Michael R. Kirkwood
General Manager &CEO

PASCOAG
UTILITY DISTRICT

Pascoag Electric • Pascoag Water

April 14, 2011

Rhode Island Public Utility Commission
Ms. Luly Massaro
Commission Clerk
89 Jefferson Blvd.
Warwick, RI 02888

RECEIVED
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PUBLIC UTILITIES COMMISSION

Re: Commission Investigation Relating to Stray and Contact Voltage

Dear Ms. Massaro:

Pascoag Utility District herewith submits an original and nine copies of its responses to the data requests in the above docket.

Pascoag will file electronically on this date, and the original and nine copies will be mailed by US postal service today.

If you have any questions, please do not hesitate to call.

Very truly yours,

Michael Kirkwood
General Manager

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
PUBLIC UTILITIES COMMISSION

IN RE: COMMISSION INVESTIGATION
RELATING TO STRAY AND CONTACT
VOLTAGE

COMMISSION'S FIRST SET OF DATA REQUESTS DIRECTED TO BLOCK ISLAND POWER COMPANY AND PASCOAG UTILITY DISTRICT
April 8, 2011

1. For the non-engineers among us, please explain stray and contact voltage and their causes.

   PUD Answer:

- **Stray voltage** describes a special case of voltage developed between two grounded objects on the grounded neutral system or appurtenances. These voltages can appear on fixtures and equipment due to a fault in the electrical power system, such as a failure of insulation.
- **Contact voltage** is defined as "A voltage resulting from abnormal power system conditions that may be present between two conductive surfaces that can be simultaneously contacted by members of the general public and/or their animals. Contact voltage is caused by power system fault current as it flows through the impedance of available fault current pathways. Contact voltage is not related to normal system operation and can exist at levels that may be hazardous."

2. For each occurrence of stray and contact voltage which has occurred in the last 5 years in BIPCO/PUD territory, please provide:

   PUD Answer:

- Pascoag District has had no instance of stray or contact voltage within the last 5 years.

   a. the date of the occurrence; **N/A**
   b. the specific location of the occurrence; **N/A**
   c. the specific object that was energized, i.e. light pole, sign post, manhole, etc; **N/A**
   d. the amount or level of the stray or contact voltage measured in volts; **N/A**
   e. how the company became aware of the occurrence, i.e. whether reported by a member of public, city/town, public works, fire, police or other public official or whether BIPCO/PUD discovered the incident, etc; **N/A**

f. the cause(s) of the stray or contact voltage; **N/A**
g. a description of any injuries to people, animals or property; **N/A**
h. whether any claims or lawsuits have been filed against BIPCO/PUD as a result of person injuries or property damages sustained as a result of stray or contact voltage; **N/A**
i. the amount of any monetary damages or settlement proceeds paid by BIPCO/PUD or its insurers as a result of personal injuries or property damage caused by the stray or contact voltage; **N/A**
j. any and all actions taken to remedy the condition or situation giving rise to the incident, either at the site of the incident or elsewhere. **N/A**

3. Please explain in detail any program(s) the BIPCO/PUD has in place to conduct surveys or to monitor or test for stray and contact voltage, and the amount of monies, if any, budgeted or set aside for this purpose. Please include in your response the following:

PUD Answer: Pascoag utilizes construction standards for Overhead and Underground utility work. We currently follow National Grid's Construction Standards dated July 2009 for all work pertaining to utility work. Additionally, Pascoag follows the National Electric Safety Code. These set of standards are guidelines which Pascoag follows and adheres to. They insure that we install a proper system and have integrity throughout.

a. the specific method(s) or technologies, if any, used by BIPCO/PUD to monitor or test for stray and contact voltage;
PUD Answer: Pascoag installs down-grounds at each pole to increase the integrity of its system. All grounds are tested to make sure they are at a resistance of 25 ohms or less.
b. with regard to subsection (a), please rate the technology employed on a scale of 1 to 10, 10 being the most advanced;
PUD Answer: Pascoag grounds all fixtures according to the specs provided. All underground fixtures have added grounds to eliminate the possibility of failure.
c. with regard to subsection (a), please state the lowest AC voltage that the technology employed is capable of detecting;

PUD Answer: Pascoag currently has multi-meters which can measure down to milli-volts if a situation arose.
d. whether the individual(s) who conduct any such surveys, monitoring or tests are employees of BIPCO/PUD;
PUD Answer: Currently, if there were ever any cases at Pascoag, the lineman, who would be a PUD employee, would investigate and troubleshoot the situation.
e. where the individuals in subsection (d) are employed, if not by BIPCO/PUD;
PUD Answer: N/A. They are employed by Pascoag Utility District.

f. the frequency of any such surveys, monitoring or tests.
   PUD Answer: They would be done on a case by case basis if a problem by one of the PUD employees or a member of the public indicated an issue.

4. Please provide the specific results of the most recent survey, monitoring or testing of stray or contact voltage performed by BIPCO/PUD or other person/entity acting on its behalf. Please provide in your response the following:

   PUD Answer: Pascoag has never had evidence of a condition of stray voltage or contact voltage.

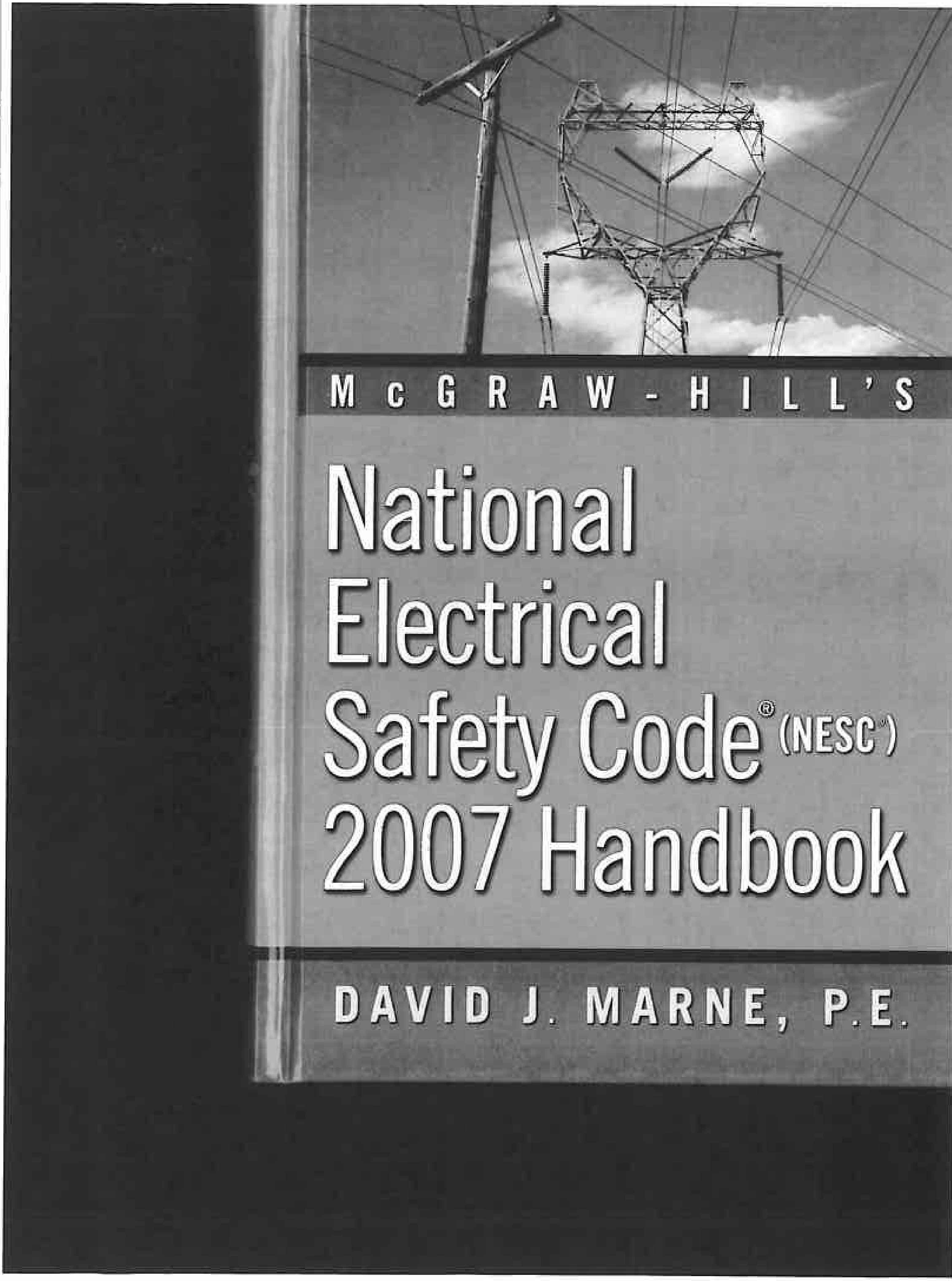
   a. the amount of stray or contact voltage detected; **N/A**
   b. the specific action(s), if any, that were taken to remedy the presence of stray or contact voltage detected. **N/A**

5. Please explain in detail any program(s) BIPCO/PUD has in place to mitigate occurrences of stray or contact voltage, and the amount of monies, if any, budgeted or set aside for this purpose.

   PUD Answer: As explained above, Pascoag follows the strict standards and guidelines set forth in the National Electric Safety Code and the Construction Standards. We feel these standards and regulations have been set forth to eliminate the above mentioned conditions. Attached are some examples of what PUD uses for the **Grounding** and **Bonding** of our system.

6. Please state whether any judgments have been entered against BIPCO/PUD, or whether BIPCO/PUD has paid any settlement proceeds, for injuries or damages resulting from stray or contact voltage, and if so, please provide the specific details of any such judgments.

   PUD Answer: N/A


McGRAW-HILL'S
National Electrical Safety Code® (NESC®) 2007 Handbook
DAVID J. MARNE, P.E.

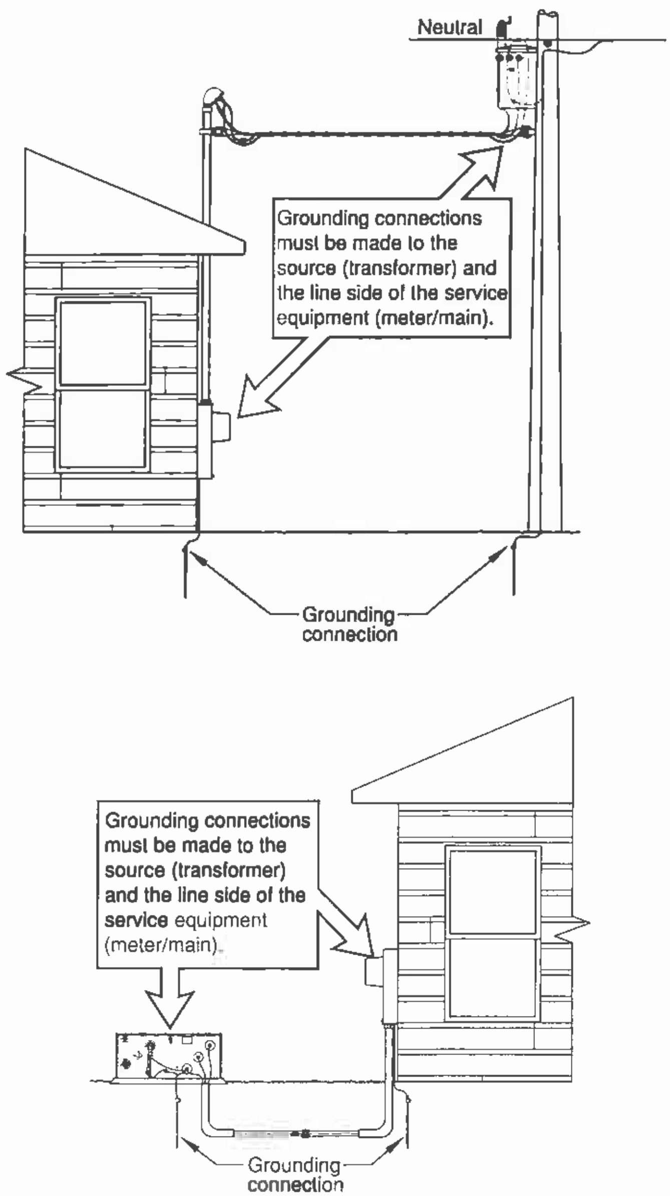
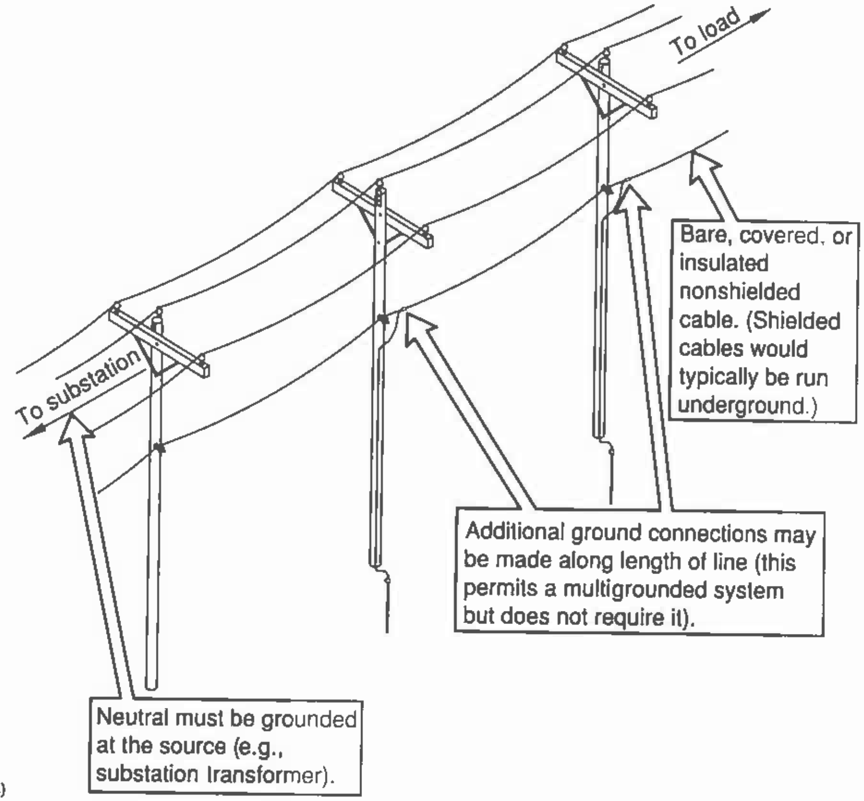


Fig. 092-3. Grounding connections at source and line side of a service (Rule 092B1).



See Photo(s)

Fig. 092-4. Grounding connections for nonshielded cables over 750 V (Rule 092B2a).

systems typically need to be multigrounded to provide sufficiently low ground impedance. Multigrounded systems are discussed in Rule 096C.

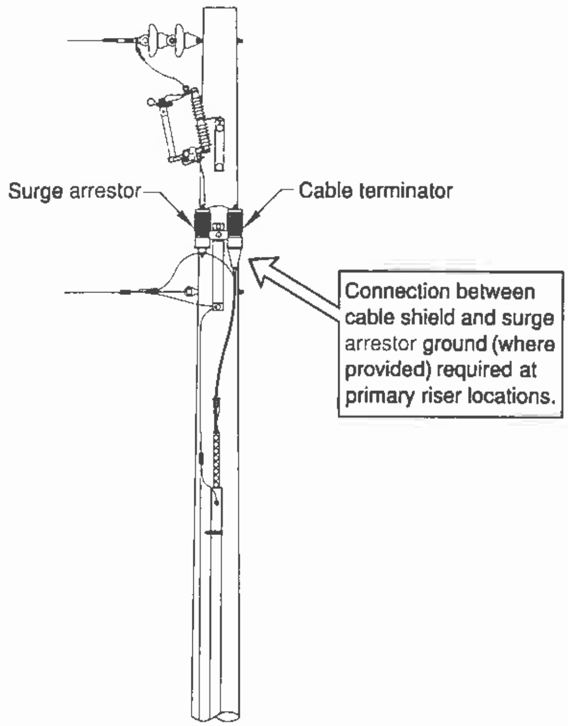
Shielded conductors on riser poles must be grounded as shown in Fig. 092-5.

Shielded cables without an insulating jacket must be grounded as shown in Fig. 092-6.

Shielded cables with an insulating jacket must be grounded as shown in Fig. 092-7.

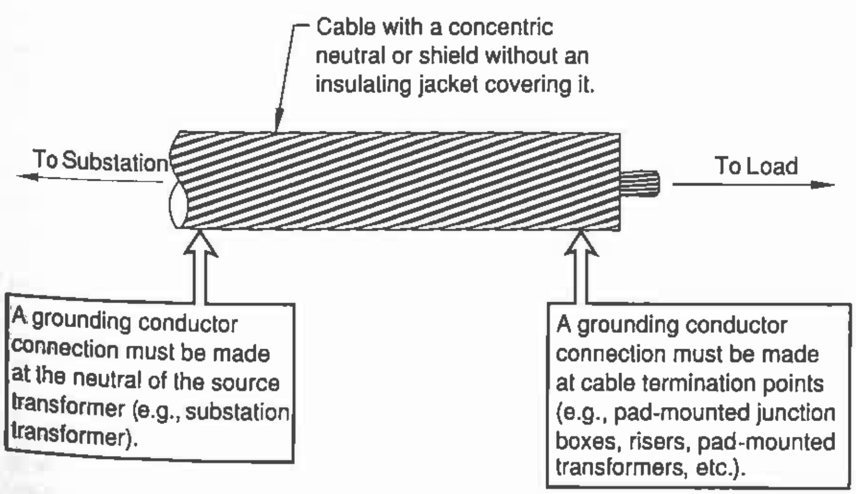
Shielded cable without an insulating jacket that is buried in direct contact with the earth has an advantage of being grounded all along its length. However, direct-buried shielded cable without an insulating jacket is susceptible to corrosion. The insulating jacket can prevent corrosion of the shield or concentric neutral, but grounding is not as effective. Shielded cables with an insulating jacket need to be terminated and grounded in pad-mounted enclosures or need to have a section of jacket removed and a ground attachment made to meet the multigrounding requirements of Rule 096C. The same applies to both bare and jacketed concentric neutral cables installed in conduit.

092B3. Separate Grounding Conductor. If a separate grounding conductor is used on an AC system to be grounded as an adjunct (joined addition) to a cable



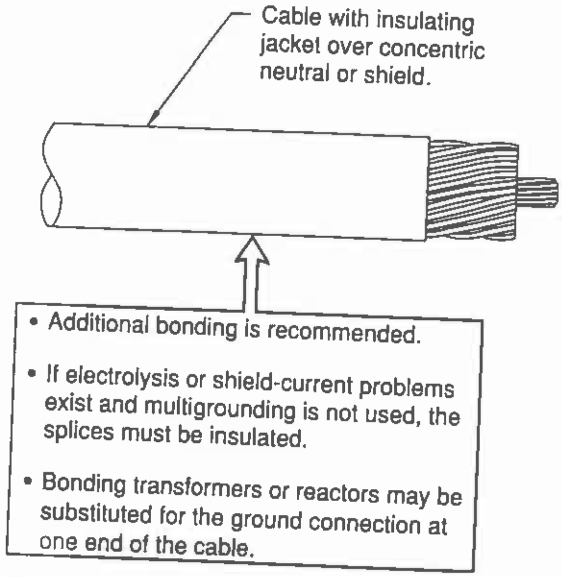
See Photo(s)

Fig. 092-5. Surge arrester cable—shielding interconnection (Rule 092B2b(1)).



See Photo(s)

Fig. 092-6. Grounding points for a shielded cable without an insulating jacket (Rule 092B2b(2))



See Photo(s)

Fig. 092-7. Grounding points for a shielded cable with an insulating jacket (Rule 092B2b(3)).

run underground, there are several conditions that apply. The separate grounding conductor must be connected directly or through the neutral to items that must be grounded. The conductor must be located as shown in Fig. 092-8.

Adjunct (joined addition) grounding conductors are typically used with shielded supply cables. If the shield on the supply cable is not a sufficient size to carry neutral current or fault current, an adjunct grounding cable can be used. An adjunct grounding conductor should not be used to replace a corroded concentric neutral conductor in a direct-buried cable. Rule 350B requires that a direct-buried cable operating above 600 V have a continuous metallic shield, sheath, or concentric neutral. The adjunct grounding conductor can be used to supplement the concentric neutral but not replace it if it has corroded away.

092C. Messenger Wires and Guys

092C1. Messenger Wires. The point of connection of the grounding conductor to messenger wires that are required to be grounded by other parts of the code is shown in Fig. 092-9.

Communications messenger wires on joint-use poles are required to be grounded in Part 2, Overhead Lines, Rule 215C and in Secs. 23 and 24 to meet certain clearance and grade of construction requirements. The messenger must meet certain ampacity and strength criteria defined in Rules 093C1, 093C2, and 093C5. For the messenger (on a joint-use structure) to meet the ampacity requirement in Rule 092C2, the messenger wire ampacity must be rated not less than one-fifth of the neutral wire ampacity. It is sometimes difficult to find the ampacity rating of messenger wires as many communications messenger wires are actually guy wires.

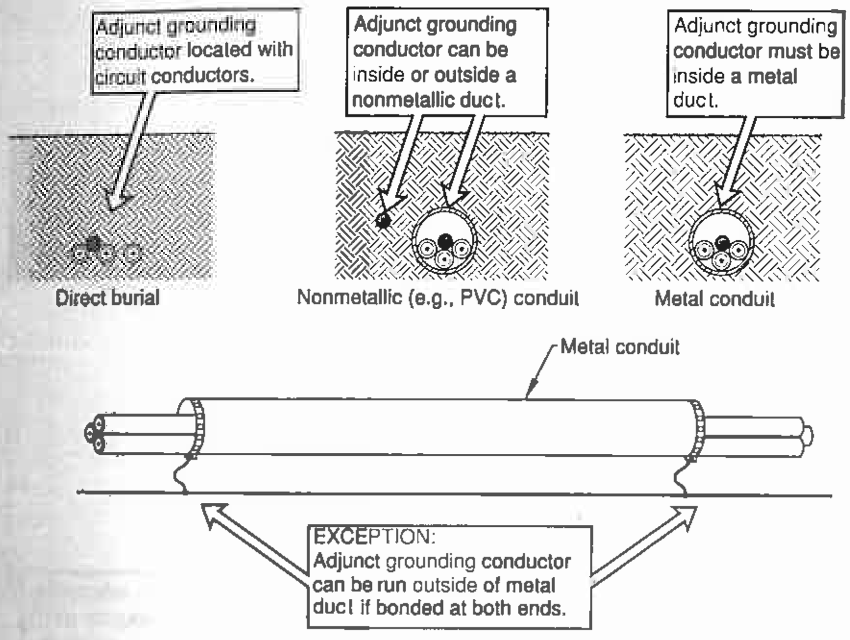


Fig. 092-8. Separate (adjunct) grounding conductor (Rule 092B3).

Manufacturers of guy wires typically provide mechanical strength ratings, not electrical ampacity ratings. The four grounds in each mile rule appears here for the first time in the Code. It is discussed in detail in Rule 096C.

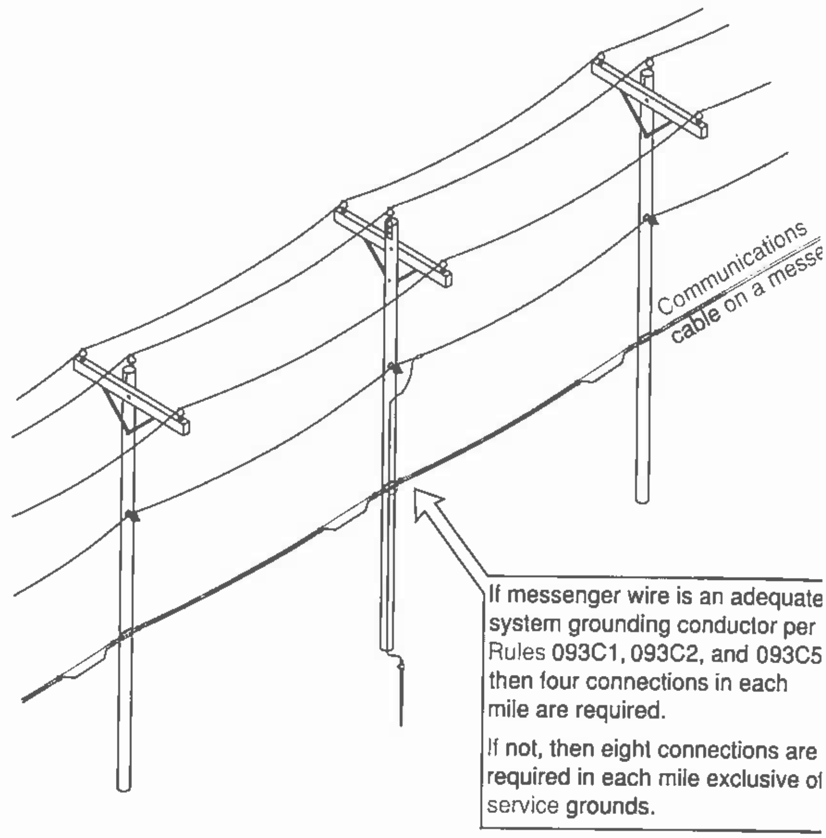
092C2. Guys. The point of connection of the grounding conductor to guys that are required to be grounded by other parts of the Code is shown in Fig. 092-10.

Guys must be either grounded (per Rule 215C2) or insulated (per the exception to Rule 215C2). If guys are grounded, they must be grounded using the methods in this rule.

092C3. Common Grounding of Messengers and Guys on the Same Supporting Structure. When messengers and guys are on the same supporting structure and they are required to be grounded by other parts of the Code, they must be bonded together and grounded by the connection methods listed in this rule. The methods listed are a combination of the messenger and guy connection requirements provided in Rules 092C1 and 092C2.

092D. Current in Grounding Conductor. This rule recognizes that multi-grounded systems, for example, a 12.47/7.2-kV, three-phase, four-wire circuit that has four or more grounds in each mile, may develop objectionable current flow on the grounding conductor (pole ground). This rule provides methods to alleviate the objectionable current flow.

Objectionable current flow may exist due to stray earth currents or other reasons. Fault currents and lightning discharge currents are not considered objectionable current flows when applying this rule and some amount of current will always be present on the grounding conductor (pole ground) during normal operation.



See Photo(s)

Fig. 092-9. Grounding of messenger wires (Rule 092C1).

092E. Fences. When fences are required to be grounded by other parts the Code (primarily in Rule 110A1), they must be connected to a ground conductor as shown in Fig. 092-11.

This rule provides both specific requirements for fence grounding (Ru 092E1 through 092E6) and general requirements by noting IEEE Standard which is the industry standard for substation grounding. Rule 093C6 a applies to fences. Fence mesh strands are only required to be bonded if fence posts are nonconducting. For conducting (metal) fence posts, the fe mesh must be under tension and electrically connected to the post for the m to be grounded. A grounding conductor feed up to barbwire strands at the t of a fence can be woven through the chain-link mesh for added grounding c tinuity. A ground grid which is typically buried under an electric supply s tion and connected to the station fence is discussed in Rule 096B. An exam of substation fence grounding is shown in Fig. 092-12.

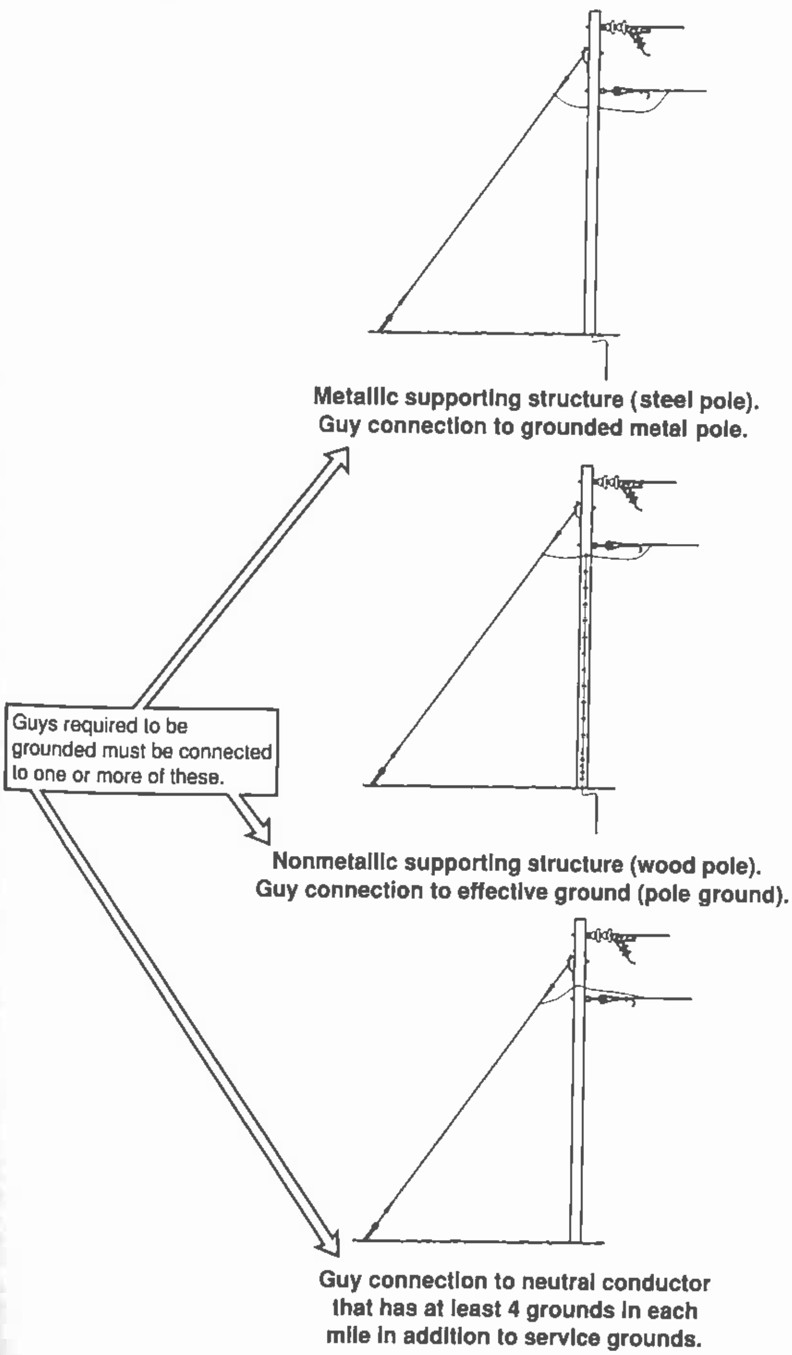


Fig. 092-10. Grounding of guys (Rule 092C2).

Supersedes 1/07 Issue – Clarified communication messenger bonding requirement.

13.0 GENERAL

13.0.10 Grounding

Grounding is an essential component of the overhead electric distribution system. Grounding certain types of circuits serve to protect workers and the public from being exposed to dangerous voltage levels. Grounding aids fuses and relays in system protective schemes to clear faulted circuits, and it also helps drain high voltage lightning surges from overhead distribution lines.

Grounding is usually accomplished by establishing an adequate connection to a driven ground rod, or rods, and then connecting to a continuous common neutral system if accessible.

Multiple grounds may be required to assure a low resistance connection to Earth. Driven grounds with connections to a continuous neutral are designed into an effectively grounded system. Driven grounds are also required on not effectively grounded (e.g. 4.8 kV) circuits through the secondary neutral, which effectively ties together all customer-owned grounds. Neutral secondary systems of not effectively grounded primary circuits shall not be electrically interconnected to effectively grounded circuit neutrals. An open section using a deadend insulator shall be provided between these two systems. This is to prevent transfer of neutral-to-Earth voltage onto the not effectively grounded secondary system from the effectively grounded system neutral. (The general bonding to communication company messengers may circumvent efforts to isolate some systems.)

When cutting over a not effectively grounded circuit to an effectively grounded circuit, a grounded neutral system shall be established.

While all low voltage circuits shown in these standards are grounded, some existing 480 V or 600 V not effectively grounded circuits are not solidly grounded. Certain circuits used in the oil industry, in tunnels, and other special applications are also ungrounded. Work on such circuits shall be done under the direction of persons who are familiar with the safety and lightning protection problems involved.

13.0.20 Bonding

Bonds are installed to limit the potential between two or more grounded systems. Bonds also improve lightning protection and general effectiveness of each system through multiple ground connections. Bonds are required between the Company's system neutral and grounded communication messengers on the same poles in grounded wye systems and between the Company's secondary neutral and grounded communication messengers on the same poles in delta and uni-grounded systems. There are some cases where a utility may desire an independent secondary grounding system, to limit stray voltage (in delta and uni-grounded systems)but, the grounded communication messengers must be bonded to the grounded system neutral where one exists.

13.0.30 Lightning Protection – General

Surge arresters provide a low resistance path across equipment when exposed to lightning or switching surges. This reduces the probability of insulation flash-over, or otherwise damaging equipment or lines. Arresters serve to drain the excess charge from lines, thereby reducing the probability of conductor burn down due to overvoltages that result. A metal oxide varistor (MOV) has very low resistance to the current of a high voltage surge and very high resistance to normal 60 Hz voltages. Once the voltage level returns to normal (below the maximum continuous operating voltage [MCOV]), negligible leakage current flows through the arrester.

Riser type, intermediate type, and station type arresters have lower discharge characteristics and therefore provide better equipment overvoltage protection. However, distribution type arresters do limit voltages from lightning strikes below the basic impulse level (BIL) of the equipment used on distribution circuits.
On effectively grounded systems, the arrester down-ground lead to a driven ground rod is always bonded to the system neutral and any available communication messengers, as shown on Page 13-115. On not effectively grounded primary systems, some special problems can be avoided by not interconnecting the arrester down-ground to the messengers of the other utilities.

13.1 WHAT TO GROUND

13.1.10 The following equipment and circuits shall be grounded:

A. Neutrals & Secondaries of Distribution Transformers
1. The neutral wire of each 120 V single phase, 2 wire circuit
2. The neutral wire of each 120/240 V single phase, 3 wire circuit
3. The neutral wire of each 208Y/120 V single phase, 3 wire circuit
4. The neutral wire of each 208Y/120 V or 480Y/277 V 3 phase, 4 wire circuit
5. One phase wire of each 240 V three phase circuit (has been general practice)

Each of the above secondary systems shall be grounded to a driven ground rod at both the transformer pole and at the customer's service point.

B. Secondaries of Metering

C. Neutrals of Effectively Grounded Primary Circuits

D. Ground Terminals of Surge Arresters

E. Metallic Cable Sheaths or Concentric Neutral Conductor on Riser Poles and Metal Conduits Containing Non-Metallic Sheathed Cables

F. Spacer Cable and Lashed Cable Sheaths and Messenger Strands

G. The Cases or Frames of:
1. Apparatus such as capacitors, reclosers, regulators, transformers, etc.
2. Any piece of equipment that is within 8 feet of the Earth. (See Section 13.2.20C)
3. Metering transformers and housing equipment.
4. Metal operating handles of switches that can be manually operated.

13.2 HOW TO GROUND

13.2.10 General

The circuits and equipment specified in Section 13.1 shall be grounded to a driven rod or rods or to another suitable connection to Earth as discussed below. Driven ground rods shall be installed in undisturbed Earth and extend at least 8 feet below grade.

On effectively grounded primary neutral systems that have at least four ground connections per rolling mile of neutral, all ground connections and bonds may be made to a single #4 or larger copper wire that is connected to a driven ground rod. Copper compression connectors shall be used for ground conductor bonds and taps. All surge arresters shall be connected to the grounding conductor through a flexible grounding lead (L6) as shown on Page 13-115.

On not effectively grounded primary systems, the surge arrester grounding conductor and the secondary neutral grounding conductor shall be run separately to two ground rods. The two

rods shall be separated by a minimum distance of 20 feet as per NESC Rule 97. To accomplish this, the secondary neutral grounding conductor can be extended to the next available pole, assuming no other grounding conductor is located on that pole, and connected to a down ground installed at that location.
A #4 soft drawn copper conductor with 45 mils HDPE cover (W11F) shall be used for most ground connections on distribution poles.

A ½ inch flexible molding shall be installed over all distribution down ground installations from finished grade up to 8 feet, for mechanical protection.

13.2.20 Ground Resistance Requirements

A. Effectively Grounded Systems
Effectively grounded primary neutral systems utilize the large number of parallel connected grounds to ensure an effective low resistance to ground system neutral. Therefore, the installation of one 8 foot rod at each required location shall be sufficient. No resistance test is required.

B. Not Effectively Grounded Systems
Not effectively grounded primary systems shall, where practical, have individual ground rod resistance to ground not exceeding 25 ohms. If a single ground rod resistance exceeds 25 ohms, two ground rods connected in parallel shall be used. (See Section13.2.30).

C. Equipment Within 8 Feet of the Ground
Metal parts, frames, and cases of the equipment listed below are required to be grounded, or connected by a low-impedance metallic path back to the grounded terminal of the local supply. Resistance to ground for installed ground rods shall be as required in Sections 13.2.20 A and 13.2.20.B above for the applicable system configuration. A ground grid, (See Page 13-114) shall be installed for items (1) and (2) below:
1. Primary instrument transformer cabinets and primary meter housings
2. Manually operated switch handles
3. Transformers
4. Regulators
5. Control cabinets *

* The lowest component (e.g. control cable drip loop) of control cabinets for capacitors, reclosers, regulators, and sectionalizers should be installed between 8 and 11 feet above ground level and shall never overhang roadways or obstruct pedestrian traffic. Control cabinets may be mounted lower than 8 feet on effectively grounded circuits with an appropriate ground grid (Page 13-113), provided such control cabinets do not overhang roadways or obstruct pedestrian traffic, and after full consideration of worker and public safety, possible vandalism, and aesthetics.

13.2.30 Obtaining Low Resistance Grounds

If a required resistance to ground of 25 ohms cannot be obtained with a single ground rod, the addition of only a second ground rod is required.

The following procedure is to be used when a required 25 ohm resistance cannot be obtained by the installation of a single ground rod:

A. If after the installation of one 8 foot ground rod (See Page 13-111) the resistance of this rod exceeds 25 ohms, drive an additional 8 foot rod with a minimum separation of 6 feet between the rods.

B. If resistance to Earth of equipment grounds cannot be reduced to less than 25 ohms, the equipment shall remain grounded but should be elevated to not less than 8 feet above grade, or interconnected, bonded, with all other non-energized conducting components within reach. The bonding conductor shall not be less than #8 copper and the short time ampacities shall be adequate for the duty involved.

13.3 BONDING

13.3.10 Bonding Between Different Parts of the Distribution System

Except as noted in Section 13.0.10 for not effectively grounded system secondaries, all grounded parts of the distribution system should be bonded together through connections to the system neutral; the effectively grounded secondary neutrals, spacer cable or lashed cable messengers; or through other grounded conductors. Guy wires on effectively grounded systems shall also be bonded to the system neutral or the effectively grounded secondary neutrals. In addition, spacer cable messengers shall be bonded to the system neutral at every pole. All messenger and phase conductor supports and fuse cutout brackets of spacer cable installations shall be bonded to the pole equipment grounding conductor.

The bonds shall be established at intervals along the line, at each location of driven ground rods which are installed not less than 4 per each rolling mile of line and at; transformers, arresters, capacitors, regulators or any other pole with a vertical grounding conductor installed.

13.3.20 Bonding Between Different Systems of the Company

The system neutral and the messengers of spacer cable or lashed cables on the distribution system shall normally be bonded or connected to station grounds at all stations feeding the distribution lines. They shall also be connected to the vertical ground of transmission lines where they occupy the same pole.

13.3.30 Bonding Between the Company and Other Grounding Systems

The Company system neutral shall be bonded to the grounding system of other utilities that occupy the same pole. Such bonds shall be made only after consultation with other utilities. Where isolation of primary and secondary neutrals is done to minimize the effects of neutral-to-Earth voltages on customer facilities, separate neutrals must be established for these two systems. The communication messengers must be bonded only to the primary neutral at these locations.

13.3.40 Bonding Between Communication Company and the Company Grounding Systems

Bonds shall be installed between power company vertical grounding conductors connected to the system neutral in a multi-grounded wye system and to the secondary neutral in other types of systems and grounded communication company messengers. Page 13-115 shows typical installations. Communication messengers shall not be bonded to electric equipment or arrester ground wires that are not connected to an electric system neutral (separate equipment and arrester grounds are common in delta or uni-grounded systems). Caution should be used when line workers of either company removes their facilities and the associated bonds. 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.

Responsibility for bonding communication cable support messengers is as follows:

- Communication Company Attaching to Pole With an Existing Downground:

Supersedes 7/08 Issue – Communication messenger bonding information modified.

Supersedes 7/08 Issue – Communication messenger bonding information modified.

The communication company bonds its support messenger to an existing downground on a pole (with an existing downground that is connected to: a system neutral on a multi-grounded wye system or a secondary neutral in other types of systems). This installation of the bond is done by the communication company at the communication company's expense. This includes bonding when existing communication company messengers and cables are transferred to replacement poles.

- <u>National Grid Installs a Downground on Existing Pole With Communication Attachment(s)</u>: When a down ground (connected to a system neutral on a multi-grounded wye system or a secondary neutral in other types of systems) is installed by National Grid on an existing pole, National Grid bonds the existing communication messenger(s) to the new downground wire. This downground installation and bonding of communication company support messenger(s) is done by National Grid at National Grid's expense.

- <u>Communication Company Requires a Bond at Pole Without an Existing Downground</u>: When newly installed communication support messengers are attached to an existing pole, must be bonded to the electric neutral at that pole, and the pole does not have an existing downground, the communication company attaches a bond wire to its newly installed support messenger and leaves it coiled up in the communication space. National Grid will bring the coiled tail (bond wire) up to the supply space and bond it to the electric neutral. As shown above, the communication support messengers must be bonded to the system neutral on a multi-grounded wye system or to the secondary neutral (and not to arrester, equipment or transformer downgrounds) in other types of systems. This bond to the electric neutral in the supply space is done by National Grid at the communication company's expense. Invoicing the communication company for this bonding is done by the engineering department as part of the work order design.

13.4 EFFECTIVELY GROUNDED PRIMARY NEUTRAL

The neutral conductor of all new distribution circuits shall be effectively grounded. Where this neutral grounding has not already been accomplished, the change from not effectively grounded to effectively grounded shall be made in connection with all new construction and large maintenance jobs.

The effectively grounded system neutral shall always follow the same route as the primary conductors and be physically located on the same pole line. The system neutral must not be opened.

On any effectively grounded section of a feeder, there shall be a minimum of four grounds per rolling mile.

The effectively grounded neutral shall be installed at the secondary level on the pole. An existing phase conductor of a single phase line on crossarms may, however, be left on 5 kV insulators and converted to an effectively grounded neutral. Where secondaries exist, the secondary neutral should be grounded at the transformer pole and bonded to the effectively grounded neutral at each end of the secondary net/crib.

Similarly, an existing conductor on a vertical or "armless" type pole top may be left on 5 kV insulators and converted to an effectively grounded neutral if there are no transformers or secondaries on the pole. If a transformer is installed on a vertical or armless pole, or if a secondary is installed on any pole, the effectively grounded neutral shall be relocated to the secondary position.

13.5 COMMON NEUTRAL

Common neutral exists wherever the same conductor serves as the neutral for both the primary and secondary circuits. Only one vertical ground wire should be installed on a pole with a common neutral.

The Common neutral shall meet the size requirement in Section 9.1.3. A common neutral shall not be used as the grounded phase conductor of a not effectively grounded secondary. It shall, however be bonded to this conductor. The secondary grounded neutral of a not effectively grounded primary circuit shall be isolated from any effectively grounded system neutral as stated above in Section 13.0.10.

Every effort should be made to preserve the continuity of the system neutral and to establish the best possible connections between the neutral and Earth. It shall meet the grounding requirements in Section 13.4 above and shall be bonded to grounded equipment whenever practicable.

13.6 LIGHTNING PROTECTION

13.6.10 General

Surge arrester protection shall be provided for capacitors, reclosers, regulators, transformers, and other equipment as prescribed below.

When any silicon carbide (SiC) porcelain arrester is replaced with an MOV polymer arrester in a cluster mount or riser pole configuration, all SiC porcelain arresters are to be removed and replaced with MOV polymer arresters.

To obtain the proper equipment protection and arrester operation, the following practices are recommended:

A. Surge arresters shall be installed on the same pole with the equipment to be protected.
B. Surge arresters shall be connected to a driven ground at the same pole as the arrester.
C. Both the line side and the ground side arrester leads shall be kept as short and as straight as possible. Long leads will significantly reduce the margin of protection provided by the arrester. For the combined line and ground lead length, normal practice is to add 1.6 kV per foot to the specified arrester discharge voltage at the discharge current level selected for coordination.
D. When installing MOV arresters, the ground lead shall be connected first. Since MOV arresters continuously conduct a small amount of current, a slight arc may be drawn when connecting the line side of the arrester.
E. When disconnecting MOV arresters, always disconnect the ground lead last. An MOV arrester should have the line end touched to the pole ground to discharge it immediately after removal since it can retain a small electrical charge for a few minutes. After removing a MOV arrester with an intact disconnector from service a restraining device should be installed to comply with U.S. Department of Transportation regulations.
F. **WARNING:** A failed arrester with a blown disconnector shall be treated as energized at full line potential at both ends of the arrester.
G. One should avoid dropping an MOV arrester. The internal charge in the disconnector could be discharged.

Supersedes 7/07 Issue – Page numbering updated.

13.6.20 Selection Criteria

It is necessary to select the proper arrester and install it in the correct location. An improperly selected or applied arrester will not provide the desired protection to the distribution system and can lead to arrester failure and poor reliability performance. For proper selection, it is necessary to determine the following:

A. Operating voltage of the circuit
Note: No part of the circuit with connected surge arresters should normally experience voltages greater than 1.05 per unit of the nominal circuit operating voltage.
B. Basic impulse level of the equipment to be protected
C. Connection of equipment to the circuit
WARNING: Some equipment may be utilized on circuits of the same voltage class but with those voltage classes having different degrees of grounding. Be sure that the arresters specified or supplied with the equipment are of the correct rating for the specified circuit.
D. Circuit grounding type

Determine whether the circuit is effectively grounded or not effectively grounded. Engineering shall confirm circuit grounding if necessary. Effectively grounded circuits have an X0/X1 ratio of 3 or less while not effectively grounded circuits have an X0/X1 ratio of greater than 3. If, via permanent field switching, equipment has the potential to lose its effective grounding and remain energized from a not effectively grounded circuit, equipment BIL requirements and arrester application should be reviewed.

After determining the above criteria, select the proper arrester from Table 1 in Section 13.7.

13.6.30 **Application**

MOV surge arresters shall be installed in accordance with the following, utilizing properly rated arresters from Table 1, in Section 13.7. Actual physical arrester locations on circuits and equipment are shown in specific standard sections for the construction involved.

A. Overhead Conductors

1. Crossarm and pole top pin construction – bare, covered, and tree wire conductors:

   Surge arresters shall be installed on each phase conductor at:
   a. end-of-line deadends provided there is no equipment with surge arresters on that pole.
   b. all transitions from bare conductor to anything other than bare conductor.
   c. all transitions from tree wire to anything other than tree wire.

2. Overhead cable – spacer cable and lashed cable

   Surge arresters shall be installed on each phase conductor at all transitions from spacer or lashed aerial cable to anything other than the spacer or lashed aerial cable. Arresters shall be installed on each phase of spacer or lashed aerial cable deadends.

   Note: At transitions from lashed aerial cable, riser pole arresters shall be specified.

3. Taps

   Surge arresters are required on all fused taps. Surge arresters shall be installed on the load side of the fused cutout on all new construction and should be installed on the same pole as the fused cutout.

   As with all standards this applies to new construction, not to maintenance on existing structures. For example, this standard does not require that arresters be installed solely because of the replacement of a potted porcelain fused cutout at a side tap. If budgets and time allow, installing arresters in this case could help improve reliability, but is not required by this standard.

   On the other hand, if an arrester should already have been installed at the tap pole for some other reason, an arrester should be installed when the cutout is replaced. For example, an arrester could be required at a side tap because of a transition between types of wire, e.g. an open wire tap of a spacer cable main line. In this case, an arrester should be installed on the load side of the cutout of each tapped phase on the pole where the transition occurs.

B. Pole mounted equipment

1. Airbreak/loadbreak/disconnect switches

Supersedes 7/07 Issue – Clarified application of surge arresters on existing fused taps.

Surge arresters are required on all phase conductors on both sides of the switches.

Where disconnect switches are installed or where phases are deadended on the loadbreak switch, arresters shall be installed on all phase conductors on adjacent source and load side poles. If there are surge arresters installed on all phase conductors within 300 feet away from the loadbreak switch, surge arresters are not required at the loadbreak switch location.

Adjacent pole arrester installation is preferred on the crossarm. If it is impossible to mount them on the crossarm, the alternative solution is to mount arresters on the three phase fiberglass equipment mount.
It is important to install surge arresters on all three phases so that all phases experience the same level of protection. Otherwise, flashover of the lightly protected phases might occur.

Note: For existing construction, if the normally closed airbreak or loadbreak switch is about to become the normally open switch, arresters shall be installed on both sides of the switch. If arrester installation is not convenient at the switch pole location, arresters should be installed on all phase conductors on the adjacent poles.

2. Overhead transformers

   a. All overhead transformers shall be protected by surge arresters. In common neutral areas, the arrester ground lead shall be interconnected with the tank ground and common neutral. Surge arrester location, and grounding and bonding methods, for overhead transformers installed on standard effectively grounded and not effectively grounded circuits are shown on Page 13-112. The arrester shall be connected to the transformer side of the primary fuse cutout for conventional transformers.
   b. Step-down and step-up transformers, also known as ratio transformers in parts of the Company, shall have surge arresters installed on all phase conductors on both the high voltage and low voltage sides of the unit. When the arresters are mounted separately (not installed on the transformers), they shall be connected between the fuse cutouts or disconnect switches and the transformer bushings, as close to the transformer bushing as practical.
   c. **WARNING** – floating wye - delta connected transformers shall not have direct connected tank mounted arresters. Surge arresters shall be crossarm mounted on the same pole as the transformer bank and connected to the source side of the fuse cutouts. This connection avoids exposure of the arresters to possible overvoltages when a fuse cutout is open. As in all arrester applications, line and ground leads are kept as short and as straight as possible.

3. Line reclosers/sectionalizers

   Line reclosers and sectionalizers shall have arresters installed on both the source and load side using the mounting provisions provided. Surge arrester connections should be made as short and as straight, and as close to the bushings as possible.

4. Regulators

Supersedes 1/07 Issue – Location of arresters at capacitors corrected.

Regulators shall have tank mounted surge arresters installed on the source and load bushings. The manufacturer may also provide a bypass arrester between the source and load bushings depending upon design.

5. Capacitors

Capacitors shall have surge arresters. When arresters are mounted separately (not installed on the capacitor bank frame), they shall be connected between the fused cutouts and the capacitor bushings. Arrester connections should be made as short and as straight, and as close to the bushings, as possible.

6. Primary metering equipment

Primary metering equipment shall be protected with surge arresters.

C. Riser poles

Riser type surge arresters shall be installed at the transition from underground cable to overhead circuits. The grounding conductor from the arrester shall be bonded to the concentric neutral or metallic sheath of the underground cable as close to the termination as possible, and to the system neutral of the overhead circuit. It shall also be connected to a driven ground at that pole.

D. Miscellaneous Applications

1. Customer equipment

Surge arrester protection for customer owned equipment served at the distribution voltage is the customer's responsibility. The customer shall be advised of the degree of surge protection that may be incidentally provided by the Company, but shall be responsible for arranging and installing any additional protection requirements.

2. Generators

Any generators connected to the distribution system may impact arrester application. This connection must undergo a Company engineering review.

Supersedes 1/07 Issue – Page numbering updated.