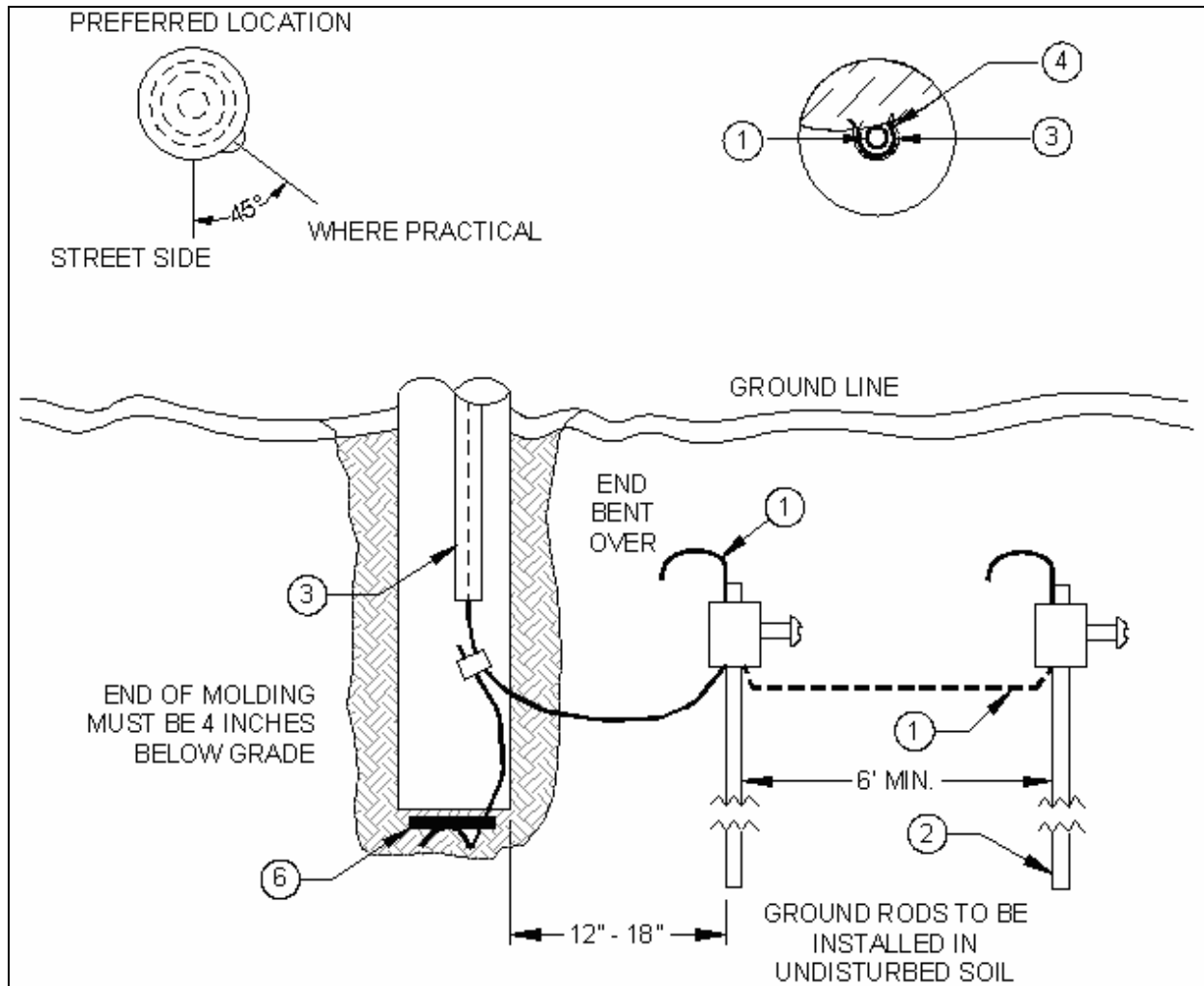


Figure 2 - Installations of Ground Rod and Butt Plate at Pole.

- Note:
1. Staple moulding to pole 12-inch spacing. Moulding must clear metal equipment by 1-1/2 inches (minimum).
 2. High vandalism (copper theft) areas require that fence staples spaced 12 inches apart be used on the 8ft. of wire in the pedestrian area. Over that install moulding with staples also spaced 12 inches apart, but staggered with the fence staples.

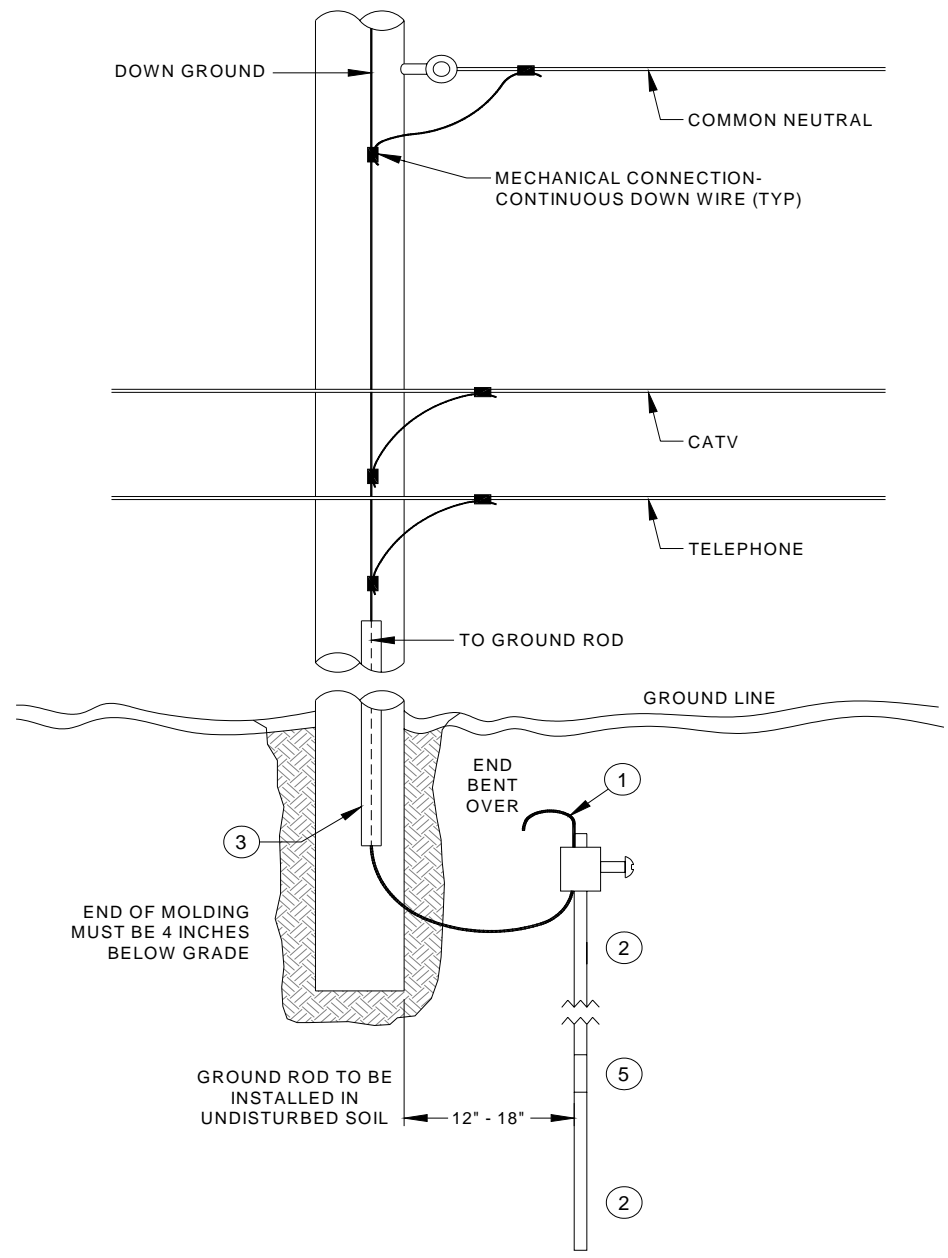


Figure 3 - Down Ground Connections.

Note: If pole mounted equipment must remain grounded (i.e., single bushing transformers and SCADA-MATE switches) make the equipment ground a permanent connection to the common neutral.

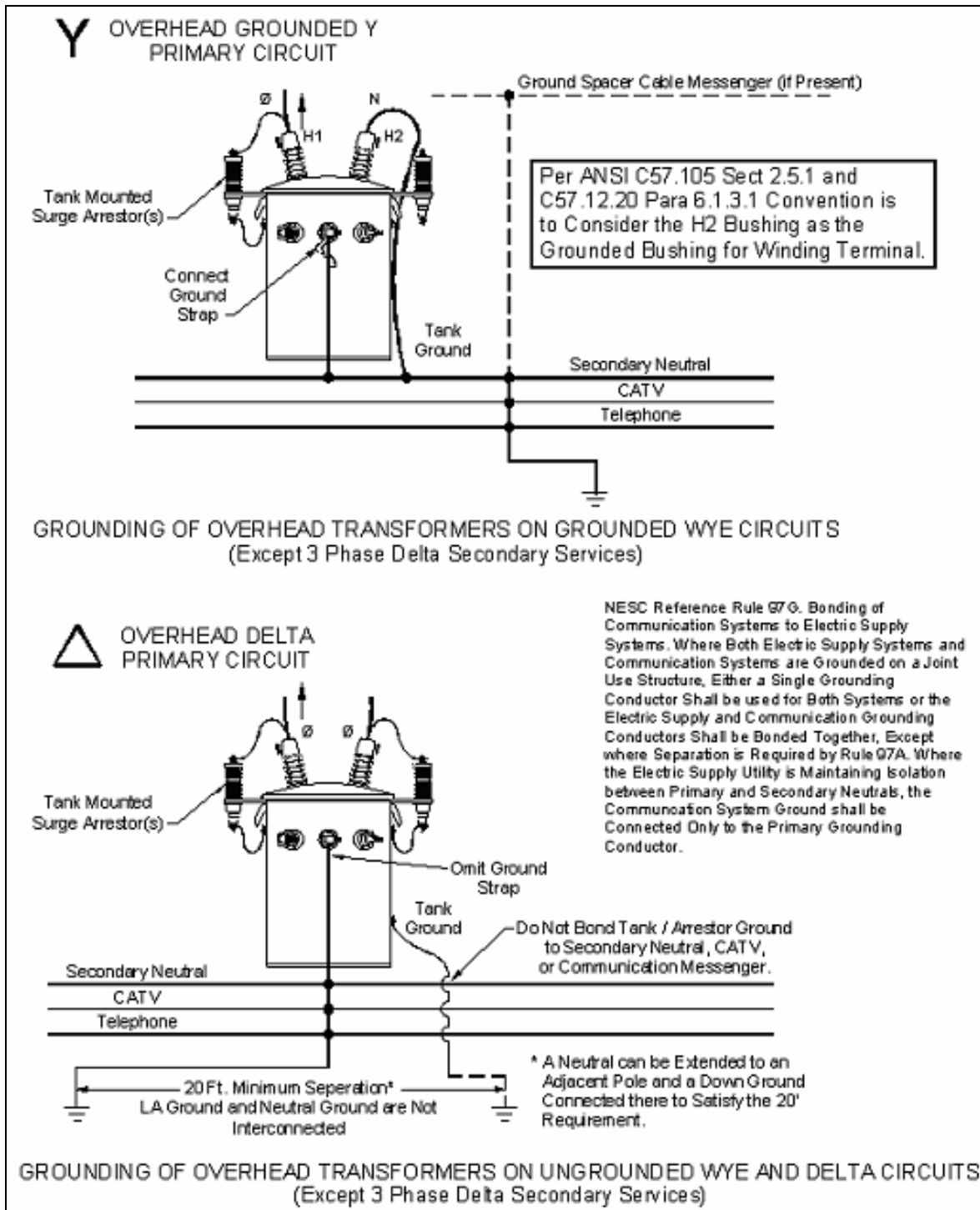


Figure 4 – Grounding of Overhead Transformers on Ungrounded WYE and Delta Circuits.

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4.0 Grounding for Delta Primary System Transformers, NSTAR South Only

- 4.1 A delta primary system does not use a primary neutral wire, and is not considered a multigrounded system. Therefore, the grounding of pole-mounted equipment on delta systems requires special attention. Surge arresters must be grounded through a dedicated ground wire and rod located at the same pole. Transformer tank, frame or any bracket ground connections will be made to the arrester ground circuit. In delta circuits, the secondary neutral must not be interconnected with this arrester/equipment ground circuit.
- 4.2 To meet the National Electric Safety Code (Rule 97D), two ground rod assemblies separated by at least twenty (20) feet must be installed for each transformer/arrester location. This will reduce the chance of a surge passing through the arrester affecting the secondaries. Delta circuits do not have as many ground paths for lightning surges like in a grounded wye system.
- 4.3 To meet the NESC requirement, it is necessary to connect any arresters directly to a driven ground rod on the same pole. Separate the arrester/tank ground from the secondary neutral by removing the tank ground strap from the (Xo) bushing. Then, the secondary neutral wire (triplex or open wire) connected to that neutral bushing will be run to a pole ground and driven ground rod assembly at the next closest pole. There should be no arresters installed on this pole.
- 4.4 Ground rods in delta systems, where practical, will have a maximum earth ground resistance of 25 ohms (Ω). In high resistance areas, two (2) sixteen (2x8") foot rods are to be installed together in an inverted "V" arrangement, {see Figure 4}. This inverted "V" separates the ground rod points for maximum benefit
- 4.5 Guy Insulators: In delta systems, a guy insulator will be installed so that even if the guy wire breaks at the anchor attachment, the free-hanging insulator will stay at least eight (8) feet above the ground. Guy wires in delta systems do not need to be bonded to the neutral (grounded) because of the insulator.

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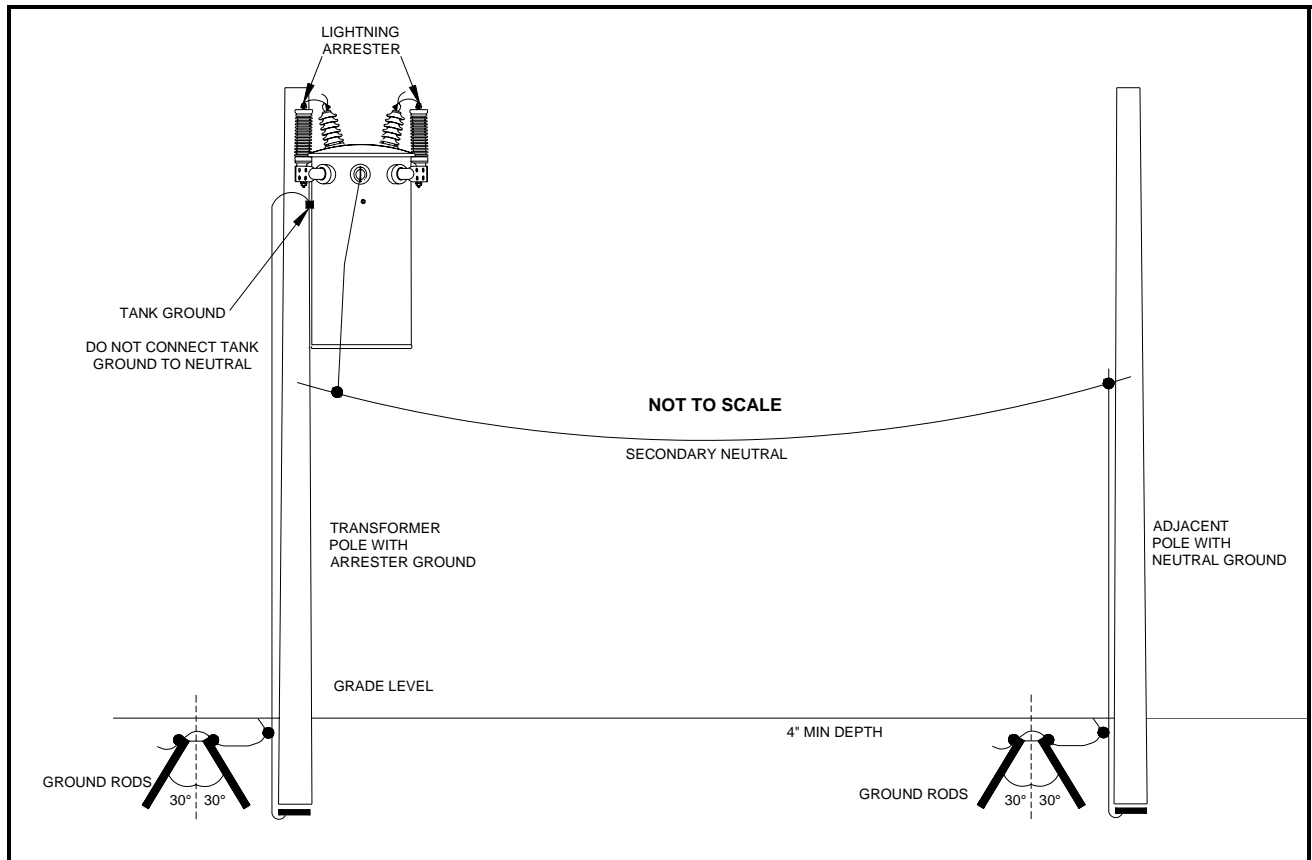


Figure 4 - NSTAR South Only - Transformer Grounding for Delta Primary with no Primary/System Neutral

NOTES:

- A. For areas that do not have a multigrounded primary system, the National Electric Safety Code (Rule 97D) requires that the arrester ground rod and neutral ground rod be separated by a minimum of twenty (20) feet. This standard drawing complies with that requirement.
- B. Dig-Safe must be notified before any ground rods are installed.
- C. Transformer mounted arresters are normally grounded to the tank. The pole ground wire of that pole must then be connected to that tank ground. Do not tie in to the neutral bushing or wire that will be grounded at the next pole.

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- D. Remove the ground strap that normally would connect the X° (neutral) bushing of the transformer to the tank.
- E. A neutral wire is to be installed to (if none exists) and grounded at the next closest pole. This neutral may be open wire copper or triplex cable. The adjacent pole must not have any arrester grounding on it already.
- F. Any other equipment such as capacitor bank arresters, riser arresters, frames, brackets, and URD cable concentric ground wires will be connected to the ground wire/rod assembly of the pole they are mounted on.
- G. In delta circuit areas, a ground wire molding should be installed all the way up the pole to the transformer. Communication companies should bond to the neutral that is grounded at the adjacent pole.
- H. The ground rods are installed in an inverted “V” arrangement to maximize the separation of the rod tips. Install the rods opposite to each other at about a 30° angle off of a vertical line. Normal ground resistance areas require using only eight (8’) foot rods, which will have tips about 8’ apart at their deepest point. In high soil resistance areas, use two eight-foot ground rods installed the same way. Install the rods in the direction of the overhead wires.

Review by: _____ Approved by: Amin Jessa
 Director, Safety and Health Director, Distribution Engineering