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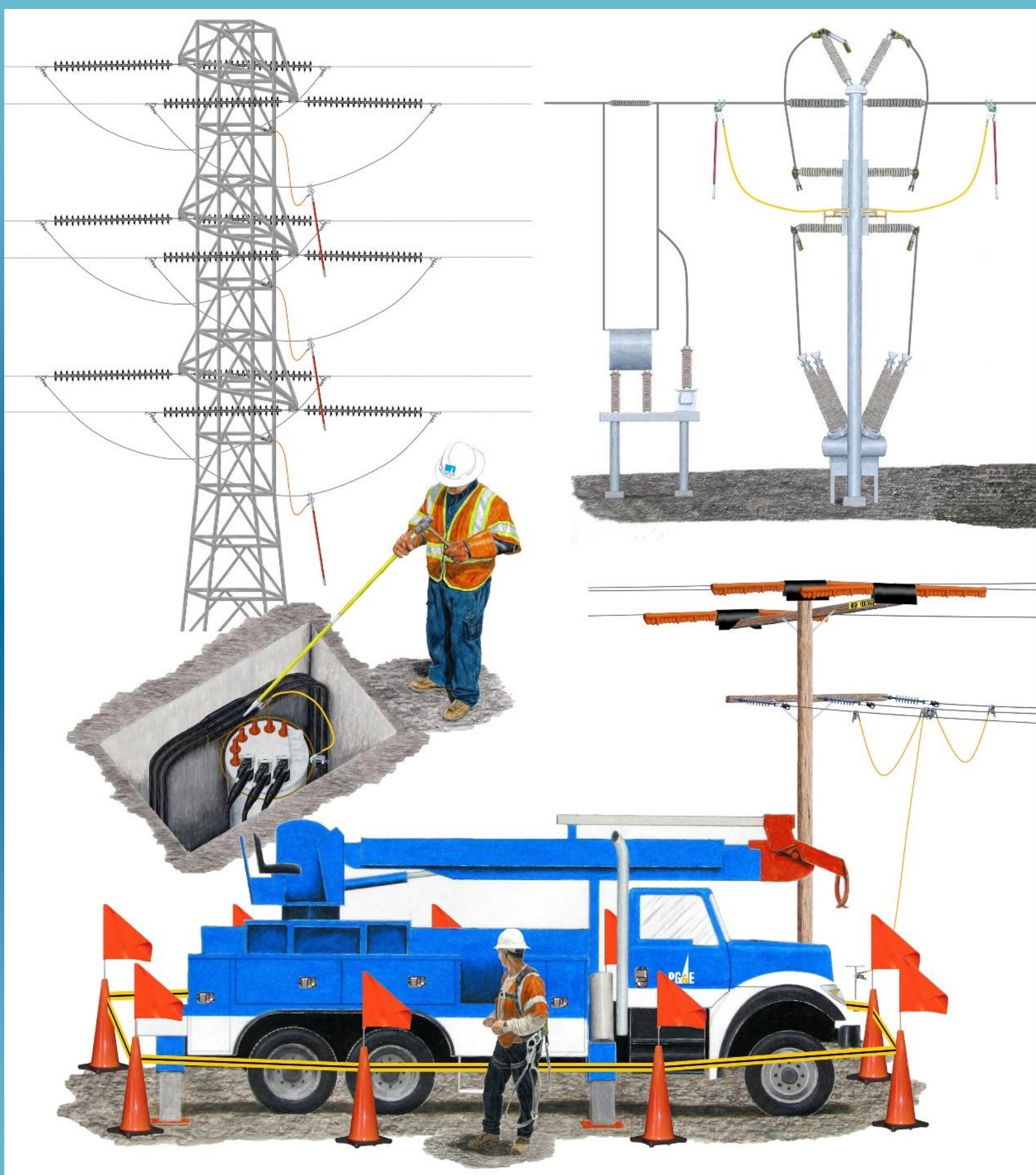
PROTECTIVE GROUNDING MANUAL

TD-2345M



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1 INTRODUCTION

1.1 Scope

The Protective Grounding Manual provides consistent grounding procedures and tools that meet or exceed all State and Federal Regulations, industry best practices, and high-voltage consensus Standards and Guidelines that cover this type of work. The use of this manual can ensure that all workers will be using procedures and tools that provide them with a safe work environment—should the de-energized and grounded circuit and/or equipment they are working on become accidentally energized.

1.2 Purpose

The primary purpose of protective grounding is to provide maximum safety for workers while they are working on de-energized lines. Protective grounding, when installed correctly, provides employees with a safe worksite and proves that an electrical circuit or electrical equipment is de-energized.

In instances when a de-energized conductor accidentally becomes energized, properly installed grounding devices provide paths for current to flow to ground, limiting the potential difference across the worker. Protective grounding reduces differences in voltage potentials at the worksite to the lowest practical value.

1.3 Manual Organization

This edition of our Protective Grounding Manual includes both new and updated material.

- Section 1 through Section 3 (white tabs) contains general information.
- Section 4 through Section 7 (red tabs) covers grounding procedures specific to each line of business.
- Section 8 and Section 9 (blue tabs) covers grounding and barricading vehicles.
- Section 10 (white tab) provides details about devices, components, and tools that are approved for use in grounding operations.
- Appendix A (white tab) contains a glossary and a list of acronyms used in the manual.
- Appendix B (white tab) contains forms and manufacturers' operating instructions.
- Appendix C (white tab) contains grounding instructions for specific distribution underground devices and operating instructions for underground instruments.

1.4 Special Comments or Instructions Used in Manual

1. A "**WARNING**" (as shown below in Figure 1.1), refers to operating procedures, techniques, etc., that, if not followed carefully, could result in **LOSS OF LIFE OR PERSONAL INJURY**.

Figure 1.1 Warning Icon

2. A "**CAUTION**" (as shown below in Figure 1.2), refers to operating procedures, techniques, etc., that, if not followed, could result in **DAMAGE TO EQUIPMENT** or a **LOSS OF SERVICE TO CUSTOMERS.**

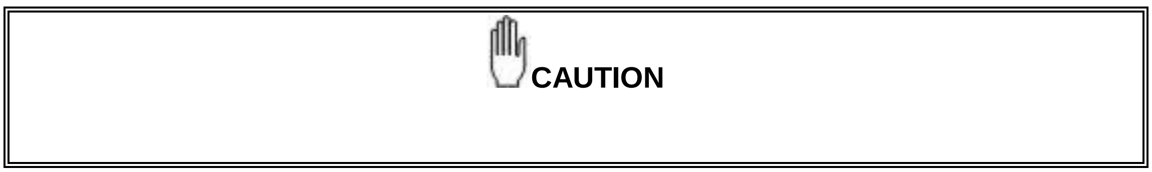

Figure 1.2 Caution Icon

Both a **WARNING** and **CAUTION** appear on the same page as the text to which they refer, if possible.

3. A **"NOTE"** is inserted to provide **ADDITIONAL INFORMATION**.

4. An **"EXCEPTION"** is inserted to provide an **ALTERNATIVE** to the given instruction.

5. All VOLTAGE references in this manual are **NOMINAL PHASE-to-PHASE**.

1.5 The Protective Grounding Oversight Committee

The purpose of the Protective Grounding Oversight Committee (PGOC) is to ensure the content of this manual conforms to all applicable industry standards, regulations and work methods that protect PG&E employees from electrical hazards. The identification, recognition, and control of all credible electrical safety hazards are fundamental to creating safe work conditions and are the goals of this manual. All training programs developed for this manual and any variations thereto require review and approval by the PGOC.

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1.5 (continued)

Under the PGOC, additional committees are used for specific issues or line of business grounding. Examples are:

- Substation Generation Grounding Committee
- Transmission Grounding Committee
- Distribution Grounding Committee

The functions of these committees are to:

- Evaluate and approve changes to the manual, alternate work methods, and new tools and equipment.
- Review and approve "one-time use" mitigation plans for special grounding situations.
- Coordinate consistent application of rules, procedures, and equipment across all PG&E departments.
- Obtain engineering approval for all new work methods, procedures, and tools per Company Standard TD-2340S, "Temporary Protective Grounding Criteria."

- Contact your departmental Work Methods and Procedures Specialist or send an e-mail to GroundingQuestions@pge.com with comments, questions, or concerns about protective grounding in general or the information contained in this manual.

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2 GENERAL

2.1 Scope

This section contains information pertaining to temporary protective grounding that is relevant to all applicable departments within PG&E. For specific information and work procedures, refer to the section of the manual that covers your work group and/or the type of grounding activity you are going to perform.

A current electronic or hard copy of the Protective Grounding Manual must be available and onsite whenever protective grounding is being performed.

WARNING

Conductors and or equipment are considered energized until they have been tested and proven de-energized by the installation of approved grounding devices.

For conditions that are not covered in this manual, contact your Supervisor or send your questions to GroundingQuestions@pge.com.

For Terms and Acronyms used in this manual, refer to Appendix A, Glossary & Acronyms for a definition or explanation.

Refer to your department-specific work procedures for personal protective equipment (PPE) required before performing grounding activities.

2.2 Electrical Sources

Workers must be protected from all possible sources. **The following are examples of electric sources:**

1. **Fault Duty sources include:**
    - Open switches and jumpers, etc., that are designated as clearance points.
    - Adjacent energized circuits, conductors, or equipment with exposed live parts.
    - Lines energized above 300V that:
        - Cross below
        - Cross over and within 10 feet
    - Elevated neutrals that are not directly tied to ground. Elevated neutrals can be connected to ground through transformers, resistors, reactors, or left open.
2. **Backfeed sources include:**
    - Generators
    - Uninterruptible power supplies (an electrical apparatus that provides emergency power to a load when the input power source fails)
    - Photovoltaic cells (solar)
    - Transformers (including station service)
    - Potential transformers (both internal to devices and external)
    - Neutral grounding transformers (power generation)
3. **Other sources include:**
    - Induction from adjacent or parallel energized, overhead distribution and transmission lines
    - Energized conductors 50 volts (V) or more that could contact the circuit being worked on
    - Capacitors
    - Tertiary reactors
    - Static, capacitive, and inductive charge
    - Commercial radio, microwave, or television transmitters

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2.3 Types of Electrical Hazard

Employees must consider all types of electrical hazards when planning their work.

Each type of electrical hazard is described in detail in this subsection.

1. Induced Voltage

Induction hazards are responsible for many electrical worker's serious injuries and fatalities. Induced voltages are not always readily apparent.

WARNING

Capacitive and electromagnetic hazards can cause SERIOUS INJURY OR DEATH. Proper protective measures must be used.

There are four types of induced voltage:

a. Capacitive Coupled Voltage (i.e., Electric Field Induction)

Capacitive coupled voltage may exist on an ungrounded object that is in the electric field of an adjacent, energized circuit, such as de-energized buses, metallic structures, or employees in rubber boots. These objects can develop a standing charge. Install grounds anywhere near the worksite for protection.

Particular areas of concern:

- Extra-high-voltage (EHV) lines energized at 230 kilovolts (kV) and above
- Underground cables of all voltages

b. Electromagnetically Coupled Voltage (i.e., Magnetic Field Induction).

Electromagnetically induced voltage is created by an action similar to what occurs in a transformer. When one winding in a transformer is energized, the other winding is energized automatically (see Figure 2.1 on Page 2-4).

The same phenomenon occurs when an energized, current-carrying conductor is adjacent and parallel to a de-energized (i.e., switched out) conductor. Circulating current will flow in all possible loops, including flowing through the individuals.

Particular areas of concern include:

- Adjacent high-current carrying lines
- Parallel lines in excess of one mile

2.3 (continued)

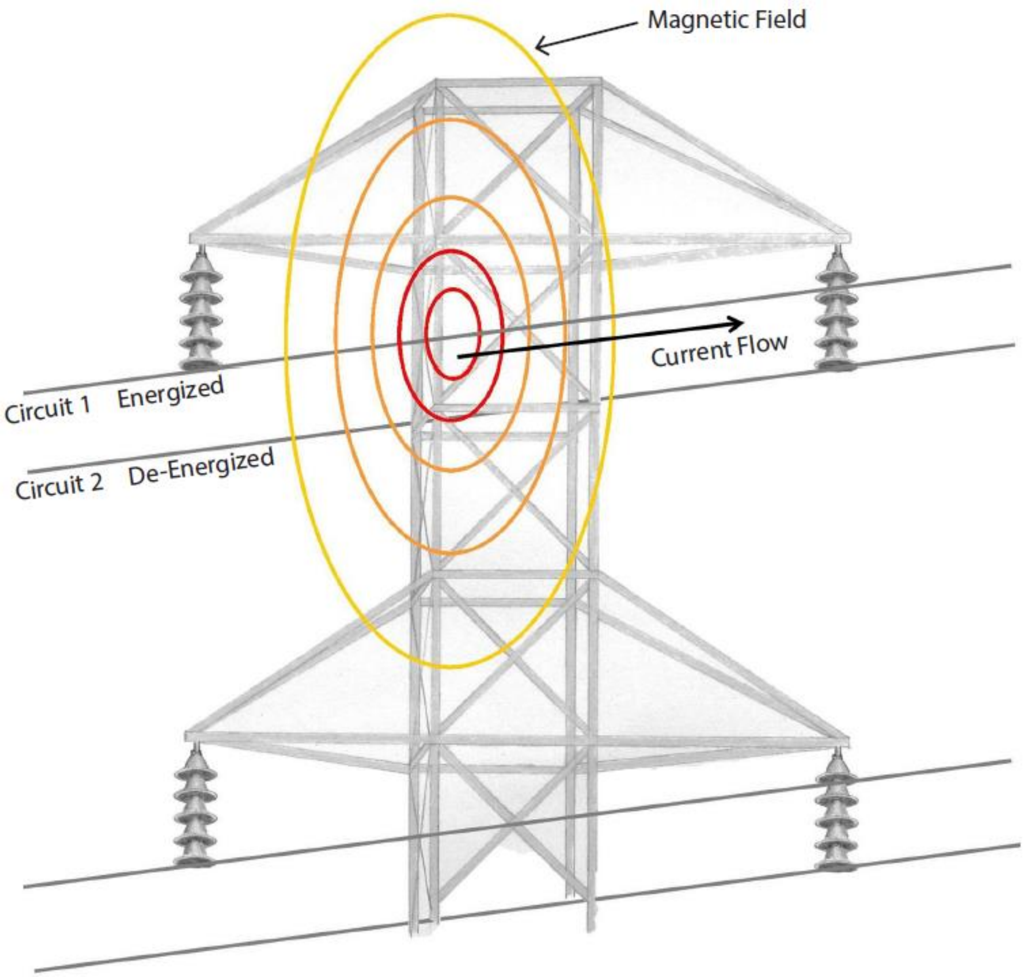

Figure 2.1. Electromagnetically Coupled Voltage.

c. Static Voltage

Static voltage is the voltage build-up on metallic objects such as steel towers, bus conductors, etc., from atmospheric conditions. Typically, static voltage build-up is less severe than other types of worksite voltages. Using personal grounds or bonding wires at the worksite is the best protection against static voltage.

Particular areas of concern:

- Dry windy conditions
- Ungrounded metallic hardware

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2.3 (continued)

d. Radio Frequency (RF)

WARNING

Contacting a metallic object that contains induced-RF energy with bare hands or leather gloves could cause serious burns.

RF energy is present whether the line is energized or de-energized. RF energy cannot be removed from an object using grounds.

NOTE

There are no transmitters near PG&E Substation facilities.

See TD-2001P-01, "Procedures for Working Around Antennas" for detailed information on working in proximity to antennas.

Types of antennas that could produce hazardous RF:

(1) Microwave (commercial radio and television transmitters)

- All employees working on lines, regardless of voltage, within 1/4 mile of an operating commercial radio or television station transmitter **must wear** Class 2 rubber gloves with approved protectors, even if the line is de-energized and grounded.

(2) Omni-directional (Whip/Cellular)

- If you must climb past the antenna to reach your work location, avoid contact and do **not** stop at the level of the antenna. Proceed until you are at least 2 feet above or below the antenna before you establish your work position.

2. Accidental Energizing

A number of sources can cause accidental energizing. **Forms of accidental energizing** that require consideration:

- Energized conductors or equipment falling into your work area
- Your work area equipment touching an energized line nearby
- Operating error (closing clearance limit)
- Backfeed through a transformer
- Backfeed from customer

Properly installed grounds and shunts will protect employees from these hazards.

2.3 (continued)

3. Lightning

When lightning is in the area, employees MUST get clear of conductors until the lightning has passed.

Lightning strikes can induce dangerously high voltages at the worksite, i.e., 100 million volts (V). Protective grounds will not mitigate these hazards.

4. Step Potential, Touch Potential, and Transferred Potential (Voltages)

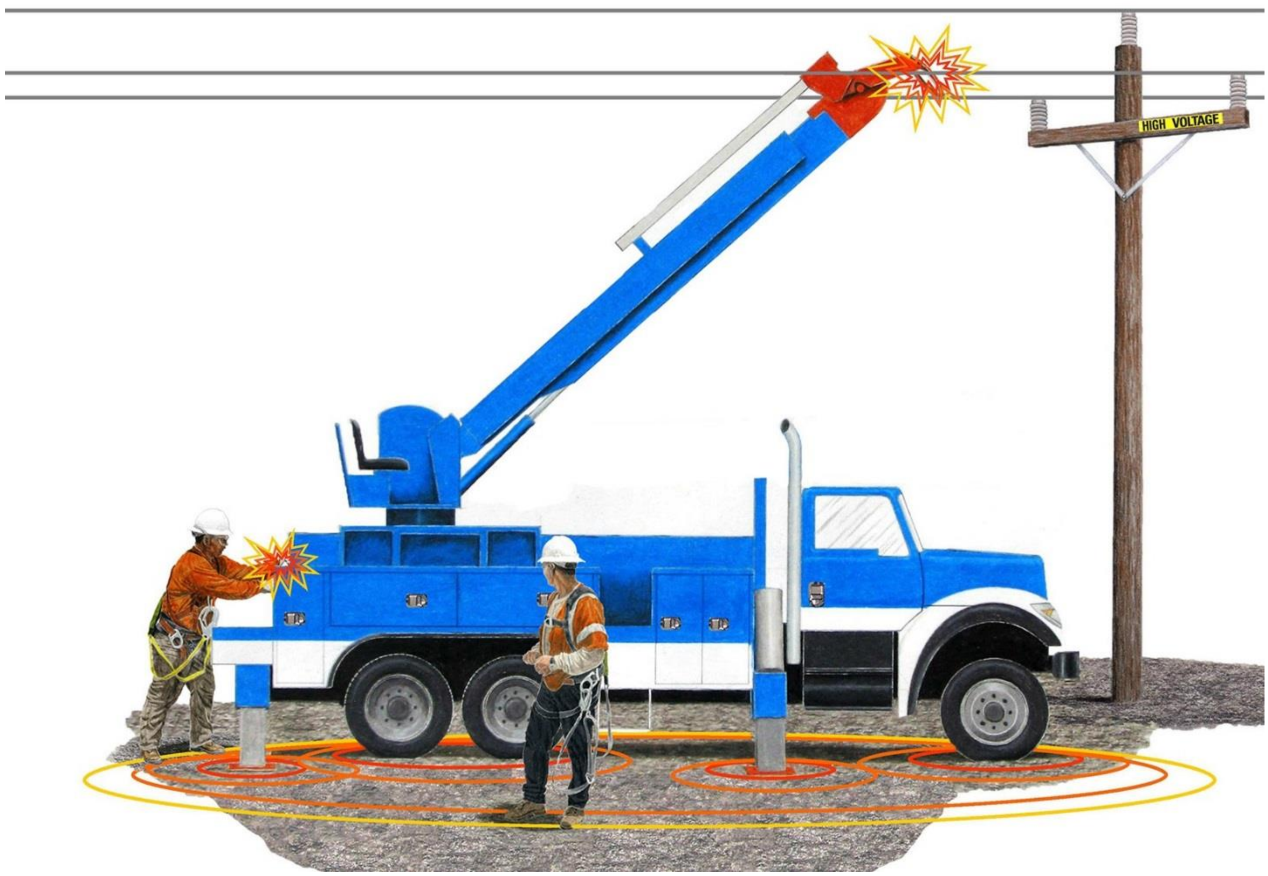

Figure 2.2. Step and Touch Potential

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2.3 (continued)

WARNING

When current flows into the earth, a voltage gradient is developed at the injection point of the current, i.e., at the energized object.

a. **Touch Potential:** When a person is standing on the earth and touches an energized object, there will be a voltage difference between their hands and feet. Wear Class 2 rubber gloves with approved protectors to protect from touch potential. See Figure 2.2 on Page 2-6.

b. **Step Potential:** When a person is walking along the earth near the energized object, there will be a voltage difference between their feet. Wear EH rated boots or dielectric footwear to protect from step potential. See Figure 2.2 on Page 2-6.

- When the work does not require physical contact with grounded objects, employees on the ground must maintain as much distance as is practical from ground rods, grounding cables, grounded structures, grounded vehicles, grounded equipment, or any other possible sources of ground current.

WARNING

There is an increased risk of transferred potential when the worksite requires protective grounds to be installed both inside and outside a substation.

c. **Transfer Potential:** When a person is standing at a remote location and is touching a conductive object that is attached to a different ground source, there will be a voltage difference between their hand on the conductive object and their feet.

- Avoid transferring the voltage away from the ground source by disconnecting from the remote ground or eliminate the difference of potential by installing a ground jumper (see Figure 2.3 on Page 2-8).
- Contact the substation department or work methods specialist for your department for specific grounding instructions, procedures, and/or work methods when it is necessary to ground both inside and outside of a substation.

2.3 (continued)

Particular areas of concern:

- Transferring substation ground potential to outside the ground grid. Special work procedures are required to protect employees that are exposed to this situation.
- Grounded conductor broken and lying on the ground.

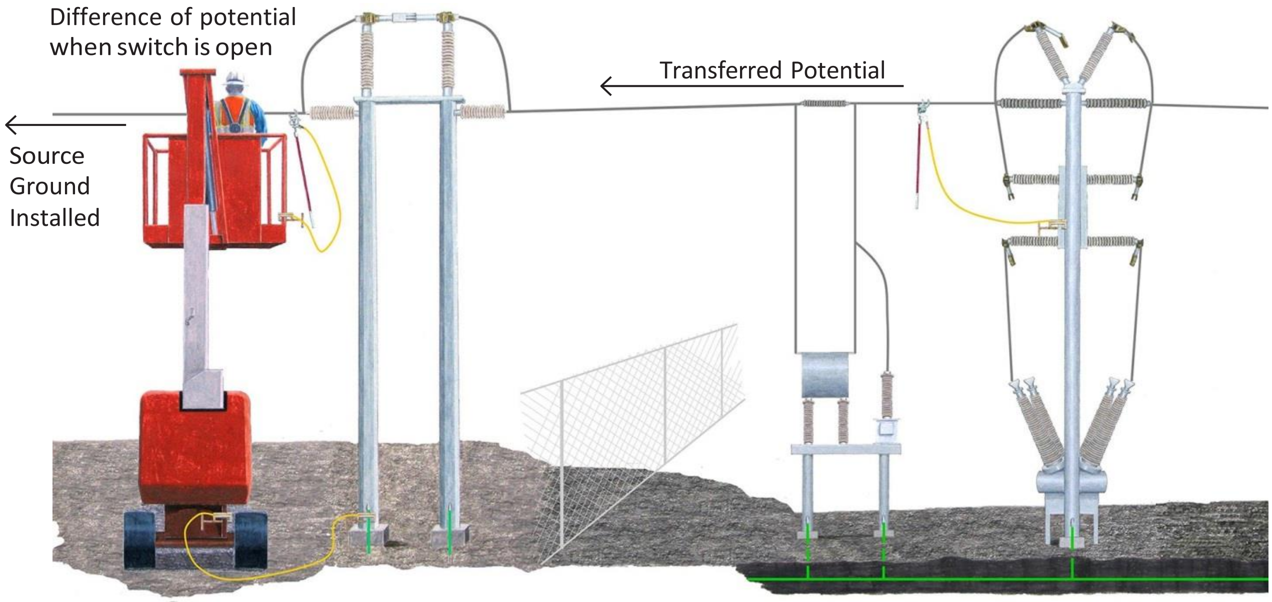

Figure 2.3. Transferred Potential

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2.3 (continued)

5. Different Ground Sources

WARNING

Never get in series with two different ground sources. Never touch an ungrounded wire.

When opening or closing a de-energized and grounded line, employees **must not** place themselves in series between different ground sources.

Lethal current is approximately 1/10 Ampere (A). Figure 2.4 below illustrates the fault current flow in an open circuit, as compared to the fault current flow through a worker that is in series with two different ground sources. The worker is exposed to over 100 times the lethal current.

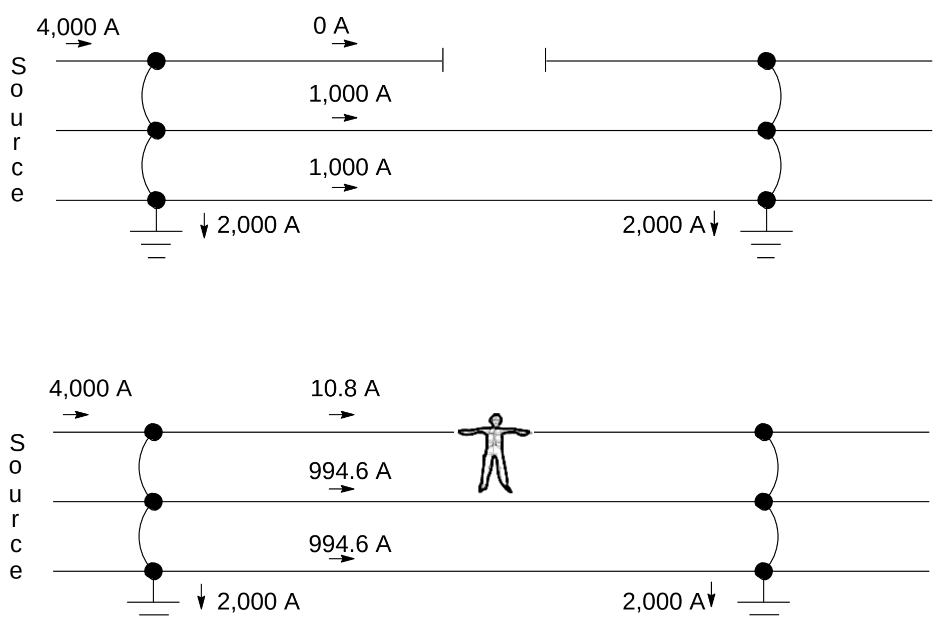

Figure 2.4. Employee in series with two different ground sources.

2.4 Ground Sources

> ⚠ **WARNING**
>
> **Temporary ground rods must be installed as far from the worksite as practical to minimize step potential.**

> ⚠ **WARNING**
>
> **Under fault conditions, a poor ground source will increase the clearing time and step- and touch-potential hazards.**

1. **The common ground source to connect TPG devices should be selected in the following order of preference.**

   a. Station grounds

   b. Adequately sized common neutral in overhead or the concentric neutral in underground

   c. Permanently driven ground rods or permanently grounded equipment

   d. Anchor rods

   e. Temporary auger-type ground rod:

   - Install to maximum depth permitted by the soil conditions.
   - Make every effort to install ground rods to the maximum depth possible.

   f. Temporary driven ground rods 3/4 inch × 5 feet:

   - Install to maximum depth permitted by the soil conditions.
   - Make every effort to install ground rods to the maximum depth possible.

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2.5 Testing the Conductors or Equipment De-Energized

WARNING

Conductors and or equipment are considered energized until they have been tested and proven de-energized by the installation of approved grounding devices.

1. Before using a voltage detector, verify the following:

The voltage detector:

- Is rated to handle the nominal voltage of the equipment or conductors that are being tested.
- Has been used on an energized source or calibrated by a PG&E test lab, Applied Technology Services (ATS), within the last year.
- Is tested on an exposed live part or the test device in the meter carrying case before and after each use to ensure that it is functioning correctly.
- Is in good condition.
- Ground lead and ground clamp (if equipped) are in good condition.
- Is attached to an approved hot stick (refer to utility procedure TD-2008P-01, "Inspection and Testing of Live Line Tools").

2. Testing De-energized

Always test conductors or equipment de-energized with an approved voltage detector before installing grounds (see Appendix B for the manufacturer's instructions for each meter).

NOTE

For information about ordering high-voltage detectors approved for use, see Section 10, "Devices, Components and Tools."

NOTE

Proximity voltage detectors will be permitted for use as long as the meter remains functional. Proximity meters are no longer approved for purchase.

2.5 (continued)

a. Overhead T&D and Substation

NOTE
A live source includes an adjacent energized circuit or the manufacturer's 3kV alternate source supplied with the tester.

NOTE
When testing ungrounded delta bus configurations, refer to "Generators," Section 7 on Page 7-29.

Use only approved live-line tools to test de-energized. A direct line contact voltage detector is the preferred device.

- Perform the manufacturer's pretest.
- Perform a "Live-Dead-Live" test every time when testing a circuit de-energized. This requires taking a meter to a live source or the manufacturer's alternate source supplied with the tester, before and after each use.
- Conductor and/or apparatus must be tested de-energized at each location where temporary protective grounds will be installed.
- Always TEST the nearest and closest conductors first when approaching a circuit.
    - Move across, up, or down sequentially, as appropriate.
    - Maintain minimum approach distance (MAD) from any conductor or apparatus that is not grounded.

b. Resistive-Type Testers

- Pre-inspect unit to ensure the test lead is rated for 15kV and that the ground connection clamp is a C-clamp style (no alligator clips).
- When using voltage meters with ground-reference leads, never use a voltage detector in such a manner that its ground-reference lead or meter housing could contact an energized bus, disconnect, or conductor.
- Ensure that the ground-reference lead is kept away from the employee performing the test and any co-workers in the area during the testing process.
- Never touch a detector's ground-reference lead if it becomes disconnected from the ground source, and immediately remove the detector from the conductor.

2.5 (continued)

c. **Underground**

- Perform a "Live-Dead-Live" test every time when testing a circuit de-energized. This requires taking a meter to a live source or the manufacturer's alternate source supplied with the tester, before and after each use.
    - Capacitive test points are not considered a live source and must not be used to test the operation of a voltage detector.
    - Use a capacitance test on insulated terminations equipped with capacitive test points (elbows).
    - Use a direct line tester on live-front terminations (e.g., stress cones).
    - If the voltage detector does not indicate any voltage, obtain permission from the PIC to continue grounding and notify the grounding observer.

3. When testing determines that voltage is present

If the voltage detector indicates the presence of voltage, STOP the grounding procedure and immediately contact the person in charge (PIC) and make the following checks:

a. Determine if the test was made within the clearance points.

b. Retest the voltage detector.

c. Retest the equipment or circuit.

d. Request that the electric control center recheck the switching operations and verify if the correct clearance points have been established.

e. Identify and eliminate or address the voltage source before proceeding.

2.6 Grounding for all Third Parties and Contractors Working Near Lines Normally Energized at 50 Volts or Above

NOTE

When grounds are installed for cranes or equipment, bracket grounds must be installed and in view of the operator.

1. Grounding requirements

a. Install source grounds for each PG&E fault duty source.

If contractor personnel will be required to make contact with PG&E's facilities to perform their work, all fault duty sources must be mitigated by performing one of the following:

- Remove source jumpers and install insulating protective devices on energized fault-duty source, use Bracket Grounding Option 1. This option cannot be used if there are energized crossings or induction.
- Establish two open points for each fault duty source, install a #2AWG TPG, at a minimum, between the two open points. Address all backfeed sources, use Bracket Grounding Option 2. This option cannot be used if there are energized crossings or induction.
- Remove a span of conductor between each fault duty source and the work location. If the source is isolated by removing a span of conductor, then PG&E grounds are not required for that source.

b. Address backfeed and induction sources, as required.

c. At least one set of grounds must be visible to the qualified person (QP) on site for the duration of the work, or all parts must be covered for the first 15 feet off the ground (in some cases the contractor may qualify as the QP).

d. A PG&E QP must remain on site until all public safety hazards associated with PG&E facilities, including fault duty sources and backfeed sources, have been identified and mitigated.

e. It is PG&E's responsibility to determine if it is safe to transfer responsibility of monitoring the protective grounds to the third party or contract crew lead.

f. Prior to leaving the worksite, the PG&E QP will transfer responsibility of monitoring the protective grounds, by having a safety discussion with the third party or contract crew lead, identifying the location of grounds and worksite boundaries.

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2.7 Approved Grounding Devices

Use only the approved grounding devices listed in Section 10, “Devices, Components, and Tools,” to create protective grounding schemes.

No repairs or modifications of the ground cables are permitted in the field.

The attachments may be changed out, as required, for field applications.

If there is a problem, deficiency, or suggestions for improvement with Section 10 parts or their application, contact one of your departmental Work Methods and Procedures Specialists to work with the PGOC to resolve the problem.

NOTE

For repair of ground sets or components contact Supplies and Solutions (S&S) at 1.800.430.8665.

2.8 Live-Line Tools (Hot Sticks)

Use an approved hot stick while maintaining MAD to install TPGs.

Use an approved hot stick to install personal grounds. Class 2 rubber gloves are not approved for the installation of personal grounds.

Wear Class 2 rubber gloves with approved protectors when installing or removing rolling/traveling grounds.

2.9 Inspecting Protective Grounding Devices

Employees MUST take the following actions to ensure that protective grounding devices are safe and ready to use before each use.

WARNING

NEVER use a grounding device with unapproved components, damaged cables, defective, or broken parts.

1. **Inspect the protective grounding devices prior to installation for the following:**

   - Damaged, broken or frayed ground cables
   - Damaged or split insulation
   - Damaged or broken ground clamps

2.9 (continued)

- Dirty component parts (use a wire brush to clean, if necessary)
- Loose component parts (must be attached tightly)
- Broken or defective mechanical parts
- Components are approved for use, per Section 10
- Current test stickers are attached to all hot sticks and extensions used to install TPGs

2. **Remove grounds from service for any of the following reasons:**
   - Ground cable has damaged or broken strands
   - Ground clamp is damaged or broken
   - Grounds have been subjected to a phase or ground fault

3. **Maintain, store, and transport** the permanently affixed, insulated handles on ground sets as described in TD-2008P-01, "Inspecting, Care and Testing of Live Line Tools."

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SECTION 3: ROLES, RESPONSIBILITIES & QUALIFICATIONS FOR GROUNDING

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3 ROLES, RESPONSIBILITIES & QUALIFICATIONS FOR GROUNDING

3.1 Scope

This section covers the roles, responsibilities, and qualifications of employees participating in protective grounding and is applicable to all departments within PG&E. It is essential that all employees involved in protective grounding perform the work competently to ensure their own safety as well as the safety of their coworkers and the public.

3.2 Employee Qualifications

The information in this section describes the minimum qualifications for PG&E employees:

- Installing and removing temporary protective grounds (TPGs)
- Acting as a grounding observer

WARNING

Employees who work inside of substations on substation assets must have a substation or generation qualified grounding observer direct and observe all grounding procedures.

1. Qualifications for Installing and Removing TPGs

All employees are qualified to install and/or remove protective grounds, provided they meet the following requirements or conditions.

a. Substation/Generation

(1) Trained in PG&E substation grounding procedures

(2) Must be a qualified electrical worker (QEW) **OR**

3.2 (continued)

(3) Under the observation of a QEW.

EXCEPTION: T&D employees may ground T&D assets within a substation using their own grounding practices.

NOTE
Other employees hired as electricians who were trained outside PG&E must have at least one-year experience at PG&E and have demonstrated competence before being considered in the apprentice or journeyman category.

b. Transmission & Distribution

NOTE
When T&D employees are required to ground substation assets, e.g., wire stringing operations, a substation or generation qualified grounding observer must be on-site to direct and observe all grounding procedures.

Employees who ground T&D assets must meet the following requirements:

- Trained in PG&E, T&D grounding procedures
- Must be a QEW **OR**
- Under the observation of a QEW and meet the current apprentice training requirements.

2. Qualifications for Grounding Observer

NOTE
Department's Protective Grounding Training must include a Grounding Observer module.

a. Substation/Generation

- Must be a QEW
- Must have passed PG&E's grounding observer training for the department
- Must have passed PG&E's protective grounding training for the department

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3.2 (continued)

b. Transmission & Distribution

NOTE
Other employees hired as journeyman lineman who were trained outside PG&E must be under the direction of a PG&E QEW or must have successfully completed PG&E's protective grounding training during the on-boarding process (boot camp).

- Must be a Qualified Person (QP)
- Must have passed PG&E's grounding observer training for the department

3.3 Employee Roles & Responsibilities

ALL employees are responsible for ensuring that all applicable safety rules and procedures are followed when testing lines and equipment de-energized, and when installing or removing protective grounds.

The following lists the Roles and Responsibilities for all employees that participate in the installation and removal of temporary protective grounds:

1. Supervisors

a. Ensure that their employees are trained and qualified to perform the protective grounding roles as assigned.

b. Ensure that their employees follow all applicable rules and procedures in this manual.

c. Review and sign all completed Grounding Tailboard/Observer Tailboard forms.

d. Retain completed PG&E Grounding Tailboard/Observer forms per GOV-7101S, "Enterprise Records and Information Management Standard."

2. Person in Charge (PIC)

a. Ensure that an electronic or hard copy of the latest Protective Grounding Manual is on-site.

b. Ensure that personnel involved are trained and qualified for the tasks they are assigned.

c. Ensure employees FOLLOW all applicable rules and procedures in this manual.

d. Notify the Electric Control Center whether "reporting on" with or without grounds, as required in the appropriate department standards for clearance reporting procedures.

e. Assign a grounding observer.

3.3 (continued)

f. Assign a QP to test the conductors or equipment de-energized in preparation for grounding.

g. Conduct and document a grounding tailboard, using the PG&E Grounding Tailboard/Observer form (GTO form) for their department (see Appendix B for forms).

h. Ensure that each crew member SIGNS the Grounding Tailboard/Observer form. (Contractors involved in the work must also sign the form.)

i. Record the following on the Grounding Tailboard/Observer form:

(1) The total number of all protective grounds installed or removed.

Count each of the following as one protective ground:

- Phase-to-phase grounding devices
- Phase-to-ground, or if applicable, structure grounding devices
- Ground and Test Device (Ground Buggy for substation/generation)
- Substation Cluster grounds (counted as three grounds)

(2) The physical location(s) of those grounds, and the place in the circuit where the grounds will be used.

The PIC is not required to count:

- Personal grounds (unless left installed and unattended at worksite)
- Pole band grounds
- Vehicle grounds
- Secondary shunts (substation only, see additional requirements on Step 3.a.(2) on Page 3-5)
- Ground switches or ground buggies (power generation specific) that are installed as part of the switching that are closed as part of the switching
- Rolling grounds or traveler grounds

j. Keep the GTO form at the jobsite while the work is in progress.

k. Check the completed GTO form for accuracy.

l. Submit GTO form to the first-line supervisor after work is completed.

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3.3 (continued)

3. Additional PIC Requirements for Substation, Generation and Metering

a. Substation:

(1) Place the GTO form in the grounding tailboard binder, located in the station control room when the crew is re-assigned to a different location.

(2) Record and count secondary shunts (as described in Section 7.3.3) in the "Note" section of the grounding part of the GTO form; they do not get reported to operations.

b. Generation:

(1) While work is in progress:

- Attach the GTO form to the field copy of the Switching Log when working at unattended stations and facilities.
- The GTO form will remain under control of the Crew Foreman or Person-in-Charge (PIC) when working at switching centers and attended stations.

(2) When work is completed and all grounds have been removed:

- Attach the completed GTO form to the field copy of the Switching Log when working at unattended stations and facilities.
- Submit the completed GTO form to the Control Room Operator when working at switching centers and attended stations.

c. Customer Metering:

Qualified T&D or Substation employees are responsible for:

- Requesting and holding clearances.
- Performing switching.

NOTE
The department most familiar with the equipment being grounded will be responsible for grounding.

3.3 (continued)

(1) The PIC of a high-voltage customer metering job must be either:

- A Meter Crew Lead **or**
- A Qualified Meter Supervisor

(2) The PIC is responsible for:

- Determining when protective grounds are required for customer metering work.
- Coordinating work with the responsible line of business.
- Defining what customer metering work will be performed.
- Determining where the customer metering work will be performed (both the physical location and the location in the circuit).
- Determining which **department** would be best suited for installing the grounds:

  If the substation department is best suited, their department is responsible for installing and removing protective grounds on substation equipment/circuits

  - A qualified observer from the Substation Department is required when substation employees will be installing the TPGs.

  If Transmission or Distribution is best suited, their department is responsible for installing and removing protective grounds on transmission or distribution circuits.

  - Meter Techs will act as the Qualified Grounding Observer for the T&D line worker(s) while they are installing TPGs in electric metering switch gear.
  - Making arrangements for a QEW to install and remove the TPGs as appropriate.
  - Verifying that the customer metering work to be performed is within the grounded portion of the circuit.
  - Notifying the Clearance Holder when the work is completed and it is safe to remove the grounds.

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3.3 (continued)

4. Qualified Employees and Grounding Observer Responsibilities

a. All Employees

(1) Ensure that an electronic or hard copy of the latest Protective Grounding Manual is on-site.

(2) Ensure that the requirements in this manual are followed at all times.

(3) Ensure employee(s) installing or removing TPGs are qualified, according to department procedures.

- **If not qualified,** employees must immediately notify the PIC or their supervisor.

(4) Stop any member of the crew that fails to follow the rules or work procedures in this manual. Contact the supervisor or PIC, if necessary.

(5) When unsure, ask questions to eliminate any misunderstanding concerning the grounding procedure.

(6) Identify and protect from all electrical sources.

b. Grounding Observer

(1) Maintain a clear line-of-site with employees installing or removing protective grounds.

(2) Verify that the line was tested de-energized with an approved voltage detector.

(3) Ensure the ground source is a clean bare metal surface.

(4) Ensure that only one worker at a time installs or removes a protective ground.

(5) Ensure that TPGs are installed in the proper sequence.

(6) Use 3-way communication and stop all unsafe acts.

(7) Verify/know the MAD for the circuit being grounded.

(8) Warn the employee(s) installing TPGs if:

- They are too close to ungrounded conductors, or grounding jumpers installed on ungrounded phases.
- They are in danger of making contact with the ground cord during installation or removal of TPGs.
- Any condition arises that could jeopardize the safety of the employee(s) or equipment.

3.3 (continued)

(9) Ensure that the ground cord is connected to the ground source before it is applied to the conductor.

(10) Ensure that all personnel are clear of the “ground cord” and “ground source” before the ground is applied to the conductor.

EXCEPTIONS:

- The grounding observer may assist with the grounding activity, as long as it does not diminish their ability to perform the observer responsibilities.
- Vehicle and equipment grounds may be installed or removed without a grounding observer.
- T&D workers may install or remove personal grounds on overhead facilities without a grounding observer.
- Underground Distribution always requires a grounding observer.
- Substation employees may install or remove personal grounds without a grounding observer only when the source grounds are within sight.

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SECTION 4: TRANSMISSION: OVERHEAD AND UNDERGROUND

CONTENTS

4.1 Scope 4-1
4.2 Temporary Protective Grounds (TPG) Size and Fault Duty 4-1
4.3 Requirements for Installation and Removal of TPGs 4-6
4.4 Overhead Transmission 4-11
4.5 Underground Transmission 4-35

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4 TRANSMISSION: OVERHEAD & UNDERGROUND

4.1 Scope

This section of the manual provides rules and procedures for creating protective grounding schemes within overhead and underground Transmission facilities.

The person in charge (PIC) will discuss with the crew and select the safest method of grounding for the work being performed. The application and procedures outlined in this section must be followed for the method chosen. The PIC must ensure an electronic or hard copy of the latest version of the Protective Grounding Manual is at the worksite.

4.2 Temporary Protective Grounds (TPG) Size and Fault Duty

1. Introduction

Source grounding devices must be able to carry the anticipated fault current at the location where the grounds will be installed—for the length of time it will take for the fault to clear, or they must be same size or larger than the conductor being grounded.

The information contained in this section will help you select the size of the temporary protective grounding components that will ensure your grounds will meet the requirements above.

Consideration of fault duty sources must include:

- Single switching error that would energize the worksite
- Credible mechanical failures of the clearance point that could result in energizing into the worksite
- The accidental contact of a nearby energized conductor
- When working on a conductor in the span of a crossing and:
    - Lines cross over any line energized at greater than 300V, or
    - Lines cross under and are within 10 feet of line greater than 300V.

4.2 (continued)

2. Selecting the Appropriate TPG Size for Overhead Work

Use one or more of the following options to ensure you select and install grounds that will protect employees if the line accidentally becomes energized.

a. **OPTION 1: Install grounds that are the same size or larger than the conductor being grounded per** Table 4-1 (the simplest method for selecting the size of TPGs).

Testing has shown that when the TPG is the same size or larger than the conductor being worked, the conductor will melt before the TPG. For conductors larger than 4/0 AWG, refer to Options 2, 3 or 4.

Table 4-1. Minimum TPG size by Conductor sizes.[1]

Source Conductor Size	TPG Size
#2 AWG or smaller	1 – #2
2/0 AWG or smaller	2 – #2 or 1 – 2/0
4/0 AWG or smaller with Distribution Source only	2 – 2/0 or 1 – 4/0
4/0 AWG or smaller with Transmission Source must use Multi-Point	2 – 2/0 or 1 – 4/0

[1] The information contained in Table 4-1 is for both Transmission and Distribution circuits regardless of fault duties or clearing times.

b. **OPTION 2: Size for Maximum Available System Fault Currents and Clearing Times.**

(1) Use 2 – 2/0 TPG for transmission circuits.

EXCEPTION:

- Circuits within one mile of a substation, use one of the other options

NOTE

If fault-current data is not known for lines that PG&E does not own, use this option.

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4.2 (continued)

c. OPTION 3: Fault Duty Mitigation Methods

(1) For the Overhead Transmission Sources – ground with a minimum #2 TPGs after establishing a double open (see Section 4.4, Step 2.g on Page 4-19) by performing a) or b) or c) below, and meet the condition of d).

a) Two inline open devices rated for the voltage

- Switches
- Disconnects
- Cutouts
- Line openers
- Strain insulators
- Jumpers

b) Or a removed span of wire

c) Implement the substation Double Open/Double Lock procedure in the substation. Refer to Section 7 (7.3.1 and 7.3.2) that list requirements for procedure not ground size.

d) All additional fault duty sources addressed

d. OPTION 4: Size TPGs for the maximum available fault duty and clearing time at your worksite, see Figure 4.1 on Page 4-4.

- When clearance limits have different fault duty sources available, the TPGs must be sized at a minimum to the fault duty available at each clearance limit.
- The 15-cycle Clearing Time columns can be used if the actual clearing time at the worksite has been verified as 15 cycles or less.
- Size per Table 4-2 on Page 4-4.

4.2 (continued)

Table 4-2. TPG Fault Duty Capability.

TPG Size	15-Cycle Clearing Time (Includes all Transmission Sources. Also applies to instantaneous zone of Distribution Sources) reclosing cut-in[2]
#2 Cu	9.5kA
2 – #2 Cu	18kA
1 – 2/0 Cu	20kA
2 – 2/0 Cu	38kA
1 – 4/0 Cu	32kA
2 – 4/0 Cu	61kA[1 3]

1. Cut out reclosing at 61kA and above, or use substation double open/double lock mitigation procedures at the time of the clearance.
2. TPG capability is downgraded when subjected to multiple faults (reclosing cut-in).
3. Single Point may not be used.

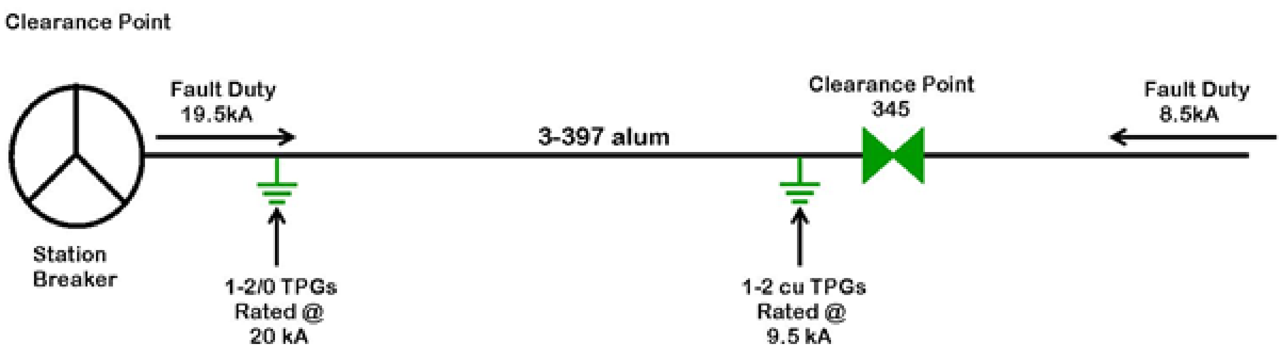

Figure 4.1.

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4.2 (continued)

3. Selecting TPG Sizes for Underground (UG) Transmission Circuits

Ground for fault duty (Option 3 or Option 4 on Page 4-3).

4. For Transmission Source and EXCEPTION Circuits List

a. METHOD 1: Use Substation Grounding Fault Duty website.

Use the fault duty of the buss that the line originates from. To navigate to the substation fault-duty website, perform the following steps. Do not forget to save the website as a "Favorite."

(1) Go to PG&E's Intranet home page, "PG&E@Work TODAY."

(2) Click on "Tools."

(3) Click on "Technical Tools" on the right side of screen.

(4) Scroll down to select "Substation Grounding Fault Duties."

(5) Scroll down to find the "Substation Buss," for Transmission Sources.

(6) Click on the tab labeled "EXCEPTION Dist Circuits," for the EXCEPTION circuits list.

b. METHOD 2: Request actual values of fault duty on your clearance request.

To request the fault duty for your worksite, use the "special set-ups" space on your clearance request. This will serve as a flag to System Protection, and will prompt them to calculate fault duty for your worksite, so you can properly size your grounds.

4.3 Requirements for Installation and Removal of TPGs

1. Installation (Overhead)

WARNING

The grounding observer or the employee installing protective grounds must ensure that all employees are clear of the ground cord before the connection is made between the ground cord and the conductor.

a. Inspect protective grounds.

- Remove from service any grounding device that fails inspection until it can be repaired or replaced.

b. Verify that all grounding devices are clean.

c. Verify the ground source is in good condition and rated for the fault duty.

d. Clean the surface of the ground source before connecting the ground cord, when required.

- Never connect ground tail clamps to painted surfaces (bare metal contact is required).

e. Connect the ground cord to the preferred ground source before applying grounds.

f. Adjust ground clamps for the proper size and angle for the conductor being grounded.

g. Ensure that the PIC has authorized the installation of grounds before installing TPGs.

h. Test the line to be grounded de-energized.

i. Maintain Minimum Approach Distance (MAD) from adjacent energized and ungrounded conductors when installing and removing TPGs (see Exception on Page 4-10).

- Extension sticks or telescopic sticks will be needed to maintain these distances when grounding circuits at or above 230kV.

j. Avoid contact with TPGs during installation and removal.

k. Install TPGs in the following manner:

(1) Always use hot sticks when installing or removing TPGs.

- Class 2 rubber gloves with approved protectors must be worn when installing traveling grounds.

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4.3 (continued)

(2) In such a way that they will not need to be relocated after the work has started.

(3) Tighten ground clamps by hand. Never use mechanical advantage other than a hot stick.

(4) Avoid placing connections directly above or directly below you.

(5) With quick, positive contact.

- Should an arc occur, do not attempt to remove the TPG from the conductor, **maintain contact** and allow the upstream protective device to de-energize the line.

l. For grounding methods that include the installation of a pole band:

(1) Place the pole band as close as possible to the line to be grounded and below the workers' feet.

(2) Tighten the chain around the pole.

(3) Screw in the lag, as far as possible.

(4) Address all foreign grounds within the EPZ.

(5) Consideration must be made to ensure the length of TPG jumper from the pole band to the line is long enough, particularly when the work entails moving the conductor, such as in a pole transfer.

m. Install the "ground source-to-phase" jumpers.

(1) Maintain MAD from ungrounded conductors.

(2) Ground the nearest or closest conductor first.

(3) Create an EPZ when working on that structure.

(4) Avoid contact with grounded conductors until ALL of the phase conductors of a circuit are grounded.

(5) Attach and position the ground clamps in a way that prevents employees from contacting them while installing or removing the grounds, or when working.

(6) Install all ground clamps immediately adjacent to each other, with no deliberate separation. The separation distance must never exceed 3 inches.

(7) TPG cables attached in parallel on a phase must all be of the same length (+/- 10%) and size.

4.3 (continued)

n. Ensure that TPGs are connected to the ground source, then connect the "ground cord" from the ground source to the line.

- If the ground cables must pass through another circuit, de-energize or insulate the circuit(s) which the ground cables must pass through (Line Department only).
- Secure ground cables which pass through energized circuits.

o. When grounding lines with bundle conductors do the following:

(1) Install ground(s) on each sub conductor of a phase before grounding the other phases.

a) Regardless of TPG requirements, install at least one ground on each sub conductor or ground one sub conductor in addition to installing shunt(s) between each sub conductor.

b) When required to install parallel grounds per phase on bundled conductor lines, install one TPG on each sub conductor.

c) If the sub conductor(s) will be separated on any portion of the line being worked, parallel TPGs must be installed on each sub conductor per phase.

WARNING

Testing has shown that a coiled ground cord, under fault conditions, will be pulled apart or destroyed by the mechanical forces created at much lower fault currents than for which they are rated.

p. Lay ground cables in a smooth continuous line (see Figure 4.2 on Page 4-9).

- Do not coil or cross ground cables.

q. Connect the ground cable that is attached to the ground source to the conductor.

- Connect the TPG to the largest conductor, where there are multiple conductor sizes.

r. Connect TPGs of different circuits to the same ground source when working on a structure that supports multiple circuits regardless of the voltage of the circuits, e.g., 12kV, 21kV, 70kV, etc.

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4.3 (continued)

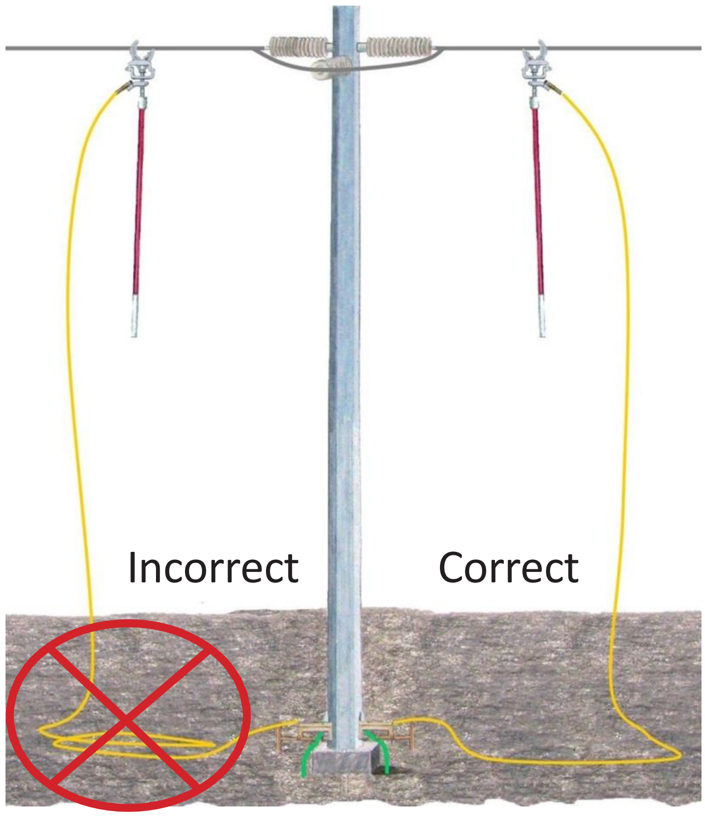

Figure 4.2. Correct and Incorrect Ground Cable Layout.

2. Removal

a. The PIC must approve the removal of TPGs after all work has been completed on the circuit, and all employees are clear of the grounded circuit and/or equipment.

b. The original Grounding Observer must be present when the grounds are removed.

If the original Grounding Observer will not be present, the PIC must:

(1) Review original Grounding Tailboard Observer (GTO) form to identify location and number of TPGs to be removed.

(2) Ensure all grounds are removed and complete per the GTO form (see Appendix B).

4.3 (continued)

WARNING

Removing the wrong clamp could result in death or serious injury.

c. Remove TPGs starting with the farthest conductor first.

d. Remove the ground cord from the ground source.

(1) ALL TPGs **must** be removed from the conductor(s) or equipment, before the ground cord is disconnected from the ground source (ground rod, anchor rod, etc.).

If there are multiple ground clamps on the same ground source that are connected within one foot of each other, remove all TPGs from the phase conductors, before removing **any** of the clamps from the ground source. (This will prevent inadvertently removing the wrong clamp.)

EXCEPTION: On steel structures, it is permissible to remove a ground from a single conductor/phase, and then remove the related ground clamp from the structure – before removing the other phase grounds – provided that:

- The MAD can be maintained after the ground has been removed, and
- All the related ground clamps are NOT attached within reach of one another on the structure.

e. The PIC must ensure the GTO form is completed when the TPGs are removed.

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4.4 Overhead Transmission

Unless working as energized, always install grounds when working on conductors or equipment normally energized in excess of 600 volts (V).

Conductors and or equipment are considered energized until they have been tested and proven de-energized by the installation of approved grounding devices. Once conductor has been deemed ready to install into its normal operating position, isolated from all grounded surfaces, ground-based employees are in the clear, and all grounds have been removed, energized work procedures can be utilized.

1. Approved Grounding Methods

a. **Multi-Point Grounding** is the combination of source grounds and a personal ground with pole band at the worksite.

For multi-point grounding, you must:

(1) Install properly rated TPGs (source grounds) located between the worksite and all fault duty sources.

(2) Locate TPG source grounds as close as possible to the worksite; and

(3) Use personal grounds at each intermediate pole/structure to be worked (see Figure 4.3 on Page 4-12). The following requirements apply to personal grounds:

- Approved #2 Cu ground jumpers may be used for all personal grounds.
- Personal ground(s) must be installed to create an EPZ around the worker.
- Foreign grounds within the EPZ must be tied to the pole band or insulated (see Section 4.4, Step 2.a on Page 4-17).
- One end of the personal ground must be connected to the phase being worked, the other end is connected to:
  - A pole band located below the worker on wood and fiberglass poles.
  - A pole step on concrete poles, or
  - A ground tab, pole band, angle iron, or pole step. Pole steps must make good electrical contact with the steel.

NOTE
If any portion of your body can contact a phase not protected by the personal ground, additional personal grounds must be installed.

4.4 (continued)

NOTE

Multi-Point Grounds can be installed at the same structure where work will be performed—provided they are installed where none of the components of the grounds can be inadvertently dislodged from the structure.

NOTE

At least one set of Multi-Point or Source Grounds must be visible to a PG&E employee for the duration of their work. If grounds are not visible to the employee, at least one of the following conditions must be applied;

- All components must be covered for the first 15 feet off the ground.
- All components must be connected at least 15 feet off the ground.

NOTE

Test de-energized and install Source Grounds from below the phase to be grounded; with the exception of horizontal configured lattice steel structures and helicopter work procedures.

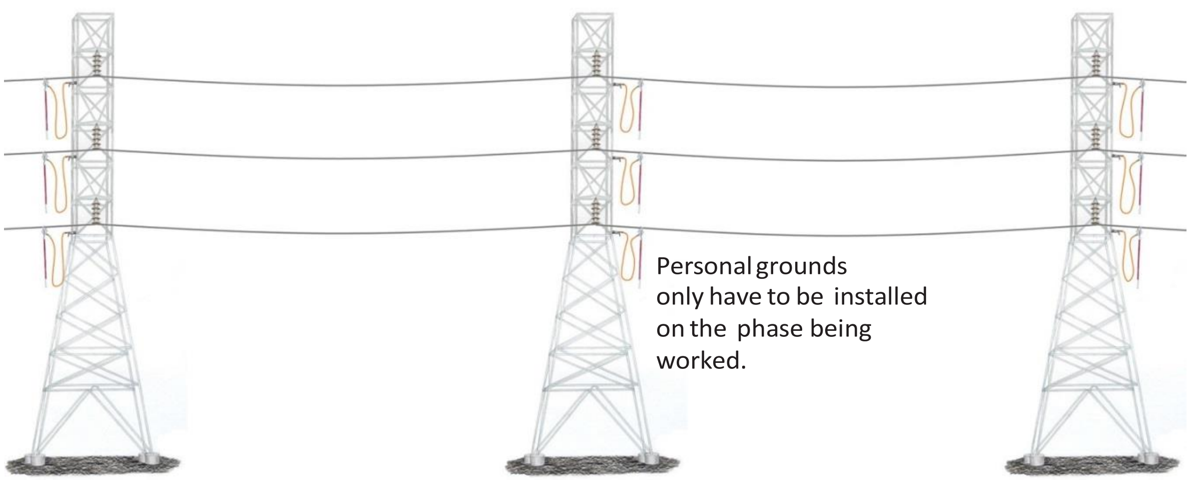

Figure 4.3. Multi-Point Grounding.

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4.4 (continued)

b. **Single Point Grounding** is the application of temporary protective grounds on all conductors at the worksite to a common ground source, establishing an equipotential zone.

Single Point Grounding may be used if ALL of the following conditions exist:

(1) The worker is within 15 feet of where the TPG is attached to the conductor.

(2) There is no more than 30 feet of TPG length in parallel with worker.

(3) Single Point Grounds are installed per Figures 4.4 through 4.7 on Pages 4-14 through 4-16.

(4) No induction hazard exposure.

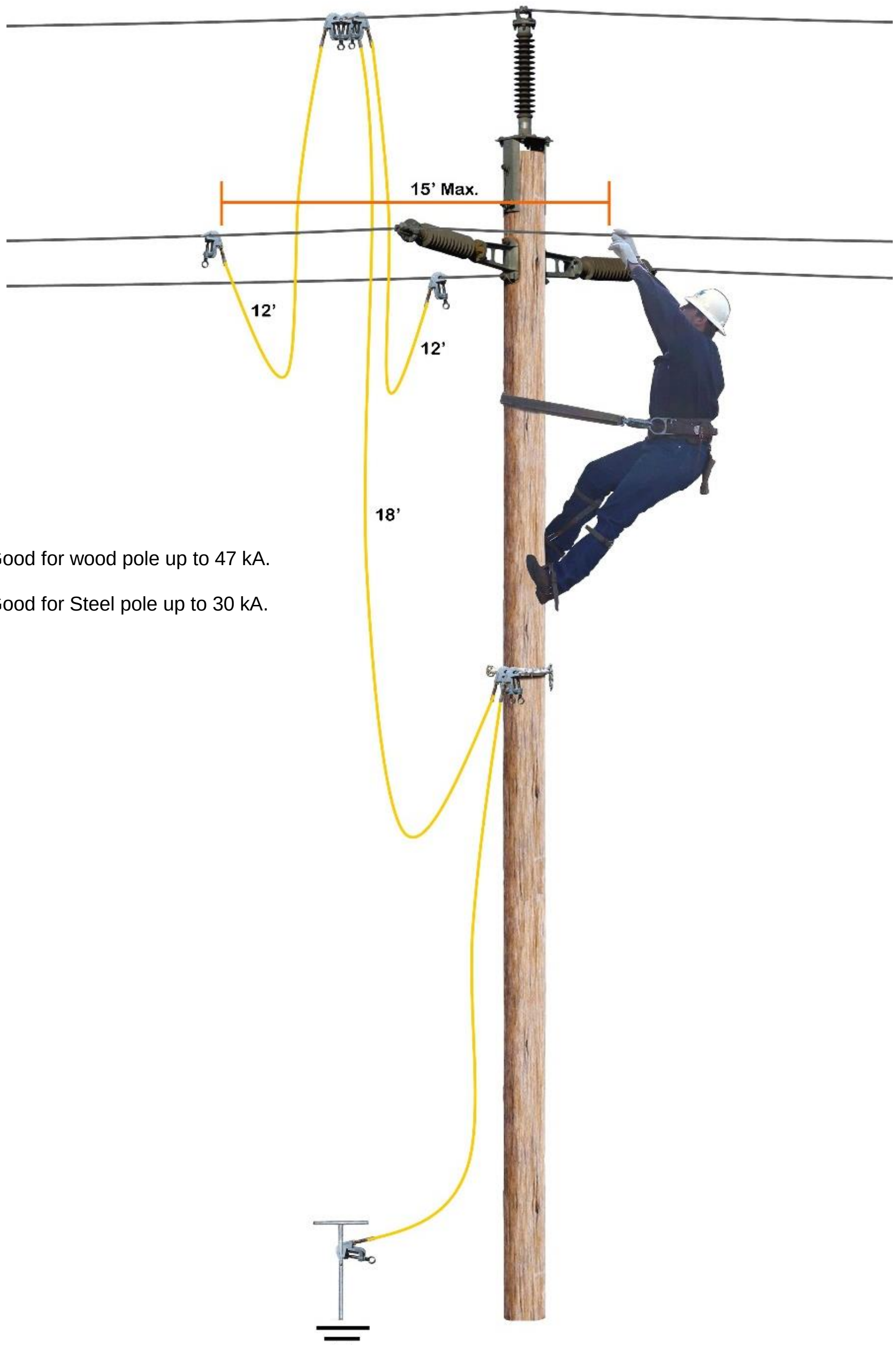
(5) Consideration must be made to ensure the TPGs are long enough, particularly when moving or transferring conductor.

Exceptions to induction hazards:

- Single point grounding can be used in any case when conductor **is not being worked,** regardless of induction exposure. Some examples include:
  - Minor maintenance, such as high signs or filling wood pecker holes
  - Installation of raptor protection
  - Painting of structures
- Single point grounding can also be used in specific cases where conductor **is being worked** regardless of induction exposure, and is limited to the following:
  - Insulator replacement
  - Reframing

Meet all conditions stated above, and address all foreign grounds per Section 4.4, Step 2.a on Page 4-17.

4.4 (continued)



Good for wood pole up to 47 kA.

Good for Steel pole up to 30 kA.

Figure 4.4. Single Point Grounding #1

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4.4 (continued)

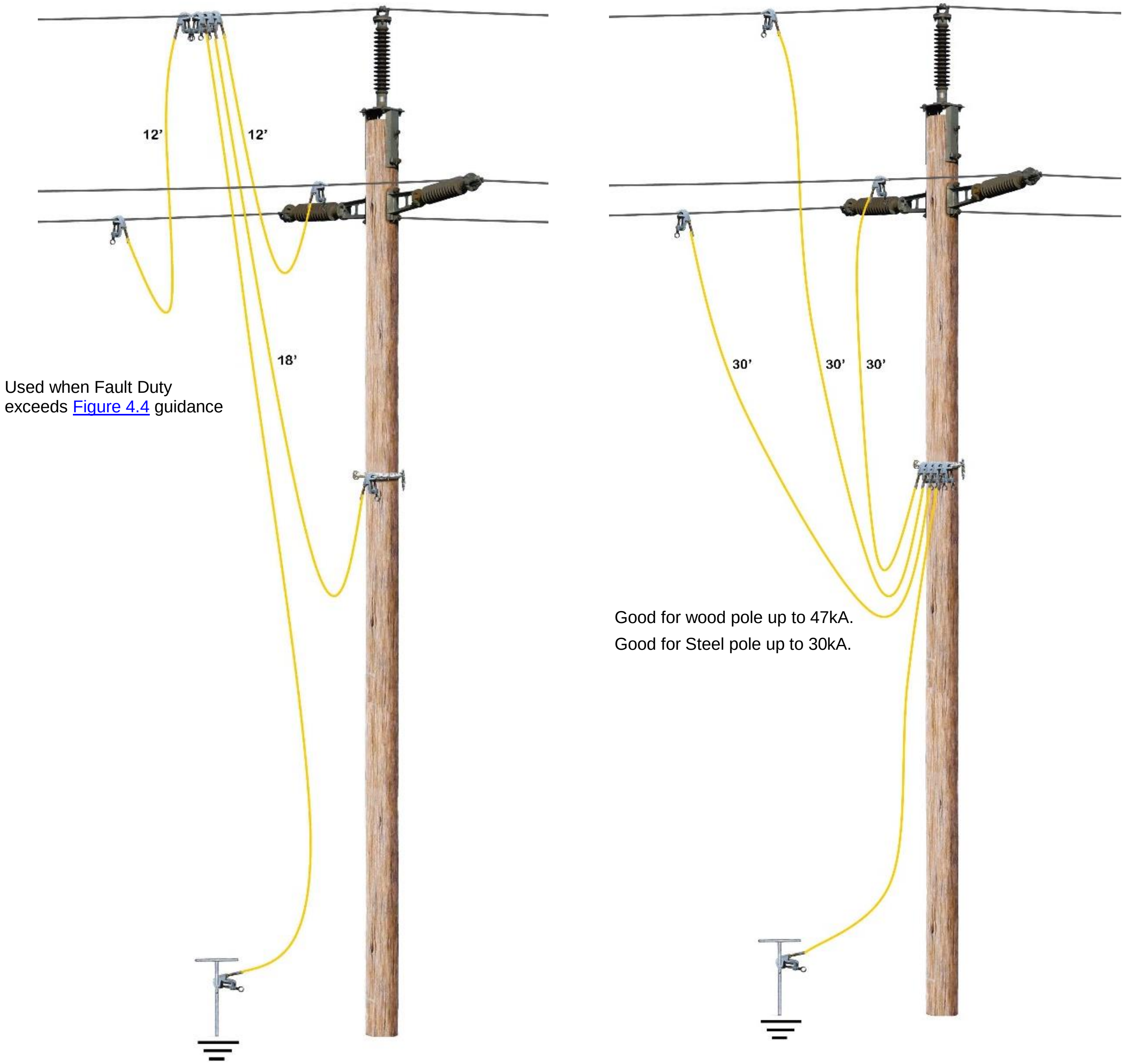

Figure 4.5. Single Point Grounding #2

4.4 (continued)

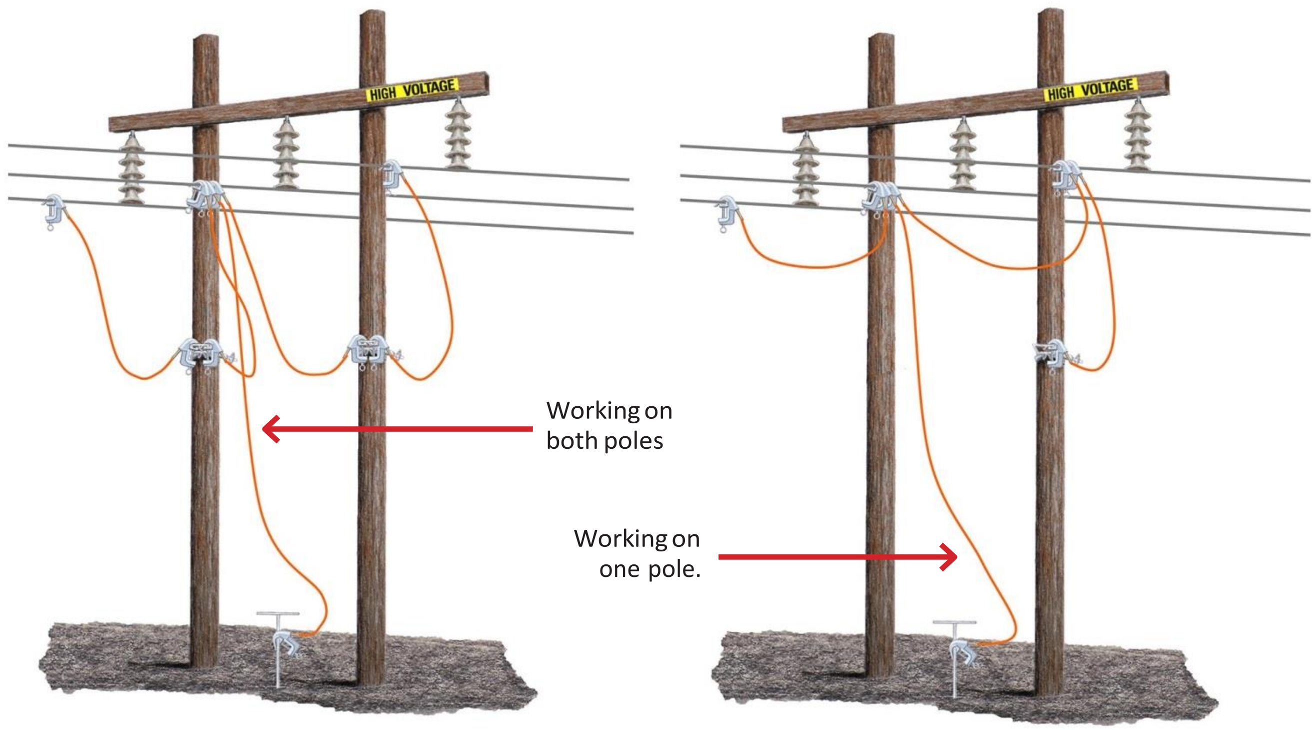

Figure 4.6. Single Point Grounding #3

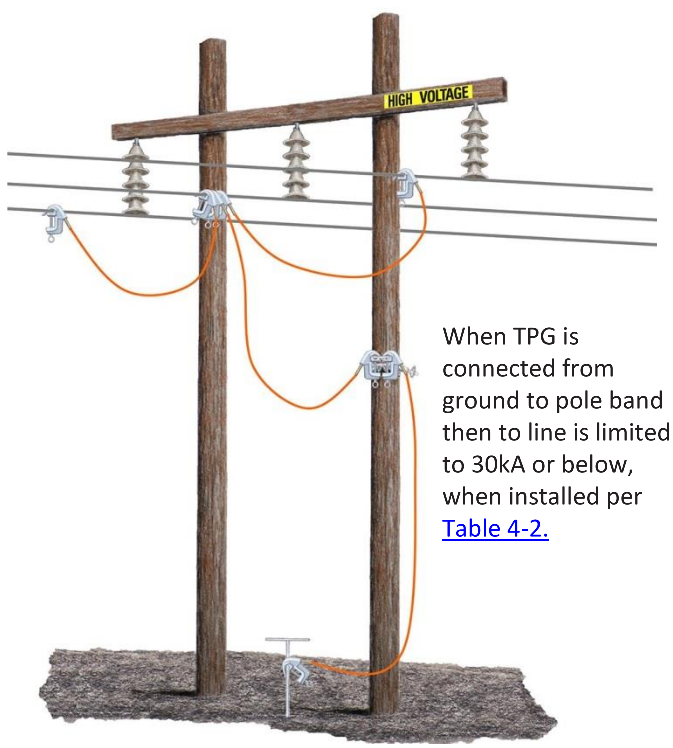

Figure 4.7. Single Point Grounding #4

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4.4 (continued)

2. General Requirements

a. Foreign Grounds at Your Worksite

When creating an EPZ on a pole, use an approved TPG to connect all foreign grounds that can be contacted from within the EPZ to the pole band. Foreign grounds not attached to the pole can be insulated using approved protective devices. Some examples of foreign grounds are:

- Down guys
- Transformer grounds
- Lightning-arrester grounds
- UG cable concentric on a riser
- Third party messengers, i.e., phone, cable TV, and fiber optic lines

b. Open Points

Open points, or devices that can create open points, represent a potential hazard. ALL open points at the worksite MUST be grounded on each side (or jumpered) before an employee can come into contact with both sides. The ground must be to a common ground source at that worksite. Examples of open points include the following:

- Switches
- Sectionalizers
- Any opened or removed section of conductor

WARNING

Never get in series with two different ground sources. Never touch an ungrounded wire.

c. Adequately Insulated and Sectionalized Guy Wires

- Tie the guy wire ABOVE the guy insulation to the ground scheme if exposed to induced electric fields.
- Workers on the ground or structure must NOT bridge the guy insulation without properly installed jumpers.

4.4 (continued)

ADEQUATELY INSTALLED guys are:

- Insulated guys exposed to only distribution sources.
- Guys with strain link stick (6 foot, at a minimum) exposed to transmission sources; the guy wire below the strain link stick may be a foreign ground.

d. Inadequately Insulated and Sectionalized Guy Wires

INADEQUATELY INSULATED guys are:

- Transmission structure with distribution underbuild.
- Transmission guy without the strain link stick (fish stick).

If guy wires are not adequately insulated:

- You MUST tie guy wire to the ground scheme.
- Workers on the ground must avoid contact with guy and anchor.
If contact is necessary, Class 2 rubber gloves with approved protectors and EH boots are required.

WARNING

Never get in series with an open point between a guy wire and any other metallic object including other guy wires and other anchor rods.

e. Anchor as a Ground Source

- Consider the physical condition, and location of an anchor rod before using it as a temporary ground source.
- Attach the ground clamp to the anchor rod, not the guy wire or preform.
- Do not use anchor extensions as a ground source (see Figure 4.8 below).

Figure 4.8. Anchor Extension

4.4 (continued)

NOTE

See Engineering Document 022221, "Anchors for Pole Line Guys"

- Rock anchors must NOT be used as a ground source.
- If work is to be performed on the down guy, consider using a different ground source instead of that anchor.
    - Disconnecting a down guy from an anchor sets up a situation in which it is easy to get in series between two different ground sources.

f. Bond Wires and Ungrounded Metal Hardware

WARNING

Avoid contacting bond wires and ungrounded metal hardware.

g. Establishing Additional Open Points (Double Open)

The use of personal grounds is not required if all of the following conditions are met (see Figure 4.9 and Figure 4.10 on Page 4-20):

(1) Install a set of fully rated grounds for each fault duty source.

(2) Remove a span of wire or establish an additional open point, and install "Caution" tag between all FAULT DUTY sources and the worksite.

For example:

- Open switches, disconnects
- Remove or open jumpers/leads (secure the jumpers/leads as necessary)
- Open temporary sectionalizing devices that are rated for the voltage:
    - Line openers
    - Strain insulators

(3) Install a set of TPGs on conductor to be worked to prove the line de-energized. This step may be omitted if fully rated TPGs were installed before the additional open points were established.

- This set of TPGs must be removed prior to working on or contacting the line. No energized line crossings 300 volts or higher.

4.4 (continued)

(4) No induced voltage from adjacent and parallel lines.

(5) No lightning in the area.

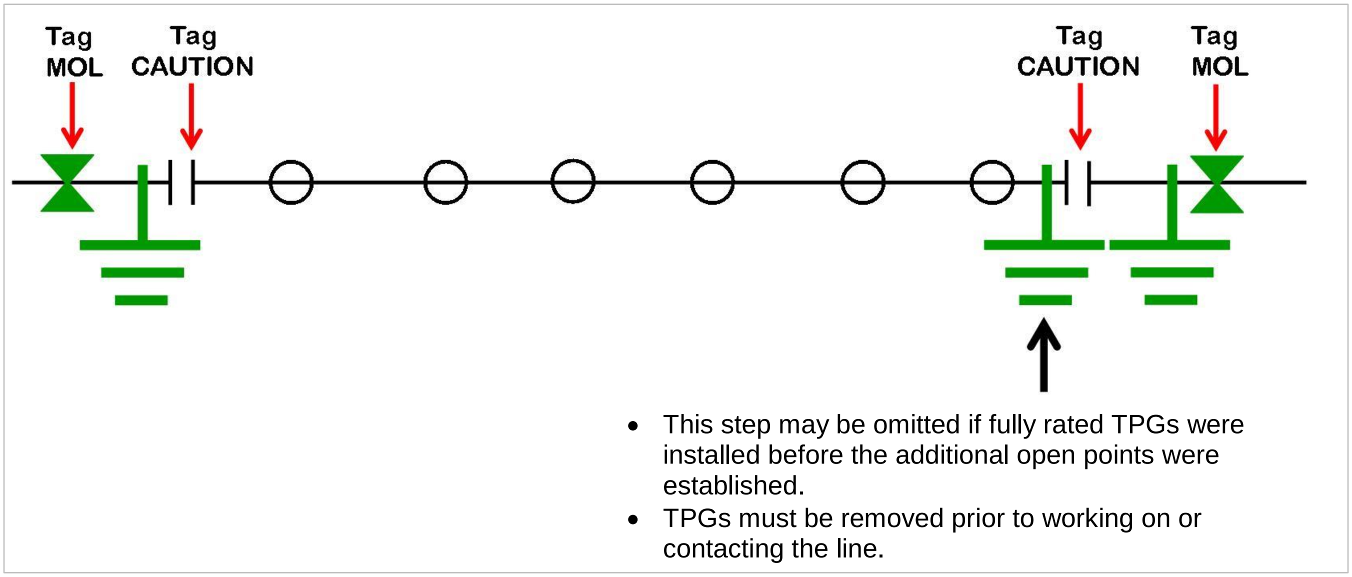

Figure 4.9. Addressing transformer backfeed within double open points.

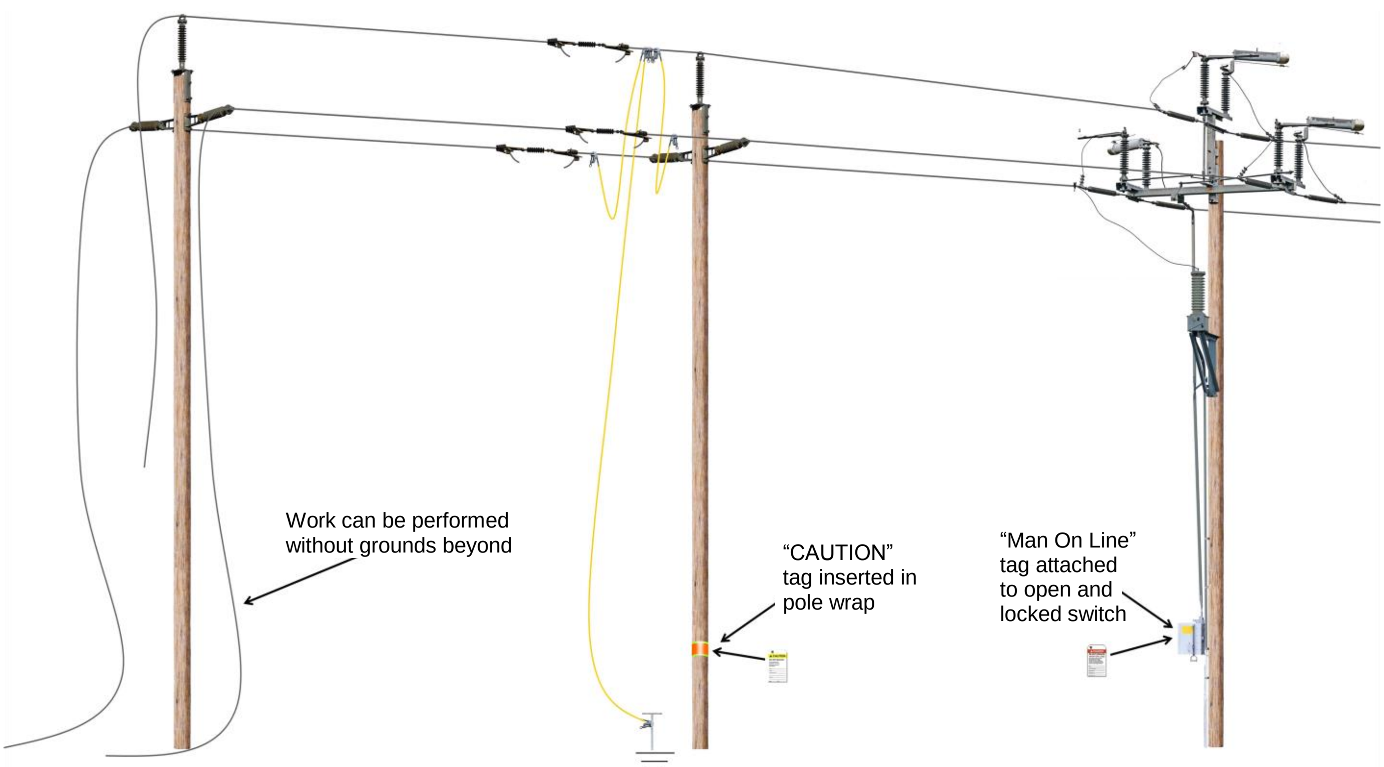

Figure 4.10. Example of double opens

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4.4 (continued)

h. Safety Clearance

A clearance that is established as described in the definition of a regular clearance (per TD-2700S, "Electric Distribution General Operating, Clearance, and Non-Test Instructions") and used in conjunction with other work performed to establish a safe working zone. Personnel cannot perform work under a safety clearance; however, the clearance holder must "Report on" the safety clearance and must specify if grounds are to be used.

Examples:

- Stringing wire in parallel with other lines which pose a hazard
- Washing insulators

i. Pole Band

A lag screw has been added to the pole band to ensure that the pole band assembly makes contact with the conductive interior of the pole.

Installing:

(1) Install the pole band where the final position will be below the workers' feet and as close as possible to the line to be grounded.

(2) Tighten the chain around the pole and screw in the lag, as far as possible.

(3) Prior to installing the TPG from the pole band to the line to be grounded, the workers' feet must be above the pole band (within the EPZ).

(4) Once TPGs are installed, nothing prevents employees from transitioning above or below the pole band.

(5) All foreign grounds between the pole band and the line to be grounded must be addressed.

(6) Consideration must be made to ensure the length of TPG jumper from the pole band to the line is long enough, particularly when the work entails moving the conductor, such as in a pole transfer.

3. Installing & Removing Overhead (OH) Lines

a. Terminology

(1) **EXPOSURE** — refers to any condition that could result in accidental contact with:

- An energized conductor
- De-energized circuits with different grounding requirements
- Induced voltage

4.4 (continued)

(2) **LINES** — include:

- Metallic pulling lines (i.e., sock lines)
- Messengers
- Guy wires
- Communication lines
- Transmission, secondary, and primary conductors (including aerial cable and common-neutral conductors)

b. **Grounding to Limit Exposure to Crossings and Induced Voltage** (see Section 2.3.1, "Induced Voltage")

When installing or removing lines where induction exposure is present, perform the following that apply:

- Ground all pulling and tensioning equipment.
- Install traveling grounds at the tension and pulling site wearing Class 2 rubber gloves with approved protectors.
- When metallic pulling lines are used, install traveling grounds or equivalent to the metallic line.
- Ground the line at the first structure adjacent to both tensioning and pulling setup.
- Ground the line at least every two miles.
- Barricade the grounded equipment.

NOTE

Grounds other than traveling grounds and vehicle grounds must be installed and removed with hot sticks.

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 Obsolete

4.4 (continued)

c. **Crossings, Overbuilds, Underbuilds** (see Figure 4.11 below, Figures 4.12 and 4.13 on Page 4-24 and Figure 4.14 on Page 4-25)

When grounded conductors are going to be moved, or the work may allow the conductor to move, and they are:

- Over a circuit energized at 300V or more, or
- Under and within 10 feet of a circuit energized at 300V or more.

YOU MUST:

- Install rope nets, or guard structures, or isolate, or insulate the workers, or the energized conductor.
- Cut out the reclosing relay.
- Ground conductor being installed on either side of crossings.
- Conductors must be kept under control by use of tension reels, guard structures, tag lines, or other means to prevent contact with energized circuits.
- Guard structures must be of adequate dimension and strength to safely support anticipated loads.

When working on lines that cross over lines normally energized below 300V, workers must insulate with appropriate PPE.

d. **Involving Substation**

When pulling cable or wires into or out of a substation, see Section 7.7.1 and contact the Transmission Methods and Procedures Specialist.

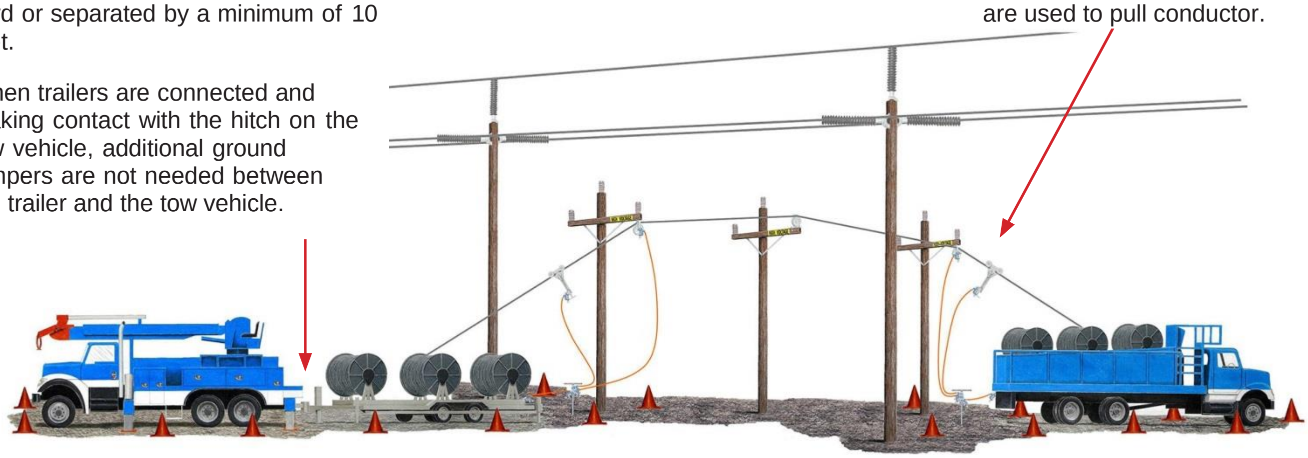

Figure 4.11. Crossing

4.4 (continued)

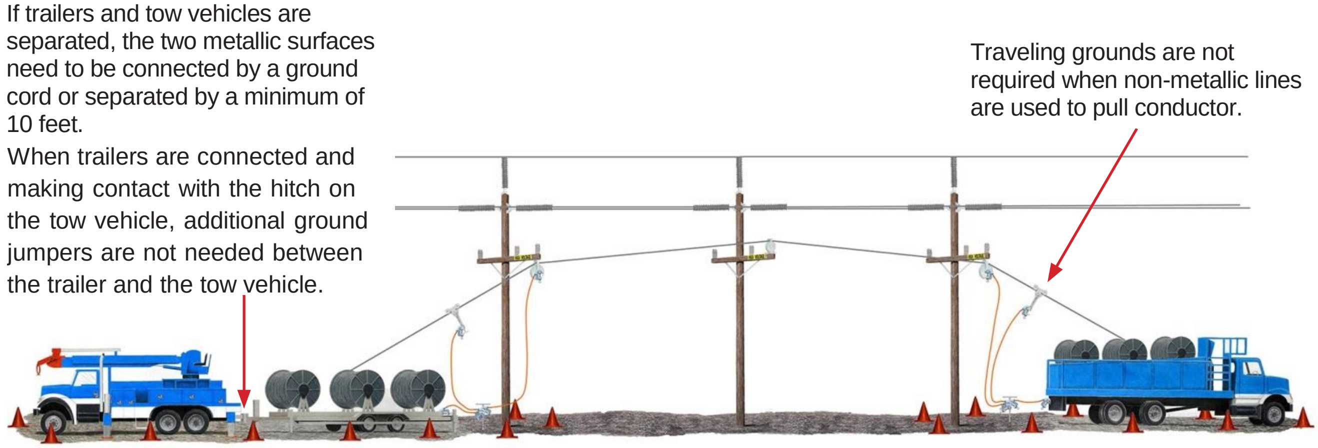

Figure 4.12. Underbuild

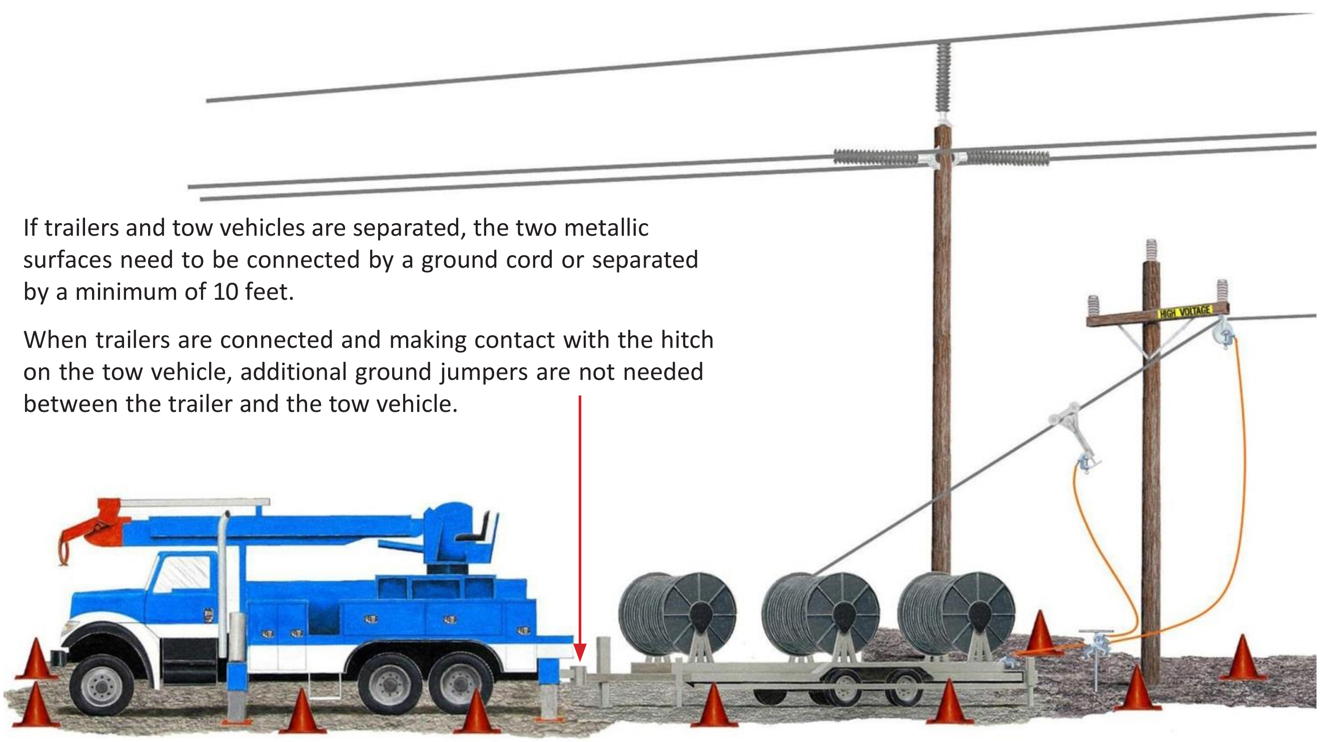

Figure 4.13. Crossing: Close-up of left side.

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4.4 (continued)

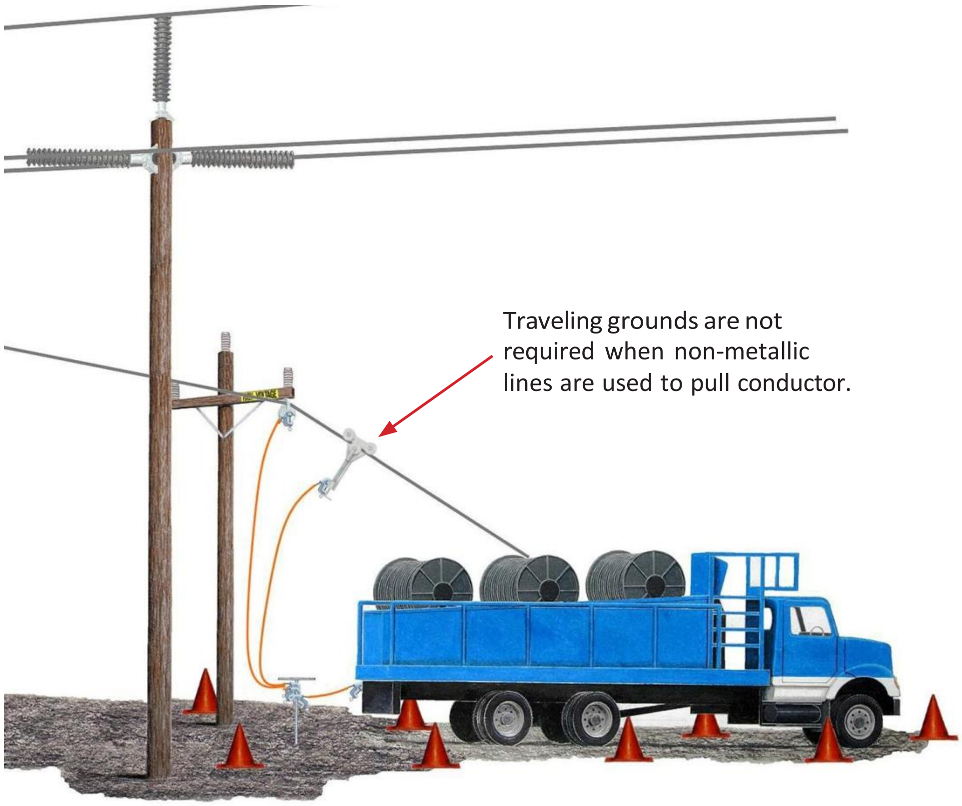

Figure 4.14. Close-up of right side.

4. Adjacent and/or Parallel

ADJACENT or PARALLEL refers to a pole line that is built next to, or built under, or built over, on the same poles of the conductor being worked. When energized, these lines induce voltage hazards into the work location.

a. Mitigation Strategies for Potentially Hazardous Induced Voltage Conditions

(1) Using multi-point grounding procedures (required):

- Install fully rated source grounds.
- Install personal grounds at each worksite.
- Install grounds on each tap line.

(2) Break cleared lines into smaller sections to reduce impact from induction. This action will minimize the current flow in the ground loop.

(3) If an employee experiences discomfort while trying to contact the conductor from an aerial position after installing a personal ground, then the employee may use:

4.4 (continued)

- Class 2 rubber gloves with approved protectors; or
- Conductive boots and, if necessary, a conductive bare-hand suit to eliminate the discomfort.

(4) Employees performing ground-based work activities can also use the following options to eliminate or reduce discomfort.

- Class 2 rubber gloves with approved protectors, or
- Install EPZ Grounding mats prior to contacting any metallic object at the worksite.

5. Handling Conductors that are Broken and/or Lying on the Ground for all Transmission Voltages

a. Install bracket grounds on each side of the broken conductor, as close to the worksite, as practical.

b. Wear Class 2 rubber gloves with approved protectors and EH boots to handle the conductor on the ground or do the work from a grounding mat with leather gloves.

c. Install a personal ground within 10 feet of the worksite, where conductors are being **spliced.** Bond the two ends of the wire that are broken to each other.

NOTE
If no induction exposures exist, you may configure per Section 4.4, Step 2.g, "Establishing Additional Open Points," create double open point, and work with leather gloves.

d. Working on a 500kV downed conductor.

(1) A personal ground will be installed within 10 feet of making any contact at the worksite.

(2) Bond the two ends of the wire that are broken to each other; and wear Class 2 rubber gloves with approved protectors and EH boots before making contact with the wire, or do the work from a grounding mat.

(3) If discomfort due to induced voltage or static charge is present, a grounding mat can also be installed before starting work.

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4.4 (continued)

6. Grounding Requirements for De-Energized Helicopter Work

The purpose of this section is to define the requirements for grounding a section of line so that work can be performed while suspended from a helicopter.

a. Install bracket grounds between the worksite(s) and all possible sources before work begins.

b. If there is a possibility of getting in series with a grounded object, install a personal ground.

c. Always install grounds using the procedures contained in Section 4.4.1 on Page 4-11.

7. 500kV Towers

a. Use the following procedures for testing and grounding 500kV lines to perform maintenance tasks. If grounding is being performed for construction work, there are additional requirements for setting up pull and tension sites (see TD-1500M, "500kV Maintenance and Construction Manual", Section 9, "Safety and Grounding").

Installation Sequence:

(1) Close the station Grounding Switches before installing grounds. Should the substation ground switch not be available, have substation department install grounds in place of the station ground switches.

(2) Install Single Point Grounds for minor maintenance work.

(3) Install multi-point grounds, as close to worksite as possible (for Construction Work).

Removal Sequence:

(1) Remove single point grounds.

(2) Remove multi-point grounds.

(3) Open the station ground switches or have substation department remove the grounds that were installed where the station ground switches were not available.

b. Station Ground Switches

The 500kV station ground switches cannot be used as temporary protective grounds as part of a multi-point ground scheme for the following reasons.

- They are used only to short-circuit and minimize the capacitive charge present when installing the grounding scheme at the worksite.

4.4 (continued)

- Station Ground Switches are neither designed nor maintained to act as a Temporary Protective Ground for employee protection.

WARNING

After the station ground switches are closed, you must always test de-energized when installing any type of protective ground.

c. Testing 500kV Lines De-energized

Test de-energized with an approved voltage detector per Section 2.5, "Testing Conductors or Equipment De-Energized."

d. Grounding 500kV Lines

When the substation ground switch is not available, ground per the requirements in Section 7, "Substation and Generation Facilities." Always install a ground device between each sub conductor of a phase you will be working on and the tower.

The hand-line used when installing or removing 500kV grounds must be kept at least 11 feet 3 inches from the conductor.

NOTE

When two employees are on the tower, one may need to control the ground stick, while the other attaches the ground clamp.

CAUTION

Do not rock the ground clamp back and forth on the conductor. Rocking the clamp while installing the ground will damage the conductor.

e. Grounding 500kV Lines Adjacent to Energized 500kV Lines

(1) Test and ground the conductor on the de-energized line farthest from the energized 500kV line.

(2) Test and ground the middle conductor.

(3) Finally, test and ground the conductor nearest the energized 500kV line.

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4.4 (continued)

(4) Remove the grounds in the reverse order, starting with the phase nearest the energized line.

WARNING

Circulating current can be very high when grounded in this configuration. Ground cords can get hot. Avoid contacting the ground cords.

8. Overhead Ground Wire (OHGW) / Overhead Ground Wire with Internal Fiber-optic Cable (OPGW)

a. General

OHGW and OPGW are not part of the electric circuit; however, they may have hazardous induced voltages. They need to be treated as though they are energized at 15kV and need to be grounded.

WARNING

Always install an approved ground jumper when working on or near an OHGW/OPGW, even when a permanent ground jumper is present.

b. Working Near

When performing work in the vicinity of OHGW/OPGW, either maintain the specified working clearance for a 15kV circuit (i.e., 27 inches), or apply TPGs using one of the following methods:

- Multi-Point
- Single-Point

c. Grounding OHGW / OPGW

(1) OHGW/OPGW grounding requirements will be discussed and documented during the pre-job / grounding tailboard.

(2) Use one TPG on each conductor to connect OHGW/OPGW to a ground source. Use a minimum of #2 when grounding OHGW/OPGW. On a wood pole, a properly grounded phase conductor may be used as a ground source for the OHGW/OPGW.

- OHGW/OPGW is NOT required to be tested prior to the application of TPGs.

4.4 (continued)

- Installation of TPGs on the OHGW/OPGW does require a grounding observer.
- Single point grounding reference. See Section 4.4.1.b on Page 4-13 (Single Point Grounding).

(3) When opening and closing an OHGW/OPGW, employees must avoid placing themselves in series between different potentials. Take the following precautions when working with OHGW/OPGW.

Examples of designed open points are:

- Dead End – Open
- Dead End – Grounded
- Dead End with OPGW splice termination

If the OHGW/OPGW has a designed open point, one of the following actions must be taken to mitigate this hazard (see Figures 4.15 and 4.16 below):

- **Option 1:** Use one TPG to connect OHGW/OPGW to a ground source and jumper out designed open point using approved ground jumpers.
- **Option 2:** Use one TPG on each conductor of the designed open point to connect OHGW/OPGW to a common ground source.

Figure 4.15. Option 1

Figure 4.16. Option 2

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4.4 (continued)

d. **OPGW Splice Box Vertical Runs**

(1) On 500kV lines the OPGW lead to splice termination is insulated from the tower.

- Either maintain the specified working clearance for a 15kV circuit (27 inches) OR apply a TPG within 10 feet of the work area on all OPGW conductors.

(2) Special consideration must be taken when working on or in the vicinity of OPGW splice box vertical runs that are insulated from the tower.

- Although the OPGW vertical runs terminate in a splice box and may look connected, the metallic shields of the OPGW vertical runs are not connected.

- Grounding only one conductor on the vertical run will not provide protection for the other conductor. Perform one of the following to mitigate this hazard:

  a) Use one TPG on each conductor of the OPGW vertical run to connect a common ground source (see Figure 4.17 below).

  b) Use one TPG to connect OPGW to a ground source and jumper out OPGW vertical runs using approved ground jumpers (see Figure 4.18 below).

Figure 4.17

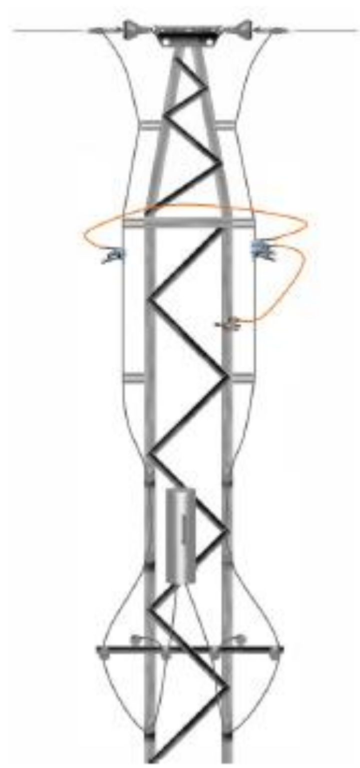

Figure 4.18

4.4 (continued)

9. OPGW Splice Box

On 500kV lines, the OPGW lead to the splice termination is insulated from the tower and should be treated as per Section 4.4.8 on Page 4-29. On lower voltages, it is attached to the tower and should not have any standing voltage on it; however, additional protective measures are required for ground-based activities.

a. Use the following procedure for working on splice boxes with leads attached to the tower (see Figure 4.19 on Page 4-34):

(1) Position the Splicing Trailer close enough to the tower to accommodate available slack coil. Unhook the Splicing Trailer and move the tow vehicle far enough away, so that you cannot touch the truck and trailer at the same time; the recommended distance is 10 feet. Barricade the Splicing Trailer by placing cones a minimum of 8 feet from the Trailer, when possible, and using barrier tape to restrict access.

- When you cannot get the Splicing Trailer close enough to the Tower to accommodate available Slack Coil, or you cannot negotiate difficult terrain, you must set up ground mat(s), connect the mat(s) to the grounding scheme, set up a barricade, and use a table to hold the Splice Case.

(2) Install ground mats in close proximity to the ground source. When using more than one ground mat, all ground mats must overlap each other a minimum of 6 inches and be connected to one another by an approved ground jumper.

WARNING

When using a grounding mat, employees must avoid stepping on or off the grounding mat unless absolutely necessary. Keep both feet on the mat at all times.

(3) Ground the splicing trailer and/or the ground mat(s), and create an Equipotential Zone (EPZ) at the worksite by:

a) Bond mats together with appropriate ground cords.

b) Bond trailer to most appropriate corner of the mat, then

c) Bond mats to the ground source.

4.4 (continued)

WARNING

When the Trailer is connected to the ground scheme, you may not contact it unless standing up on the grounding mat.

d) Install ground clamps to the tower, and then install the other end of the ground clamp to OPGW.

e) Use a hand-line to lower the Splice Case to the ground.

f) Utilize a hot stick to ground the splice case and pull it on to the grounding mat.

g) While remaining on the mat and wearing leather gloves, (1) install the shunting jumper, and (2) install the personal ground.

h) Commence splicing work.

i) Upon completion of splicing work, remove grounds by following these steps:

1. Supervisor/PIC gives permission to remove grounds.
2. Crew verifies all personnel are in the clear of cables and clamps.
3. Remove both clamps from OPGW before removing either clamp from the tower.
4. Verify removal of all grounds.
5. Replace galvanized coating, if needed, to areas of the Tower the ground clamps were attached to.
6. Supervisor/PIC notifies both TCC and GCC that the crew is no longer on-site.

4.4 (continued)

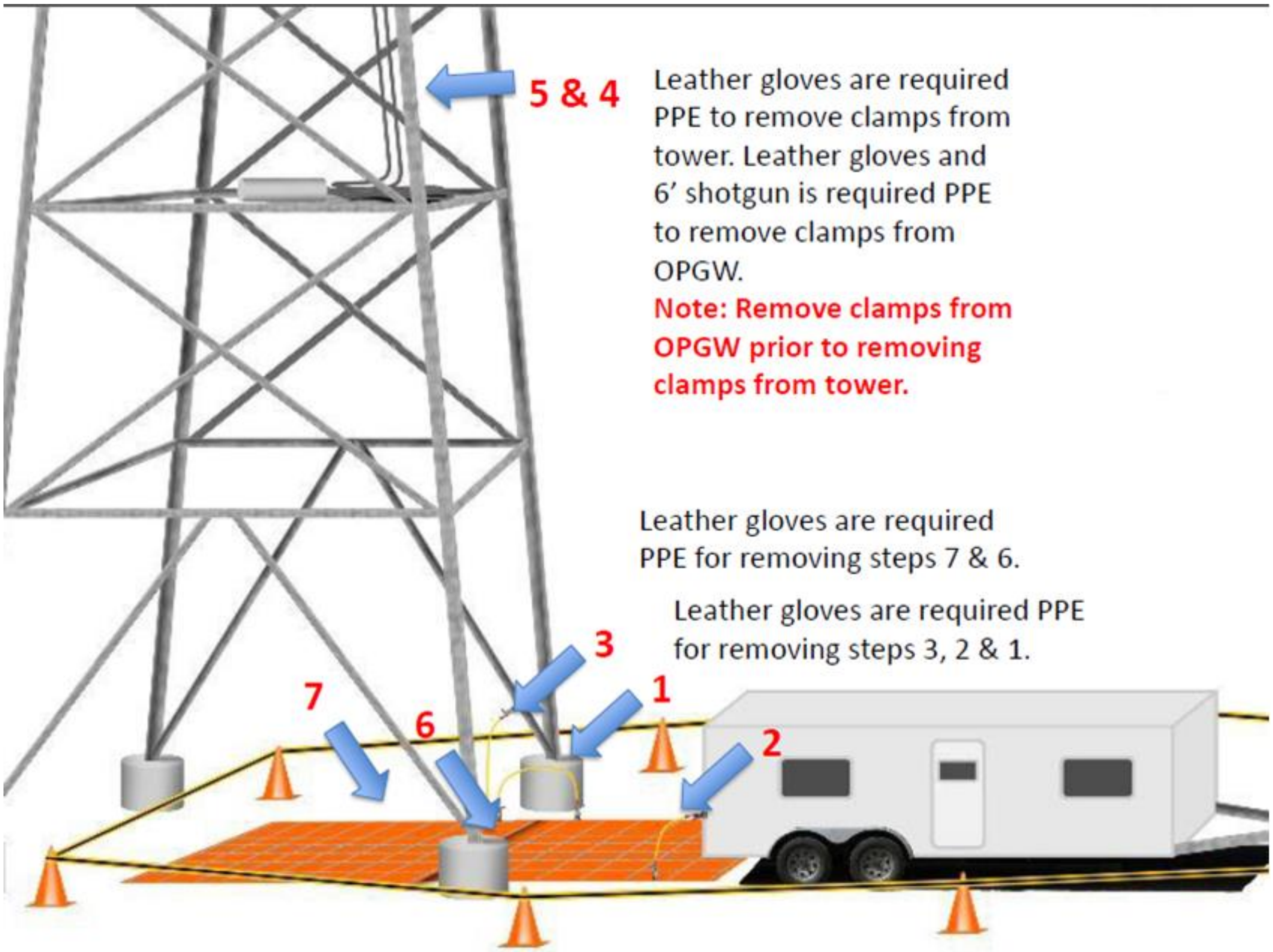

Figure 4.19

CAUTION When using a grounding mat, employees must avoid stepping on or off the grounding mat unless absolutely necessary. Keep both feet on the mat at all times.

NOTE
These procedures are only for OPGW on overhead line structures. When OPGW enters a substation or generation facility, you must contact the local substation supervisor and request them to install and/or remove grounds as needed on the OPGW (see Section 7, "Substation and Generation Facilities").

NOTE
This procedure is not applicable to 500kV OPGW, which has its own grounding procedure.

4.4 (continued)

WARNING

When OPGW or OHGW part and fall between energized conductors, contact the appropriate T-Line headquarters to install temporary protective grounds.

4.5 Underground Transmission

1. Scope

This section provides safety precautions for employees who work in vaults and trenches around high-pressure fluid-filled (HPFF), high-pressure gas-filled (HPGF), and cross-linked polyethylene (XLPE) underground transmission circuits.

2. Methods of Grounding

a. Approved Grounding Method

Multi-point ground underground transmission circuits unless the circuit is listed among EXCEPTION Circuits below, AND the adjacent circuit is kept energized. Because of the close proximity of adjacent, energized circuits, multi-point grounding in that case will result in abnormally high circulating current on the cable sheath.

b. EXCEPTION Circuits

(1) Cayetano-Vineyard 230kV

(2) North Dublin-Vineyard 230kV

(3) Vineyard-Newark 230kV

(4) Lone Tree-Cayetano 230kV

(5) Monte Vista-Wolfe 115kV

(6) Stelling-Monte Vista 115kV

(7) Pittsburg-Los Medanos #1. 115kV

(8) Pittsburg-Los Medanos #2. 115kV

(9) Newark-Applied Materials 115kV

(10) Applied Materials-Britton 115kV

4.5 (continued)

WARNING

Do NOT multi-point ground underground transmission exception circuits that can have abnormally high circulating current on the cable-lead sheath because of the close proximity of adjacent, energized circuits.

The circuits listed under "EXCEPTION Circuits" must not be worked with the adjacent circuit energized.

3. Station Ground Switches

- Station ground switches are devices that are permanently installed in some substations on the underground transmission cable systems.
- Station ground switches are installed to drain off the capacitive charge. Release of capacitive charge is accomplished during switching.
- No further action is required by the person applying grounds to address the cable's capacitance charge.

WARNING

Do not use underground station ground switches as protective grounds.

4. Grounding Pipe on HPFF or HPGF Circuits

- On pipe-type, transmission-cable circuits, pipe ground switches are installed in cabinets. The pipe ground switch is designed to ground the pipe solidly.
- Before performing work on any pipe-type cable circuit, ground the pipe by closing the pipe ground switch.
  - Grounding the pipe will disable the pipe cathodic protection scheme.
- When the situation requires grounding the pipe itself, notify the underground transmission maintenance supervisor.
- When the line is placed normal, the pipe ground switches should be opened, re-establishing the pipe cathodic protection system. The pipe ground switch can be operated on both energized and de-energized circuits.

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4.5 (continued)

5. Working in Underground Transmission Vaults

WARNING

To ensure your personal safety when entering an underground transmission vault, always follow the rules established in Utility Procedure TD-3320P-01, "Electric T&D Confined Space Work Procedures."

a. Always use a grounding mat when performing work in underground transmission vaults that have not been constructed with an internal ground grid (i.e., Faraday Cage).

b. Attach the grounding mat ground leads directly to the pipe using primary gloves.

- Installing the grounding mat creates an equipotential zone from which to work.
- Newer underground transmission vaults have built-in, internal ground grids that include copper ground leads at each end of the vault that bond the upper and lower concrete vault sections.
- Underground transmission vaults containing an internal ground grid may be identified by such ground leads.

c. Grounding mats are not necessary when working in an underground transmission vault constructed with an internal ground grid.

6. Grounding XLPE Cable Sheath

- There are two methods for grounding the metallic sheath surrounding the cable on an XLPE transmission circuit.
- One method is to solidly bond the cable sheath to ground. The other method is to ground the cable sheath through a sheath voltage limiter (SVL).
- SVLs allow the sheath voltage to rise to a controlled level, and then allows current to flow to ground. This relieves any voltage that is present and allows for a higher ampacity rating on the circuit.
- Cable sheath ground switches, usually located on the circuit termination structures, connect the cable sheath to ground and usually are kept closed.
- The circuit grounding scheme and specific work to be performed dictate whether to open or close the cable sheath ground switches while performing work on the circuit.
- Whether or not the switch is closed or opened depends on the type of work to be performed. If the jacket is to be worked on or separated, the ground switch must be left open to avoid transfer ground potential.

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SECTION 5: DISTRIBUTION OVERHEAD

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5 DISTRIBUTION OVERHEAD

5.1 Scope

This section of the manual provides rules and procedures for creating protective grounding schemes within distribution facilities.

The person in charge (PIC) will discuss with the crew and select the safest method of grounding for the work being performed. The application and procedures outlined in this section must be followed for the method chosen. The PIC must ensure an electronic or hard copy of the latest version of the Protective Grounding Manual is at the worksite.

5.2 Temporary Protective Grounds (TPG) Size and Fault Duty

1. Introduction

Grounding devices must be able to carry the anticipated fault current at the location where the TPGs will be installed for the length of time it will take for the fault to clear, or they must be the same size or larger than the conductor being grounded.

The information contained in this section will help you select the size of the temporary protective grounding components that will ensure your grounds will meet the requirements above.

Properly sized and installed TPGs provide protection from:

- A single switching error that would energize the worksite
- A credible mechanical failure of a clearance point that could result in energizing into the worksite
- The accidental contact of a nearby energized conductor
- Lines energized above 300V that:
  - Cross below
  - Cross over and within 10 feet

2. Options for Selecting the Appropriate TPG size for Overhead Work

Select **only one** option for each worksite. Options cannot be combined or mixed at any one worksite.

Options for selecting TPG size:

Option 1

The simplest method for selecting the size of TPGs is to install grounds that are the same size or larger than the conductor to be grounded. See Table 5-1 below.

Table 5-1 – TPG for Size of Conductor

Conductor Size	TPG Size
#2 AWG or smaller	1 - #2 cu.
2/0 AWG or smaller	2 - #2 cu. or 1 -2/0 cu.
4/0 AWG or smaller	2 - 2/0 cu.

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5.2 (continued)

Option 2

NOTE
On distribution circuits with a transmission source (crossings or overbuild) **within 1 mile of a substation**, use Option 1 or Option 3.

All distribution circuits not on the exception circuit list and that do not have a transmission source: Use 1 – 2/0 TPG per phase.

Exception circuits: Use 2 – 2/0 TPG per phase.

To access the exception circuit list, follow the instructions below.

Distribution **EXCEPTION** Circuit List and Substation Bus Fault Duty:

a. Go to PG&E's Intranet home page, "PG&E@Work TODAY."

b. Click on "Tools."

c. Click on "Technical Tools" on the right side of screen.

d. Scroll down to select and open "Substation Grounding Fault Duties."

For the **EXCEPTION** circuits list, click on the tab labeled "20kA EXCEPTION (Dist Sub)."

Transmission source: Use 2 – 2/0 TPGs per phase.

Option 3

To determine if the instantaneous zone (15 cycle clearing time or less) applies to the portion of the circuit being worked, contact the planning engineer responsible for that circuit. Distribution Instantaneous Zones typically extend less than 1 mile from the substation.

Distribution circuits: Size TPGs for the fault duty of the source-side device, provided the distribution circuit is not on the exception circuit list.

Use "Accessing Fault Duty Information" instructions and Table 5-2, "TPG Fault Duty Rating" on Page 5-4 to select the proper size TPGs.

Access the Distribution Operators Tool Box (D.O.T.) for Distribution Sources:

a. Go to PG&E's Intranet home page, "PG&E@Work TODAY."

b. Click on the address line to highlight and type in DOT and hit "Enter." This will take you to the D.O.T. home page.

c. From the home page, click on the "FEEDER CALC" tab which is located at the top of the page.

5.2 (continued)

d. From the Feeder and Device information page, select "Division" from the drop-down menu.

e. Enter device number in the device name box; click on Search.

f. Choose Sym Amps to size TPGs.

Table 5-2. TPG Fault Duty Rating

TPG Size (AWG)	MAX Fault Duty Rating Distribution 60 Cycle Clearing Time		MAX Fault Duty Rating Distribution Instantaneous Zone[1]	
	Reclosing relay cut-in	Reclosing relay cut-out	Reclosing relay cut-in	Reclosing relay cut-out
1 - #2 cu.	4.8kA	8.6kA	9.5kA	15kA
2 - #2 cu.	9.0kA	16kA	18kA	30kA
1 – 2/0 cu.	11kA	16kA	20kA	30kA
2 – 2/0 cu.	20kA	32kA[2]	38kA	57kA[2]

[1] Distribution Instantaneous Zone is typically the portion of a Distribution Circuit that is within one mile of a substation
[2] Single Point may not be used

5.3 Overhead Approved Grounding Methods

General Information and Requirements

Unless working as energized, always install TPGs using one of the following methods when working on conductors or equipment normally energized in excess of 600 volts (V).

Conductors and/or equipment are considered energized until they have been tested and proven de-energized by the installation of approved grounding devices.

Test all conductors to be grounded de-energized with an approved voltage detector.

Maintain minimum approach distance (MAD) from ungrounded conductors while testing and installing TPGs.

Install TPGs using approved live-line tools with a quick positive contact. Connect TPG to the closest phase; move across, up, or down sequentially, as appropriate. Avoid placing connections directly above or below the worker.

At least one set of TPGs must be visible to a crew member for the duration of their work. If TPGs are not visible to a crew member, at least one of the following conditions must be applied:

- All components must be covered for the first 15 feet off the ground.
- All components must be connected at least 15 feet off the ground.

Once conductor has been deemed ready to install into its normal operating position, isolated from all grounded surfaces, all personnel are in the clear, and all TPGs have been removed, energized work procedures can be utilized.

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5.3 (continued)

To protect from backfeed when a transformer is on the pole being worked, test the secondary de-energized, then perform one of the following options:

- Install shunts on the secondary leads.
- Disconnect the secondary hot leads.
- Address each service fed by the transformer per Section 5.4.2.c. on Page 5-19.

Approved Grounding Methods

1. Multi-Point Grounding

Multi-Point grounding is the combination of bracket grounds and a personal ground with pole band at the worksite. Multi-Point grounding provides the maximum level of protection. This is the preferred method of grounding (see Figure 5.1 on Page 5-6).

Multi-Point Grounds can be installed at the same structure where work will be performed, provided they are installed where none of the components of the grounds can be inadvertently dislodged from the structure.

NOTE
If any portion of the worker's body can contact a phase not protected by the personal ground, additional personal grounds must be installed.

Multi-point grounding instructions (see Section 5.6 "Requirements for Installation and Removal of Temporary Protective Grounds" for additional information):

a. Install properly rated TPG bracket grounds between the worksite and all fault duty sources. For a radial tap line, this requires only one set of bracket grounds be installed between the faulty duty source and the worksite.

b. Locate bracket grounds as close as possible to the worksite.

c. If work is to be done where bracket grounds are installed, an EPZ must be created.

d. The use of a personal ground at each intermediate pole/structure to be worked is preferred. As an alternative, Class 2 rubber gloves with approved protectors may be worn in-lieu of installing a personal ground, provided no transmission fault duty sources exist and no contact is made with any un-insulated part of the body. The following requirements apply to personal grounds:

- Approved #2 Cu ground jumpers may be used for all personal grounds. Personal ground(s) must be installed to create an EPZ around the worker.
- Foreign grounds within the EPZ must be tied to the pole band or covered with protective devices.
    - Once the EPZ is established foreign grounds may be tied to the EPZ utilizing leather gloves.

5.3 (continued)

- One end of the personal ground must be connected to the conductor being worked.

  If the remaining conductors:

  - Are to be worked,
  - Are within reach,
  - Can be inadvertently contacted,

  Then, they must be incorporated into the EPZ with an approved TPG jumper.

- The other end of the personal ground is connected to the structure below the worker using:

  - A pole band on wood and fiberglass poles.
  - A pole step in a tree.
  - A pole step or grounding tab on steel and concrete poles.
  - A step or angle iron on lattice structures. Pole steps must make good electrical contact with the steel.

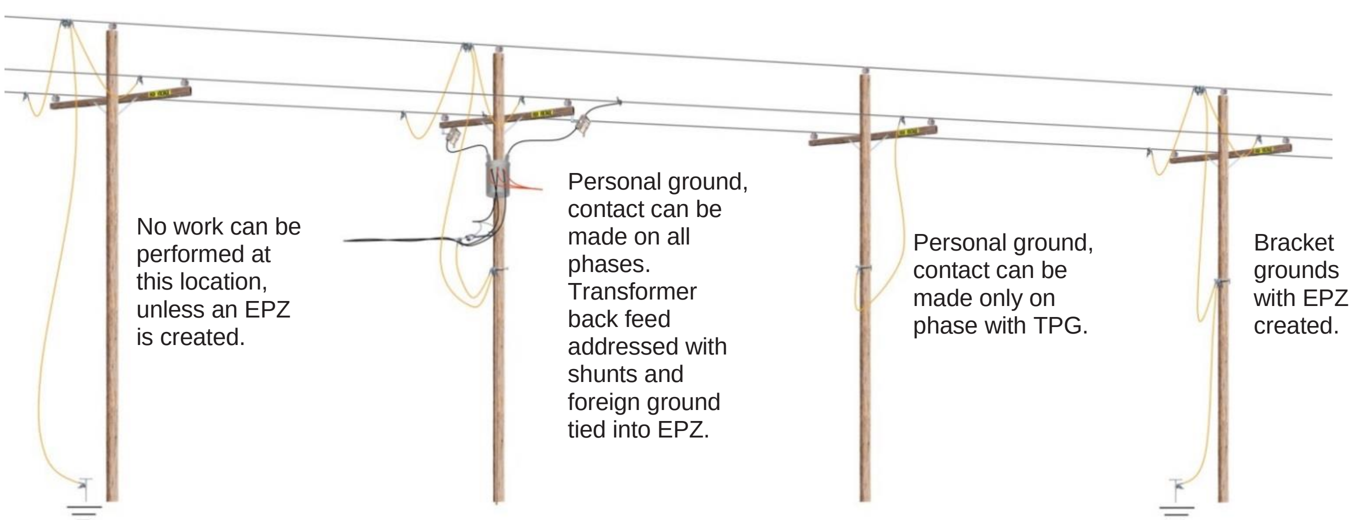

Figure 5.1. Multi-point Grounding

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5.3 (continued)

2. Single Point / Worksite Grounding

Single Point/Worksite Grounding is the combination of TPGs with a pole band at a worksite. See Figure 5.2 below for an example of single point grounding.

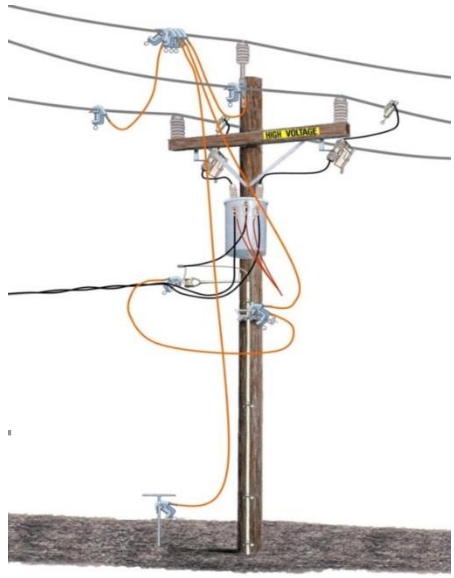

Figure 5.2
Single Point grounding with ground cord installed directly to the conductor.

a. Requirements

WARNING

When moving conductors, the TPGs must be of adequate length to avoid damaging the conductor(s) or the TPGs. When using mechanical devices to move the conductor, care must be taken to avoid dislodging the TPGs.

- The worker is within 15 feet of where the TPG is attached to the conductor.
- There is no more than 30 feet of TPG length in parallel with the worker. See Figure 5.3 on Page 5-8.
- The fault duty does not exceed 23kA with the reclosing cut-in and 30kA with reclosing cut-out.
  - If the fault duty exceeds 30kA, Multi-Point grounding must be used.

5.3 (continued)

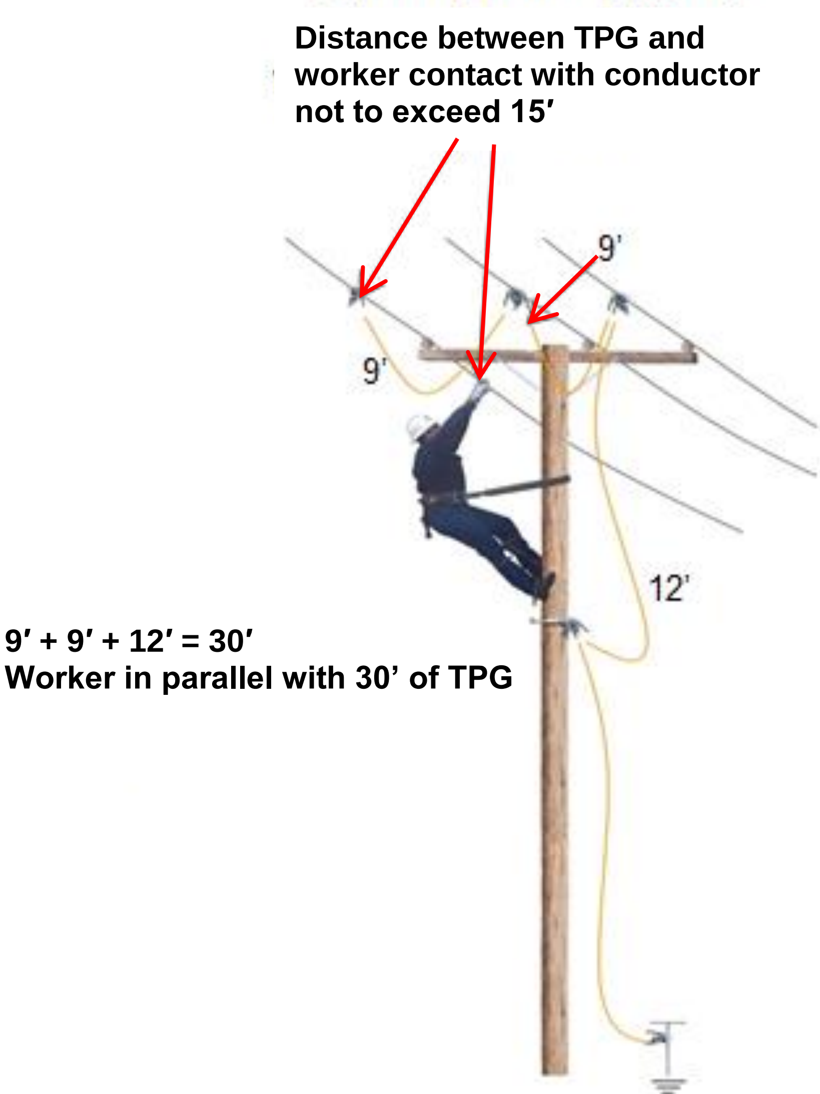

Figure 5.3

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5.3 (continued)

b. **Single Point Grounding Instructions** (see Section 5.6 "Requirements for Installation and Removal of Temporary Protective Grounds" for additional information)

Install properly rated TPG devices at the worksite:

(1) Install phase-to-phase jumpers to short circuit the phase conductors (when practical).

(2) When using tower grounds on a distribution lattice structure, phase-to-phase jumpers (TPGs) are not required.

(3) Install a pole band as close as possible below the workers feet when working from a wood or fiberglass pole.

When working from a tree, concrete or steel pole, in lieu of a pole band, use the option below that applies to the type of structure:

- **Tree –** A pole step installed as close as possible below the worker's feet.
- **Steel or Concrete Pole –** A pole step or grounding tab installed as close as possible below the worker's feet.
- **Distribution Lattice Structure –** For each phase conductor, connect the ground clamp of a tower ground to the angle iron, as close as possible below the worker's feet.

(4) Connect the ground cord from the ground source to the pole band/structure or connect the ground cord from the ground source to the conductor. See Figures 5.4 and 5.5 on Page 5-10.

- When using tower grounds on a distribution lattice structure, a ground cord is not required.
- When necessary, the ground cord may be installed from the ground source to the conductor first.

(5) From a position entirely above or entirely below the pole band, step, grounding tab, or angle iron, connect a grounding jumper from the structure to the line. This grounds the line when the ground cord is connected from the ground source to the pole band and creates an EPZ for both configurations.

(6) Foreign grounds within the EPZ must be tied to the pole band or covered with protective devices.

- Once the EPZ is established, foreign grounds may be tied to the EPZ utilizing leather gloves.

5.3 (continued)

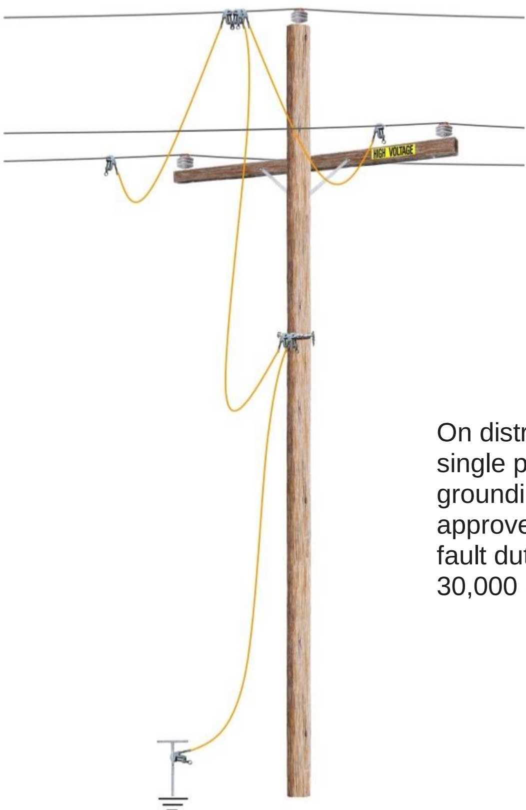

Figure 5.4
Single Point Ground cord connected from the ground source to the pole band.

On distribution circuits, single point EPZ grounding is only approved for circuits with fault duties less than 30,000 amps (30kA)

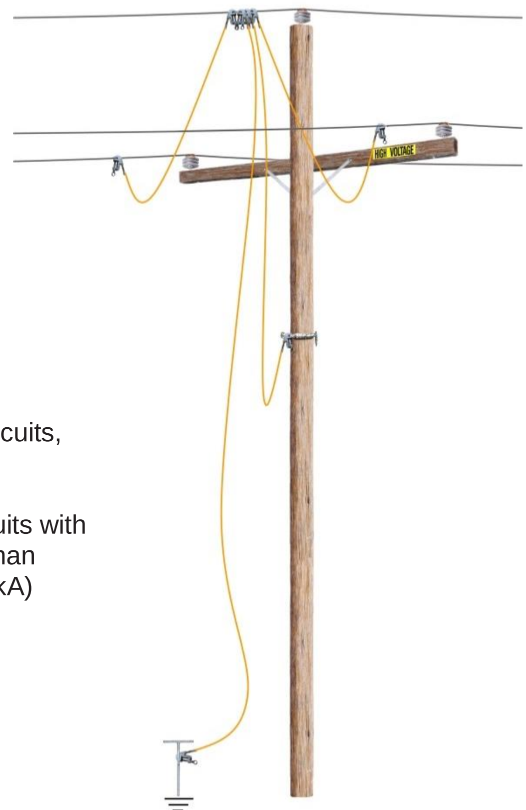

Figure 5.5
Single Point Ground cord connected from the ground source to the conductor.

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5.3 (continued)

3. Overhead (OH) Bracket Grounding

a. Bracket Grounding – Option 1

This method can only be used when the risk of accidental energization has been eliminated.

WARNING

Additional measures and specific actions must be completed to isolate the worksite and to ensure there is no possibility of contact with any energized source.

All the following conditions must be met to use this option:

- No induction hazards.
- No energized overbuild or underbuild above 300 volts.
- No energized crossings above 300 volts.

When working between bracket grounds on de-energized and bracket grounded distribution circuits, workers must ensure they do not get in series with different ground potentials (e.g., bracket grounds).

OH Bracket Grounding Option 1 will require the removal of all primary jumpers at each fault duty source (clearance point). The energized source side conductors at each clearance point MUST BE covered with approved insulating protective equipment. The removal of the jumpers and covering of the energized source conductors prevent accidental energization of the worksite (see Figure 5.6 on Page 5-13).

WARNING

Bracket Grounding "Option 1" must not be used when there is only one strain insulator between the energized source and the line to be grounded. Examples include, but are not limited to, the following: in-line bypass disconnects, flying bells, line openers, cut-outs and switches installed beneath a flying bell.

5.3 (continued)

Option 1 Instructions (see Section 5.6 "Requirements for Installation and Removal of Temporary Protective Grounds" for additional information):

(1) Physically remove the primary jumpers at each open clearance point to mitigate the fault duty source towards the worksite.

- On devices equipped with a bypass, the device jumpers **AND** bypass jumpers must be removed. In-line bypass disconnects must not be used for this option.
- On single disconnects, the disconnect door AND source jumpers must be removed. **EXCEPTION:** Part 57H cutouts.
- On combo disconnects, the disconnect doors AND source jumpers must be removed from both sets of disconnects.

(2) The energized source side conductors at each clearance point must be covered with insulating protective equipment.

(3) Bracket grounds must be installed:

- Between each clearance point and the worksite.
- As close to the worksite as possible.

(4) Address all secondary backfeed sources.

- Secondary backfeed mitigation at the primary conductor level:
  - Open primary fuses on conventional transformers.
  - Remove primary jumpers for SP transformers.
- Secondary backfeed mitigation at the secondary conductor level:
  - Open secondary leads.
  - Remove self-contained meter, glass meter socket, and tag "Caution."
  - Install approved transformer shunts.

(5) Address stored energy on capacitors banks by:

- Installing bracket grounds between the worksite and the capacitor bank, or
- Installing TPGs on the capacitor bank.

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5.3 (continued)

(6) When a capacitor is on the pole being worked, ensure there is no stored energy left in a capacitor by:

- Waiting 5 minutes after de-energizing, or
- Short-circuiting the units, or
- Grounding the leads between the units and the switches.

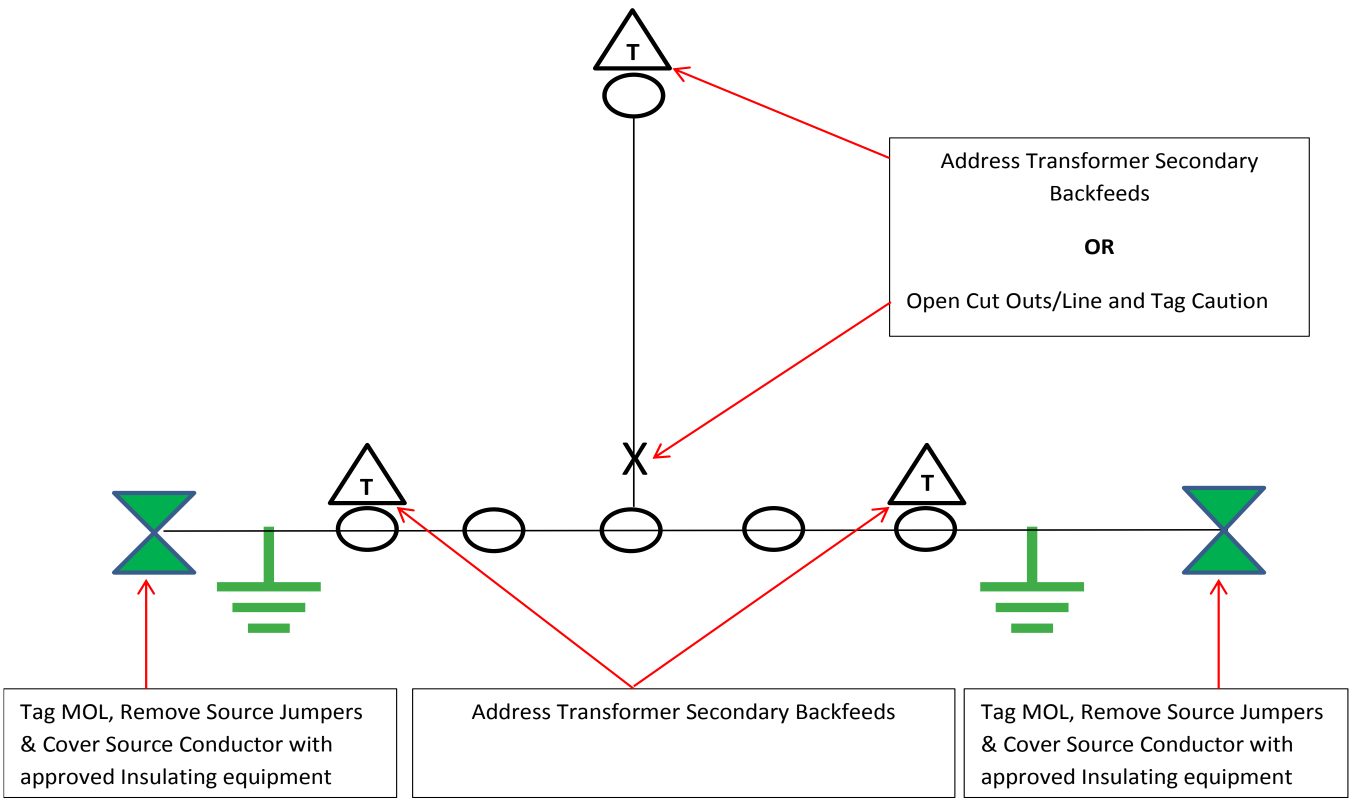

Figure 5.6

5.3 (continued)

Figures 5.7 through 5.11 below are examples of open points that are allowed for Bracket Grounding Option 1 with jumpers removed, insulating protective devices installed on energized source conductor and bracket grounds installed on conductor to be worked.

Figure 5.7. Double Dead-End

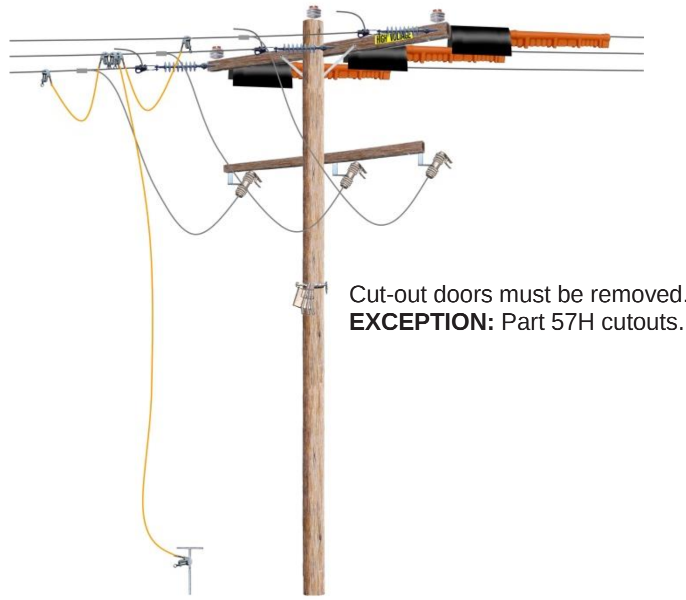

Figure 5.8. Double dead-end with cut-outs

Figure 5.9. Line & Buck

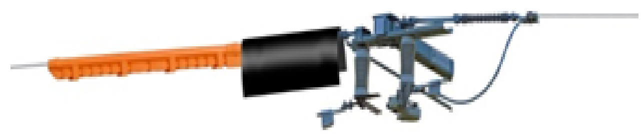

Figure 5.10. Underarm Side-Break Switch

Figure 5.11. KPF Switch

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5.3 (continued)

Figure 5.12 below shows some examples of open points that are **not** allowed with bracket grounding Option 1.

Figure 5.12. Sectionalizing Devices that Utilize a Single Strain Insulator

b. Bracket Grounding – Option 2

Bracket Grounds Installed between Double Open Points

Bracket grounds may be used when they are installed between two visual open points established in series. The two visual open points **must be** located between each fault duty source and the worksite (see Figure 5.13 on Page 5-17).

TD-2340P-01, "TPG Design Calculations" states that TPGs of a lower rating than the fault duty may be used in this configuration, #2 AWG at a minimum must be used.

All the following conditions **must** be met to use this option:

- No induction hazards, energized overbuild, underbuild, static, or parallel lines.
- No lightning in the area.

Bracket Grounds Installed between Double Open Points Instructions (see Section 5.6, "Requirements for Installation and Removal of Temporary Protective Grounds" for additional information):

(1) Establish two visual open points by using devices rated for the voltage; examples of these devices are:

- Switches
- Cutouts
- Line openers
- Strain insulators (e.g., Flying Bells, Double Dead-End bells)

5.3 (continued)

- Jumpers
- A removed span of wire

(2) Install a set of TPGs on the conductor to be worked to prove the line de-energized. The preferred method is to install TPGs before establishing the second visual open.

- If the 2nd open point was established before the TPGs are installed, a set of TPGs must be installed on the conductor to be worked for 5 minutes. After 5 minutes, the set of TPGs installed on the conductor to be worked, must be removed.

(3) Address all secondary backfeed sources (transformer shunts must not be used for this option)

- Secondary backfeed mitigation at the primary conductor level:
  - Open primary fuses on conventional transformers.
  - Remove primary jumpers for SP transformers.
- Secondary backfeed mitigation at the secondary conductor level:
  - Open secondary leads at transformer.
  - Remove self-contained meter and glass meter socket and tag “Caution.”

(4) Address stored energy from capacitors banks by:

- Opening the primary fuses, or
- Opening the primary jumpers.

(5) When a capacitor is on the pole being worked, ensure there is no stored energy left in a capacitor by:

- Waiting 5 minutes after de-energizing.
- Short-circuiting the units.
- Grounding the leads between the units and the switches.

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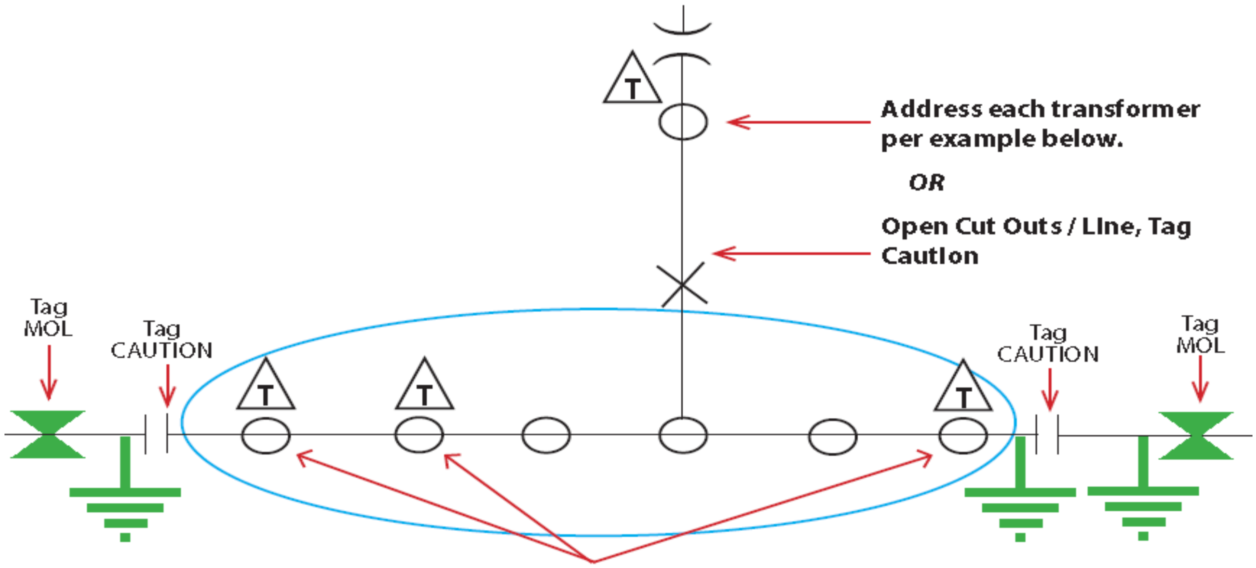
5.3 (continued)



IF the **2nd** open point was established before the TPGs are installed, **THEN** a set of TPGs must be installed on the conductor to be worked for 5 minutes. After 5 minutes, the set of TPGs installed on the conductor to be worked**, must** be removed.

Figure 5.13

5.4 Protection from Backfeed When Working Grounded Primary Conductors

1. Poles without Transformers or Capacitors

a. Multi-point and Single-Point Grounding Methods

Both Multi-Point and Single-Point grounding methods provide protection from backfeed from transformers and stored energy from capacitors located on adjacent poles.

b. Bracket Grounding, Option 1 and Option 2

> ⚠ **WARNING**
>
> **Before removing a meter to address backfeed, verify what type of meter it is. Removing some types of meters will not result in isolating the backfeed source from the section of the line being worked on.**

Bracket grounding Option 1 and Option 2 do not provide protection from transformer backfeed or stored energy from capacitors located between the worksite and the bracket grounds.

5.4 (continued)

(1) Address backfeed from transformers between the worksite and the bracket grounds by performing one of the following:

- Install an additional set of bracket grounds between the worksite and the transformer(s).
- Address each transformer by performing one of the following:
  - Open service main, lock, and tag "Caution."
  - Remove self-contained meter, cover, and tag "Caution."
  - Open the service leads.
  - Open primary fuses.
  - Remove primary jumpers.
  - Install shunts on the transformer secondary leads.
  - Lift and isolate secondary leads.

(2) Address a capacitor on an adjacent pole by performing one of the following:

- Open primary fuses or high-side jumpers.
- Install an additional set of bracket grounds between the worksite and the capacitor.
- Install TPGs on the capacitor units.

2. Primary Poles with Transformers

NOTE

When installing shunts or lifting secondary leads to mitigate backfeed, the worker must be positioned so that no part of their body can extend above the level of the secondary bushings.

WARNING

If the transformer primary leads will be separated from the grounded line, shunts must not be used, the secondary transformer leads must be disconnected.

When working on a pole with a transformer, test the secondary de-energized and protect from backfeed by selecting Option a, b or c in Step 5.4.2 on Page 5-19.

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5.4 (continued)

a. Install shunts on the secondary leads.

b. Disconnect the secondary hot leads.

c. For each service connected to the transformer, perform one of the following:

- Open service main, lock, and tag "Caution."
- Remove self-contained meter, cover, and tag "Caution."
- Open the service leads.
- Install shunts (pull section or weatherhead).

3. Poles with Capacitors

All grounding methods

When a capacitor is on the pole being worked, you must ensure there is no stored energy left in a capacitor by:

a. Waiting 5 minutes after de-energizing.

b. Short-circuiting the units.

c. Grounding the leads between the units and the switches.

5.5 Testing the Conductors or Equipment De-Energized

NOTE

Proximity voltage detectors are permitted for use if the meter remains functional. Proximity meters are no longer approved for purchase.

WARNING

Conductors and/or equipment are considered energized until they have been tested and proven de-energized by the installation of approved grounding devices.

1. Before using a voltage detector, verify that the voltage detector:

- Is rated to handle the nominal voltage of the equipment or conductors that are being tested.
- Has been used on an energized source or calibrated by a PG&E test lab, Applied Technology Services (ATS), within the last year.
- Is tested on an exposed live part or the test device in the meter carrying case before and after each use to ensure that it is functioning correctly.

5.5 (continued)

- Is in good condition.
- Ground lead and ground clamp (if equipped) are in good condition.
- Is attached to an approved hot stick (refer to Utility Procedure TD-2008P-01, "Inspection and Testing of Live Line Tools").

2. Testing De-energized

Always test conductors or equipment de-energized with an approved voltage detector before installing TPGs (see Appendix B for the manufacturer's instructions for each meter).

NOTE
Direct line tests on 4kV apparatus may result with minimal movement of the meter. After performing a direct line test, switching the meter to Capacitance Test "C" and bringing the meter close to, but NOT touching, the apparatus can confirm a direct line test, with a full deflection.

Use only approved live-line tools to test de-energized. A direct line contact voltage detector is the preferred device.

- Perform the manufacturer's pretest.
- Perform a "Live-Dead-Live" test every time when testing a circuit de-energized. This requires testing the meter on a live source or the manufacturer's alternate source supplied with the tester, before and after each use.
- Conductor and/or apparatus must be tested de-energized at each location where TPGs will be installed.
- Always TEST the nearest and closest conductors first when approaching a circuit.
    - Move across, up, or down sequentially, as appropriate.
    - Maintain MAD from any conductor or apparatus that is not grounded.

Additional Requirements for Resistive-Type Testers

- Pre-inspect unit to ensure the test lead is rated for 15kV and that the ground connection clamp is a C-clamp style (no alligator clips).
- When using voltage meters with ground-reference leads, never use a voltage detector in such a manner that its ground-reference lead or meter housing could contact an energized bus, disconnect, or conductor.
- Ensure that the ground-reference lead is kept away from the worker performing the test and any co-workers in the area during the testing process.

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5.5 (continued)

- Never touch a detector's ground-reference lead if it becomes disconnected from the ground source, and immediately remove the detector from the conductor.

For information about ordering high-voltage detectors approved for use, see Section 10, "Devices, Components and Tools."

3. When testing determines that voltage is present

If the voltage detector indicates the presence of voltage, STOP and immediately contact the PIC and make the following checks:

- Determine if the test was made within the clearance points.
- Retest the voltage detector.
- Retest the equipment or circuit.
- Request that the Electric Control Center recheck the switching operations and verify if the correct clearance points have been established.
- Identify and eliminate or address the voltage source before proceeding.

5.6 Requirements for Installation and Removal of Temporary Protective Grounds

1. Installing

⚠WARNING

The grounding observer and the worker installing protective grounds must ensure that all personnel are clear of the ground cord before the connection is made between the ground cord and the conductor.

⚠WARNING

Temporary ground rods must be installed as far from the worksite as practical to minimize step potential.

⚠WARNING

Under fault conditions, a poor ground source will increase the clearing time and step- and touch- potential hazards.

5.6 (continued)

a. Inspect TPGs (see Section 2.9, "Inspecting Protective Grounding Devices").

- Remove from service any grounding that fails inspection until it can be repaired or replaced.

b. Verify that all grounding devices are clean.

c. Verify the ground source is in good condition and rated for the fault duty.

d. Clean the surface of the ground source before connecting the ground cord, when required.

- Never connect ground clamps to painted surfaces (bare metal contact is required).

e. Connect the ground cord to the preferred ground source before applying grounds.

f. Adjust ground clamps for the proper size and angle for the conductor being grounded.

g. Ensure that the PIC has authorized the installation of grounds before installing TPGs.

h. Test the line to be grounded de-energized.

i. Maintain MAD from adjacent energized and ungrounded conductors when installing and removing TPGs (see Exception in Step **k** below).

j. Avoid contact with ground cord during installation and removal.

k. Install TPGs in the following manner:

- Always use hot sticks when installing or removing TPGs.

  EXCEPTION: Class 2 rubber gloves with approved protectors must be worn when installing traveling grounds.

- In such a way that they will not need to be relocated after the work has started.
- Tighten ground clamps hand-tight. Never use mechanical advantage other than a hot stick.
- Avoid placing connections directly above or directly below the worker.
- With quick, positive contact.
- Should an arc occur, do not attempt to remove the ground from the conductor. **Maintain contact** and allow the upstream protective device to de-energize the line.

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5.6 (continued)

l. Grounding methods that include the installation of a pole band:

(1) Place the pole band as close as possible to the line to be grounded and below the workers' feet. At no time may it be installed less than 12 feet above ground level.

(2) Tighten the chain around the pole.

(3) Screw in the lag as far as possible.

(4) Tie all foreign grounds within the EPZ to the pole band or cover with protective devices.

- Once the EPZ is established, foreign grounds may be tied to the EPZ utilizing leather gloves.

  Consideration must be made to ensure the length of TPG jumper from the pole band to the line is long enough, particularly when the work entails moving the conductor, such as in a pole transfer.

m. Install the "phase-to-phase" jumpers.

(1) Maintain MAD from ungrounded conductors.

If it is not practical to maintain MAD while installing phase-to-phase jumpers, perform the following steps:

a) Ground the lowest and nearest conductor first.

b) Create an EPZ.

c) Install a TPG jumper from the grounded conductor to the adjacent nearest and closest un-grounded conductor. Repeat this process until all conductors are grounded.

(2) Avoid contact with grounded conductors until ALL of the phase conductors of a circuit are grounded.

(3) Attach and position the ground clamps in a way that prevents workers from contacting them while installing or removing TPGs, or when working.

(4) Install all ground clamps immediately adjacent to each other, with no deliberate separation. The separation distance must never exceed 3 inches.

(5) Ground cables attached in parallel on a phase must all be of the same length (+/- 10%) and size.

5.6 (continued)

CAUTION

Testing has shown that a coiled ground cord, under fault conditions, will be pulled apart or destroyed by the mechanical forces created at much lower fault currents than for which they are rated.

n. Ensure that TPGs are connected to the ground source, then connect the "ground cord" from the ground source to the line.

(1) Lay ground cables in a smooth continuous line. Do not coil or cross ground cables.

(2) If the ground cables must pass through another circuit, de-energize or insulate the circuit(s) which the ground cables must pass through.

(3) Secure ground cables which pass through energized circuits.

o. When multiple circuits installed on the same structure are to be grounded, start at the lowest level and ground all conductors of the lower circuit first, then move up to next level.

- When grounding multiple circuits on the same structure, the same ground source must be used.

p. When grounding a circuit installed on a structure at multiple levels, perform the following steps:

(1) Start at the lowest level and ground all conductors,

(2) Move up to next level and either:

- Install an additional set of TPGs.
- Connect the common phases together with a grounding jumper.
- When grounding same circuits installed at multiple levels on the same structure, the same ground source must be used.

When required to install parallel grounds, install one TPG on each phase conductor at each level.

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5.6 (continued)

2. Removing

WARNING

The line must be considered energized when TPGs are removed.

a. The PIC must approve the removal of TPGs after all work has been completed on the circuit, and all personnel are clear of the grounded circuit and/or equipment.

b. The original Grounding Observer must be present when the TPGs are removed.

If the original Grounding Observer will not be present, the PIC must:

- Review original Grounding Tailboard Observer (GTO) form to identify location and number of TPGs to be removed.
- Ensure all TPGs are removed and complete per the GTO form.

c. The MAD must be maintained after the ground cord has been removed from the line.

d. Remove TPGs, starting with the farthest conductor first.

WARNING

ALL TPGs must be removed from the conductor(s) or equipment, before the ground cord is disconnected from the ground source (ground rod, anchor rod, etc.).

e. Remove the ground cord from the ground source last.

WARNING

Removing the wrong clamp could result in death or serious injury.

If there are multiple ground clamps on the same ground source that are connected within one foot of each other, remove all TPGs from the phase conductors, before removing any of the clamps from the ground source. (This will prevent inadvertently removing the wrong clamp.)

EXCEPTION: On steel structures, it is permissible to remove a TPG from a single conductor/phase, and then remove the related ground clamp from the structure before removing the other phase TPGs, provided that all the related ground clamps are NOT attached within reach of one another on the structure.

f. The PIC must ensure the GTO form is completed when the TPGs are removed.

5.7 General Requirements

1. Transitioning In and Out of an EPZ

WARNING

Workers must never be positioned where their feet are outside of the EPZ while performing work within the EPZ (e.g., below the pole band).

Workers may transition in and out of the EPZ, provided all the following conditions are met:

- Other workers within the EPZ are not making contact with grounded conductors.
- The transition is performed as quickly as possible and without hesitation.
- The worker does not make contact with grounded conductors during the transition.

2. Foreign Grounds at Your Worksite

When creating an EPZ on a pole, use an approved grounding jumper to connect all foreign grounds that can be contacted from within the EPZ to the pole band.

- Once the EPZ is established, foreign grounds may be tied to the EPZ utilizing leather gloves.
- Foreign grounds not attached to the pole, can be insulated using approved protective devices.

Some examples of foreign grounds are:

- Down guys
- Transformer/equipment grounds
- Lightning-arrester grounds
- UG cable concentric on a riser
- Third party messengers, i.e., phone, cable TV, and fiber optic lines

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5.7 (continued)

3. Open Points

Open points, or devices that can create open points, represent a potential hazard.

> **WARNING**
>
> - **Never get in series with two different ground sources.**
> - **Never touch an ungrounded wire.**

ALL open points at the worksite must be grounded on each side (or bypassed with a jumper) before a worker can come into contact with both sides. The TPG must be to a **common ground source** at that worksite. Examples of open points include the following:

- Fuses
- Solid blades
- Switches
- Reclosers
- Sectionalizers
- Any opened or removed section of conductor
- Removing current transformers (CT)

4. Adequately Insulated & Sectionalized Guy Wires

> **WARNING**
>
> **Never get in series with an open point between a guy wire and any other metallic object, including other guy wires and other anchor rods.**

Workers must tie the guy wire above the guy insulation to the ground scheme if exposed to induced electric fields.

Workers on the ground or structure must not bridge the guy insulation without a properly installed and approved grounding jumper.

ADEQUATELY Insulated Guys

- Guys that are properly sectionalized by the installation of a strain insulator and are exposed to only distribution sources.
- Guys with a strain link stick (6-foot minimum) exposed to transmission sources. The guy wire below the strain link stick may be a foreign ground.

5.7 (continued)

5. Inadequately Insulated & Sectionalized Guy Wires

If guy wires are not adequately insulated, and can be contacted from the work area on the structure, they must be tied to the grounding scheme.

Workers on the ground must avoid contact with any guy or anchor that is tied to the grounding scheme.

If contact is necessary, Class 2 rubber gloves with approved protectors and EH boots or di-electric over shoes are required.

INADEQUATELY Insulated Guys

- Distribution guys with a strain insulator that is not adequate for the voltage.
- Transmission guy without a strain link stick (fish stick).
- Inadequately insulated transmission guys connected to a common anchor with a distribution guy (transmission and distribution circuits are on the same structure).
    - The insulator in the distribution guy will flash across in the event the transmission guy becomes energized at transmission voltage (see Figures 5.14 and 5.15 below).

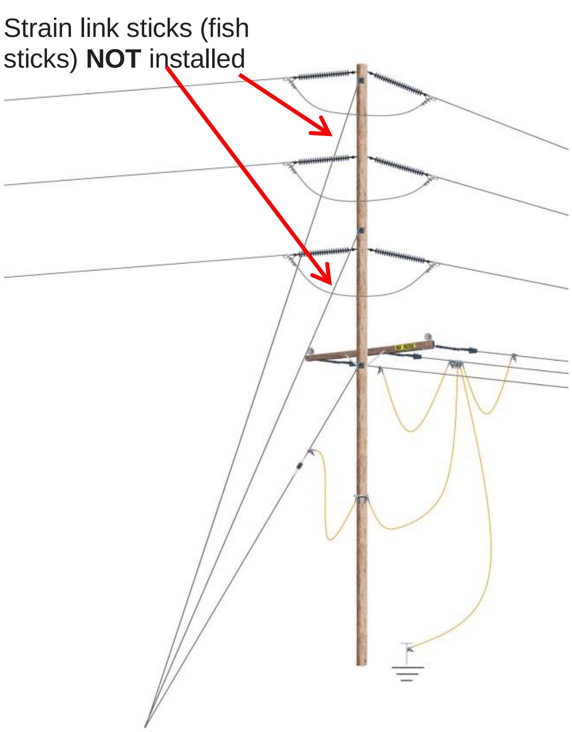

Figure 5.14. Inadequately Sectionalized

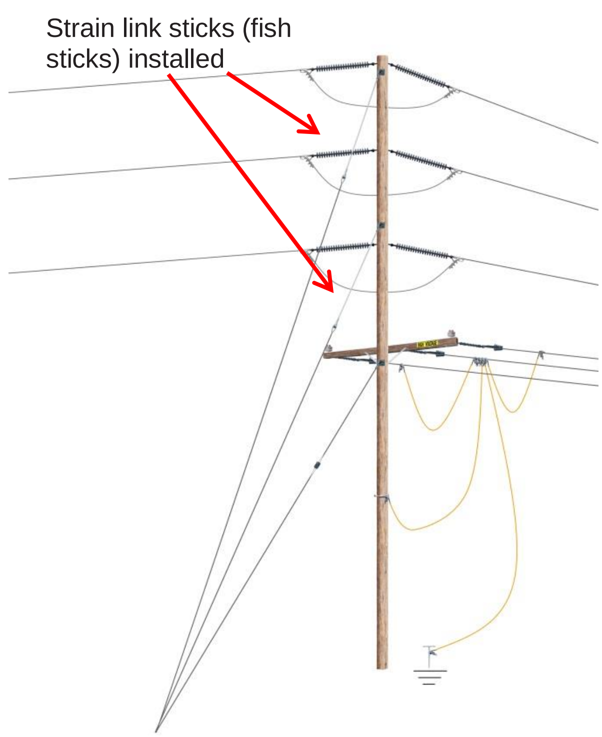

Figure 5.15. Adequately Sectionalized

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5.7 (continued)

6. Common Neutral (CN) Used as a Ground Source

The CN must be capable of carrying the fault duty.

The following is the minimum common neutral conductor size when the CN is used as the ground source:

- Single #2 Cu TPG – #2 or larger CN conductor is required.
- Single 2/0 Cu or parallel #2 Cu TPG – 2/0 or larger CN conductor is required.
- Parallel 2/0 Cu TPG – 4/0 or larger CN conductor is required.

If the CN is smaller than the TPG, consider the CN as a foreign ground.

- Establish an additional primary ground source.
- Connect the CN to the grounding scheme.

7. Anchor as a Ground Source

- Consider the physical condition and location of an anchor rod before using it as a temporary ground source.
- Attach the ground clamp to the anchor rod, not the guy wire or preform.
- Do not use anchor extensions as a ground source. Anchor extensions can be identified by the number stamped below the eye (see Figure 5.16). See Engineering Document 022221, "Anchors for Pole Line Guys" for additional information.

Figure 5.16. Anchor Extension

- Do not use rock anchors as a ground source.
- If work is to be performed on the down guy, consider using a different ground source.

WARNING

Disconnecting a down guy from an anchor sets up a situation in which it is easy to get in series between two different ground sources.

5.7 (continued)

- Wear Class 2 rubber gloves with approved protectors and EH boots or di-electric over shoes if disconnecting a down guy from an anchor rod that is used as a ground source.

8. Bond Wires and Ungrounded Metal Hardware Supporting Energized Conductor

NOTE
Bond wires and hardware that support de-energized and grounded lines do not require any additional TPGs be installed.

Avoid contact with bond wires and ungrounded metal hardware that support energized conductors except when:

- Using approved hot stick/rubber glove work methods.
- Bond wires and metal hardware have been tested and grounded with an approved #2AWG TPG.

Consider using a bond wire grounding lug to prevent damage to the bond wire when practical (see Figure 5.17 below).

Figure 5.17. Bond Wire Grounding Lugs

5.8 Installing & Removing OH Lines

1. Terminology

a. EXPOSURE — refers to any condition that could result in accidental contact with:

- An energized conductor
- De-energized circuits with different grounding requirements
- Induced voltage

5.8 (continued)

b. LINES — include:

- Metallic pulling lines (i.e., sock lines)
- Messengers
- Guy wires
- Communication lines
- Transmission, secondary, and primary conductors (including aerial cable and common-neutral conductors)

2. Crossings, Overbuilds, Underbuilds Energized at 300V or More

NOTE

When pulling cable or wires into or out of a substation, refer to Section 7.7, and contact the substation or transmission methods and procedures specialist.

When grounded conductors are going to be moved in a manner that could cause the grounded conductor to come in contact with energized circuits, above or below and they are either:

- Over or crossing over conductors energized at 300V or more,
- Under or crossing under, within 10 feet of conductors energized at 300V or more,

Perform the following:

- Install properly rated TPGs on both sides of the crossing on the conductor being worked (see Section 5.2 when selecting TPG size).
- Cut out the reclosing relay on energized crossings.
- Install insulating protective equipment (when applicable).
- Install guard structures or nets at the crossing.
  - The conductors being moved must be kept under control by the use of tension reels, guard structures, tie lines, or other means to prevent contact with energized conductors.
  - When installed, rope nets or guard structures must be of adequate dimension and strength to safely support anticipated loads.

3. Grounding to Limit Exposure to Crossings and Induced Voltage

When traveling grounds are installed or removed, Class 2 rubber gloves with approved protectors must be worn.

Grounds other than traveling grounds must be installed and removed with hot sticks.

5.8 (continued)

When installing or removing lines that could possibly receive a hazardous, induced voltage from an adjacent and/or parallel line (see Figure 5.18 below):

- Ground all pulling and tensioning equipment.
- Ground the line between the tensioning reel and the first structure.
- Install traveling grounds or equivalent on metallic pulling lines.
- Ground the line at the first structure adjacent to both tensioning and pulling setup.
- Ground the line at least every two miles.
- Install barricades around the pulling equipment, to protect the public and the workers.

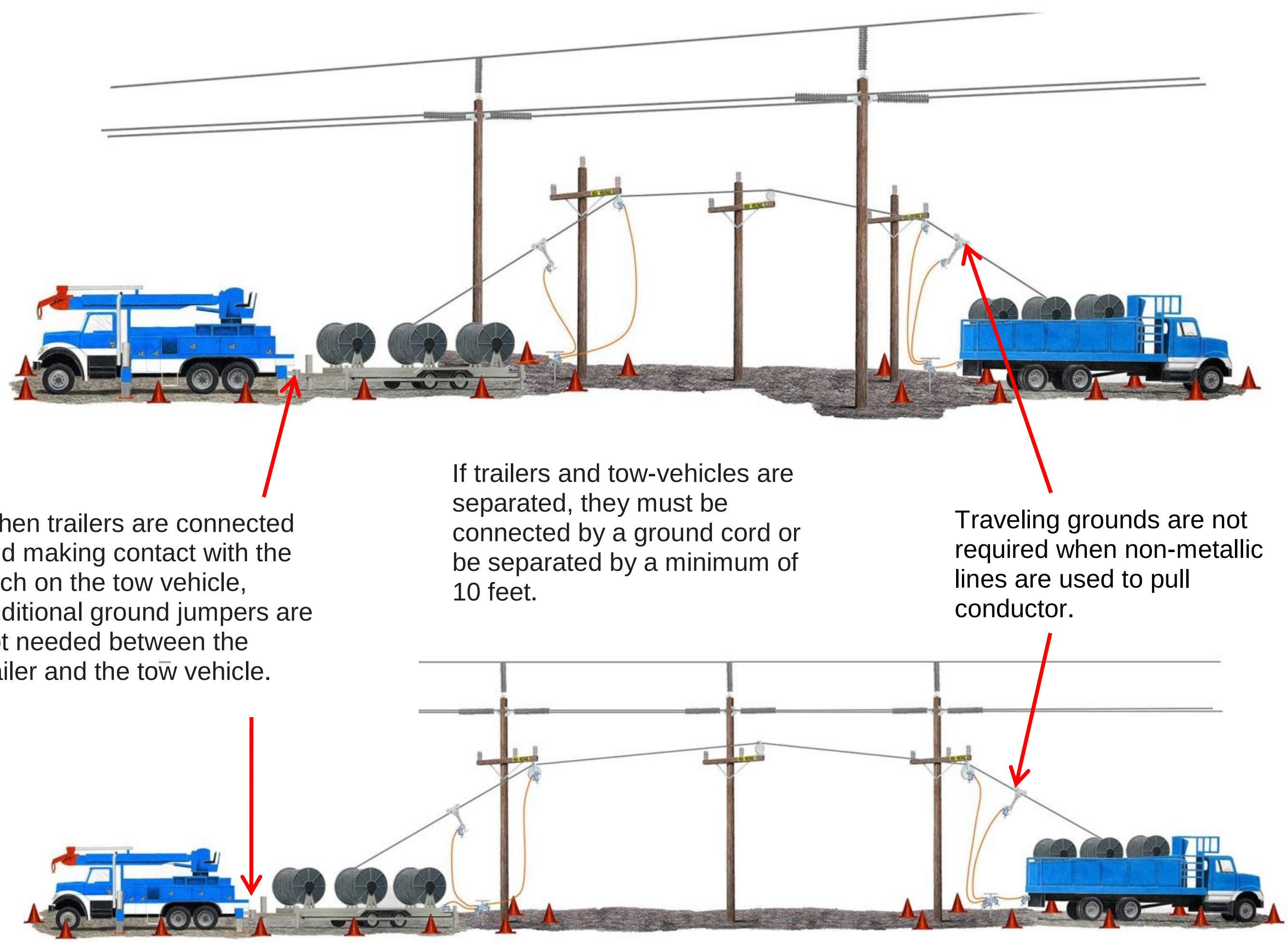

Figure 5.18
Vehicle Grounding for Exposure to Energized Crossings and Underbuild

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5.8 (continued)

4. Installing or Removing Insulated or Covered Overhead Conductors Exposed to Energized Conductors

WARNING

There is no insulation value for the outer covering of tree wire.

When installing or removing insulated or covered overhead conductors exposed to energized conductors, personnel must be isolated from the conductor that is being installed or removed. Once pulling on the conductor has stopped, it must be grounded prior to contact.

5.9 Adjacent or Parallel

ADJACENT or PARALLEL refers to a pole line that is built next to, built under, built over or on the same pole(s) as the conductor being worked. When energized, these lines could provide an induced voltage hazard.

1. Mitigation Strategies for Potentially Hazardous Induced Voltage Conditions

a. Using multi-point or single-point grounding procedures is required.

- Install properly rated bracket grounds.
- Install personal grounds at each worksite.
- Install TPGs on each tap line.
    - Tap line TPGs can be the same size as personal grounds.

b. Break cleared lines into smaller sections to reduce the impact from induction. This action will minimize the current flow.

If a worker experiences discomfort while trying to contact the conductor from an aerial position after installing a personal ground, then the worker may use Class 2 rubber gloves with approved protectors.

c. Workers performing ground-based work activities can use the following options to protect from induction.

- Class 2 rubber gloves with approved protectors, or
- Install EPZ grounding mats prior to contacting any metallic object at the worksite.

5.10 Handling Conductors that are Broken and/or Lying on the Ground

1. **When working from the ground on downed conductors with no exposure to adjacent energized circuits, perform one of the following:**

   a. Configure per Section 5.3.3.b, "Bracket Grounding – Option 2," create a double open point, and work with leather gloves.

   b. Lines with more than one fault duty source: Install bracket grounds as close to the worksite as practical, between the worksite and each fault duty source, then perform the following:

      (1) Wear Class 2 rubber gloves with approved protectors and EH boots to handle the conductor or work from a grounding mat wearing leather gloves.

      (2) If the conductor(s) are broken:

      Bond the two ends of the broken wire together before splicing, **OR** wear Class 2 rubber gloves with approved protectors when splicing the conductors.

   c. Lines with one fault duty source (taplines): Install bracket grounds as close as practical between the worksite and the fault duty source.

      - Address all backfeed sources.
      - Wear Class 2 rubber gloves with approved protectors and EH boots to handle the conductor or work from a grounding mat wearing leather gloves.

   If backfeed is addressed by installing an additional set of TPGs, follow the instructions in Section 5.10.1.b above.

2. **When working on downed conductor with exposure to adjacent energized circuits, perform the following:**

   a. Install bracket grounds as close as practical on each side of the worksite.

      (1) Wear Class 2 rubber gloves with approved protectors and EH boots before making contact with the wire or do the work from a grounding mat.

      (2) If the conductor(s) are broken, perform the following:

         a) Install a temporary ground rod within 10 feet of where the conductors are being spliced. See Figure 5.20 on Page 5-35.

         b) Attach a personal ground (minimum #2 Cu).

         c) Bond the two ends of the broken wire together before splicing (see Figure 5.20 on Page 5-35).

            - If the conductor(s) are not broken, skip Step c) and continue to Step d) on Page 5-35.

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5.10 (continued)

d) Wear Class 2 rubber gloves with approved protectors and EH boots before making contact with the wire or do the work from a grounding mat. See Figures 5.19 below.

Figure 5.19
Use of Grounding Mat

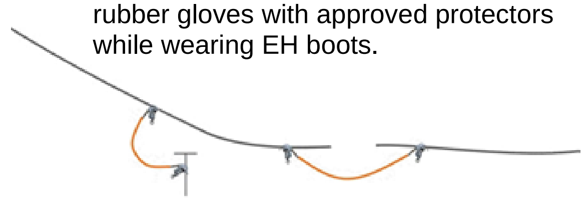

Figure 5.20
Personal ground with conductor bonded together

5.11 Distribution System Neutrals

> **WARNING**
>
> **Getting in series with a system neutral may result in serious injury or death.**

1. System Neutral Types

a. Radial Overhead Primary Neutral (PN)

Primary neutrals are grounded at the first pole after the take-off pole and then are not grounded elsewhere on the tap line. The primary neutral should be treated just like a phase wire and must be opened and grounded anytime the phase conductor is opened and grounded.

Clearing a Primary Neutral

When sectionalizing for the first time where a fuse is provided in the phase(s) and the primary neutral is fed straight through, perform the following:

(1) Create an open point in the PN at the fuse.

(2) Permanently install a solid blade cutout to provide a sectionalizing point in the PN.

All PN fuse locations should have a solid blade disconnect in the radial overhead primary neutral conductor.

5.11 (continued)

b. 4kV Neutral

Overhead 4kV Neutrals are installed in the primary position and should be in a grid configuration with at least two paths back to the source substation ground grid. 4kV Neutrals are grounded at the substation and when they feed into the underground. 4kV Neutrals should be treated the same as a phase conductor and must be opened and grounded anytime the phase conductor is opened and grounded. 4kV Neutrals **must**:

- Not be opened without first being bypassed with a jumper.
  - When it is not practical to jumper out the 4kV neutral, follow the instructions in Section 5.11.2 "Clearing a 4kV Neutral, 12kV or 21kV Common Neutral Without Bypassing with a Jumper."
- Be incorporated into the grounding scheme using a properly rated grounding jumper.

c. Common Neutral (CN)

Common Neutrals are multi-grounded, combined with secondary neutral, constructed in grid configuration with at least two metallic paths back to the substation ground grid. Common Neutrals should not be opened without first being bypassed with a jumper.

- When it is completely impractical to jumper out the Common Neutral, follow the instructions in Section 5.11.2 "Clearing a 4kV Neutral, 12kV or 21kV Common Neutral Without Bypassing with a Jumper".

2. Clearing a 4kV Neutral, 12kV or 21kV Common Neutral without Bypassing with a Jumper:

When it is necessary to open a 4kV Neutral or a Common Neutral, the engineer responsible for the circuit being worked must be contacted.

NOTE
Source grounds must be installed a minimum of 25 feet away from any grounds on the neutral that are still connected to the system.

NOTE
There will always be some current flowing from a system neutral to one of its grounds.

a. When it is necessary to clear a neutral without first being bypassed with a jumper, proceed as follows (see Figure 5.21 on Page 5-37).

(1) De-energize the primary conductor.

(2) Establish the clearance, leaving the neutral intact.

5.11 (continued)

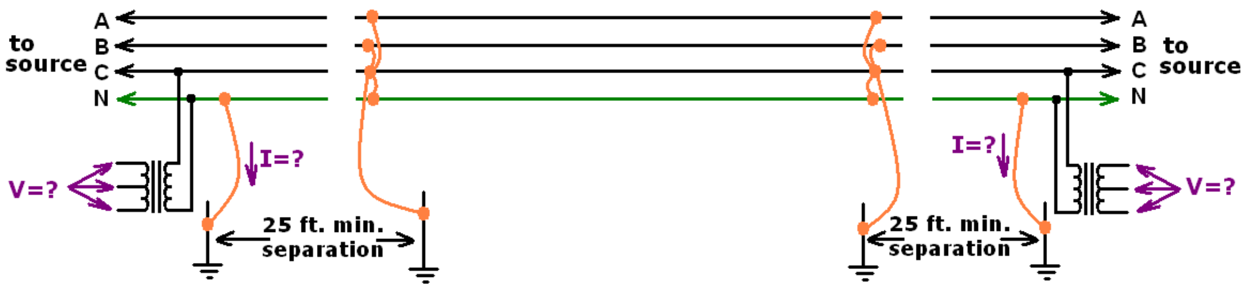

Figure 5.21 – Clearing a Neutral Conductor

b. For each point where the neutral is to be opened, perform the following steps, in order:

(1) If there is not an existing ground on the system neutral at the first transformer on the source side of where the neutral is to be opened, add a temporary ground to the system neutral.

(2) At the first transformer outside the clearance limits:

- Read and record the current from the system neutral into the ground (on the existing ground or the added TPG).
- Read and record the secondary voltage.

(3) Install a temporary disconnect at the designated open point on the neutral.

(4) Open the neutral (Break Safe, Loadbuster, etc.)

(5) At the first transformer outside clearance limits, **immediately**:

- Read and record the current from the neutral into the ground (on the existing ground or the added TPG).
- Read and record the secondary voltage.

(6) If the voltage is out of the allowed range per Rule 2 (see Table 5.3 on Page 5-38), or if the current into the ground is abnormally high, showing a marked change from before, then **immediately** close the temporary disconnect on the system neutral.

- This indicates that there is a continuity problem with the neutral going back to the source.

If the out-of-range voltage or the excessive current flow cannot be resolved, close the temporary disconnect installed on the system neutral and advise the system engineer.

5.11 (continued)

c. Repeat Steps (1) through (6) in sub-section **b** on Page 5-37, for each point where the neutral is to be opened.

Table 5.3 Service Voltages and Allowable Limits on Secondary

Service Voltage (Volts)	Measured Voltage (Volts)	Maximum (Volts)	Minimum (Volts)
120/240 Volt (V) 3-wire(w)1ø	120V phase-to-ground 240V phase-to-phase	126 252	114 228
120/208V 3w 1ø	120V phase-to-ground 208V phase-to-phase	126 218	114 198
120/208V 4w 3ø	120V phase-to-ground 208V phase-to-phase	126 218	114 198
120/240V 4w 3ø	120V phase-to-ground 208V phase-to-ground 240V phase-to-phase	126 218 252	114 198 228
277/480V 4w 3ø	277V phase-to-ground 480V phase-to-phase	291 504	263 456
240V 3w 3ø	240V phase-to-phase	252	228
480V 3w 3ø	480V phase-to-phase	504	456

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SECTION 6: DISTRIBUTION UNDERGROUND

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6 DISTRIBUTION UNDERGROUND

6.1 Scope

This section of the manual provides rules and procedures for creating protective grounding schemes within underground distribution facilities.

The person in charge (PIC) will discuss with the crew and select the safest method of grounding for the work being performed. The application and procedures outlined in this section must be followed for the method chosen. The PIC must ensure an electronic or hard copy of the latest version of the Protective Grounding Manual is available at the worksite.

6.2 General Information

1. Distribution System Neutrals

a. **4kV Neutrals** — Are in the primary position in the overhead, but are grounded when they feed underground. They should always be in a grid configuration with at least two paths back to the source substation ground grid. They should be tied into the temporary protective grounds (TPG) scheme. When practical, they should not be opened without first being jumpered out. When it is not practical to jumper out the 4kV neutral, contact your local Work Methods & Procedures (WM&P) Specialist.

b. **12kV and 21kV Common Neutral** — Multi-grounded, combined with secondary neutral, grid constructed with at least two metallic paths back to the substation ground grid. It is strongly preferred that Common Neutrals should not be opened without first being jumpered out. When it is not practical to jumper out the common neutral, contact your local WM&P Specialist.

6.2 (continued)

c. **Radial Overhead Primary Neutral (PN)** — Grounded at the first pole after the take-off pole, and then is not grounded elsewhere. The radial primary neutral should be treated just like a phase wire (must be opened and grounded for work). When sectionalizing for the first time where a fuse is provided in the phase(s), but the primary neutral is fed straight through — create an open point in the PN at the fuse and permanently install a solid blade cutout to allow isolation of the primary neutral. All PN fuse locations should have a solid blade disconnect in the radial overhead primary neutral conductor.

d. **Multi-Grounded Primary Neutral** — UG neutral: An underground neutral connected to equipment, ground rods, primary, and secondary neutrals.

Multi-grounded primary neutrals are installed in close proximity to primary cables and provide multiple ground paths for return currents. These may be composed of concentric wires, 600-volt insulated cables, or primary insulated cables.

When working on a grounded WYE system, use a bypass to connect or disconnect the multi-grounded primary neutral when a return path to the source cannot be verified.

If a return path to the source can be verified, a bypass is not required to open or close the primary neutral. For example, when replacing a section of cable, it is permissible to open the multi-grounded primary neutral. Verify the return path to the source by using an amp meter, maps, workers' knowledge of the circuitry, etc.

When a return path to the source cannot be verified and work requires connecting or disconnecting the multi-grounded primary neutral, use live-line work method.

In those cases where it is known that the return path to the source does not exist, extend the clearance points or establish a return path with a temporary bypass.

These work procedures are necessary in grounded WYE systems because the neutral cable normally carries load current.

2. Substation Grounding

Contact the local Substation Supervisor when grounding inside the substation is required.

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6.3 The Multi-Point Grounding Method

The Multi-Point Grounding Method is the only method approved for grounding underground distribution. Install grounds when working on de-energized underground conductors or equipment usually energized in excess of 600 volts (V).

The Multi-Point Grounding Method includes:

1. The installation of temporary protective grounds between the worksite and all possible sources of energy.
2. The installation of personal temporary protective grounds.
3. The creation of an equi-potential zone (EPZ) at each worksite.
4. Addressing all secondary backfeed sources:
   - Remove transformer fuses; i.e., bay-o-net fuses.
   - Ground secondary with clamp-to-clamp grounded jumpers or ground-clamp shunt TPG (see Figure 6.1 below).

Figure 6.1. #2 Ground-Clamp Shunts

   - Lift and isolate secondary leads.
   - Remove meter and glass meter socket and tag “Caution.”

NOTE
Opening the transformer switch or secondary breaker does not provide adequate protection from backfeed.

6.4 Temporary Protective Grounds (TPG) Size and Fault Duty

1. Introduction

Grounding devices must be able to carry the anticipated fault current at the location where the TPGs will be installed for the length of time it will take for the fault to clear, or they must be the same size or larger than the conductor being grounded.

The information contained in this section will help you select the size of the temporary protective grounding components that will ensure your grounds will meet the requirements above.

Properly sized and installed TPGs provide protection from:

- A single switching error that would energize the worksite.
- A credible mechanical failure of a clearance point that could result in energizing into the worksite.
- The accidental contact of a nearby energized conductor.

2. Selecting TPG Sizes for UG Distribution Circuits

a. For 200 amp systems

- Separate cable from equipment and ground with #2 TPG.

  If unable to separate, ground for fault-duty or use 2/0 TPG, unless exception circuit.

NOTE

Grounding for fault duty is not required when cable is removed from the source.

b. **For 600 amp systems**, do **one** of the following:

(1) Separate cable from equipment and ground with #2 TPG.

NOTE

Grounding for fault duty is not required when cable is removed from the source.

(2) Leave cable attached to the equipment and ground with a grounded elbow attached to 2/0 TPG, unless on an EXCEPTION circuit.

(3) Exception circuits have fault duties above 20kA. If on an EXCEPTION circuit, terminations must be separated from equipment before grounding, or 2 – 2/0 TPGs are required.

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6.4 (continued)

3. Grounding for Fault Duty

To determine if the instantaneous zone (15 cycle clearing time or less) applies to the portion of the circuit being worked, contact the planning engineer responsible for that circuit. Distribution Instantaneous Zones typically extend less than 1 mile from the substation.

Size TPGs for the fault duty of the source-side device, provided the distribution circuit is not on the exception circuit list.

To select the proper size TPGs, use Table 6-1 and access the fault duty information on the Distribution Operator's Toolbox (D.O.T.) home page, as described below:

a. Go to PG&E's Intranet home page, "PG&E@Work TODAY."

b. Click on the address line to highlight, type in DOT, and hit "Enter". This will take you to the D.O.T. home page.

c. From the home page, click on the "FEEDER CALC" tab which is located at the top of the page.

d. From the Feeder and Device information page, select "Division" from the drop-down menu.

e. Enter device number in the device name box; click on "Search."

f. Choose Sym Amps to size TPGs.

Table 6-1. TPG Fault Duty Rating

TPG Size (AWG)	MAX Fault Duty Rating Distribution 60 Cycle Clearing Time		MAX Fault Duty Rating Distribution Instantaneous Zone[1]	
	Reclosing relay cut-in	Reclosing relay cut-out	Reclosing relay cut-in	Reclosing relay cut-out
1 - #2 cu.	4.8 kA	8.6 kA	9.5 kA	15 kA
2 - #2 cu.	9.0 kA	16 kA	18 kA	30 kA
1 – 2/0 cu.	11 kA	16 kA	20 kA	30 kA
2 – 2/0 cu.	20 kA	32 kA	38 kA	57 kA

[1] Distribution Instantaneous Zone is typically the portion of a Distribution Circuit that is within one mile of a substation

6.4 (continued)

4. Installation of Source TPGs

Perform the following steps:

a. Test all conductors de-energized and ground all individual phases of a circuit.

b. Install properly rated source grounds between the worksite and each electrical source.

c. Locate the source grounds, as close as practical to the worksite. When practical, avoid installing the source grounds at the immediate worksite where workers could make inadvertent or incidental contact during their work.

NOTE

Source TPGs may be removed for cable testing or phase identifying purposes once they have been in place on all the conductors or equipment, at the same time – with the approval of the PIC.

For fault-locating when live-line work methods are used, source grounds are not required.

5. Installation of Personal Grounds

a. Personal grounds at the worksite:

- Must be minimum of #2 cu.
- Prove the conductor or equipment is de-energized.
- Help to drain off capacitive charge.
- May be removed once they have been in contact with the conductor.

b. At your worksite, verify that you are on the correct circuit by cable tagging, and **one** of the following:

- Testing de-energized with approved voltage detector.
- Physical movement from the location with grounds.
- Visually traced.
- For Cable Spiking procedures, see Section 6.4.7 on Page 6-9. In situations where leaving a personal ground in place is not practical, only source temporary protective grounds between the worksite and each possible source of energy and an EPZ are required.

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6.4 (continued)

6. Establishing an EPZ

a. General Information

- The concentric cable associated with high voltage underground cables can, in some instances, represent a hazardous potential to workers while working on underground equipment and/or cables. The phase conductors are not in the EPZ and are still exposed to transfer potential hazards — minimize contact time, or bond phase conductor to EPZ for prolonged contact.

CAUTION

Cutting concentric wires in the underground generally should NOT be done, unless removing conductor, as they are tied to everything and used as the neutral on 4-wire (4kV, 12kV, 21kV, 34.5kV) systems. See Standard Drawing 068183, "PG&E Neutral Systems" for information on primary neutrals.

- Establishing an EPZ protects employees from transferred voltage potential brought into your worksite from the external-source grounds that are connected to the concentric wires and/or the cable conductor.

- When a fault occurs while a cable is de-energized and grounded, a transfer of voltage through the cable conductor and the concentric wires is possible.

- A difference of potential between ground sources may also cause a hazardous level of current to flow.

- The use of grounding mats can protect workers from possible hazards by placing the worker on a grounded surface that is connected to the concentric and an approved ground source, which creates an equi-potential zone.

b. Establishing an EPZ in an Enclosure (subsurface, vault, etc.)

- In new concrete enclosure installations, the rebar will be grounded through a grounding lug visible in the enclosure. Grounding the rebar creates an EPZ in the enclosure.

- On existing enclosures, when practical, permanently ground the enclosure. Document 060462, "Grounding of Underground Equipment" in the general section of the Underground Construction Manual provides the installation information.

6.4 (continued)

c. In situations where establishing an EPZ is not practical (e.g., rerouting cables during enclosure replacement), do the following:

(1) At the clearance limit(s):

- Separate the source terminations from equipment.

(2) At the worksite(s) do at least **one** of the following:

- Cover termination or cable end with protective equipment /material, including concentric wires/shielding.
- Work with Class 2 rubber gloves with approved protectors.
- Connect the concentric wires or shielding to a ground.
- Maintain continuity of the concentric wires or shielding of at least one cable at the worksite between the source grounds.

(3) Avoid putting yourself in series when disconnecting or connecting the concentric wires by installing a jumper or wearing Class 2 gloves with approved protectors.

d. Use of Temporary Ground Mats to Create an EPZ

Ground mats **are not required** if:

- Work is performed using live-line tools.
- Work is performed wholly inside a concrete enclosure or vault that is tied to the ground rod in accordance to, TD-060462B-001, “Grounding Distribution Underground Primary Electric Concrete Enclosures and Vaults.”
- Work is performed, as in step **c** above.

Installing a ground mat:

(1) Roll out the ground mat.

(2) The mat may be folded into different sizes to accommodate the work location.

(3) Attach the ground mat lead to the ground source.

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6.4 (continued)

(4) Multiple mats may be used at one location. Always connect the mats to a single grounding source. They are to be connected to each other in such a manner that they do not conduct current and so that workers cannot place themselves in series across the mats. See Figure 6.2 below for an example of properly installed ground mat.

Figure 6.2. Properly Installed Ground Mat.

While working on a ground mat:

- Keep all parts of the body on the mat.
- Avoid contact with exposed conductive surfaces that are not tied into the EPZ (e.g., concentric wires, cable conductor).
- Minimize contact that crosses the boundary of the EPZ.

7. Cable Spiking

a. Requirements for Cable Spiking

A cable spike is a testing/grounding device that is used to prove that underground cable conductors are de-energized. Use the grounded cable spike to test that cable conductors are de-energized when ANY of the following conditions apply:

- The cable termination or apparatus cannot be tested de-energized with an approved voltage detector before grounding.

6.4 (continued)

- The underground cables cannot be visually or physically traced from a grounded point to the worksite.

b. Procedures Prior to Cable Spiking

To ensure that you are spiking the right cable and to reduce the risk of spiking energized cable, one of the following methods of cable identification must be used:

- E1. PTC-2 Hipotronics — Phase Tracer (Capital Tool).
- E2. VCI-3 Voice Cable Identification System (Capital Tool).

NOTE
The load detecting amp meter is no longer an approved tool for cable identification prior to cable spiking.

c. Cable Spiking Procedures

Cable-spiking tools are portable testing devices used to prove that underground cable conductors are de-energized. Only use approved spiking tools to spike cable.

Always consider the cable(s) as energized, until the spiking operation is completed. While performing a cable-spiking operation, maintain as much distance from the spiking point as possible.

Cable-spiking devices may be used only by – or under the direct supervision of – a qualified electrical worker (QEW).

After all clearance, cable identification methods, and protective grounding requirements have been met, complete the following steps:

(1) Connect the cable-spiking device's ground lead to an approved ground source.

(2) Wear Class 2 rubber gloves with approved protectors when performing a cable spiking operation.

(3) Use the appropriate cable-spiking device to spike the cable at the worksite.

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6.4 (continued)

d. Cable-Spiking Tools

NOTE
All cable-spiking tools must be equipped with a ground cable and ground clamp.

(1) Hydraulic Cutter Spike

a) The Hydraulic Cutter Spike may be used to spike any distribution cable.

b) Install the Hydraulic Cutter Spike around the cable and lock it into place.

- Ensure that the assembly is supported by using the rigging eyelets provided on the spiking head. Supporting the tool prevents it from dropping onto adjacent cables or equipment.
- Also, ensure that the cable being spiked is secured, so that the cable will not move after completing the cutting procedure, as shown in Figure 6.3 below.

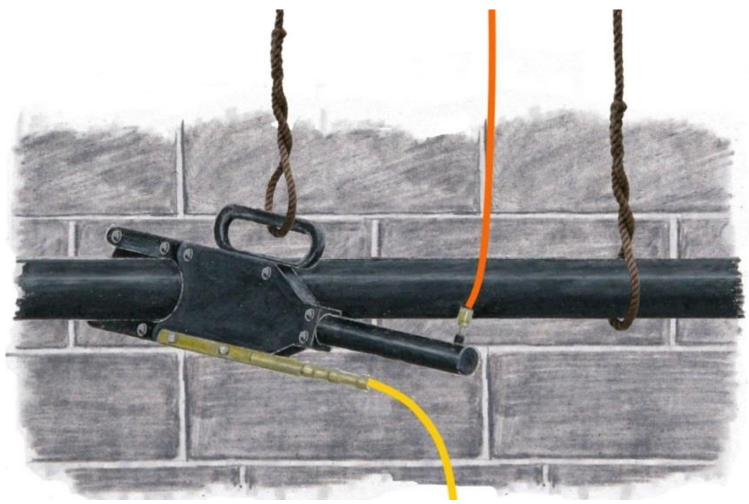

Figure 6.3. Hydraulic Cutter Spike: Tool Setup.

c) While in a position away from the enclosure or manhole opening, and wearing Class 2 rubber gloves and approved protectors, spike the cable by operating the hydraulic pump until the pressure automatically releases.

d) Verify that the cutter sliced through the cable.

(2) Cable Spike Model 1710 (see Figure 6.4 on Page 6-12)

a) The Cable Spike Model 1710 is recommended for spiking lead cable. It may be used on any other distribution cable.

b) To use the Cable Spike Model 1710, choose either the spike or the chisel point and assemble the fiberglass rods.

6.4 (continued)

c) From outside of the vault or enclosure, center the spike tip on the cable.

d) To help hold the cable rigid and allow the conductor to be spiked more efficiently, place a piece of wood under the cable on the opposite side from the spiking point, as shown in Figure 6.4 below.

Figure 6.4. Cable Spike Model 1710: Tool Setup.

e) While wearing Class 2 rubber gloves and approved protectors, use a hammer to strike the impact end of the fiberglass rod assembly. Continue striking the assembly until the spike point or blade contacts the cable conductor.

f) When using the Cable Spike Model 1710 to spike cable-in-conduit (CIC), first cut a hole in the conduit. The opening should be large enough to allow the spike to be driven into the conductor.

g) Verify the spike or blade point has contacted the conductor. Look for obvious exposed conductor on aluminum cables or carefully inspect the spike for copper residue on copper cables.

WARNING

When the model 1710 is used on non-lead cable, support target cable to ensure proper penetration of cable jacket by the spike and definite contact has been made with the conductor. All simplex cables must be spiked, and spiked individually.

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6.5 Grounding Specific Devices

For operating separable terminations, see TD-2303P-01, "Operating Procedures for Primary Underground Separable terminations."

1. **Live-Front Pad-Mount Equipment** (see Figure 6.5 below)

Figure 6.5. Installing Grounding Jumpers.

a. Ensure the protective barriers and stress-cone covers, where applicable, are in place.

> **CAUTION**
>
> All precautions should be exercised to prevent any touching or moving of the interphase barriers and all applicable safety rules must be observed.

b. Test the cable de-energized with an approved voltage detector attached to a live-line tool, ensuring the voltage selector switch is on "L" for testing direct line.

> **NOTE**
>
> Direct line tests on 4kV apparatus may result with minimal movement of the meter. After performing a direct line test, switching the meter to Capacitance Test "C" and bringing the meter close to, but NOT touching, the apparatus can confirm a direct line test, with a full deflection.

c. Attach the required number of grounding jumper clamps to the equipment ground bus with a live-line tool, as required.

6.5 (continued)

d. Install approved clamp-to-clamp grounds.

e. Reverse Step a through Step d, on Page 6-13 and above, when removing the grounds.

2. **200 Amp Separable Connectors** (see Figures 6.6 and 6.7 below)

Figure 6.6. 200 Amp Source Grounds

Figure 6.7. 200 Amp Personal Grounds

a. Visually ensure that all the separable-connector bails and capacitance test-point caps are in place and secure.

b. Attach the required number of grounding-standoff jumpers to the equipment's ground bus.

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Obsolete

6.5 (continued)

> **NOTE**
>
> If a clearance is issued from an open switch, the cables do not have to be installed onto insulated standoff brackets.

c. Test the cables de-energized with an approved voltage detector attached to a live-line tool. Use live-line tools to remove the insulated standoff and separable connector from the equipment's parking stand.

d. Apply silicone grease to the grounding standoff. Place the grounding standoff in the equipment's parking stand, adjacent to the separable connector to be grounded.

> **NOTE**
>
> Standoff brackets may be placed by hand if capacitance test caps are in place and there are no exposed live parts.

e. Using an approved voltage detector attached to a live-line tool, retest the de-energized separable connector while it is on the insulated standoff bushing.

f. Using live-line tools, transfer the separable connector from the insulated standoff bushing, or de-energized switch, to the grounding standoff.

g. When removing the grounds, transfer the separable connector back to the insulated standoff bushing. For a de-energized switch, always test the insulated covers or candled elbows on the switch before removing them.

3. 600 Amp Separable Connectors

Figure 6.8. 600 Amp Trayer Switch 2/0 Grounded Elbow

6.5 (continued)

Pad-Mounted Interrupter 600 Amp

Figure 6.9. Cable Separated #2 Grounded Jumper

Figure 6.10. Cable Attached 2/0 Grounded Jumper

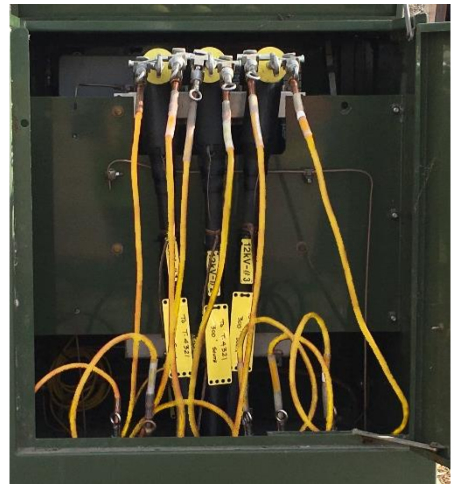

Figure 6.11. Cable Attached Exception Circuit 2–2/0

WARNING

Only use live-line tools to separate 600A connectors. Rubber gloves cannot be used as a substitute for live-line tools in underground activities.

a. Visually ensure that all the separable-connector bails and capacitance test-point caps are in place and secure.

b. If there is a 600A / 200A reducing tap plug and the circuit is not an EXCEPTION circuit, ground as follows (see Figure 6.10 above):

(1) Attach the required number of 2/0 grounding elbow jumpers to the equipment's ground bus.

(2) Using an approved voltage detector, ensure that the 200A separable connector, or the basic insulating plug located on the 600A separable connector, is de-energized.

(3) Using a live-line tool, remove the 200A separable connector.

(4) Install 2/0 grounding elbow jumpers on each 600A / 200A reducing tap plug to be grounded.

(5) Reverse steps to remove grounds.

c. If the 600A connector assemblies are constructed with basic insulating plugs and the circuit is not an EXCEPTION circuit, using live-line tools, remove the basic insulating plug and replace it with a 600A / 200A reducing tap plug and then ground per Step b above (see Figure 6.8 on Page 6-15).

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6.5 (continued)

d. If the circuit is an EXCEPTION circuit, do one of the following:

(1) Separate and install grounding studs (see Figure 6.9 on Page 6-16):

a) Using an approved voltage detector, ensure that the 200A separable connector, or the basic insulating plug located on the 600A separable connector, is de-energized.

b) Using live-line tools, remove the basic insulating plug or 600A / 200A reducing tap plug.

c) Using live-line tools, remove the 600A termination from device.

d) Cover the exposed equipment bushing with a 600A insulated cap with a capacitance test point (Code 303828).

e) Install a 600A ground stud/plug in the isolated 600A elbow connector.

f) Ground the ground stud/plug with #2 ground jumpers.

g) Repeat Steps a) through f) above until all of the 600A elbow connectors are grounded.

h) Reverse steps when removing the grounds.

(2) Install grounding studs without separating (see Figure 6.11 on Page 6-16):

a) Using an approved voltage detector, ensure that the 200A separable connector, or the basic insulating plug located on the 600A separable connector, is de-energized.

b) Using live-line tools remove the basic insulating plug or 600A / 200A reducing tap plug.

c) Install a 600A ground stud/plug into the 600A elbow connector.

d) Repeat for the other phases.

e) Ground the ground stud/plugs with 2–2/0 ground jumpers.

f) Reverse steps when removing the grounds.

6.5 (continued)

4. Risers

a. If installing multi-point grounds at a primary riser and using a ground source other than the common or multi-grounded neutral system, always install a grounding jumper between the multi-point grounds and the cables concentric.

b. If the riser is constructed with paper-in-lead cable (PILC):

- The preferred method is to replace one of the pothead mounting bolts on each pothead with a bolt of sufficient length to provide a grounding bar to which the grounding jumper can be connected.

- Install the bolt so that the smooth part of the shank, between the head and the thread, is exposed to provide a point to which the grounding jumper can be connected.

5. TGRAM and TGRAL Oil Switches (see Figure 6.12 below)

See Appendix C, "Underground Identification Tools and Devices."

Figure 6.12. TGRAM With Adjustable-Head Ground Clamps Installed on the Test-Ground Bushings.

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6.5 (continued)

6. **D&W Type Underground Cutouts** (see Figure 6.13 below)

See Appendix C, "Underground Identification Tools and Devices."

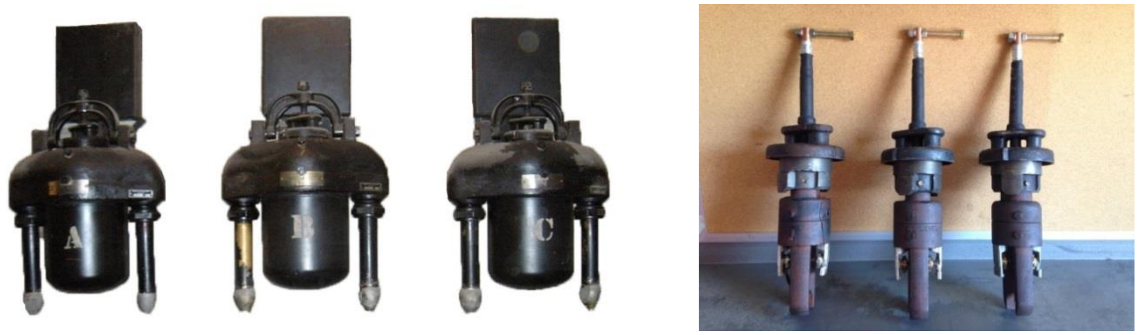

Figure 6.13. D&W Underground Fused Cutouts and Grounding bushings.

7. **Network Feeders**

CAUTION

Network feeders will stay energized after the source breaker is opened – until all of the associated network protectors have automatically opened or manually been opened.

a. Network feeders must be de-energized at the source, tested de-energized with an approved voltage detector, and grounded. Do this either at the station or at a sectionalizing switch between the station and the worksite.

b. Install multi-point grounds on each side of the worksite at the next accessible upstream and downstream electrical device/separable connection to eliminate all possible sources of backfeed.

c. Network protectors (NWPs) are engineered to prevent backfeed. If the NWPs are open, then the source of backfeed has been eliminated. It is not required to ground more than what is detailed above or to remove the cable. See Figure 6.14 on Page 6-20.

d. When possible, ground the feeder conductors at the worksite. Use the network transformer ground switch and tag "CAUTION," or use personal grounds.

e. Record the total number of grounds and their locations on a "PG&E Grounding Tailboard/Observer Form." Document the position of the ground switch before operating it for future reference. Count each network transformer ground switch as one ground.

f. After completing the work, verify that all ground switches have been placed in the same operating position as when they were received, unless instructed to do otherwise by the PIC. Remove the "CAUTION" tags, as appropriate.

6.5 (continued)

g. Confirm the “CAUTION” tag count. Verify that all grounds are in the clear. Report the number of ground switches operated to the DOs when reporting off.

Figure 6.14. Network Operating Handle.

8. Network 40kA Switches (see Figure 6.15 below)

These switches are remotely operated using a control box outside of a manhole or vault. There is no manually operated handle.

Fig 6.15. 40kA Switch

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6.5 (continued)

9. Network Transformer Ground Switches

The integral switch has an electrical interlock that prevents the switch from being grounded or opened while the transformer is energized. The switch prevents the operating handle from being moved when the transformer is energized.

WARNING

The operating direction and the labeling vary with manufacturer and year. Verify operation positions before operating.

Following are the three positions of the integral switch on a network transformer:

a. CLOSED — Transformer is connected to the network feeder.

b. OPEN — Transformer is disconnected from the network feeder, but the feeder is not grounded.

c. GROUND — Transformer is disconnected from the network feeder and the feeder is grounded.

See Figure 6.16 below for an example of a typical Ground Switch Operating Handle.

Figure 6.16. Ground Switch Operating Handle.

NOTE

Network transformers without an integral switch will have a two-position switch (i.e., open or closed) immediately ahead of the transformer. The transformers are connected with separable connectors. First, open the switch, then open the network protector to de-energize the network transformer. The separable connectors can be operated in the standard method to test and ground the primary cables.

6.5 (continued)

10. Primary Metering Compartments (see Figure 6.17 below)

a. Using Class 2 rubber gloves with approved protectors, carefully remove protective cover.

b. Using live-line tools:

(1) Test cables de-energized with approved voltage detector.

(2) Apply #2 or 2/0 ground clamps, as required, to the ground bus.

(3) Apply appropriate ground clamps to bus bars.

(4) If needed, apply ground clamps around CTs.

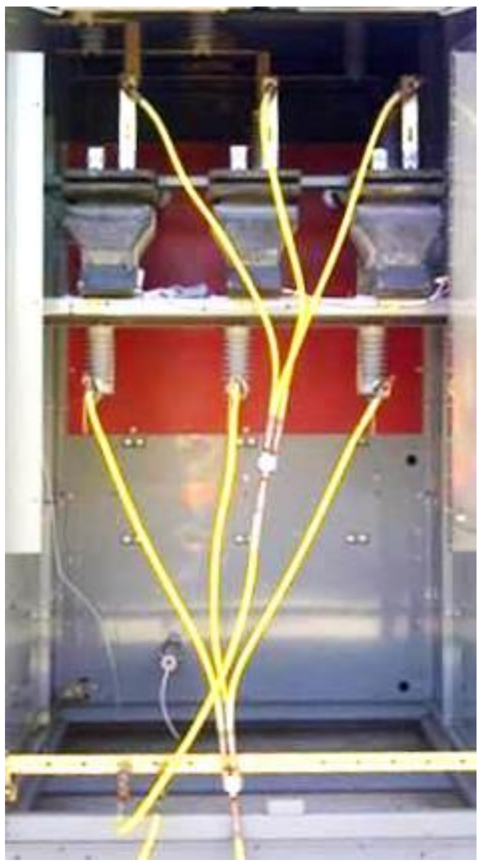

Figure 6.17. Primary Metering Compartment.

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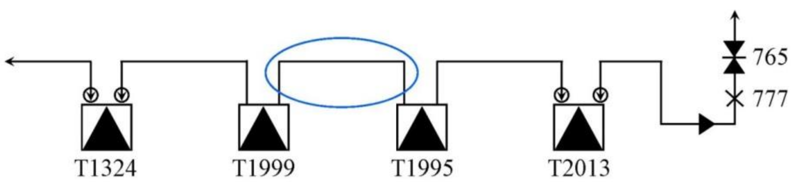
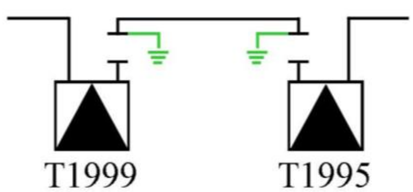
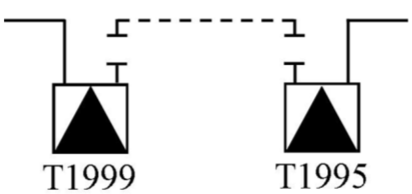
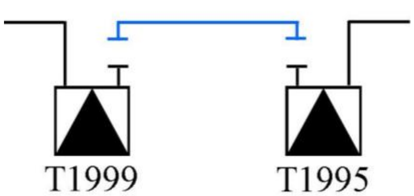
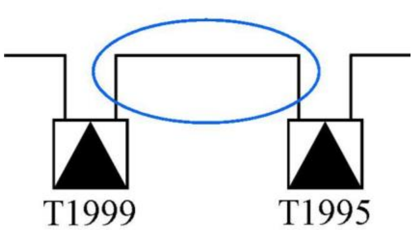
6.6 Examples of Underground Scenarios

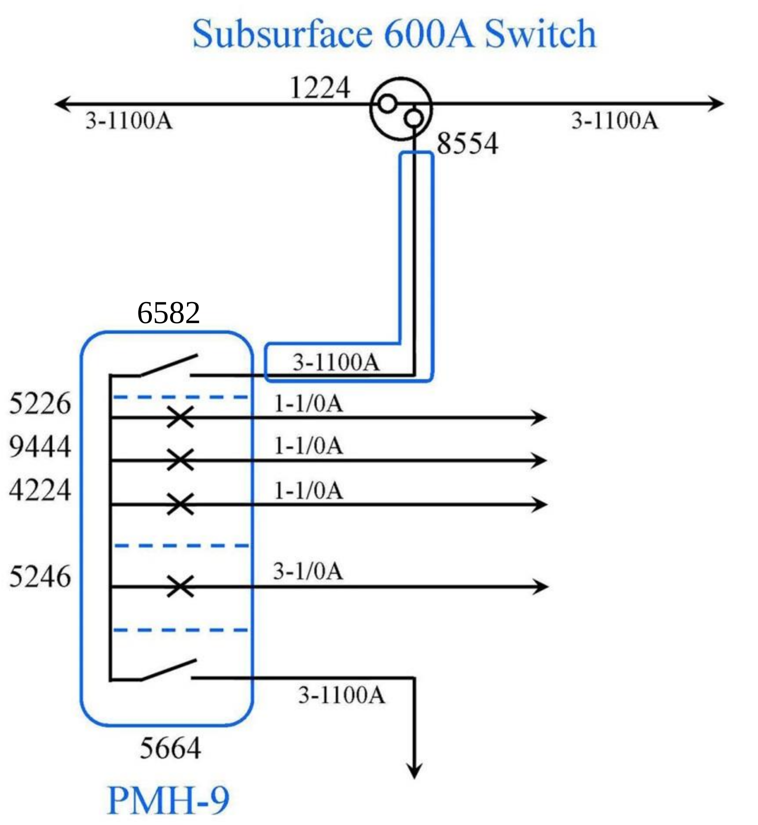
The following are examples of common grounding scenarios that will help you understand how to clear and effectively ground a section of line where your work is to be performed.

1. Cable Replacement Between Dead-Front Pad-Mounts

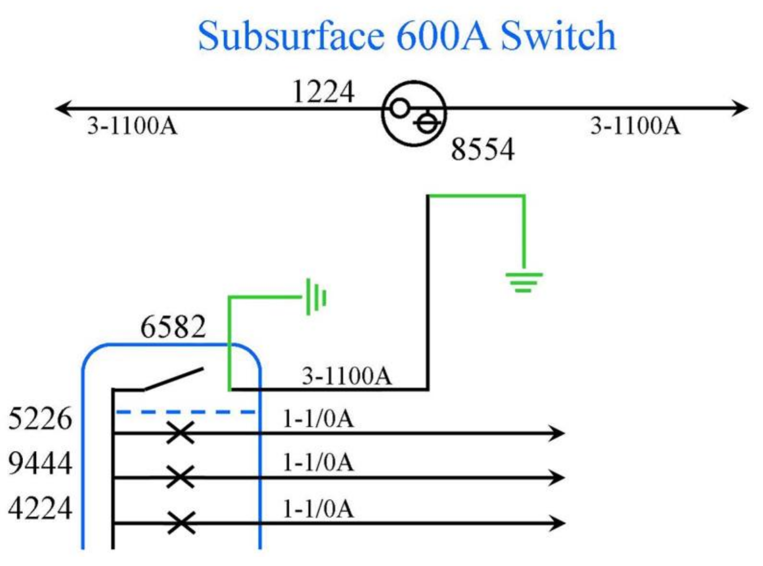
	**Job Scope:** Crew to replace cable between T1999 and T1995. T1999 and T1995 will be taking short shutdowns to establish clearance limits and to ensure cables are marked properly. • Clearance Limits: COIS@T1999 towards T1995 and COIS@T1995 towards T1999.
	• Crew checks both T1999 and T1995 energized with candled elbows in place, and tagged MOL. • Crew reports on section, from COIS @ T1999 TWDS T1995 and COIS @ T1995 TWDS T1999 using grounds. • Crew tests COIS de-energized and installs grounds. • Crew establishes EPZ, as required.
	• Crew cuts the terminations off the cables they will be removing, with grounds still installed (best practice to ensure you are cutting the correct cables). • Crew removes grounds from ground bus. • Crew pulls the cable out, then pulls in replacement cable between the pad-mount transformers.
	• Crew makes up 200A elbow terminations at both locations and places on insulated stand-off. • PIC calls the DO, reports off with grounds removed, and section ready for service. • Crew gets OK to continue switch log to restore section normal.
	• Crew tests all cables de-energized at T1999 and T1995. • Crew places elbows into normal operating positions at T1999 and T1995 with live-line tools. • Crew energizes T1999 and T1995 and proves phasing.

6.6 (continued)

2. 600 A Cable Replacement between Switches

<table>
<tr>
<td>
</td>
<td>Job Scope: Crew to replace cable between 600A SW-8554 and PMH-9 SW-6582.

Clearance Limits: SW-8554 and SW-6582, using grounds.

PIC has determined that it is safe to pull cable at the enclosure containing the 600A switch and a QEW will be feeding cable at the PMH-9.</td>
</tr>
<tr>
<td>
</td>
<td>Crew reports on section from SW-8554 and SW-6582 using grounds.
Crew tests SW-6582 and SW-8554 de-energized and installs grounds.
Crew removes 600A terminations from SW-8554 and installs protective equipment, as required, utilizing live-line tools.
Crew establishes EPZ, as required.</td>
</tr>
</table>

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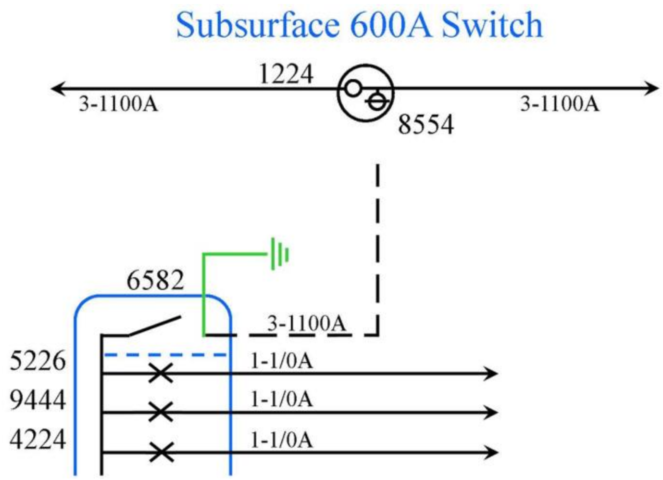
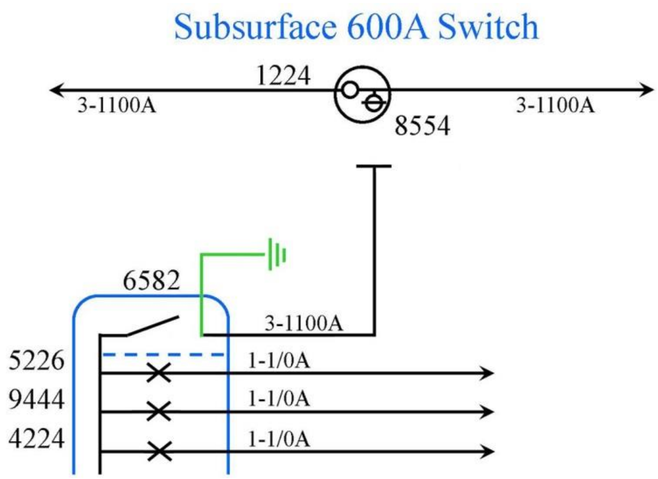
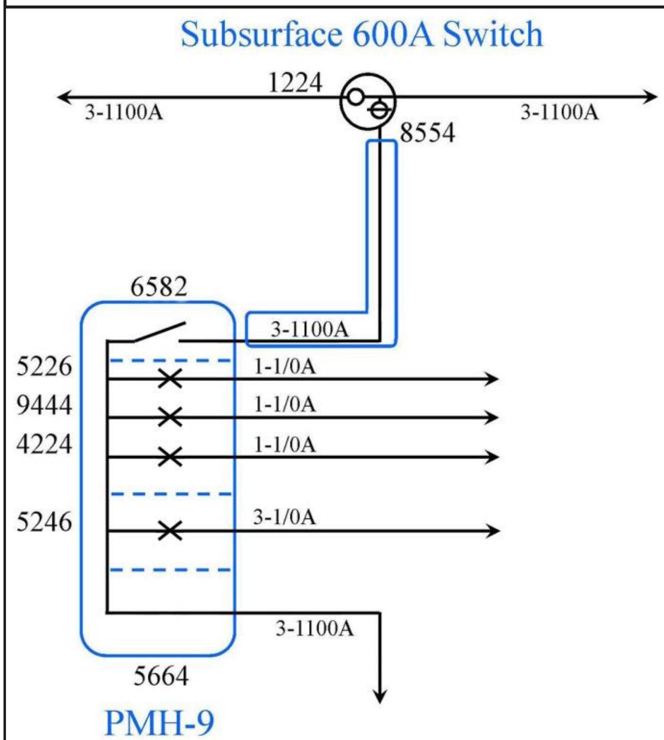
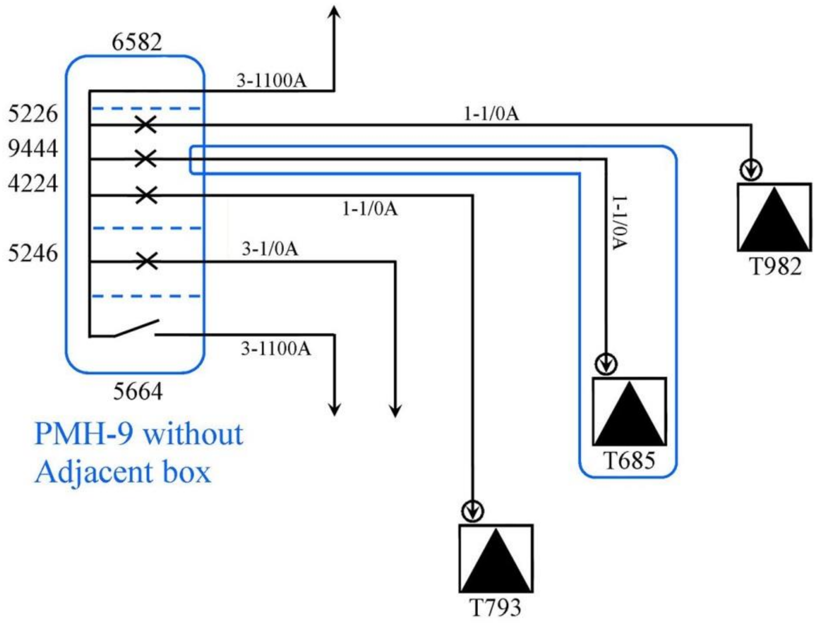
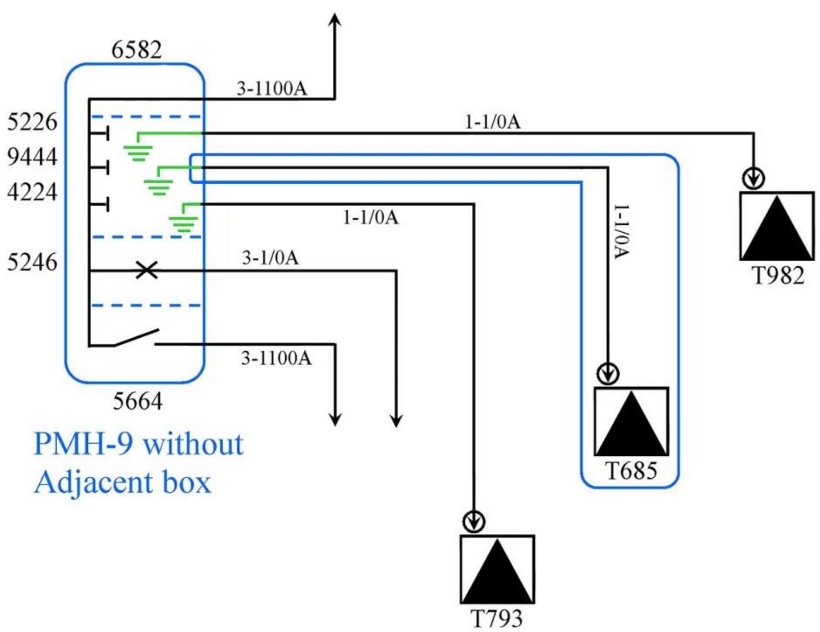
6.6 (continued)

	• Crew cuts terminations off cable at SW-8554 and removes 3 grounds. • Crew cuts terminations off cable at SW-6582 and leaves lugs grounded at SW-6582. • Crew pulls old cable out and new cable in.
	• Crew installs new cable terminations at SW-6582. • Crew installs new terminations at SW-8554. • Crew places terminations at SW-8554 to normal operating position, utilizing live-line tools. • Crew removes grounds from SW-6582.
	Crew reports off with grounds removed; energizes, and checks phasing OK.

6.6 (continued)

3. Replace a Transformer and Cable from a PMH9

	**Job Scope:** Crew to replace T685 and cable between T685 and FCO-9444. Clearance Limits: FCO-5226, FCO-9444, and FCO-4224 to the end of line. One compartment of the PMH contains 3 separate cable feeds, FCO-5226, FCO-9444, and FCO-4224.
	When feeding cable at a PMH by a QEW, only the one cell needs to have barriers in place, de-energized and grounded. When terminating or connecting cable within one cell, all three cells must have protective barriers in place, de-energized and grounded. At the PMH-9, crew installs barriers, tests de-energized, reports on section. Crew tests de-energized and installs grounds at FCO-5226, FCO-9444, and FCO-4224.

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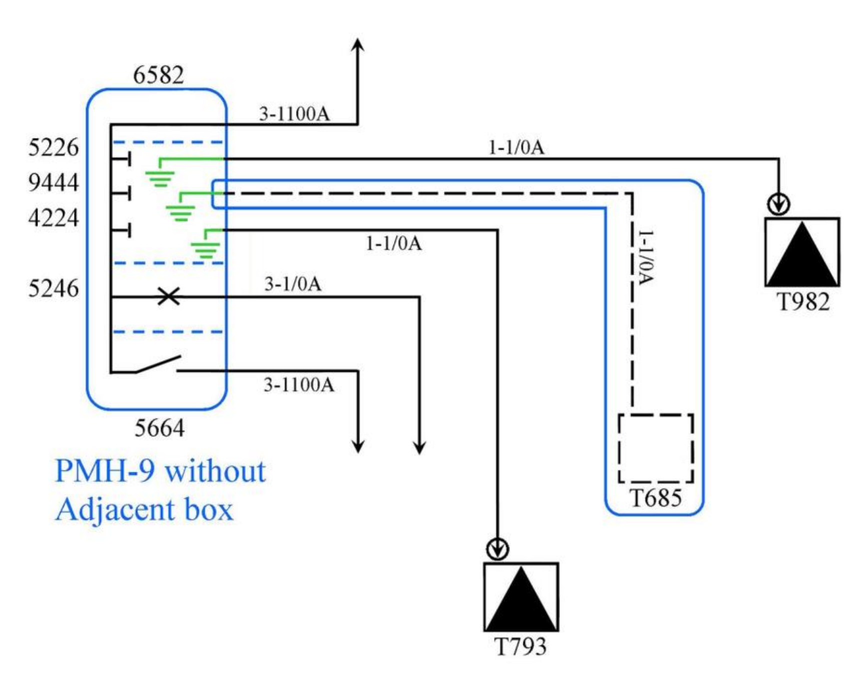
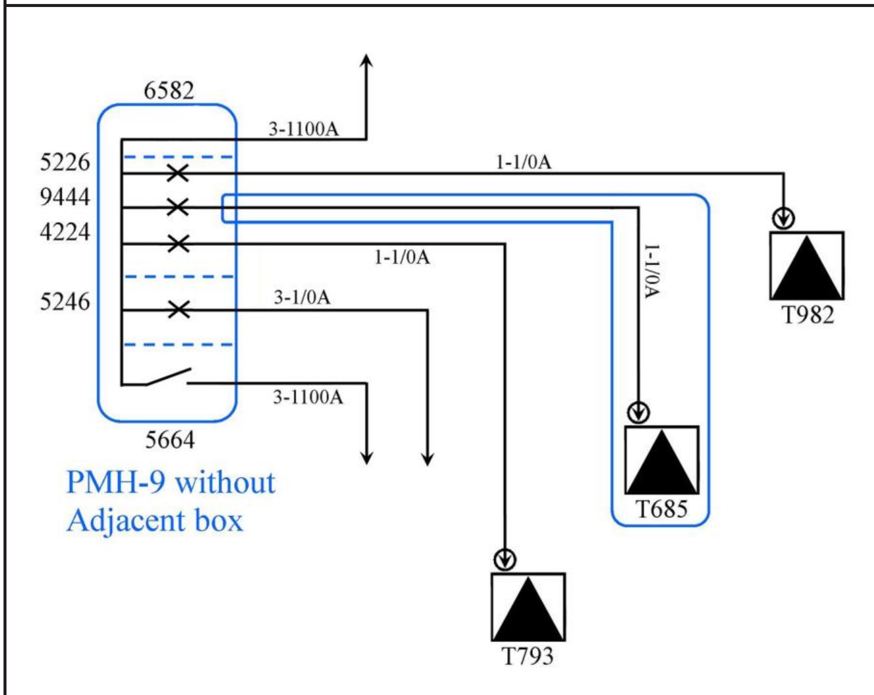
6.6 (continued)



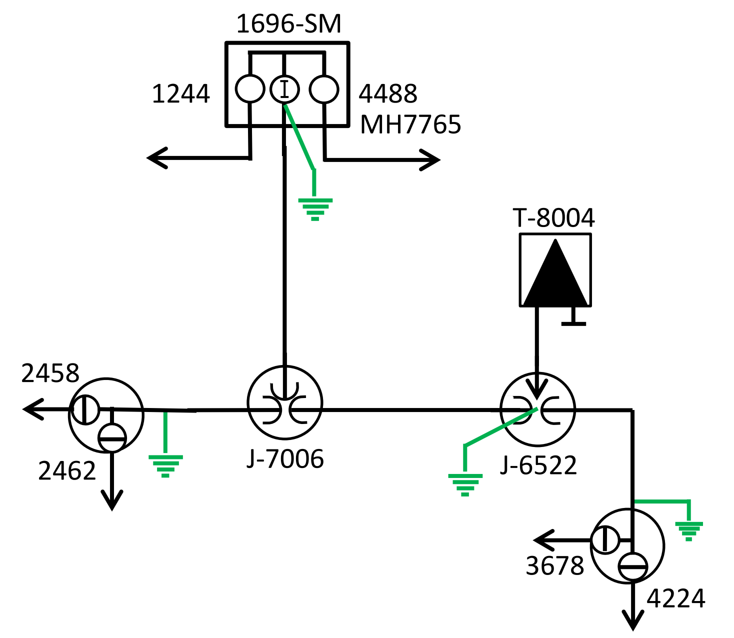
- At T685, crew addresses backfeed, tests the primary cable de-energized, installs a ground.
- Crew establishes an EPZ, as required.
- Crew pulls out old cable and removes the transformer.
- Grounds remain in place on grounding lugs at the PMH.



- Crew installs new cable and transformer.
- Crew removes grounds, reports off section.
- Crew gets permission to close fuses at PMH, energizing.
- Crew checks power OK at T982, T685, and T793.

6.6 (continued)

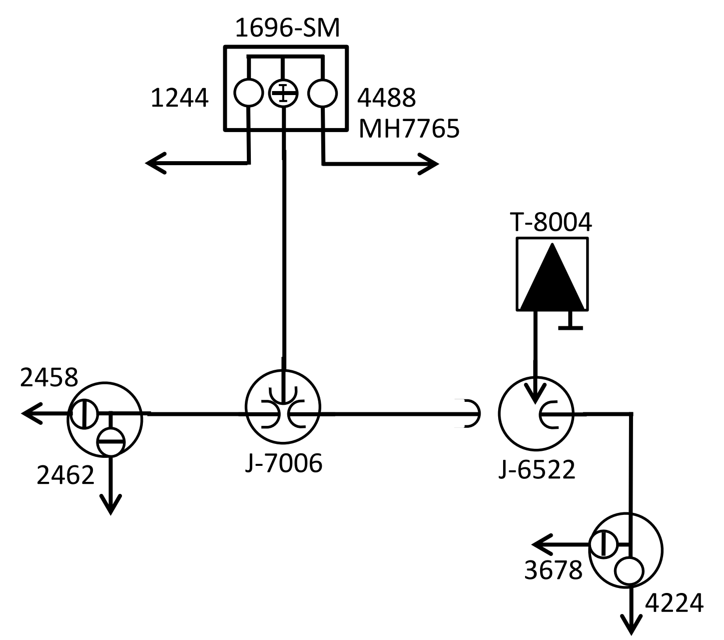
4. 600A Junction Replacement



Job Scope: Crew to replace 600A Junction J-7006 with same.

Initial Clearance Limits:
SW-1696, SW-2458, SW-2462, SW-3678, SW-4224.

- Crew reports on initial clearance with grounds.
- Crew installs source grounds at SW-1696, hard tap twds J-7006, hard tap twds J-6522, personal grounds at J-6522, and addresses backfeed from T8004.
- Crew establishes EPZ, as required.



- Crew isolates cable at J-6522 twds J-7006.
- Crew removes source grounds at SW-1696, hard tap twds J-7006, hard tap twds J-6522.
- Crew reports clear of initial clearance and, per switch log, closes SW-4224 and energizes T-8004.

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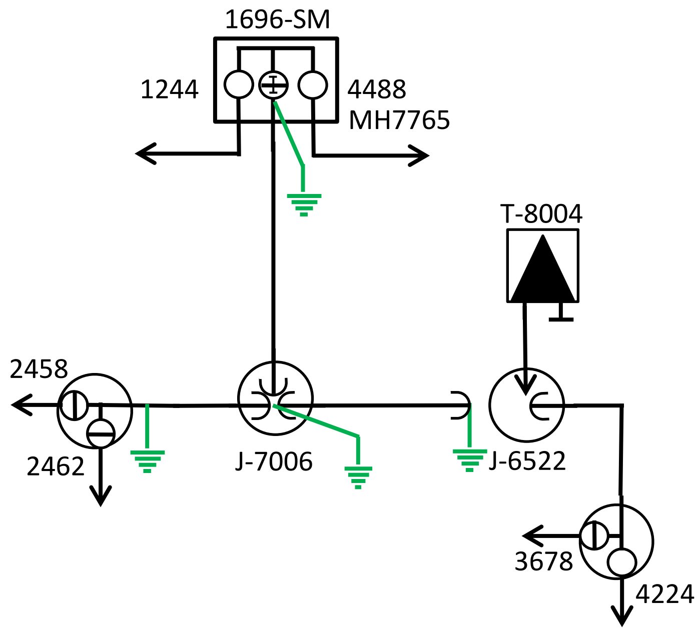
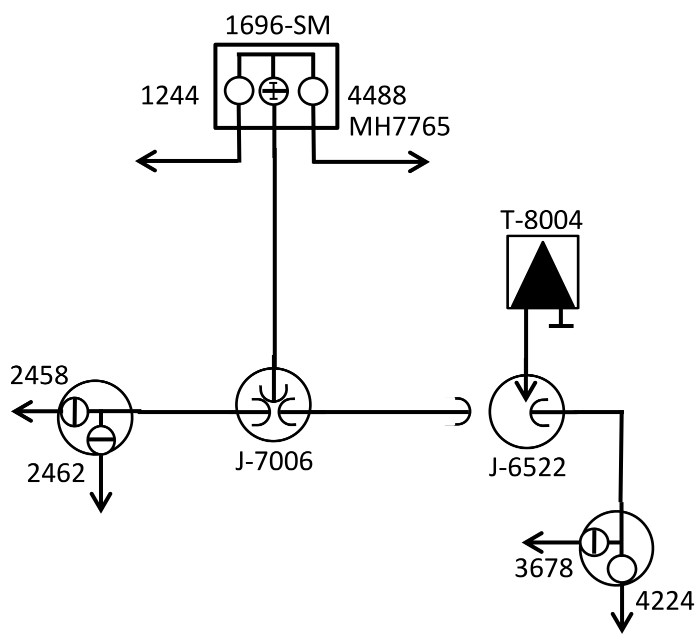
6.6 (continued)

<table>
<tr><td>
</td><td>

- Crew reports on new section from SW-1696, SW-2458, SW-2462 and COIS at J-6522 twds J-7006 with grounds.
- Crew installs source grounds at SW-1696, hard tap twds J-7006, and J-6522 twds J-7006, with personal grounds at J-7006.
- Crew establishes EPZ, as required.

</td></tr>
<tr><td>
</td><td>

- Crew completes work at J-7006.
- Crew removes grounds from SW-1696, hard tap twds J-7006 and J-6522 twds J-7006.
- Crew reports off with grounds removed.

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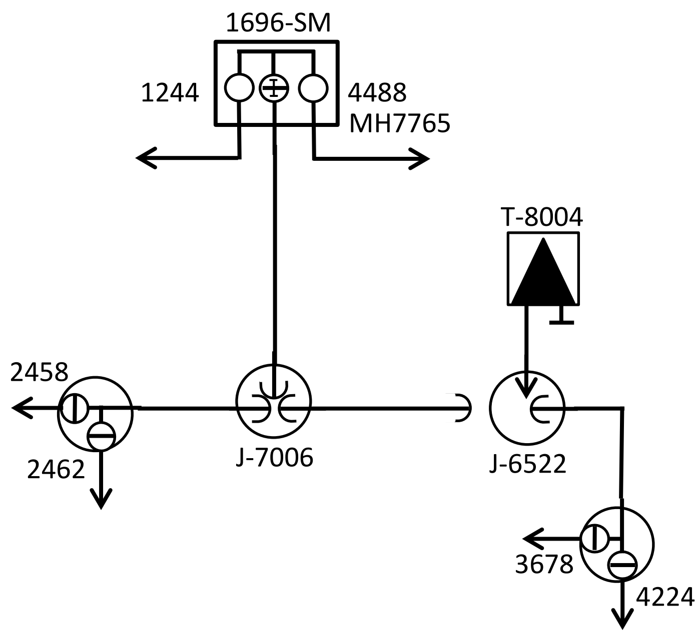
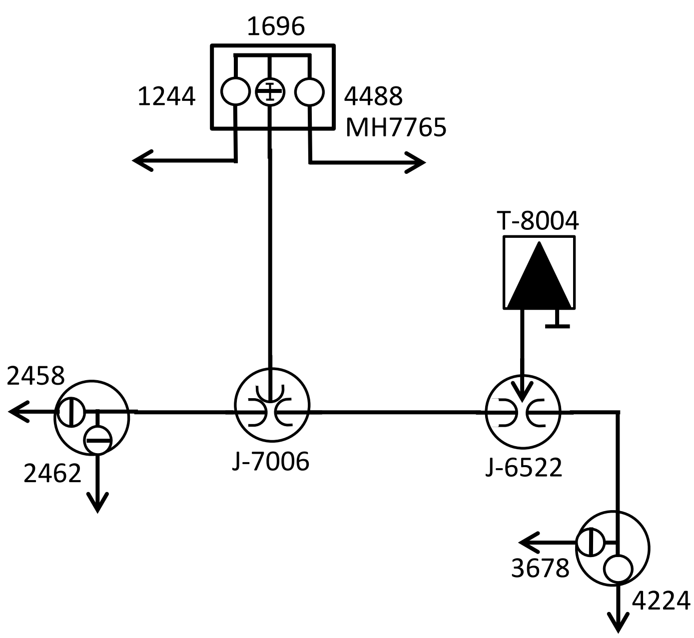
6.6 (continued)

	• J-6522 de-energized to place cable to normal operating position at J-6522. • Crew utilizes live-line tools to place cables to normal operating position at J-6522.
	• Crew gets permission to close SW-4224, energizing T-8004; verifies voltage and rotation OK. • Crew confirms phasing at SW-2458, SW-2462 and SW-1696, SW-1244 and SW-4488.

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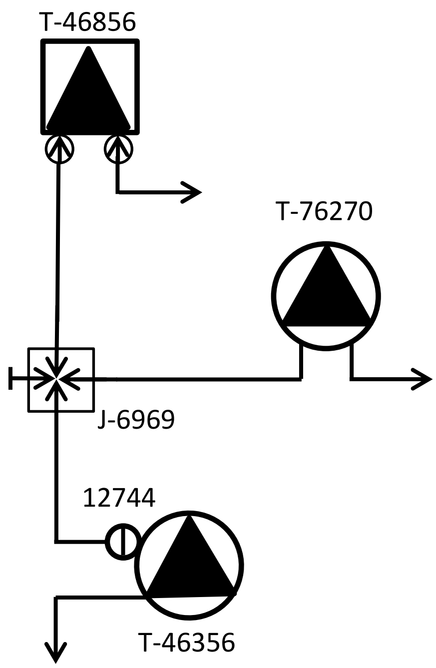
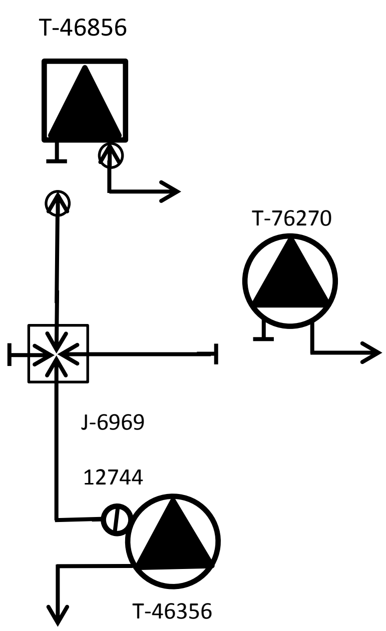
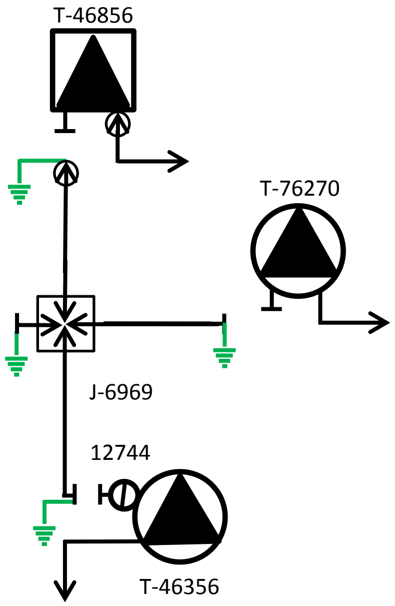
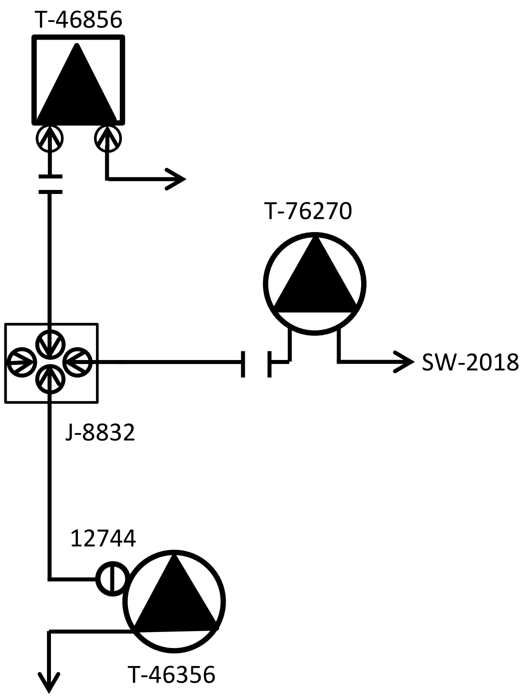
6.6 (continued)

5. Replace 4-way Dead-break Junction with 4-way Load-break Junction

<table>
<tr>
<td>
</td>
<td>Job Scope: Crew to replace 4-way J-6969, Dead- break with Load-break.

Clearance limits: COIS at T-46856 twds J-6969, COIS at T-76270 twds J-6969, and SW-12744.</td>
</tr>
<tr>
<td>
</td>
<td>Crew reports on section from COIS at T-46856 twds J-6969 COIS at T-76270 twds J-6969, and SW-12744 with grounds.</td>
</tr>
</table>

6.6 (continued)

	• Crew reports on section from COIS at T-46856 twds J-6969 COIS at T-76270 twds J-6969, and SW-12744 with grounds. • Crew tests J-6969 de-energized and applies personal ground (grounded elbow) on vacant position of J-6969. • Crew establishes EPZ at J-6969, as required.
	• Crew replaces existing 4-way Dead-break J-6969 with new 4-way Load-break J-8832. • Crew removes grounds at T-46856 twds new J-8832 and installs cable onto insulated stand-offs at T-46856. • Crew removes grounds T-76270 twds new J-8832 and install cable onto insulated stand-offs at T-76270. • Crew test candled elbows de-energized at SW-12744 removes grounds, and places cable twds new J-8832 onto operating position at SW-12744 twds new J-8832.

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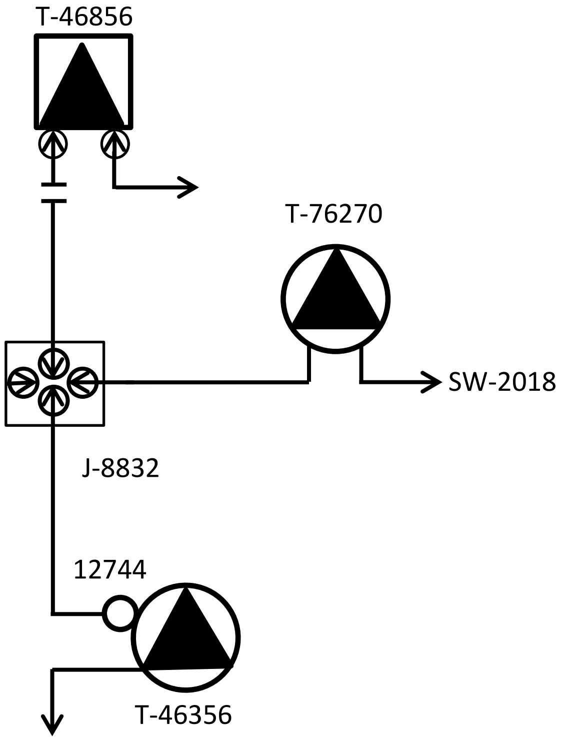
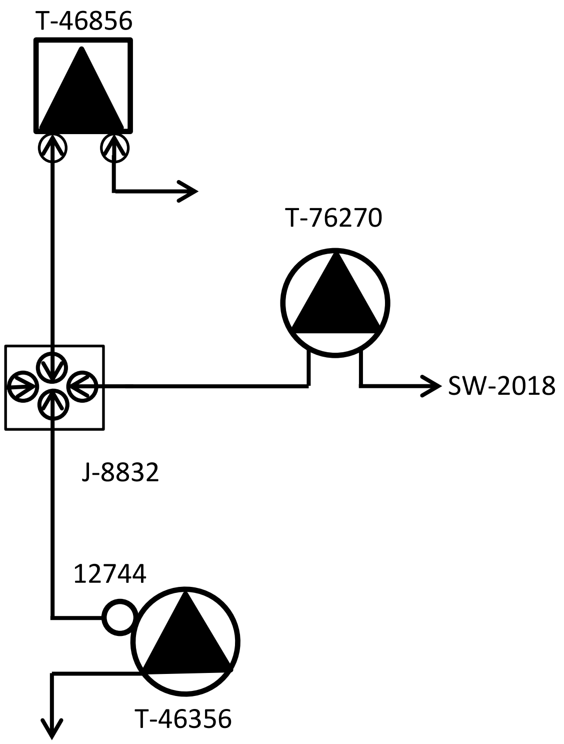
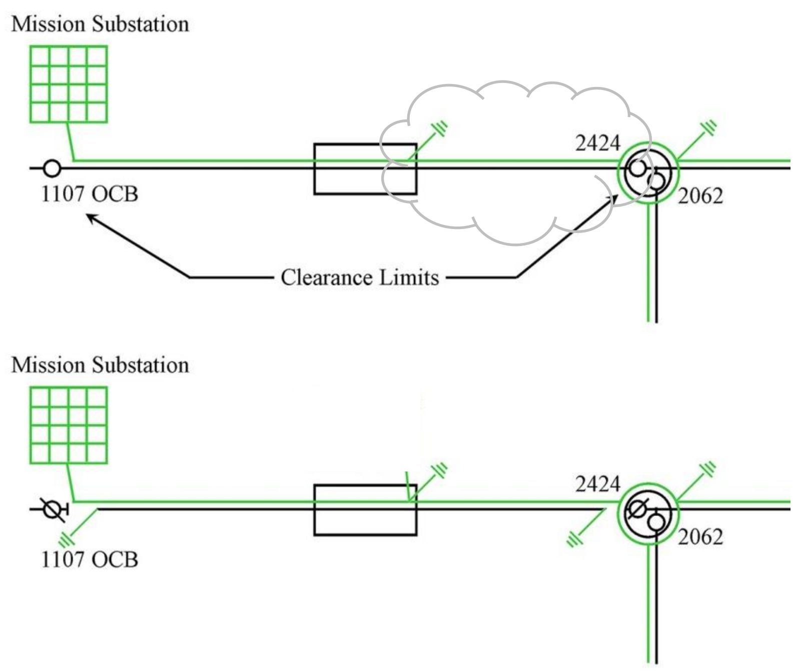
6.6 (continued)

	T-76270 is de-energized. Test all cable de-energized at T-76270 and place cable onto operating position twds new J-8832. • Crew closes SW-12744 energizing. • Crew checks phasing at SW-2018. • Crew checks power OK at T-76270.
	• Crew verifies phasing at T-46856 and installs cables from new J-8832 onto operating position at T-46856. • Crew completes switch log to return circuit normal.

6.6 (continued)

6. Working at First Enclosure Outside the Substation

NOTE
Consult the appropriate substation supervisor if grounding in substation is needed.



Job Scope: Replace cable from first enclosure outside Mission Substation to SW-2424. Clearance Limits: Mission Sub 1107, between Substation breaker 1107 and SW-2424.

- Crew reports on using grounds.
- Crew tests conductors de-energized on load side of OCB 1107 and SW-2424. Grounds are installed at the substation, per substation requirements.
- Crew installs 2/0 grounded elbows at SW-2424, using live-line tools.

- Crew identifies and marks cable at the subsurface enclosure that will be replaced with the VCI-3 cable identifier (so that grounds do not need to be removed).
- Crew spikes cable at worksite.
- Using live-line tools, crew removes 600A terminations at SW-2424 and installs protective equipment.
- Crew establishes EPZ, as required.
- Crew replaces cable and makes up connections.
- Crew removes grounds and reports clear with grounds removed.

SECTION 7: SUBSTATIONS & GENERATION FACILITIES

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7 SUBSTATIONS & GENERATION FACILITIES

7.1 Scope

This section of the manual provides rules and procedures for creating protective grounding within substations and generation facilities.

Sections 1 through 3 of this manual provide the general requirements that are common for all PG&E departments.

Employees from other departments who are required to ground within a substation or generation facility, and who are not trained in substation- or generation-specific grounding practices, must have a substation- and/or generation-qualified grounding observer direct and observe all grounding procedures within the facility.

7.2 TPG Size and Fault Duty

1. Introduction

Grounding devices must be able to carry the anticipated fault current at the location where the grounds will be installed for the length of time it will take for the fault to clear. Temporary protective grounds must meet one of the two following conditions:

a. **Grounds must be physically larger than the conductor being grounded, or**

b. **Grounds must be thermally larger than the expected fault duty and clearing time.**

The information contained in this section will help you select the size of the temporary protective grounding components that will insure your grounds will meet the requirements above.

Consideration of fault duty sources must include:

- Single human switching error that would energize the work location.
- Credible mechanical failures of the clearance point that could result in energizing into the worksite.
- Work accidents that could result in contact of a nearby energized conductor.

7.2 (continued)

2. Obtaining Fault Currents: Substation

a. Obtain the bus-fault duties for the station being grounded. These are listed in the “Substation Grounding Fault Duties” tables provided on the Company’s intranet.

b. Employees must know the fault duty available at the location where the grounds will be installed, in order to determine the correct sizes and required number of protective grounds required.

c. A ground count calculator and a smart phone app that links to the above-mentioned table have also been created to help obtain fault duty and ground count information.

d. Additional columns have been added to share the following information:

- “P-grounds required” statement depicts certain transmission busses that require a p-ground due to slow clearing time on the bus. Only one p-ground is needed, even if it is also triggered by connecting to steel or cable length in Table 7-1 on Page 7-3.

- “Distance to maintain 8 cal inches” statement depicts certain busses that require double layer flame resistant (DLFR) clothing protection when the listed minimum approach distances cannot be maintained during hazardous work.

3. Obtaining Fault Currents: Generation

Obtain the generation bus-fault duties from the generation-specific fault duty spreadsheet, located on the Company’s intranet.

4. Bus Fault Duty Calculations

Fault duties provided on the company intranet are for system normal configuration.

Contact a system protection engineer for line-specific or configuration-specific fault duties and clearing times, when:

- The clearance involves closing bus ties creating parallels, which can increase the fault duty.

- If reduced fault duty created by opening lines may simplify grounding requirements.

⚠ WARNING

The TPG assembly cannot be used above the rating of its lowest component, i.e., cable, ferrule, crimp, or either clamp.

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7.2 (continued)

Table 7-1. Substation TPG Selection

CLEAR TPG 2/0						
	0-12 kA	**12-15 kA**	**15-23 kA**	**23-25 kA**	**25-40 kA**	
22' to electrode	1	1	1	1	2	
22' to steel	1	1	1 + P	1 + P	2 + P	
23' - 40' to electrode	1	1	1	2	2 + P	
23' - 40' to steel	1	1 + P	1 + P	2 + P	2 + P	
YELLOW TPG 2/0						
	0-12 kA	**12-15 kA**	**15-23 kA**	**23-30 kA**	**30-47 kA**	**47-57 kA**
22' to electrode	1	1	1	1	2	2 + P
22' to steel	1	1	1 + P	1 + P	2 + P	2 + P
23' - 40' to electrode	1	1	1	1 + P	2 + P	2 + P
23' - 40' to steel	1	1 + P	1 + P	1 + P	2 + P	2 + P
SLOW CLEARING 2/0 – Distribution Busses Only						
	0-6 kA	**6-12 kA**	**12-15 kA**	**15-24 kA**	**24-32 kA**	
22' to electrode	1	1	1	2	2 + P	
22' to steel	1	1 + P	1 + P	2	2 + P	
23' - 40' to electrode	1	1	1 + P	2 + P	2 + P	
23' - 40' to steel	1	1 + P	1 + P	2 + P	2 + P	
RED TPG 4/0						
	0-12 kA	**12-16 kA**	**16-25 kA**	**25-39 kA**	**39-47 kA**	**47-63 kA**
22' to electrode	1	1	1	1	1 + P	2 + P
22' to steel	1	1	1 + P	1 + P	1 + P	2 + P
23' - 40' to electrode	1	1	1	1 + P	1 + P	2 + P
23' - 40' to steel	1	1 + P	1 + P	1 + P	1 + P	2 + P
SLOW CLEARING 4/0 – Distribution Busses Only						
	0-6 kA	**6-12 kA**	**12-15 kA**	**15-20 kA**	**20-24 kA**	**24-54 kA**
22' to electrode	1	1	1	1	1 + P	2 + P
22' to steel	1	1 + P	1 + P	1 + P	1 + P	2 + P
23' - 40' to electrode	1	1	1 + P	1 + P	1 + P	2 + P
23' - 40' to steel	1 + P	1 + P	1 + P	1 + P	1 + P	2 + P

- An electrode is a 250MCM or 500MCM copper ground tail that extends from the ground grid to a length above the ground surface. The connection of the TPG to the electrode must be less than 6 feet from the ground surface or the connection would be equivalent to connecting to a steel structure.

- The Substation Fault Duty Table will also list certain transmission busses that require a p-ground due to slow clearing time on the bus. Only one p-ground is needed even if it is also triggered by connecting to steel or cable length in Table 7-1 above.

- P-Ground is not required when working from a fiberglass bucket that has been annually tested and rated for the voltage class of equipment being worked on.

- Vehicle ground cables follow the same rules, but the additional personal ground is not required.

7.2 (continued)

5. Substation Surface Treatment

Some substations use a surface treatment (e.g., asphalt) to reduce the step-and-touch potentials to a safe level within the substation. These substations are identified with a "CAUTION" sign. For a description of this sign, refer to Section 10, "Devices, Components, and Tools."

At these substations, employees must:

- Verify that the surface treatment is in good condition before starting work.
- Remain on the treated surface when contacting grounded metal objects.

7.3 Fault Duty Mitigation

Fault duties can be mitigated to a single 2/0 ground per phase with no personal grounds required, if the source is mitigated by one of the methods listed below:

- **Double opens:** Two independently controlled open points in series between the worksite and all sources.
- **Double locks:** When the clearance **point** is controlled by two independently applied and controlled locks.

The use of a double open or double lock mitigation practice can only be implemented where there is no possibility of a credible mechanical failure that could result in inadvertent energization of the work area.

1. Requirements for Double Open (See Figure 7.1 on Page 7-5)

When using double open mitigations, the following definition and rules will apply:

Double Open Mitigation definition: A clearance point and an additional open created by an open disconnect switch or open loop within your clearance limits. The additional open disconnect switch or open loop must be in series with the clearance point and prevent exposure from the high fault duty source.

a. Inside the clearance limits, the person in charge (PIC) must establish an additional open point once they have reported on. The PIC must install a caution tag and if practical, must install an independently applied and controlled lock.

b. The PIC must also note this on the Grounding Tailboard Form in Section 3, "Fault Duty."

c. It is the PIC's responsibility to restore second open to its original (as found) position before reporting off.

d. When choosing to create open loop or jumper as the second open, the PIC is responsible to ensure that the circuit is properly grounded when performing this work.

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7.3 (continued)

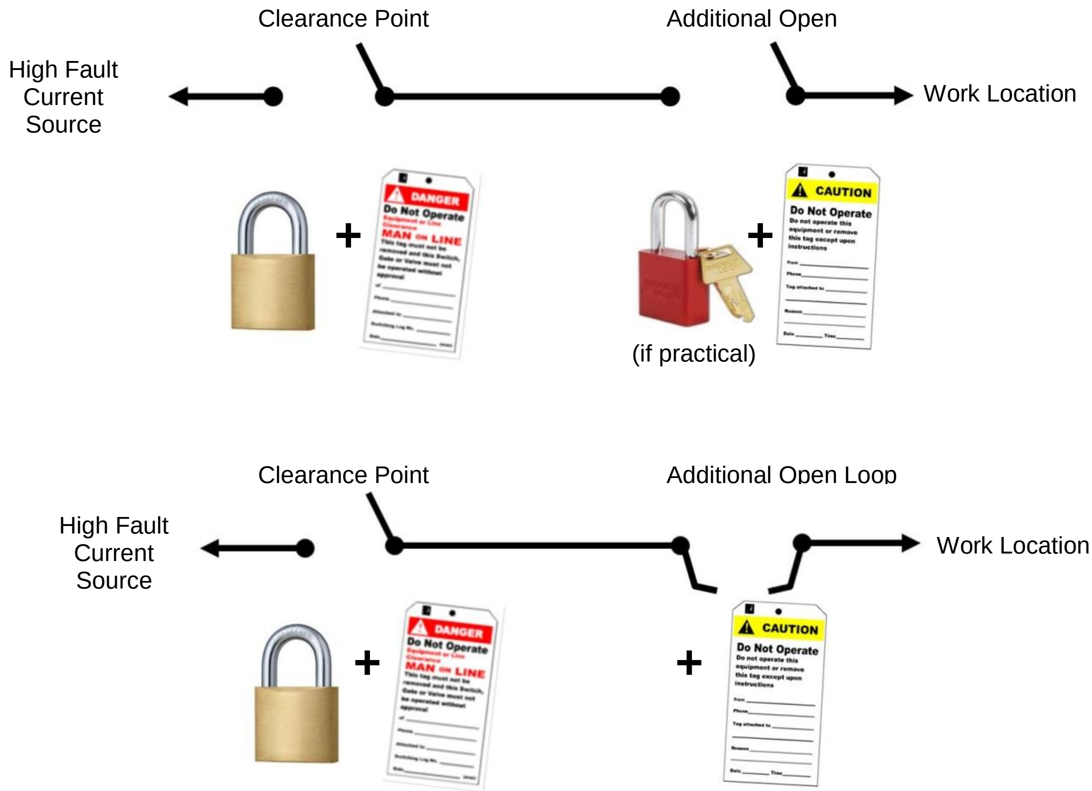

Figure 7.1. Examples of Double Open.

2. **Requirements for Double Lock** (see Figure 7.2 on Page 7-6)

When using double lock mitigations, the following definition and rules will apply.

Double Lock Mitigation. Installing a lock out / tag out hasp on a lockable clearance point that would allow both our standard lock (from operations) and an additional lock (controlled by PIC) to the clearance point. The purpose of the additional lock is to prevent a switching error of closing a disconnect switch that would energize a work location.

- The lock-out / tag-out hasps may be installed on all effected switches before the switching begins or the employee setting up the clearance may request the lock out / tag out hasps be installed on the application for work section "Crew Special Setups." This will be a part of the switching instructions.

- Approved secondary locks added to lock-out / tag-out hasp on clearance limits must be keyed separately from the locks installed by switching personnel.

- Once they have reported on, the secondary lock(s) will be installed/removed and managed by the PIC and noted on the grounding tailboard form in Section 3, Fault Duty.

- If the PIC is performing the switching then the locks will be managed by the grounding observer.

7.3 (continued)

- Lock-out and tag-out hasps and approved secondary locks can only be used by special permission through the SGGC as situations arise.

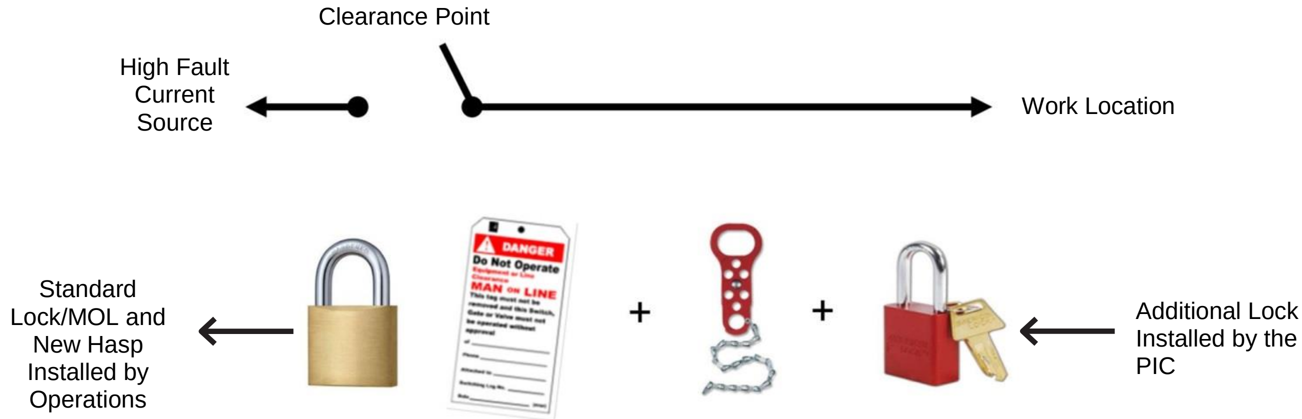

Figure 7.2. Example of Double Lock

3. Low Energy Fault Duty Sources

a. Backfeed sources from station service and potential transformers require one 2/0 per phase (see Figure 7.3 below).

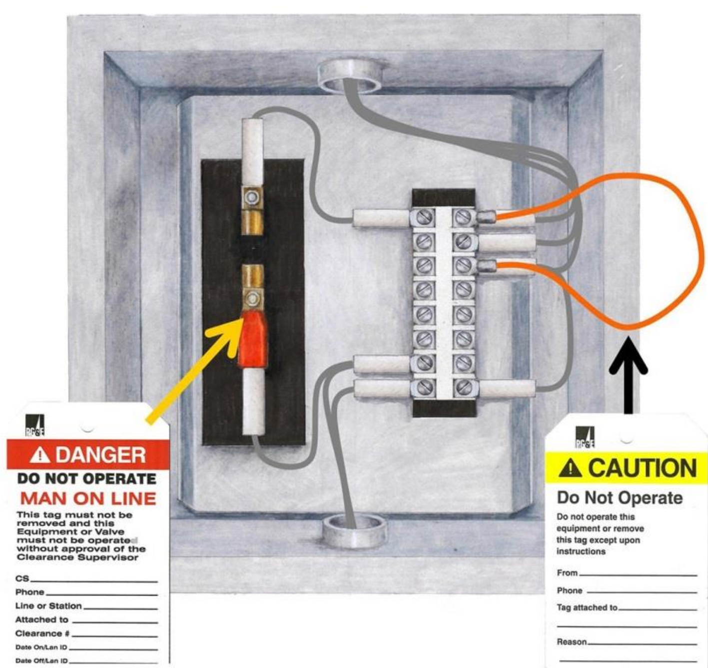

Figure 7.3. Example of Low Energy Source.

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7.3 (continued)

b. When lifting the grounded primary lead of a station service or potential transformer the backfeed source can be mitigated by shorting the secondary winding as shown in Figure 7.4 below.

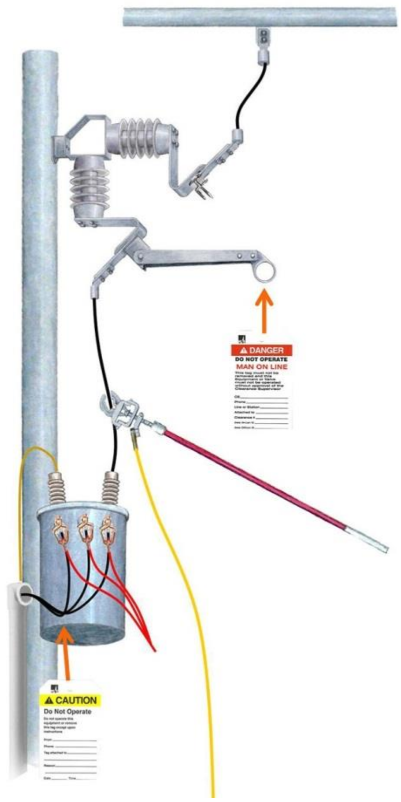

Figure 7.4. Shorting secondary winding of station service when job requires lifting the primary lead. Transformer Shorting Ordering Code: Three Phase 018047, Single Phase 205051.

WARNING

Station service primary conductors must be tested de-energized and grounded before secondary shunts can be installed.

4. Conductor Restricted Sources

a. Conductors smaller than 2/0

For conductors smaller than 2/0, one 2/0 per phase is all that is required regardless of the fault duty. Small conductor clamps (refer to Section 10) may be required.

WARNING

Never use ground clamps outside their approved use range.

7.4 Methods of Grounding

1. Multi-Point Grounding

Multi-point grounding is the preferred grounding method for Substation and Generation facilities. All protective grounds must be installed to common ground source.

a. Where there is only ONE electrical source, multi-point grounding only requires protective grounds installed between the worksite and the electrical source (see Figure 7.5 below).

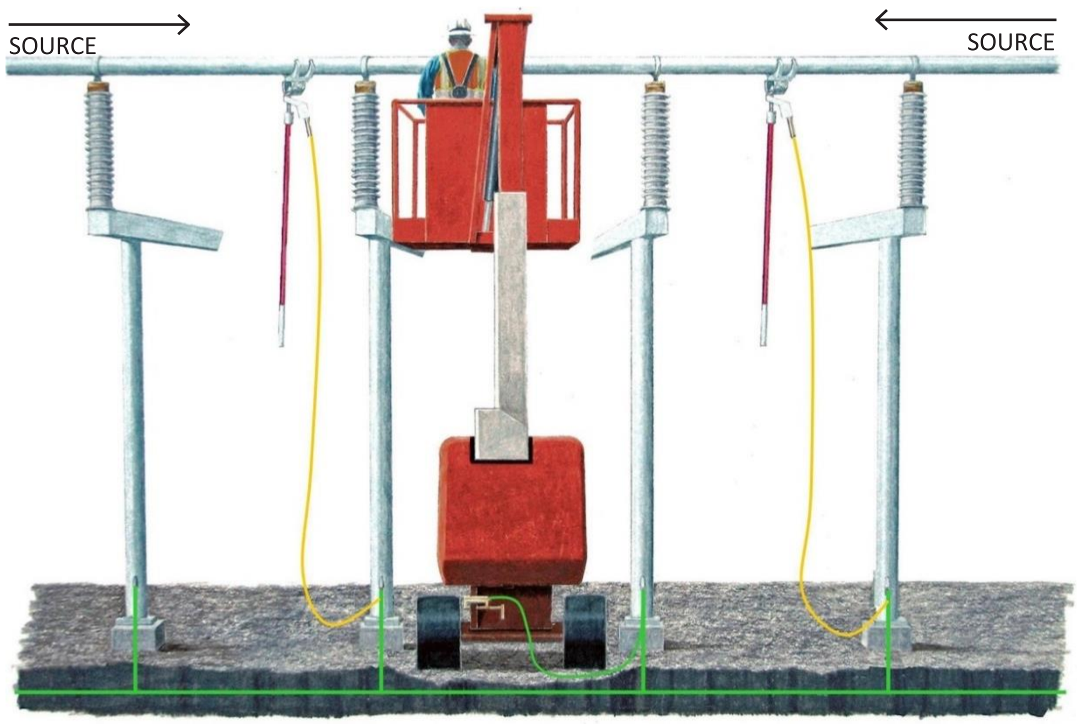

Figure 7.5. Multi-Point Grounding Method.

b. Where there are MULTIPLE energy sources with differing levels of fault current, protective grounds must be rated and applied for the fault duty of EACH source. See Figure 7.6, “Grounding Against Different Fault-Duty Sources: Multi-point Grounding Method” on Page 7-9.

c. Where there are MULTIPLE energy sources with differing levels of fault current, install protective grounds to the HIGHEST fault-duty source first and remove them last.

d. Minimum approach distance does not need to be maintained when installing additional ground sets to a grounded line, provided:

- The additional ground set is installed within the line of sight of the initial ground set.
- No open in the conductor.
- No intentional contact is made until all sources are grounded.
- All cables used to protect against a single source must be +/- 10% in length.

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7.4 (continued)

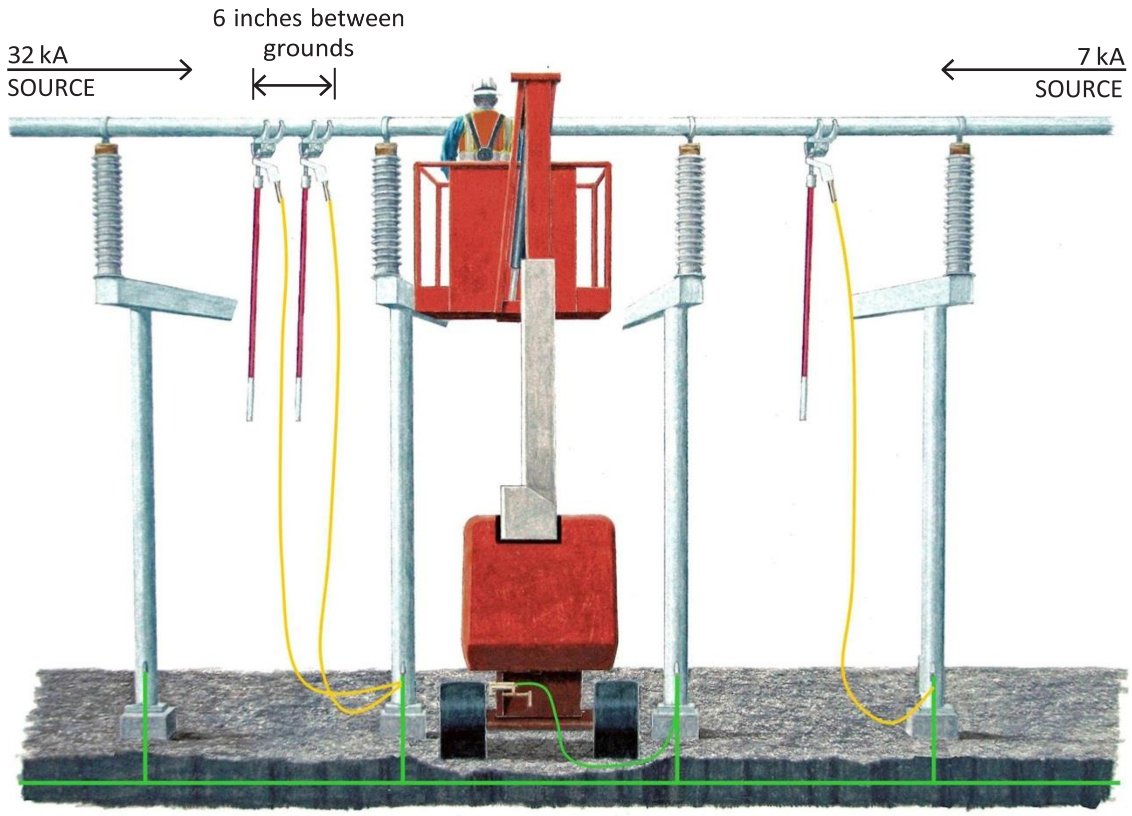

Figure 7.6. Grounding Against Different Fault-Duty Sources: Multi-Point Grounding Method.

2. Personal Grounds

A Personal Ground is an additional ground applied to an already grounded circuit used to limit current through the worker in the event of accidental energization. It is applied to the phase being worked on and within 15 feet of the work location.

See Table 7-1 on Page 7-3 for situations when personal grounds are required.

Personal grounds are not required when:

- Working inside grounded metal-clad switch gear.
- Working inside an indoor station where protective grounds are installed within the facility.
- When fault-duty mitigation methods are used, per Section 7.3 on Page 7-4.
- Working out of an insulated bucket that has been dialectically rated and annually tested.

7.4 (continued)

3. Single-Point Grounding

Single-point grounding method is allowed only in certain situations that meet **ALL** criteria listed below.

a. All work is performed within 15 feet from the ground location.

b. The ground cables cannot be longer than 22 feet and must be tied to an electrode.

c. When personal grounds are not required, as shown in Table 7-1 on Page 7-3.

d. No open points are created between you and your ground during work activity.

e. The protective ground must be connected to the same electrode of the equipment the employee is standing on.

CAUTION

Single-point EPZ grounding requires you to connect your vehicle ground to the same location as your source ground (see Figure 7.7 below).

When you must remove the vehicle ground in proximity of the source ground, follow the rules in Section 9.6.

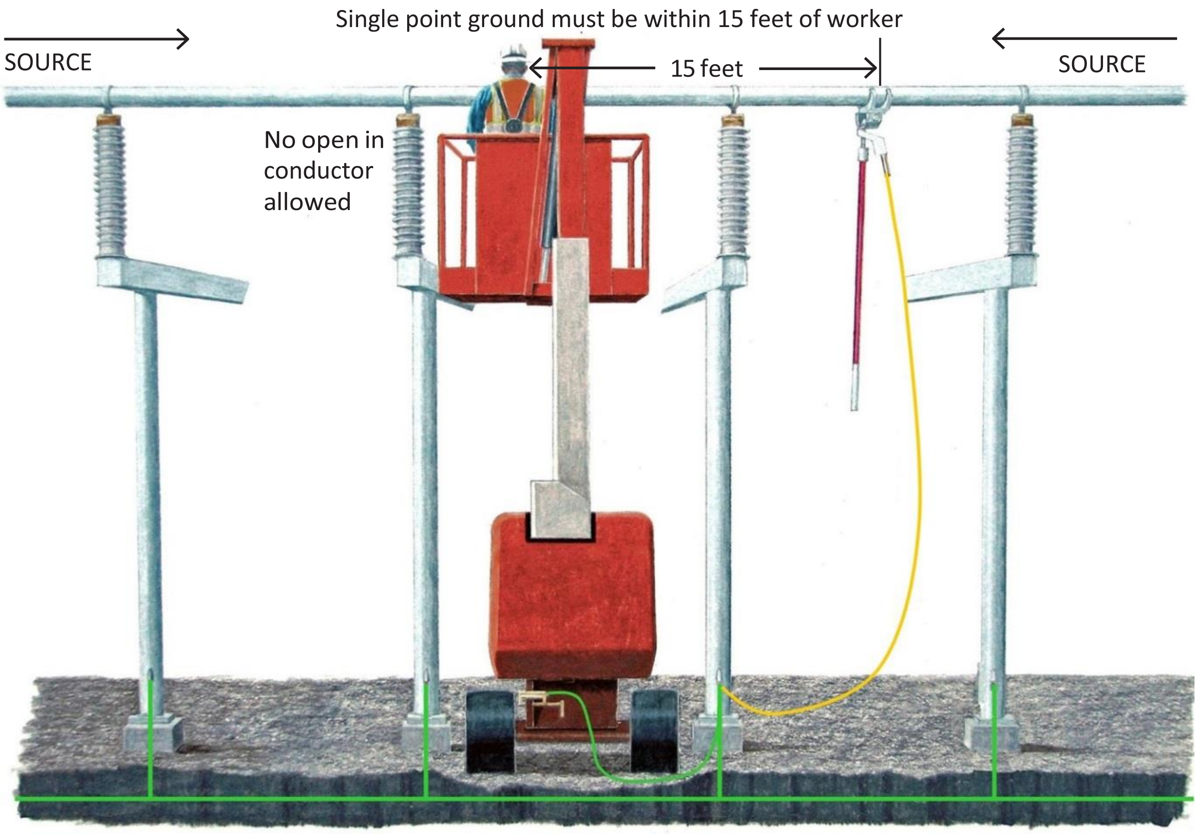

Figure 7.7. Single-Point EPZ Grounding Method.

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7.5 Clearance Walk-Through

The Person in Charge (PIC) must conduct a walk-through AFTER VERIFYING the clearance points, and BEFORE WORKING within a cleared area.

If an additional employee(s) joins a job while it is in progress, the employee(s) must receive a tailboard and walk-through from the PIC before starting work with the crew.

If the scope of the work changes during a clearance, the PIC must stop the job, hold a revised tailboard briefing, and perform another walk-through before continuing the job.

7.6 Requirements for Installation and Removal of Grounds

1. Installing

a. Line must be confirmed de-energized per Section 2.5, "Testing Conductors or Equipment De-Energized."

b. Perform a protective grounding inspection as described in Section 2.9.

c. Ensure that the PIC has authorized the installation of TPGs.

d. Before connecting the protective grounds to any de-energized conductor or apparatus ensure that the grounds are connected to the ground source first.

NOTE

The ground source must be verified in good condition and rated for the fault duty. For acceptable ground sources, see Section 2.4, "Ground Sources."

NOTE

Never connect ground tail clamps to painted surfaces (bare metal contact is required).

e. Adjust ground clamps for the proper size and angle for the conductor being grounded. Never over-tighten ground clamps. Tighten clamps by hand and never use a mechanical advantage.

f. Maintain Minimum Approach Distance (MAD) from adjacent energized and ungrounded conductors when installing and removing TPGs. Extension sticks or telescopic sticks may be needed to maintain these distances when grounding circuits at or above 230kV. If at least one set of grounds are not in sight, then MAD must be maintained while installing personal grounds.

g. Ground each phase starting with the phase closest to you. Ensure that when grounding subsequent phases, the ground cables do not make contact with ungrounded phases.

h. Install grounds using approved live-line tools with a quick positive contact, do not stop. Avoid damaging porcelain insulators and other equipment.

7.6 (continued)

WARNING

If a protective grounding device does not make positive contact, extensive arcing may occur if it is pulled away from an energized conductor or piece of equipment.

i. Attach and position the ground clamps in a way that prevents employees from contacting the ground cord while installing or removing the grounds.

WARNING

The grounding observer and the employee installing protective grounds must ensure that all employees are clear of the grounding cable before making contact with the conductor.

j. All ground clamps on the same conductor must be installed immediately adjacent to each other, with no deliberate separation. The separation distance may never exceed 6 inches. The TPG cables attached in parallel on a phase should all be of the same length and size.

k. Every attempt should be made to not tie-off or coil/cross ground cables. When exposed to a fault, the electro-mechanical forces will pull apart the ground cables at a much lower current from their normal rating. Ground cables should be laid in a smooth continuous line (see Figures 7.8 and 7.9 below).

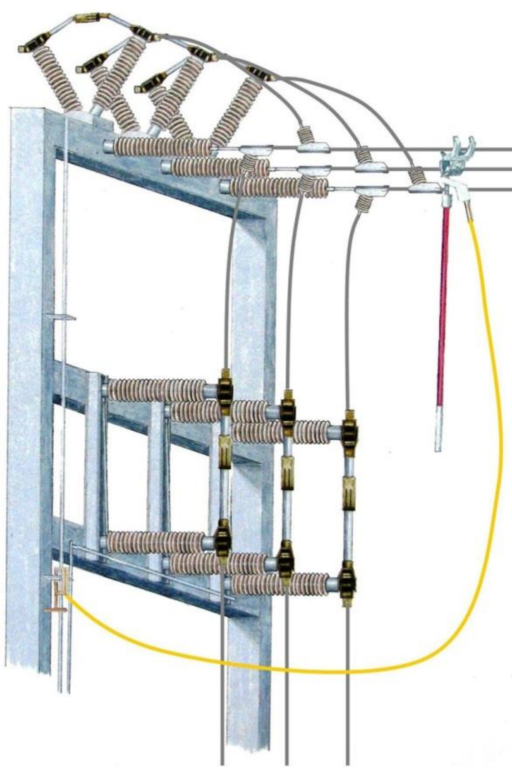

Figure 7.8
Lazy J configuration off the ground.

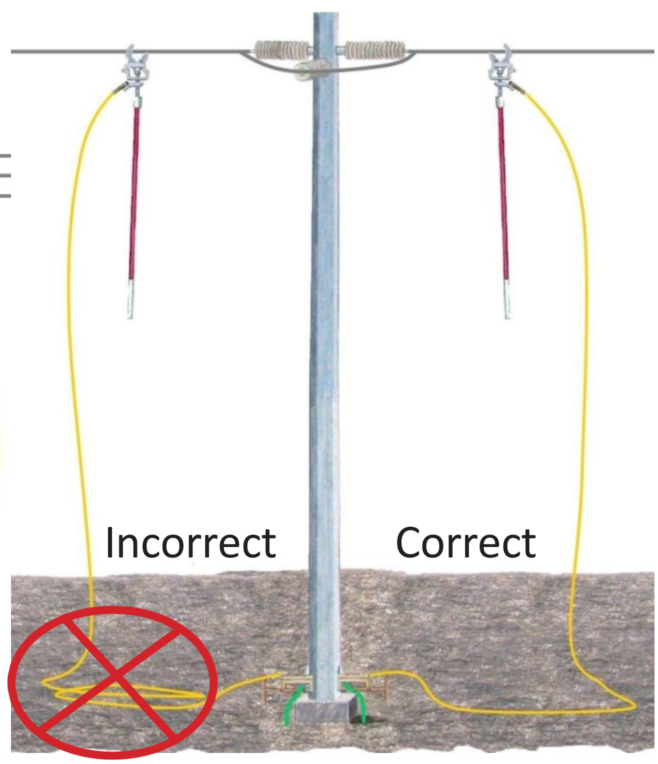

Figure 7.9
Correct and Incorrect Ground Cable Layout.

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7.6 (continued)

I. Bag Grounds with a single drop cable can be used to reduce cable layout issues (see Figure 7-10 below).

WARNING

Always use a live-line tool to install jumpers and ensure that one side of the jumper is always grounded during installation and removal practices.

No contact with jumpers, clamps, or cables can be made until all phases are grounded.

Procedural Steps:

1. Maintain MAD from all ungrounded conductors at all times during this process.
2. Test all conductors de-energized before installing any ground sets.
3. Install long jumper first by connecting to grid electrode and then installing on the middle first conductor.
4. Install 1st jumper to the already grounded line and then to the desired adjacent phase.
5. Install 2nd jumper to the already grounded line and then to the desired adjacent phase.
6. On removal, remove the jumper outside clamp connections first.
7. Then all connections on the middle conductor.

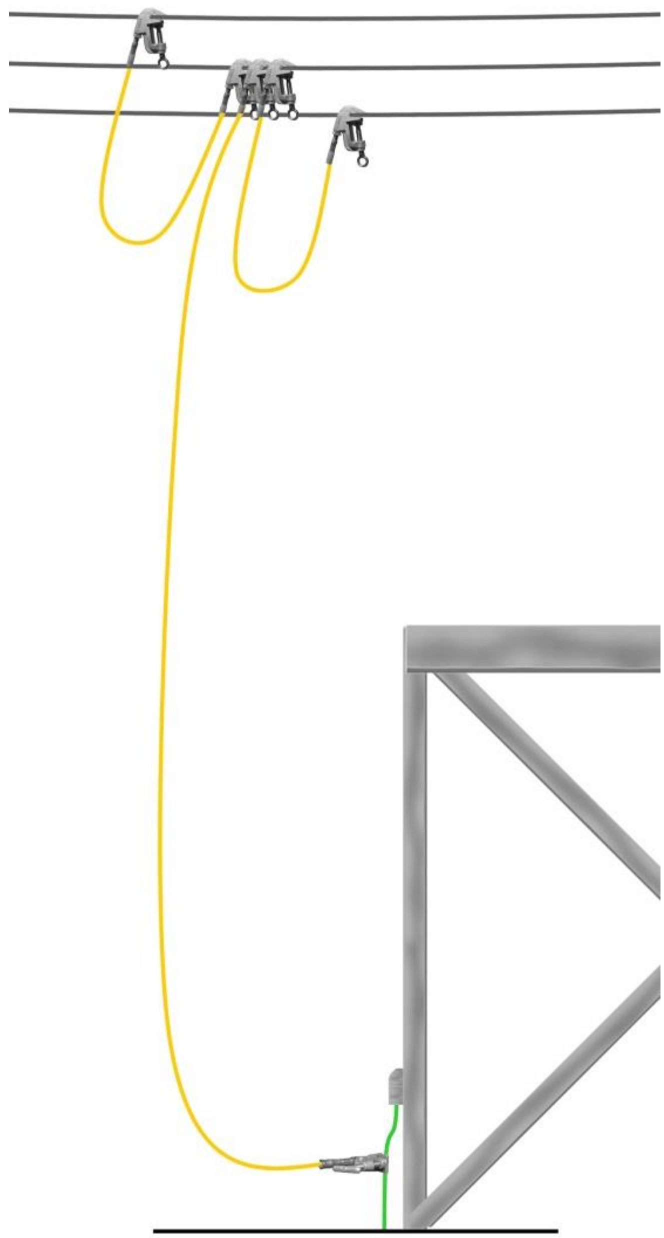

Figure 7.10. Bag Grounds with a single drop cable

7.6 (continued)

2. Removing

a. The PIC approves the removal, after all work has been completed on the circuit and all employees are clear of the grounded circuit and/or equipment.

b. The PIC will review the Grounding Tailboard Observer (GTO) form to identify location and number of TPGs to be removed.

c. The PIC will assign the appropriate number of grounding observers needed for the removal process.

d. Grounds must be removed from the conductor(s) or equipment before removing from the ground source. Remove from the farthest conductor first.

e. When there are multiple ground clamps on the same ground source (within one foot of each other), all of the phase ground clamps should be removed before any of the ground source clamps are removed. (This prevents inadvertently removing the wrong clamp.)

WARNING

Removing the wrong clamp could result in death or serious injury.

EXCEPTION: On steel structures, it is permissible to remove a ground from a single phase, and then remove the related ground clamp from the structure — before removing the other phase grounds — provided that:

- The MAD can be maintained after the ground has been removed; and
- All the related ground clamps are NOT attached within reach of one another on the structure.

f. The PIC will ensure all grounds are removed and complete the GTO form.

g. Once the protective grounds are removed, notify all employees and consider the circuit as energized. Complete the GTO form.

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7.7 Examples of Specific Situations

1. Stringing Incoming Lines into Substations

When lines are being sagged into and out of substation facilities, refer to the procedure in this subsection for methods of eliminating difference of potential hazards. For assistance with this practice contact the SGGC engineer or chairperson.

The following scenarios describe the methods for creating a grid extension to the first tower OUTSIDE the substation to eliminate difference of potential hazards during re-conductoring practices.

The grid extension can be done on the ground by installing a bonding jumper between the station grid and the first tower out (see Figure 7.12 and Figure 7.13 on Page 7-18), or it can be done in the air by always leaving one phase acting as the bonding jumper between both the station grid and the first tower out (see Figure 7.14 on Page 7-19) during the re-conductor process.

The bonding jumper must be a continuous conductor with no opens or splices.

WARNING

Before driving ground rods, reference the conduit and ground grid and high-voltage feeder cable prints.

USA North must be notified previous to installing ground rods at ALL times. Please call 811 or 1-800-227-2600.

WARNING

Never make contact with fence and objects connected to the station grid.

a. Creating an Open Loop

(1) Prepare the line side of the circuit according to Figure 7.11 on Page 7-16, before creating the grid extension in Step **b** on Page 7-17.

a) Install protective grounds on each side of the tower.

b) Create an open loop on the incoming line.

7.7 (continued)

Creating an Open Loop

1. Install protective grounds on each side of the tower.
2. Create an open loop on the incoming line.

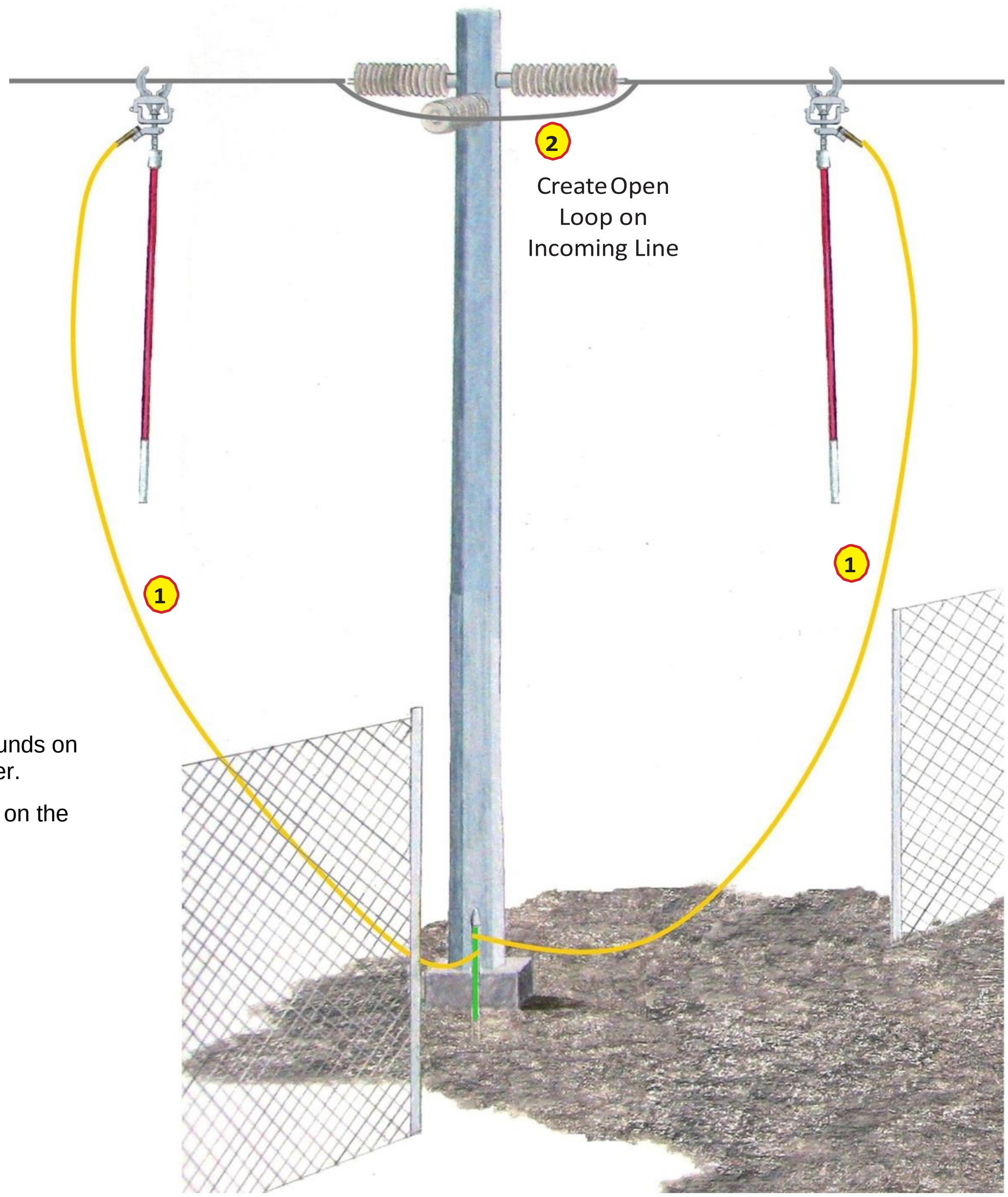

Figure 7.11. Creating the Grid Extension.

7.7 (continued)

b. Grid extension on the ground

(1) Lay out temporary grid extension conductor (i.e., > 250 mcm).

- Grid extension may be coned-off or buried under 6 inches of soil to avoid employee contact and tripping hazards.

(2) Run grid extension through an opening created in the fence or under the fence through a polyvinyl chloride (PVC) pipe.

(3) See Figure 7.12, "Installing a Temporary Grid Extension Through an Opening Created in the Fence" and Figure 7.13, "Install a Temporary Grid Extension under the Fence Through a PVC Pipe," on Page 7-18.

(4) Install the grid extension at the tower.

(5) Use a live-line tool to connect the grid extension to the substation grid.

- First, connect ground-tail clamp to the substation grid.

(6) Install vehicle grounds on the aerial lift as described in the appropriate Fault-duty Rules.

(7) Install protective grounds as described in the appropriate Fault-duty Rules.

(8) Install or remove conductors, as needed, depending on the scope of the job.

WARNING

To avoid possible GPR hazards, employees must not make contact with the temporary grid extension once it is installed.

7.7 (continued)

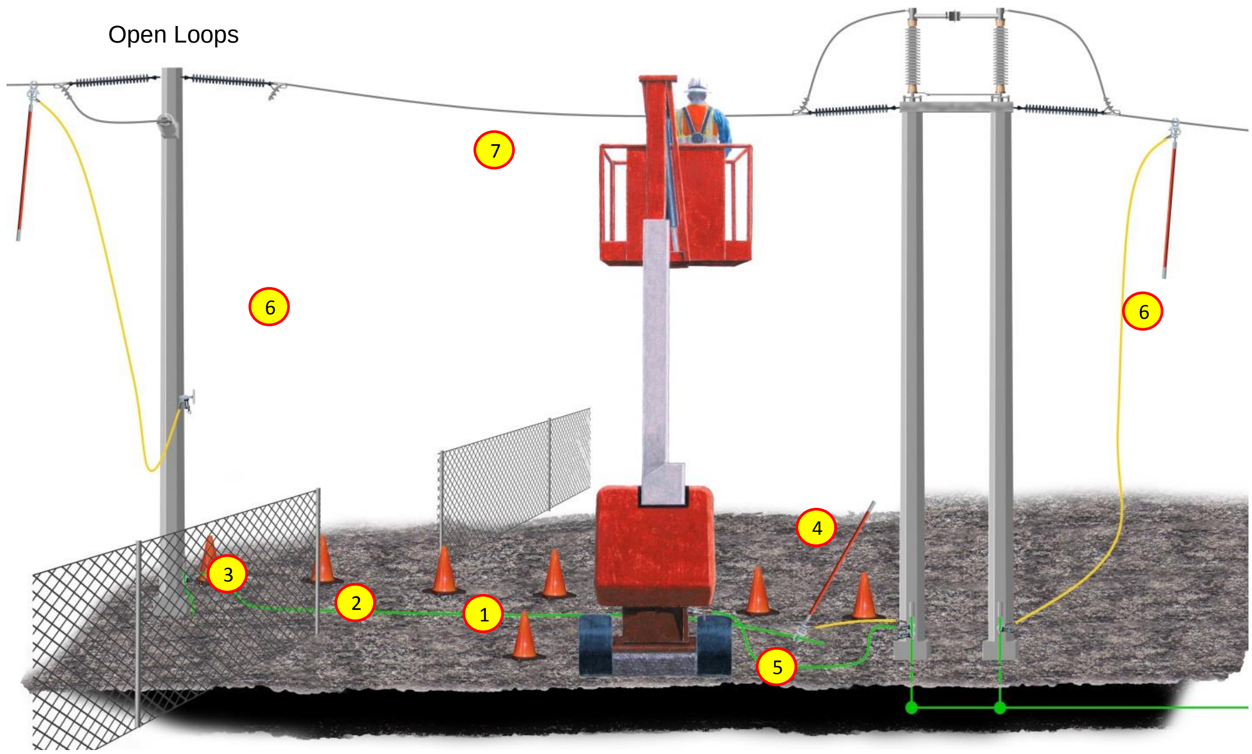

Figure 7.12. Installing a Temporary Grid Extension Through an Opening Created in the Fence.

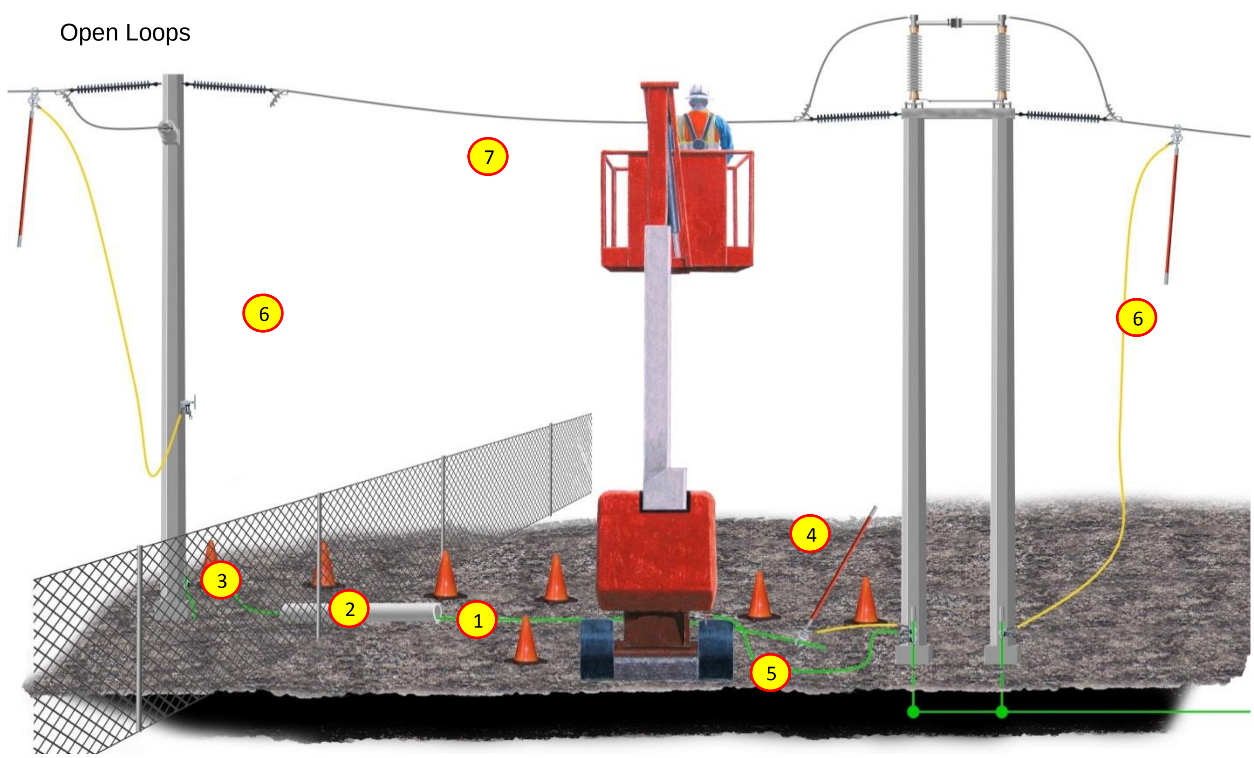

Figure 7.13. Installing a Temporary Grid Extension Under the Fence Through a PVC Pipe.

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7.7 (continued)

c. Grid extension in the air using the overhead conductor

(1) Create an open loop, as shown in Figure 7.11 on Page 7-16.

(2) Install vehicle grounds on the aerial lift as described in the appropriate Fault-duty Rules.

(3) Install protective grounds against all sources per the appropriate Fault-duty Rules listed in Table 7-1. Multiple tower structures (off the grid) will need to be bonded together.

(4) Re-conductor the circuit one phase at a time. The protective ground for the substation source can be moved on the other side of the disconnect of the phase being worked.

(5) Ensure that one phase not being worked on is always connected as the bonding jumper between both the station grid and the first tower out. The bonding jumper must be a continuous conductor with no opens or splices (see Figure 7.14 below).

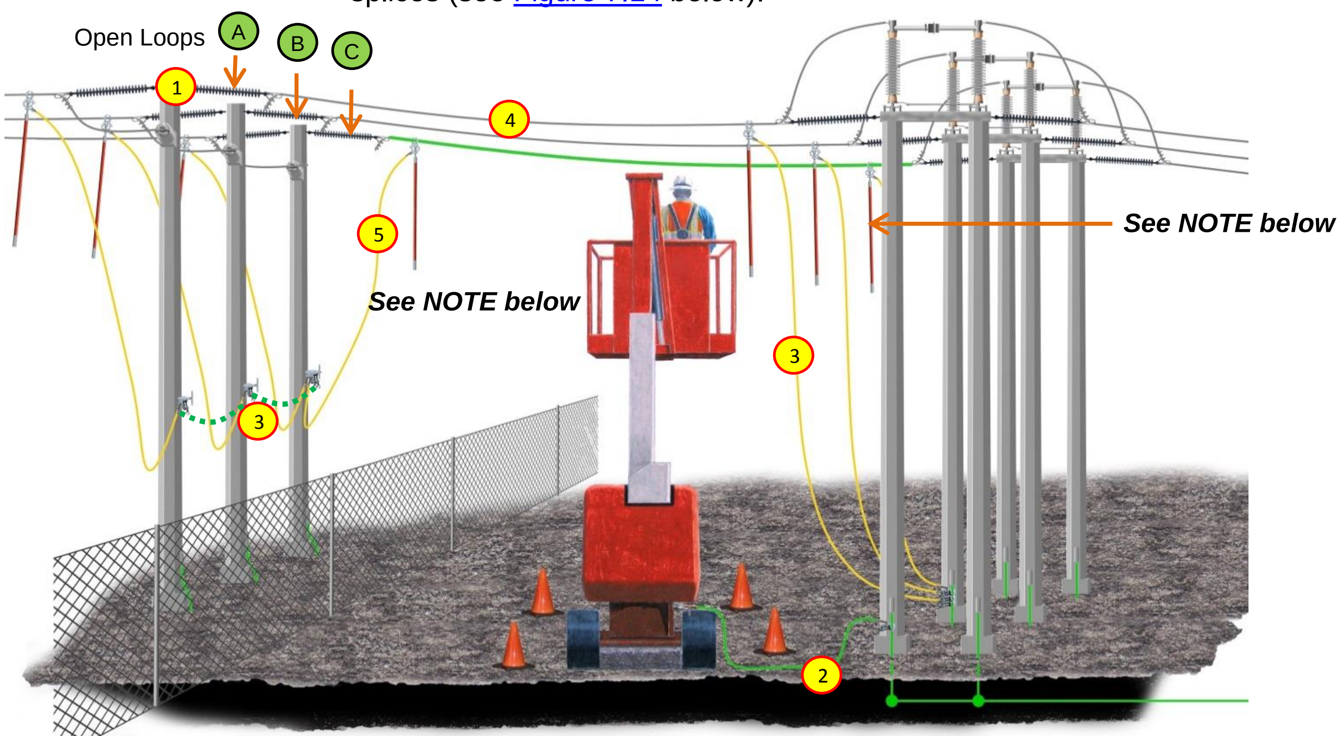


Figure 7.14. Overhead bonding Jumper Method.

(6) Once the phase has been re-conductored replace the protective grounds in their original locations.

NOTE
C Phase will remain grounded as shown and act as the bonding jumper between both the station grid and the first tower out. When the time comes for it to be replaced one of the other phases will be grounded the same way and become the bonding jumper during that process.

7.7 (continued)

2. Installing Protective Grounds When 40-Foot Ground Cable Will Not Reach

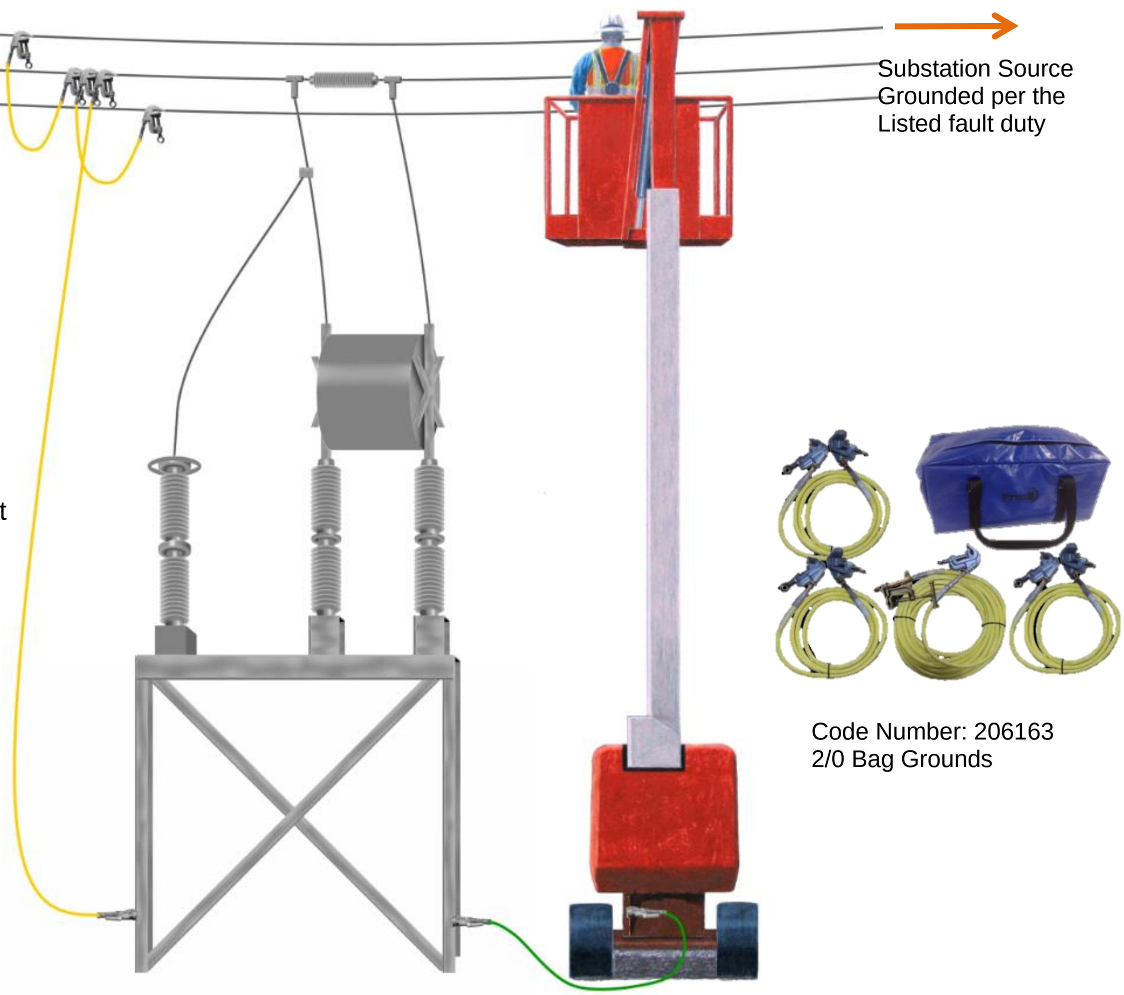
In situations such as installing a wave trap or CCVT on the line side of a breaker, and the conductor cannot be reached with the standard 40-foot ground cable, refer to this procedure as an alternative grounding method (see Figure 7.15 below).

- Install grounds based on the HIGHEST available fault duty at the circuit breaker.
- Contact System Protection Engineer for specific line fault duties.

WARNING

Always use a live-line tool to install jumpers and ensure that one side of the jumper is always grounded during installation and removal practices.

No contact with jumpers, clamps, or cables can be made until all phases are grounded.



Procedural Steps:

1. Maintain MAD distance from all ungrounded conductors at all times during this process.
2. Test all conductors de-energized before installing any ground sets.
3. Install long jumper first by connecting to grid electrode and then installing on the middle first conductor.
4. Install 1st jumper to the already grounded line and then to the desired adjacent phase.
5. Install 2nd jumper to the already grounded line and then to the desired adjacent phase.
6. On removal, remove the jumper outside clamp connections first.
7. Then all connections on the middle conductor.

Figure 7.15. Installing Drops to CCVT When 40-foot Cable Will Not Reach.

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7.7 (continued)

3. Grounding Jack Buses Crossing Over an Energized Bus

a. When grounding Jack Buses that cross over an energized bus, protective grounds may be installed at the "T-Taps." Details are shown in Figure 7.16 below.

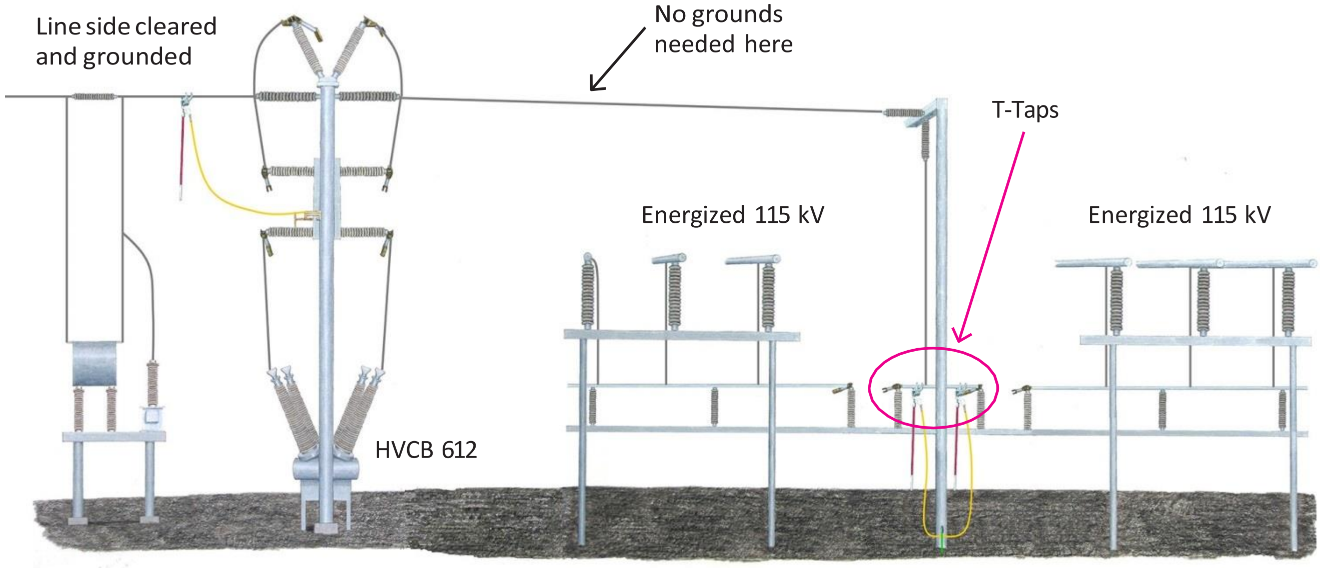

Figure 7.16

7.7 (continued)

b. When ground sets are placed within 1 foot of the “T-Taps,” the ground sets can be considered grounding against both sources. See Figure 7.17 below for details.

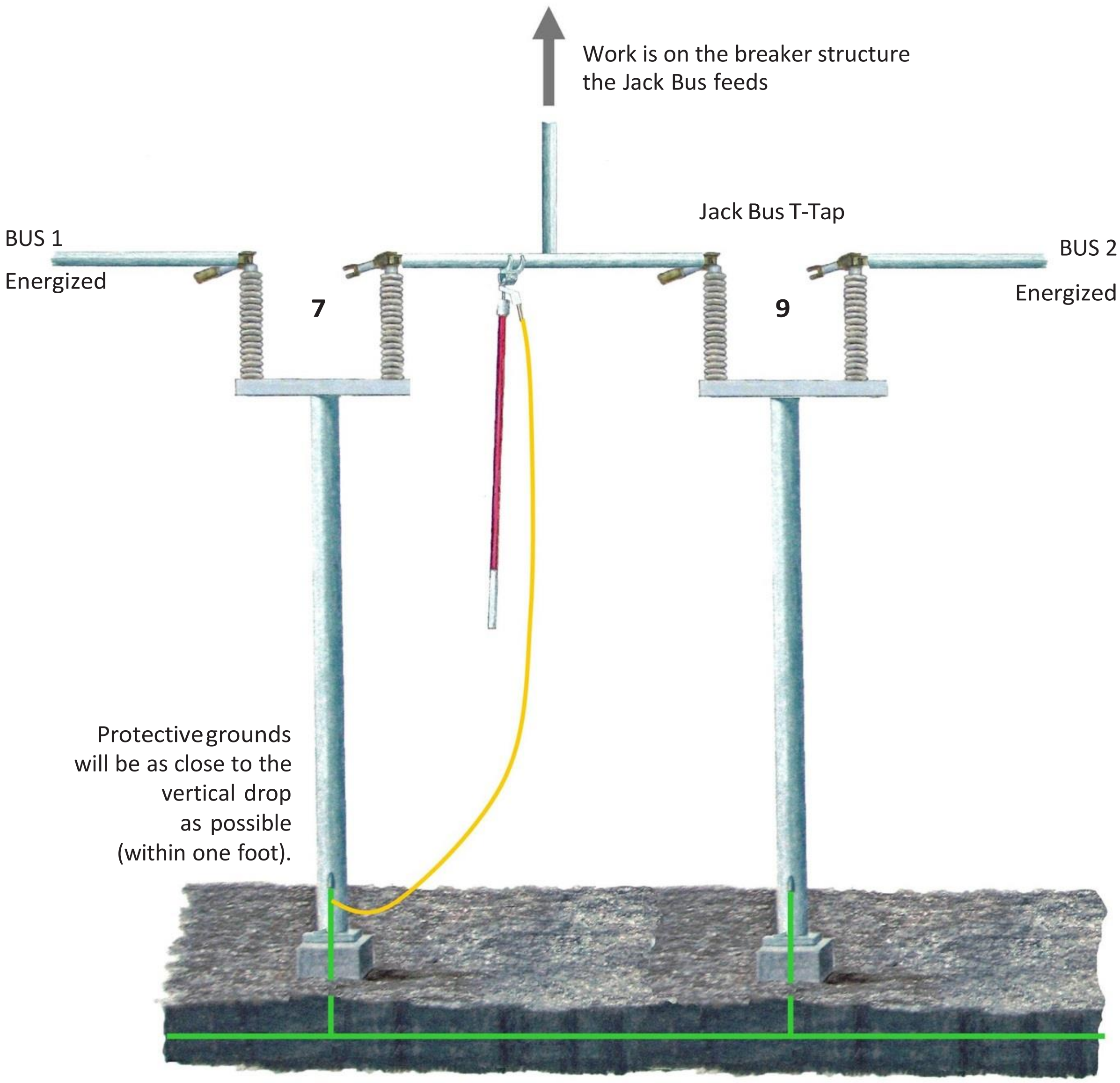

Figure 7.17

7.7 (continued)

4. Diagnostic Equipment Testing

a. PIC must be notified PRIOR to performing diagnostic equipment testing to ensure the safety of employees.

After the protective grounds are installed, test leads can be connected to high-voltage conductors or equipment.

WARNING

Circuit must be tested, de-energized, and grounded BEFORE test leads can be installed.

b. Barricade test equipment and leads with electrical barricade tape when high voltages are involved during testing.

The PIC is responsible to ensure employees stay in the clear while tests are being performed.

c. When protective grounds are removed for testing purposes, operations personnel do not have to be notified, and the PG&E Grounding tailboard/Observer form does not need to be updated.

Also, the test leads do not have to be noted on the PG&E Grounding Tailboard/Observer Form.

d. De-energize the test unit after performing the test.

e. Re-install the protective grounds before removing the test leads, OR remove the test leads with a live-line tool.

If the decision is made to remove test leads with a live line tool and not re-install protective grounds, the PIC must report to operations and update the PG&E Grounding Tailboard/Observer form the change in ground counts.

f. Remove the test leads from the conductor FIRST, and from the test unit LAST.

WARNING

Test leads must be removed from the conductors or equipment FIRST and the test unit LAST.

7.7 (continued)

5. Open-Air Station Ground Switches

Open-Air Station Ground Switches are devices installed permanently in substations on the 500kV systems, and on underground Transmission cables. These switches are not intended to provide adequate ground protection for employees working inside substation facilities.

Always test circuits de-energized and install protective grounds after closing these switches.

6. Substation Disconnect Switches

When there is no other alternative, protective grounds may be applied to the de-energized blades of an open disconnect switch. Only use grounds applied to the blades of disconnect switches for the time necessary to re-install conductors. Ensure that the following conditions are met when installing or removing protective grounds on disconnect switches.

a. Lock the switch in the open position and render it inoperable.

NOTE
Most distribution switches cannot be locked open and are not designed so that minimum approach distances can be maintained. Contact your local work method specialist for options when needing to work on these types of switches.

b. Ensure that the switch blades in the open position are beyond the minimum approach distance.

c. Ensure the switch blades can accommodate the weight of the protective grounds without damaging the disconnect.

d. Ensure the switch blades are within the ground-clamp use range specifications described in Section 10.

e. Install the protective grounds on the switch blades according to Section 7.6, before removing the conductors from the disconnect switches.

f. Relocate the protective grounds from the switch blades to the conductors immediately after re-installing the conductors.

7. Overhead Ground Wires

a. Because of the possibility of induction, apply a protective ground to the OHGW when working at or within 25 inches of this wire.

b. Install a protective ground from the steel structure to the OHGW.

c. At open points, install grounds on each side.

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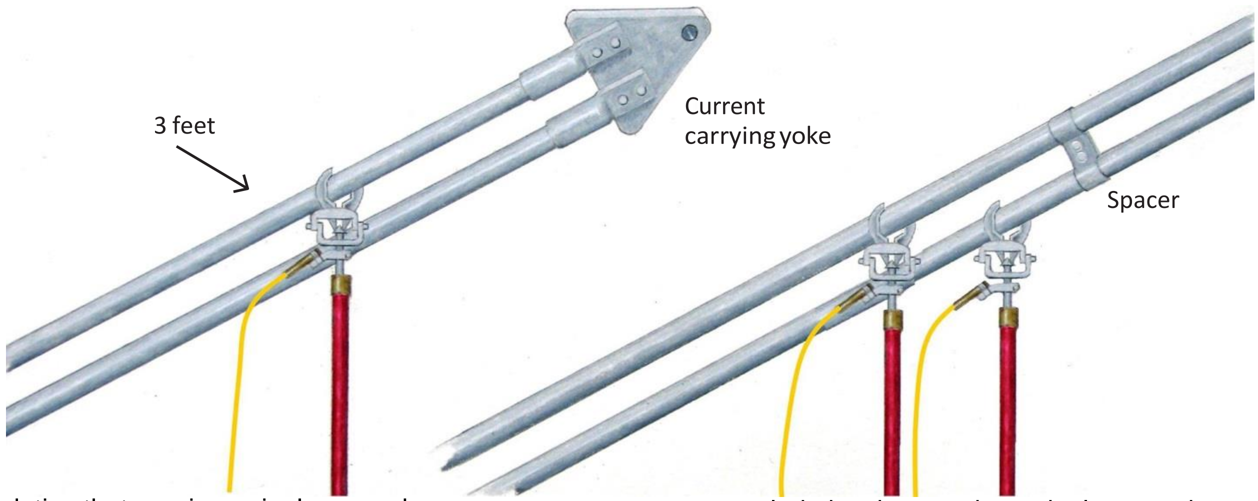
7.7 (continued)

8. **Bundle Conductor** (see Figure 7.18 and 7.19 below)

a. When installing personal or protective grounds 3 FEET OR LESS FROM a current-carrying connector, install grounds on either conductor of the bundled phase per the Fault Duty requirements in Table 7-1.

b. When installing personal or protective grounds FURTHER THAN 3 FEET FROM a current-carrying yoke, install grounds on each conductor of bundled phase per the Fault Duty requirements in Table 7-1.

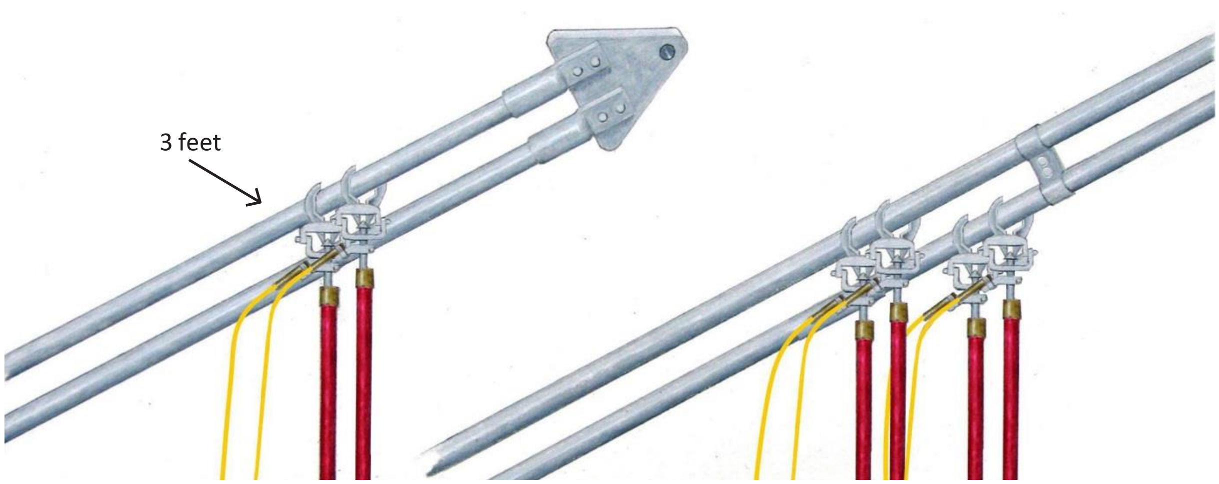


Fault duties that require a single ground within 3 ft. of a current carrying yoke.

Fault duties that require a single ground not within 3 ft. of a current carrying yoke.

Figure 7.18

> **WARNING**
>
> **A conductor spacer is NOT considered to be a current-carrying yoke.**



Fault duties that require double grounds within 3 ft. of a current carrying yoke.

Fault duties that require double grounds not within 3 ft. of a current carrying yoke.

Figure 7.19

7.7 (continued)

c. If a current carrying connector does not exist, then a 2ft - 2/0 small jumper(s) can be installed to shunt conductors together.

- The jumper and protective ground must be placed right next to each other, as shown in Figure 7.20 below.

Figure 7.20

d. An additional ground set may be required depending on fault duty per Table 7-1.

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7.7 (continued)

9. Transformers

When working on a transformer, apply protective grounds against ALL potential sources.

a. Ground the high side for its fault duty.

b. Ground the low side for its fault duty.

c. If applicable, ground the tertiary bus with a single ground per phase (as shown in Figure 7.21 below).

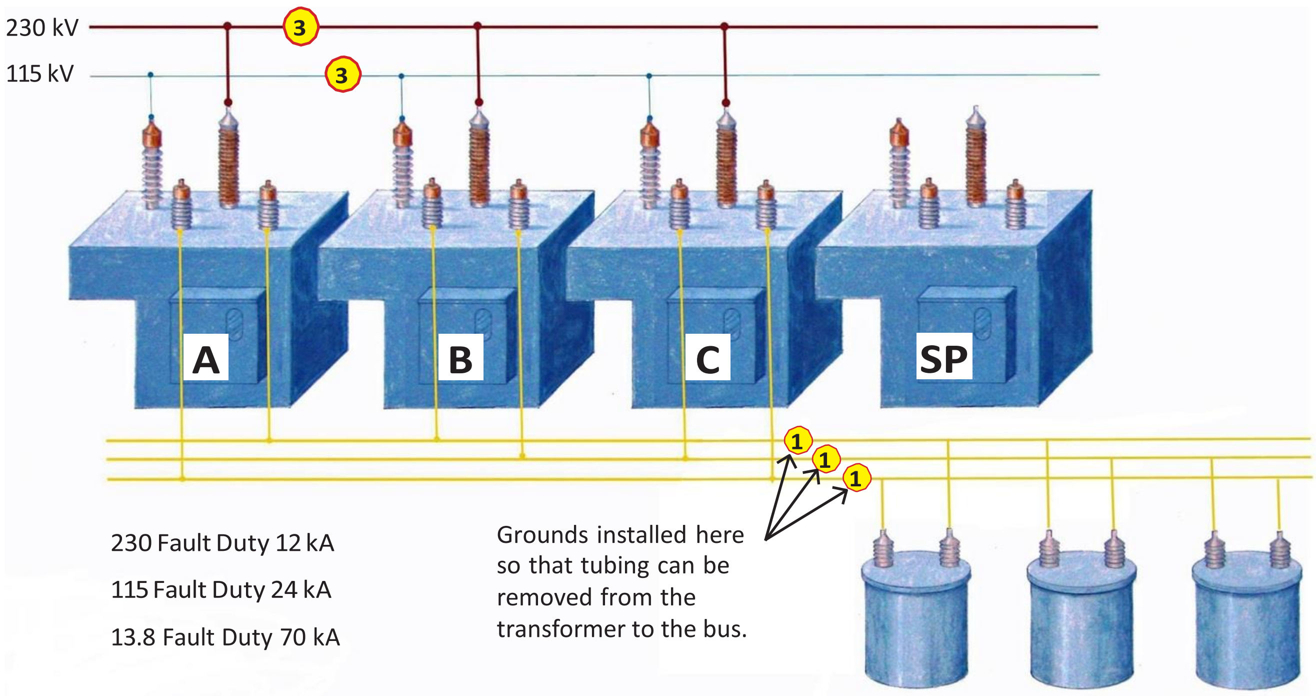

Figure 7.21. Grounding when removing tubing off tertiary bus.

NOTE
If grounded conductors to the transformer are lifted, a bonding jumper connected across all bushings and connected to case ground can be installed to eliminate capacitive and inductive charges. It is extremely important to ensure bonding wires are removed once the grounded conductors to the transformer are re-installed.

⚠ WARNING
Never install a protective ground on an energized neutral bus that has a neutral reactor.

7.7 (continued)

10. Tertiary Connected Equipment

When working on equipment connected to a transformer tertiary, protect against ALL potential sources.

a. Ground the high side for its Fault Duty, or double open or double lock.

b. Ground the low side for its Fault Duty, or double open or double lock.

c. Ground the tertiary bus with a single ground per phase.

d. When working on a Station Service transformer, short the secondary winding, when lifting the primary leads as shown in Section 7.3.3, "Low Energy Fault Duty Sources."

11. Underground Installations

a. Transmission Underground

See Section 4.5: Transmission Overhead and Underground.

b. Distribution Underground

When working on the termination points for underground distribution circuits INSIDE substations, install grounds on the potheads, using the pothead ground lugs, as described in numbered Document 050861, "Termination and Structure for 12 kV and 21 kV Underground Feeders Low Profile Substations."

For ordering information, see Section 10.

If the work requires removing pothead jumpers, keep all the conductors grounded and wear Class 2 rubber gloves with approved protectors.

Contact the SGGC Chairman or member if a difference of potential exists when re-conductoring in and out of the substation.

WARNING

Stainless steel is NOT an approved material for pothead grounding lugs and must be replaced with lugs listed in Section 10.

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7.7 (continued)

12. Generators

After generators are de-energized and all of the generator's prime movers are cleared, install protective grounds to provide protection from ALL available electrical sources.

a. Verifying Clearance Points

In cases where generator cables run inside walls and vaults, it is not always possible to verify visually that the clearance points are open. The crews must research the **single line meter and relay** and **single line diagrams** to verify that all the clearance points are open before installing grounds.

b. Testing Equipment De-Energized

Use the following procedure to test a generator bus de-energized between the generator and the low-side terminals of the step-up transformer. This procedure is REQUIRED because of ungrounded, delta bus configurations.

(1) Test each phase de-energized, using an approved high-voltage tester.

(2) Install grounds in the following sequence.

- Test Phases 1, 2, and 3. Install grounds to Phase 1.
- Test Phases 2 and 3. Install grounds on Phases 2 & 3.

13. Generator Star Point & Elevated Neutral Transformer

a. Prior to contacting the generator star point, elevated neutral transformer or any equipment connected directly to the generator elevated neutral transformer, install one single phase secondary shunt/jumper or similar cable on the secondary terminals of the elevated neutral transformer (see Figure 7.22 below).

	**Single Phase Secondary Shunts** Code: 205051

Figure 7.22

b. If a primary jumper or secondary shorting jumper cannot be physically installed then disconnect the elevated neutral transformer from the star point using a hot stick or Class 2 gloves with approved protectors.

> **WARNING**
>
> **Generators must be cleared and grounded before installing grounds on the generator star point or elevated neutral transformer.**

7.7 (continued)

14. Substation Capacitors

Employees working on capacitors MUST follow the procedures outlined in the Code of Safe Practices and the Substation Maintenance and Construction Manual (TD-3322M).

15. Potential Devices & Coupling Capacitors

When working on the coupling capacitors of a grounded potential device with two or more segments, bond each segment to each other and to ground.

ONLY Qualified Electrical Employees wearing Class 2 rubber gloves with approved protectors may install the bond wires.

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7.8 Metal-Clad Switchgear & Unit Subs

Single point grounding is the approved method when grounding in unit subs and metal clad switchgear. When performing single point grounding within these units, cable lengths must not exceed 12 ft. in length.

Personnel are not required to be within 15 feet of the protective grounds as noted in the Single Point Grounding description (Section 7.4.3 on Page 7-10).

If the generic grounding plans listed in this chapter do not apply to the style and type of equipment that you are working on, then contact the Substation Grounding Committee Chairmen or Local Grounding Committee member.

Signs

When grounds are installed in an enclosure such that they are not clearly visible, magnetic or hanging, Caution signs stating, "Grounds Installed Within This Enclosure," must be installed on the enclosure panel or door. See example in Figure 7.23 below.

Figure 7.23. Caution Sign

Improvised Ground Buggies

Electricians may use modified circuit breakers as a grounding device, provided they DO NOT ADD modifications that change the manufacturer's original current-carrying connections and/or mechanical design of the original unit. They may remove the circuit breaker's original operating mechanism and components, and add only ground knobs to the unit where practical.

Each modified circuit breaker must meet the following conditions before it can be used in the PG&E system as a protective grounding device:

- MUST be reviewed by the substation and generation grounding committee BEFORE use.
- Unit must be serial numbered and field-tested (hi-pot and megger).
- Only be used in the unit-sub style and design designated by the manufacturer, (see its nameplate).

7.8 (continued)

1. Switch Gear Generic Plan with Modified Ground Buggy

a. Who is Qualified?

Substation Maintenance Electricians who have reviewed and practiced the work methods associated in this attachment. This document will be used in all grounding tailboards that are conducted before grounding operations begin.

b. Types of Grounding Equipment

You have the option of using three different methods of performing protective grounding in this switch gear.

(1) Applying ground sets on the main bus drops.

(2) Applying ground sets in the distribution cable termination cabinets.

(3) Applying grounds sets utilizing the ground buggy device.

The following are brief descriptions of the types equipment used in each method:

- **Outdoor Main Bus Grounding for Switch Gear (switch suit is not required)**

Figure 7.24

Typical sets of protective ground devices will be needed to apply grounds on the bus drops into the Switch Gear building. See Figure 7.24.

NOTE
The number and type of grounds may change depending on the Fault Duty rules and the type of bus installed.

- **Grounding Distribution Cable Termination Cabinets (switch suit is required)**

Figure 7.25

Requires the use of a single-cluster 8-foot 2/0 cable w/ball stud-style clamps on each end, and a shotgun-style hot stick for grounding in the cable termination cabinet. See Figure 7.25.

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7.8 (continued)

c. Grounding Using the Ground Buggy Device

This method requires the use of 2/0 protective ground cables connected from the ground reference to the appropriate terminal set.

It is extremely important that you determine what terminal sets are connected to the bus or the line, so that you ground in the right location on a de-energized conductor.

Modified Buggies will use either the mushroom or Ball Stud connectors connected to 2/0 or 4/0 with approved ferrules, (see Figure 7.26 below).

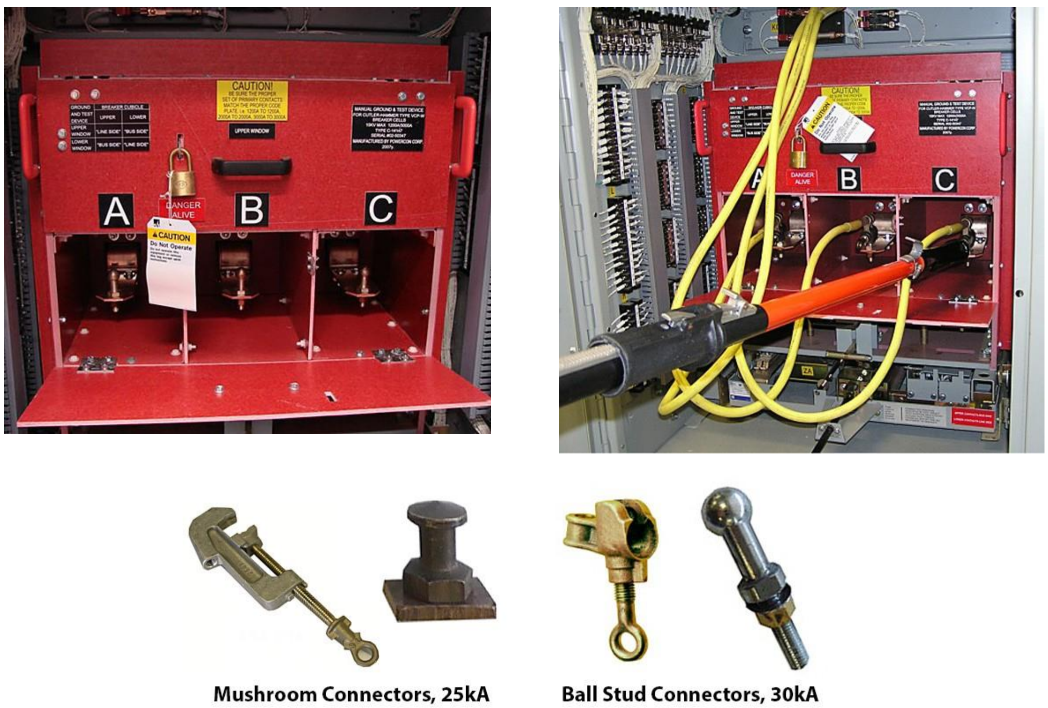

Figure 7.26

NOTE
Racking a ground buggy in or out requires the use of a properly rated switching suit unless remote racking devices are used.

⚠ WARNING
Never bypass the circuit breaker's shutter interlocks.

7.8 (continued)

d. Ground Buggy Inspection

Before using a grounding buggy, inspect and prepare it by ensuring:

(1) The stab or cluster ring has the correct rating and is aligned properly, (see Figures 7.27 and 7.28 below).

Figure 7.27. 1200 A stab cluster ring

Figure 7.28. 3000 A stab cluster ring

(2) Fault duties do not exceed the manufacturers “short circuits withstand rating” of the equipment or ground cables being used.

(3) The buggy is clean and lubricated adequately.

(4) The buggy is operating properly.

(5) Verify that the insulation is in good condition.

(6) Ensure that the buggy is in an ungrounded state BEFORE being racked in, BEFORE testing de-energized.

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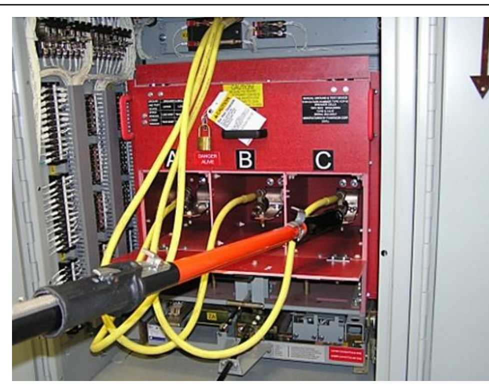
7.8 (continued)

e. Indoor Grounding Using the Ground Buggy and Remote Racking Device

1	**Insert Grounding Buggy into the empty breaker cell cabinet** (do not rack in). Open or remove door flaps (depending on manufacturer) to expose terminal sets.	
2	**Rack buggy in** using a remote racking device or manually with properly rated arc flash protection. **Test all phases needing to be grounded de-energized, while wearing properly rated arc flash protection.**	
3	The terminal set not being grounded may be closed off, locked, and tagged before you rack the buggy into place.	
4	**After the terminal set has been tested de-energized, the ground cable must be connected to the ground source first; and then to each phase terminal while wearing properly rated arc flash protection.**	

7.8 (continued)

2. Switch Gear Generic Plan with Un-Modified Ground Buggy

a. Who is Qualified?

Substation Maintenance Electricians who have reviewed and practiced the work methods associated in this attachment. This document will be used in all grounding tailboards that are conducted before grounding operations begin.

b. Types of Grounding Equipment

You have the option of using three different methods of performing protective grounding in this switch gear:

(1) Applying ground sets on the main bus drops.

(2) Applying ground sets in the distribution cable termination cabinets.

(3) Applying grounds sets utilizing the ground buggy device.

The following are brief descriptions of the types equipment used in each method:

- **Outdoor Main Bus Grounding for Switch Gear (switch suit is not required)**

Figure 7.29

Typical sets of protective ground devices will be needed to apply grounds on the bus drops into the Switch Gear building. See Figure 7.29.

> **NOTE**
> The number and type of grounds may change depending on the Fault Duty rules and the type of bus installed.

- **Grounding Distribution Cable Termination Cabinets (switch suit is required)**

Figure 7.30

Requires the use of a single-cluster 8-foot 2/0 cable w/ball stud-style clamps on each end, and a shotgun-style hot stick for grounding in the cable termination cabinet. See Figure 7.30.

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7.8 (continued)

c. Grounding Using the Ground Buggy Device

This method requires the use of cable jumpers or flat bar ground straps that bolt from ground reference to the appropriate terminal set. This practice is performed with the buggy racked out, after the unit's terminal sets have been tested de-energized (see Figure 7.31 below)

It is extremely important that you determine what terminal sets are connected to the bus or the line, so that you ground in the right location on a de-energized conductor.

Long Jumpers for Upper Bus. Terminations.

Short Jumpers for Lower Line Terminations.

Flat Bar Ground Straps

Figure 7.31

NOTE
Racking a ground buggy in or out requires the use of a properly rated switching suit unless remote racking devices are used.

WARNING
Never bypass the circuit breaker's shutter interlocks.

7.8 (continued)

d. Ground Buggy Inspection

Before using a grounding buggy, inspect and prepare it by ensuring:

(1) The stab or cluster ring has the correct rating and is aligned properly (see Figures 7.32 and 7.33 below).

Figure 7.32. 1200A stab cluster ring

Figure 7.33. 3000A stab cluster ring

(2) Fault duties do not exceed the manufacturers "short circuits withstand rating" of the equipment or ground cables being used.

(3) The buggy is clean and lubricated adequately.

(4) The buggy is operating properly.

(5) Verify that the insulation is in good condition.

(6) Ensure that the buggy is in an ungrounded state BEFORE being racked in, BEFORE testing de-energized.

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7.8 (continued)

e. Indoor Grounding Using the Cable Jumper Ground Buggy
(Preferred method to reduce Arc Flash hazards)

1	**With the buggy racked out, open the top or the lower flap doors to expose the terminals that need to be grounded.** Close, lock and caution tag the door that does not need to be grounded.	
2	**Rack buggy in using the remote racking device; or rack device in manually with the properly rated arc Flash protection.** Test all phases de-energized. **SWITCH SUIT IS REQUIRED** unless you are using clip-on voltage detectors.	
3	**Rack buggy completely OUT using the remote racking device; or rack device OUT manually with the properly rated arc Flash protection.** Install cable jumpers.	
4	**With ALL ground cables installed, rack buggy back IN using remote racking device; or rack device IN manually with the properly rated Arc Flash Protection.** Follow ALL lock out and tagging procedures for your facilities as it pertains to the ground and test device.	

7.8 (continued)

f. Indoor Grounding Using the Flat-Bar Ground Buggy Device
(Use remote racking devices to reduce Arc Flash hazards)

1	**With buggy racked OUT, check that buggy is un-strapped and not grounded.** Block off, lock and tag the terminal set that does not need to be grounded and install.	
2	**Rack buggy IN using the remote racking device; or rack device IN manually with the properly rated arc Flash protection.** Test ALL phases de-energized. SWITCH SUIT IS REQUIRED unless you are using clip-on voltage detectors.	
3	**Rack buggy completely OUT using the remote racking device; or rack device OUT manually with the properly rated arc Flash protection.** Install Flat Bar Ground Straps. 	
4	**With ALL ground straps installed, rack buggy back IN using remote racking device; or rack device IN manually with the properly rated switching suit.** Follow ALL lock out and tagging procedures for your facilities, as it pertains to the ground and test device.	

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7.8 (continued)

3. Unit Sub Generic Ground Plans

The following attachment has been created as added guidance for employees involved in grounding operations in unit subs.

a. Who is qualified?

Substation Maintenance Electricians who have reviewed and practiced the work methods associated in this document are qualified to ground unit subs.

This document is to be used in all grounding tailboards that are conducted before grounding operations begin.

Unit Sub Design and Issues associated with grounding operations:

There are inherently two design issues that MAY EXIST that are associated with unit subs within the PG&E system:

- A verified engineered ground grid (if no ground grid arrangement print exists).
- Unit design did not include locations to apply protective grounds.

b. Grounding Work Methods for Unit Subs

Momentary contact between the employees and pieces of equipment within these facilities (where no proof of grid exists) will be allowed in situations where employees are performing short-term work such as monthly inspections and routine trouble shooting.

Prolonged maintenance activities that involve protective grounding will require additional work methods listed below.

In units where there are no designed locations to apply protective grounds the best practice is:

- To clear the unit and ground on the first terminal outside of the substation for both the primary side and secondary sources.
- Personal grounds should be added to conductors at the work location to eliminate differences of potential. These connections can be made to bushing terminals.

7.8 (continued)

In units where there is no verified engineered ground grid:

- A Ground Potential Rise Hazard sign should be posted at the front gate (see Figure 7.34 below).
- Where employees can make contact with two units (buildings) at the same time, a Temporary 2/0 Jumper can be installed to eliminate the difference of potential.
- A Ground Mat should be placed in work locations where prolonged contact is made (i.e., LTC overhaul). See Figure 7.35 below.
- See Section 10 for ordering information.

Figure 7.34. Caution Sign

Figure 7.35. Personal Ground Package.

- A double open must be created on secondary windings where there are no physical locations to apply personal grounds.
- For Generic Ground Plan for Unit Subs Summary, see Figure 7.36 on Page 7-43.

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7.8 (continued)

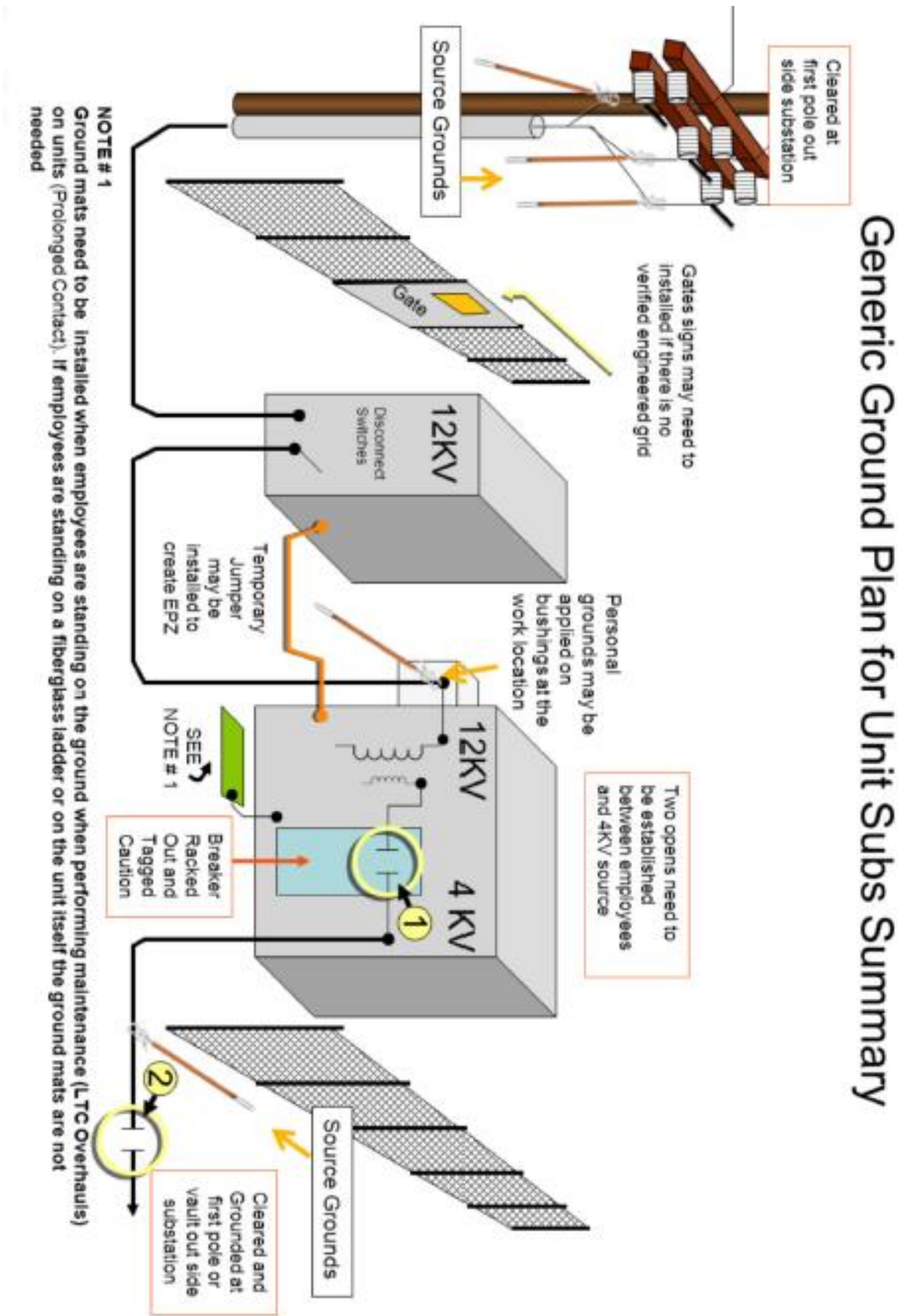

Figure 7.36. Generic Ground Plan for Unit Subs Summary -

7.9 Gas Insulated Substation (GIS) Units

Employees must be trained on the basic design and functionality of the GIS equipment before they can perform work. GIS units must be grounded according to the manufacturer's instructions and PG&E's site-specific “DESCRIPTION OF OPERATION” guidance documents.

Due to the design of GIS switch gear, protective grounding will be conducted by operations department as part of the switching process. This equipment will be switched into the grounded position (remotely) before the crew reports on.

The local field crews reporting on will walk down all clearance points and ensure that:

1. The unit is cleared properly from all possible sources.

2. All ground switches are fully engaged and grounded against all possible sources.

3. All ground switches are locked and tagged as described in the “DESCRIPTION OF OPERATION” guidance documents.

These types of units are equipped with 3-way Disconnect/Grounding Switches designed to protect personnel while performing work tasks requiring protective grounding.

The 3-way Disconnect/Grounding Switches have three positions (see Figure 7.37 below):

- Closed
- Neutral (OPEN)
- Open and Grounded

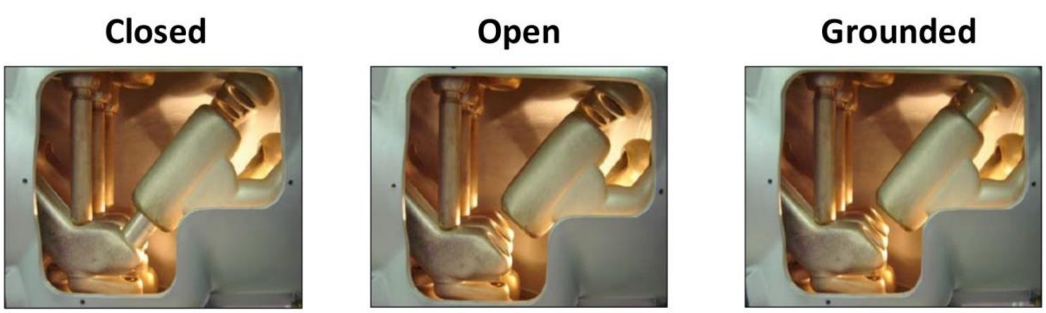

Figure 7.37. 3-way disconnect/grounding switches have three positions.

7.9 (continued)

WARNING

Under no circumstances, shall a switch viewport be looked into while switch is being operated. This may result in an injury to an employee's eyes.

NOTE

Testing the circuit de-energized before operating into the grounded position is not required per the design of the equipment.

Contact the SGGC Committee Chairmen or your local SGGC member for any questions or concerns you might have with GIS grounding practices.

7.10 Repairing or Splicing Ground Grids

Precautions are necessary when splicing into existing ground grids in energized substations.

- If damage to an existing grid conductor requires cutting the electrode to replace a damaged section then a 2/0 jumper must be installed around the damaged area while repairs are being made.
- If an above ground electrode has been stolen, please refer to utility procedure TD-3320-11, "Repairing Damaged or Missing Equipment Ground Leads."
- If an open has been created due to damage to a grid conductor, then a 2/0 jumper must be installed around the open, using a live line tool or Class 2 rubber gloves with approved protectors before repairs can be performed.

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SECTION 8: T&D VEHICLES & EQUIPMENT GROUNDING AND BARRICADING

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8 T&D VEHICLES & EQUIPMENT GROUNDING AND BARRICADING

8.1 Scope

This section covers the methods for transmission and distribution (T&D) departments for when and/or how to ground and barricade vehicles and equipment. The procedures in this section have been designed to protect electric workers and the public from electrical hazards that are associated with grounded vehicles and equipment.

8.2 Definitions

See Table 8-1 below for definitions.

Table 8-1. Definitions

Type:	VEHICLE	EQUIPMENT
Definition:	Has a boom or similar device that can make contact with an energized high voltage circuit.	Cannot, by its design, make contact with an energized high voltage circuit.
Examples:	• Aerial lifts • Boom trucks • Backhoes • Cranes • Forklifts • Loaders • Trucks or other vehicles with devices that may be extended • Directional boring equipment	• Office trailer • Tool vans • Trailer mounted equipment

8.3 General Information

All personnel are responsible for protecting the public and other workers from vehicles and equipment that are connected to, or operating near energized or de-energized and grounded transmission or distribution lines and facilities.

1. **Vehicle Ground Lugs on PG&E Vehicles, Rental Vehicles, and Equipment (Overhead T&D)**

> **WARNING**
>
> **Stainless steel ground lugs fail when exposed to fault currents higher than 15,000A.**

   a. If stainless steel lugs are discovered – do not use. They must be removed and replaced. Contact the local fleet services department for assistance with the installation of an approved grounding lug.

   b. There are currently two types of approved ground lugs that will meet the minimum 30,000 ampere (A) fault duty.

      (1) Bronze Style Ground Lug: Installed by the vehicle or equipment manufacturer. These can be either bolted or welded to the vehicle or equipment frame, and are rated at 30,000A fault duty (see Figures 8.1 and 8.2 below).

      (2) Mild Steel Bar Stock and Copper-Style Ground Lug: Installed by Fleet Services, rated at 30,000A fault duty.

   c. An additional ground jumper may need to be installed between the frame and the body of the vehicle if there are rubber insulating mounts between the body and the frame.

Figure 8.1 - Welded Bronze Style Lug

Figure 8.2 – Ground Clamp Attached

2. When grounding a vehicle for fault duty, vehicle grounds must be 2/0 AWG copper, at a minimum.

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8.3 (continued)

3. When grounding a vehicle for induction hazards only, vehicles grounds may be #2 AWG copper, at a minimum.

4. In the event a vehicle becomes energized, the operator must remain on the vehicle until one of the following conditions exists:

a. The vehicle is clear of the electrical contact.

b. The circuit is de-energized.

c. The person in charge confirms that it is safe to exit the vehicle.

If exiting the vehicle is necessary before the conditions in **a** through **c** can be met, jump clear of the vehicle without touching the vehicle and ground at the same time.

8.4 Requirements

Work Zone clearance applies only to lines that are energized or lines that are de-energized and not grounded.

1. Vehicles involved in work outside of the Work Zone clearance distance do not need to be grounded, provided there is no possibility for a dropped conductor to energize the main frame of the vehicle (see Table 8-2 below).

Table 8-2. Work Zone Clearance

Voltage	Work Zone Clearance Distance
600V to 50kV	10 feet
50 through 75kV	11 feet
75 through 125kV	13 feet
125 through 175kV	15 feet
175 through 250kV	17 feet
250 through 370kV	21 feet
370 through 550kV	27 feet

2. Vehicles not insulated for the voltage being worked that are involved in work within the Work Zone clearance distance of an energized or ungrounded circuit, must be grounded with a TPG that is rated for the fault duty (see Table 8-3 on Page 8-4).

Obsolete

8-4 (continued)

Table 8-3. When Vehicle Grounding Is Required

	Working De-energized and Grounded		Working Energized	
	Less Than 46 kV	Greater Than or Equal to 46 kV	Less Than 46 kV	Greater Than or Equal to 46 kV
Aerial Lift, with current dielectric certification	No[1,2,3]	Yes	No[1,2,3]	Yes
All other vehicles	Yes	Yes	Yes	Yes

[1] The boom cover must be removed.

[2] If using an aerial lift that is equipped with a telescoping boom, the insulated boom section must be extended to completely expose the 1-inch wide red paint mark.

[3] If within 10' of a grounded vehicle, must be bonded together at a common point with temporary grounding jumper and connected to a common ground source.

8.5 Installing & Removing Grounds on Vehicles and Equipment

WARNING

Temporary ground rods must be installed as far from the worksite as practical to minimize step potential.

To reduce the risk of exposing an employee to transfer potential and to eliminate sparks near flammable equipment, always connect the ground cable to the vehicle or equipment first and to the ground source last.

CAUTION

On rental trucks with ground lugs installed on the body, additional ground jumpers between the frame and body are required if there are rubber insulating mounts between the frame and body.

To create a ground connection on a rental vehicle or equipment that is not equipped with a grounding lug, follow the instructions in Step 8.5.1.e on Page 8-5.

1. Installing

a. The ground rod must be barricaded and installed in a safe location, as far as practical from the worksite.

b. Connect vehicle grounds at a worksite to the same ground source as the conductor when a worker is standing on a structure and could simultaneously make contact with separate ground sources (e.g., a grounded line and an uninsulated boom or metallic winch line).

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8.5 (continued)

c. When vehicles or equipment are positioned within 8 feet, and one or more of these vehicles is grounded, the vehicles/equipment must:

- Be bonded together at a common point with a grounding jumper(s), rated for the fault duty.
- Be connected to a common ground source with a temporary grounding jumper(s), rated for the fault duty (see Figure 8.3 below).

Figure 8.3 - Multiple Vehicles Connected to a Common Ground Source

d. Ensure that the ground lug or connection point is clean.

e. Attach the ground clamp to either:

(1) A ground lug that is welded or bolted to the frame of the vehicle or equipment.

(2) An exposed, unpainted mass of metal on the vehicle or equipment such as a step or section of the frame.

- If the frame is painted, expose the frame and wire-brush the metal before connecting the ground clamp.
- The frame must be repainted once the clamp is removed.

If the vehicle or equipment will be left grounded for an extended period, coat the exposed area with cold galvanized coating before connecting the ground clamp to prevent rusting.

8.5 (continued)

WARNING

When connecting a vehicle ground to a ground source where conductors are already grounded, Class 2 rubber gloves with approved protectors or a hot stick must be used to connect the vehicle ground to the ground source.

f. Install the other end of the vehicle ground cable to the ground source.

g. Install barricades around the vehicle and the ground cable (see Section 8.6 below).

2. Removing

To reduce the amount of step and/or touch exposure time, disconnect any grounded vehicles and/or equipment from the ground scheme as soon as possible after they are no longer exposed to grounded lines or other grounded equipment.

WARNING

When a vehicle or equipment ground-tail clamp is in proximity to other ground-tail clamps, caution must be taken to prevent removing the wrong clamp.

a. To prevent removing the wrong ground clamp when a vehicle must be relocated, wear Class 2 rubber gloves with approved protectors and perform the following:

(1) Hand-trace the ground cable from the vehicle or equipment to the ground source connection. This ensures that you have the right cable.

(2) Disconnect the vehicle ground from the ground source (a hot stick may also be used to perform this step).

(3) Disconnect the ground cord from the vehicle and store with the vehicle.

8.6 Barricading Grounded Vehicles and Equipment

1. Barricade to physically isolate grounded vehicles or equipment.

Always use a barricade to physically isolate grounded vehicles or equipment. Temporary barricades provide a visual warning and physically protect people from making inadvertent contact with grounded vehicles or equipment. See Figure 8.4 on Page 8-7.

NOTE

Kits that use barrier tape in conjunction with traffic cones are available, see Section 10 (“Cones and Barricading” on Page 10-38).

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8.6 (continued)

The location of barricades depends on the worksite and traffic conditions. Use the following methods of barricading:

a. Whenever practical, place the barricades a minimum of 10 feet from the grounded vehicles and/or grounded equipment.

b. Use electrical hazard barricade tape along with traffic cones, to identify and restrict access to areas where the general public could contact grounded vehicles or equipment.

- Cones alone may be used to meet the minimum requirements for barricading, provided there is minimal risk of the general public entering the barricaded area.

Figure 8.4. Barricaded Truck.

8.7 Contacting a Grounded Vehicle

1. Operating within the Work Zone Clearance – Energized or De-energized and Ungrounded Facilities.

a. Avoid making contact if possible.

b. If contact must be made:

Leather gloves may be used to make contact, provided the vehicle/equipment boom is outside of the work zone clearance.

When the boom of a grounded vehicle is inside of the work zone clearance, Class 2 rubber gloves with approved protectors must be worn to make contact, or contact must be made from a grounding mat.

(1) Notify the operator of the vehicle and wait for the operator's instructions.

The operator must:

- Stop all operations in a safe position – outside of the MAD, unless covered with insulating protective devices, and
- Stay clear of the controls.

If rubber glove work is being performed from the grounded vehicle to be contacted, the aerial lift must be moved out of the contact area.

(2) Ensure all parts of the vehicle, including the winch lines are outside of the MAD or are not in contact with insulating protective equipment.

(3) Approach or contact the vehicle only after the operator says it is OK to do so.

(4) Notify the operator when all employees are clear of the vehicle and no further contact is needed.

(5) The operator may then resume the normal operation of the vehicle.

2. Operating in Proximity to De-Energized and Grounded Facilities

a. Avoid making contact if possible.

b. If contact must be made:

(1) Leather gloves may be used to make contact if all the following conditions are met:

- The vehicle's boom is outside of the MAD the line would normally be energized at.
- The vehicle or equipment is not connected to the same ground source as the line being worked.

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8.7 (continued)

(2) Class 2 rubber gloves with approved protectors must be worn to make contact, or contact must be made from a grounding mat when the following conditions exist:

- The boom of a grounded vehicle is connected to the same ground source as the line being worked.
- The boom of a grounded vehicle is within the MAD for the voltage the line would normally be energized.

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SECTION 9: SUBSTATION/GENERATION VEHICLES, EQUIPMENT GROUNDING & BARRICADING

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9 SUBSTATION/GENERATION VEHICLES, EQUIPMENT GROUNDING & BARRICADING

9.1 Scope

This section covers the methods for substation and generation personnel to perform vehicle and equipment grounding and barricading. The procedures in this section have been designed to protect the public and employees from electrical hazards.

9.2 General Information

Vehicles and equipment exposed to electrical hazards require grounding or bonding. See Table 9-1 below for definitions.

Table 9-1. Definitions

Type:	VEHICLE	EQUIPMENT
Definition:	Has a boom or similar device that can make contact with an energized high voltage circuit.	Cannot, by its design, make contact with an energized high voltage circuit.
Examples:	• Aerial lifts • Boom trucks • Backhoes • Cranes • Forklifts • Loaders • Trucks or other vehicles with devices that may be extended • Directional boring equipment	• Office trailer • Tool vans • Trailer mounted equipment

1. Vehicle Grounding

Vehicles that may be exposed to high voltage incidental contact must be grounded for the fault duty using approved clamps and cable connections. See Section 10, "Devices, Components & Tools," for PG&E vehicle/equipment ground lug information.

The vehicle must be located within 40 feet of the substation grid or a ground rod must be used. The ground rod must be barricaded and installed in a safe location, as far as possible from the worksite.

9.2 (continued)

2. Equipment Grounding / Bonding

When equipment is exposed to a difference of potential and/or induced voltage hazards (see Section 2.3) – including capacitive and low voltage safety hazards – it must be grounded/bonded with a minimum of #2 AWG cable and connectors.

The vehicle must be located within 40 feet of the substation grid or a ground rod must be used. The ground rod must be barricaded and installed in a safe location, as far as possible from the worksite.

- Always notify Underground Service Alert (USA) at least 2 working days before beginning any earth-disturbing activities in a substation. Call 811 or 1-800-227-2600 to contact USA. USA requests all utilities in the area to identify and mark their lines within the substation.

- All vehicles and equipment must be physically located at least 8 feet away from all points of contact with substation fence.

3. Substation Mobile Equipment

All substation mobile equipment has specific grounding requirements. See Engineering Standard 070089, "Grounding Requirements for Mobile Substation."

9.3 Vehicle Clearance and Distances

Vehicle grounding is not necessary if the distances listed below are maintained from all exposed energized circuits and conductors where the chance of electrical contact can be made. See Table 9-2 below.

- If the vehicle is rated by the manufacturer and has a current dielectric certification for the voltage hazard at the worksite, then vehicle grounding is not required.

Table 9-2. Clearance Distance

Voltage	Clearance Distance
Under 46kV	10 feet
46.1 through 121kV	15 feet
121.1 through 242kV	20 feet
242.1 through 552kV	27 feet

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9.4 Vehicle / Equipment Ground Lugs

1. PG&E Vehicles / Equipment

Only approved ground lugs installed by PG&E Fleet department are allowed for use on PG&E fleet vehicles.

See Section 10, "Devices, Components & Tools," for PG&E vehicle/equipment ground lug information.

2. Rental Vehicles / Equipment

To create a ground connection on a rental vehicle or equipment, follow the instructions below:

a. Remove enough paint from the main frame of the unit to accommodate ground clamp(s), using proper PPE and safety precautions (see Figure 9.1 below).

b. Coat the bare metal surface with Cold Galvanizing Coating (Code 130479) to prevent rusting (see Figure 9.2 below).

c. This procedure can also be used to create a personal ground connection point on aerial metal basket railings (see Figure 9.3 below).

Figure 9.1

Figure 9.2

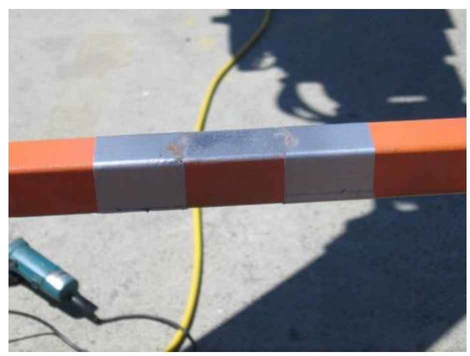

Figure 9.3

WARNING

Never use stainless steel ground lugs. Stainless steel material is not fault duty rated.

CAUTION

On rental trucks with ground lugs installed on the body, additional ground jumpers between the frame and body are required if there are rubber insulating mounts between the frame and body.

9.5 Procedure to Install Grounds on Vehicles and Equipment

To reduce the risk of exposing an employee to transfer potential and to eliminate sparks near flammable equipment, always connect the ground cable to the vehicle/equipment first and to the ground source last. Immediately after grounding the vehicle/equipment, install a barricade around the vehicle and the ground cable.

The vehicle/equipment must be located within 40 feet of the substation grid or a ground rod must be driven in a safe location.

1. **Wire brush all corroded connection points.**

2. **Attach the ground clamp to either:**

   a. Approved ground lug on the vehicle or equipment.

   b. The vehicle/equipment frame exposed and coated with Cold Galvanized Coating (as described in Section 9.4 on Page 9-3).

3. **Install the other end of the cable to a ground grid electrode, rod, steel tower surface, or other acceptable ground source.**

   a. Never connect vehicle or equipment grounds to a station fence.

⚠ **WARNING**

On a substation ground grid, make every effort to install the vehicle's ground-tail clamp(s) so that they are not in close proximity to protective ground-tail clamps. Whenever possible, they should be separated from each other by at least 6 feet.

EXCEPTION – Single Point Grounding Applications. See Section 7.4.

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9.5 (continued)

WARNING

Never connect a vehicle or equipment ground to a Ho/Xo electrode. A serious electrical hazard (damage to the Ho/Xo) would be created if the vehicle was relocated with the ground cable still connected, except when performing single point grounding in substation and generation facilities. See Figure 9.4 below.

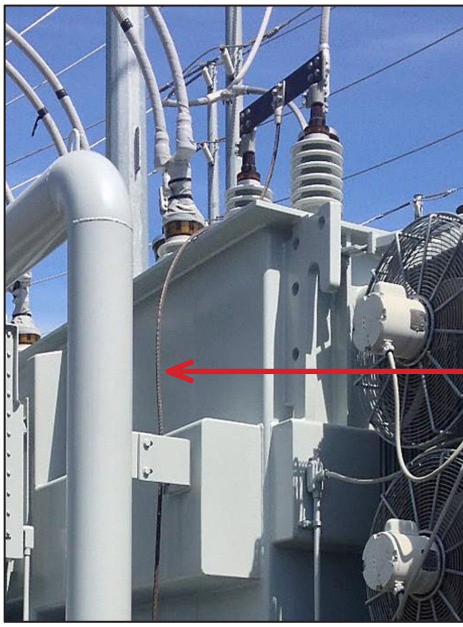

Figure 9.4. Ho/Xo

9.6 Procedure to Remove Grounds from Vehicles and Equipment

WARNING

When a vehicle /equipment ground-tail clamp is in proximity to other ground-tail clamps, caution should be taken to prevent removing the wrong clamp.

1. **When a vehicle/equipment ground clamp is attached to a ground source in close proximity to other protective ground clamps, do the following:**

   a. Hand-trace the ground cable from the vehicle/equipment to the ground source connection to ensure you have the right cable first.

CAUTION

Avoid getting in series between the two different grounds.

   b. Remove the ground from the ground source.

   c. Remove the ground clamp from the vehicle/equipment.

2. **When a vehicle/equipment ground is attached to a ground source and no other protective ground clamp is in close proximity, do the following:**

   a. Remove the ground from the ground source.

   b. Remove the ground clamp from the vehicle/equipment.

3. **Accidental Vehicle Energization**

   If a vehicle becomes energized while it is grounded, the operator must remain on the vehicle until one of the following conditions exists:

   a. The circuit is de-energized and grounded.

   b. The person in charge confirms that it is safe to exit the vehicle.

   c. If exiting the vehicle is necessary, jump clear of the vehicle without touching the vehicle and ground at the same time.

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9.7 Barricading Grounded Vehicles and Equipment

Always use a barricade to physically isolate a grounded vehicle/equipment. The location of barricades depends on the worksite and traffic conditions (see Figure 9.5 below). Use the following methods of barricading:

1. If practical, place the barricades 8 feet from the grounded vehicles and/or grounded equipment.
2. Place temporary barricades to provide a visual warning and/or to physically protect people from contact with grounded vehicles and/or grounded equipment.
3. Cones may be used to meet the minimum requirements for barricading, provided there is minimal risk that the general public will enter the barricaded area.
4. Electrical hazard barricade tape may be used, along with traffic cones, to identify and restrict access to areas where the general public could be exposed to electrical hazards.

NOTE

To order kits that use barrier tape in conjunction with traffic cones, see Section 10 (page 10-38, “Cones and Barricading”).

Figure 9.5 Barricaded truck.

9.8 Contacting a Grounded Vehicle

Two methods are available to protect employees who need to contact a grounded vehicle. The choice of method depends on whether the contact will be momentary or prolonged.

1. Procedure for *Momentary* Contact

If it is necessary to contact a grounded vehicle momentarily, for example, when getting on and off the vehicle or handing material to a person in a bucket:

a. NOTIFY the operator of the vehicle and WAIT for the operator's instructions.

b. The operator MUST STOP ALL OPERATIONS in a safe position and then stay clear of the controls.

c. Approach or contact the vehicle only after the operator says it is OK to do so.

d. Notify the operator when all employees are clear of the vehicle and no further contact is needed.

e. The operator may then resume the normal operation of the vehicle.

2. Procedure for *Prolonged* Contact

If it is necessary to make a prolonged contact with a grounded vehicle, for example, to work from the bed of a truck, using a vise, etc.:

a. NOTIFY the operator of the vehicle. WAIT for the operator's instructions.

b. The operator must place the boom of the vehicle in the stowed position.

c. Remove the vehicle ground when instructed to do so by the operator. For information on the removal method, see Section 9.6 on Page 9-6.

d. Contact the vehicle and perform the work tasks.

e. Notify the operator when all employees are clear of the vehicle and no further contact is needed.

f. Reinstall the vehicle ground when instructed to do so by the operator. For information on the installation method, see Section 9.5 on page 9-4.

g. Notify the operator when all employees are clear of the vehicle. The operator may then resume the normal operation of the vehicle.

NOTE

When working near and an electrical observer is required as per CSP – Rule 813 it is advised that a Spec. 4 insulated hot rope be used as a tag line.

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9.8 (continued)

3. On-the-Grid / Off-the-Grid Power Sources/Transfer Potential Hazards Isolation Transformers

Isolation transformers (see Figure 9.6 below) must be used when extending power circuits/sources from on-the-grid to off-the-grid or from off-the-grid onto the grid.

Off-the-grid is considered when equipment is located more than 40 feet from the grid or outside **the substation.**

Figure 9.6 Isolation Transformer

a. Procedure Steps for Installing an Isolation Transformer

(1) Select the appropriate isolation transformer from Table 9-3 below.

Table 9-3. Material Codes

KVA	120 Volts Primary 120 Volts Secondary	208 Volts Primary 208 Volts Secondary	120/240 Volts Primary 120/240 Volts Secondary
1.0	M260350	M260143	M260237
3.0	M260351	M260150	M260255
5.0	M260411	M260166	M260271
7.5	M260538	M260170	M260311
10	M260539	M260175	M260323
15	M260567	M260209	M260324

(2) Locate the isolation transformer on the grid and case ground the unit to the grid using the approved cables and connectors.

(3) Check that the internal connections of the windings are not bonded together or bonded to ground.

(4) Install the unit needing power off the grid and ground it to an individually driven ground rod at that location.

(5) Install a non-metallic conduit between the isolation transformer and the unit needing power.

(6) Install the circuit between the isolation transformer and the unit needing power.

9.8 (continued)

(7) Megger test the circuit and the isolation transformer (at the proper test voltage for the unit and circuit) to ensure it has no reference to ground.

(8) Connect the circuit to the remote unit.

b. Alternative Procedure When Isolation Transformer is Not Available or is Impractical: Grid Extension Practice

Option 1

An external power source from a distribution service pole (not connected to the grid) can also be used to supply units that are off the grid as an alternative to the isolation transformer, provided it has an 8-foot clearance from conductive objects connected to the station grid.

Option 2

(1) Lay out cable for trailer power circuit from source to load equipment being serviced (off the grid).

(2) Lay out 250 mcm cable from grid to trailer grid extension.

(3) Run both cables through 2 ft PVC conduit if going under station fence.

(4) Install ground rod and bond AC panel and grid extension together.

(5) Connect load side service connections first to AC panel (ground rod already installed and connected to panel).

(6) Connect source side connections using Class 2 rubber gloves with approved protectors and 1,000V tools.

(7) If trailer or equipment is outside substation fenced area, then temporary fencing should be installed.

(8) Install momentary contact signs on trailer doors and access point.

(9) Trailer or equipment connected to the grid extension must maintain 8-foot distance from all fence material.

- For more information on fence grounding see Engineering Standards 020607, "Method for Grounding Fences and Wire Trellises" and 069310, "Isolation Transformer Application."
- For making power connections see TD-3320P-22, "Temporary AC Power Connections for Portable Equipment in Substation Facilities Utility Procedure."

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SECTION 10: DEVICES, COMPONENTS, AND TOOLS

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10 DEVICES, COMPONENTS & TOOLS

10.1 Scope

This section of the Protective Grounding Manual contains illustrations and material codes for devices and components used in protective grounding practices.

It also contains “Assembly Ratings” and “Individual Clamp Ratings” for protective grounding devices and components.

- Assembly Ratings are based off the lowest rated components within the assembly for use in SINGLE (1 ground per phase) and DOUBLE (2 grounds per phase) configurations.
- Individual Clamp Ratings are based off the individual clamp when used in SINGLE (1 ground per phase) and DOUBLE (2 grounds per phase) configurations.

10.2 Devices, Components & Tools

2/0 Bag Ground Set 1 — Code: 205879

Line Department

Bag Ground Assembly

Rated Single 30 kA Double 57 kA

Components:

60'	2/0 Yellow Grounding Cable
8ea	2/0 Threaded Copper Ferrule
2ea	C-Clamp w/ Parking Stand
5ea	C-Clamp
1ea	Bronze Flat Face Clamp
8ea	6” Heat Shrink Tubing (CanusaCFM1100)
1ea	Storage Bag

Build to:

2ea	9' Line to Line lead w/ 1 CS & 1 C-Clamp
1ea	12' Lead Line to Pole Band w/ 2 C-Clamps
1ea	60' Pole Band to Ground w/1 C clamp and 1 Bronze Flat face
1ea	Finished Product packaged in Bag for Delivery with all contents listed above

Pole Band ordered separately;
see Miscellaneous Components

C-Clamp

Code: 205884 (w/stand)

Code: 205883 (w/o stand)

Range: .19 – 1.25

Bronze Flat Face Clamp

Code: 205918

Range: .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”

Torque: 25 ft-lb.

2/0 cable with pressed ferrules on each end

9 ft 2/0 – Code: 206053
12 ft 2/0 – Code: 206950
60 ft 2/0 – Code: 206054

T Handle

Code: 205017

T - Handle 5/8 Thread

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2/0 Bag Ground Set 2 — Code: 206163

Line Department

Bag Ground Assembly

Rated Single 30 kA Double 57 kA

Components:

60'	2/0 Yellow Grounding Cable
8ea	2/0 Threaded Copper Ferrule
2ea	C-Clamp w/ Parking Stand
5ea	C-Clamp
1ea	Bronze Flat Face Clamp
8ea	6” Heat Shrink Tubing (Canusa CFM1100)
1ea	Storage Bag

Build to:

3ea	15' Lead Line to Line w/ 2 C-Clamps
1ea	60' Pole Band to Ground w/1 C-Clamp and 1 Bronze Flat face
1ea	Finished Product packaged in Bag for Delivery with all contents listed above

Pole Band ordered separately;
see Miscellaneous Components

C-Clamp

Code: 205884 (w/stand)

Code: 205883 (w/o stand)

Range: .19 – 1.25

Bronze Flat Face Clamp

Code: 205918

Range: .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”

Torque: 25 ft-lb.

2/0 cable with pressed ferrules on each end

15 ft 2/0 – Code: 206205
60 ft 2/0 – Code: 206054

T Handle

Code: 205017

T - Handle 5/8 Thread

2/0 Bag Ground Set 3 — Code: 206746

Substation Department

Substation Bag Ground Assembly

Rated Single 30 kA Double 57 kA

Components:

27’	2/0 Yellow Grounding Cable
6ea	2/0 Threaded Copper Ferrule
2ea	C-Clamp w/ Parking Stand
3ea	C-Clamp
1ea	Bronze Flat Face Clamp
8ea	6” Heat Shrink Tubing (Canusa CFM1100)
1ea	Storage Bag

Build to:

2ea	6' Line to Line lead w/ 1 CS & 1 C-Clamp
1ea	15' Lead Line to Ground w/ 2 C-Clamps
1ea	Finished Product packaged in Bag for Delivery with all contents listed above

C-Clamp

Code: 205884 (w/stand)

Code: 205883 (w/o stand)

Range: .19” – 1.25”

Bronze Flat Face Clamp

Code: 205918

Range: .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”

Torque: 25 ft-lb.

2/0 cable with pressed ferrules on each end

6 ft 2/0 – Code: 206154
15 ft 2/0 – Code: 206205

T Handle

Code: 205017

T-Handle 5/8 Thread

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2/0 Bag Ground Set 4 — Code: 206152

Line Department

Bag Ground Assembly

Rated Single 30 kA Double 57 kA

Components:

60'	2/0 Yellow Grounding Cable
8ea	2/0 Threaded Copper Ferrule
2ea	C-Clamp w/ Parking Stand
5ea	C-Clamp
1ea	Bronze Flat Face Clamp
8ea	6” Heat Shrink Tubing (Canusa CFM1100)
1ea	Storage Bag

Build to:

2ea	6' Line to Line lead w/ 1 CS & 1 C-Clamp
1ea	15' Lead Line to Pole Band w/ 2 C-Clamps
1ea	60' Pole Band to Ground w/1 C clamp and 1 Bronze Flat face
1ea	Finished Product packaged in Bag for Delivery with all contents listed above

Pole Band ordered separately see Miscellaneous Components

C-Clamp

Code: 205884 (w/stand)

Code: 205883 (w/o stand)

Range: .19 – 1.25

Bronze Flat Face Clamp

Code: 205918

Range: .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”

Torque: 25 ft-lb.

2/0 cable with pressed ferrules on each end

6 ft 2/0 – Code: 206154
15 ft 2/0 – Code: 206205
60 ft 2/0 – Code: 206054

T Handle

Code: 205017

T-Handle 5/8 Thread

#2 Bag Ground Set 1 — Code: 202092

Line Department

Specify Cable Length when ordering phase jumpers

Bag Ground Assembly

Rated Single 15 kA Double 30 kA

Components:

60'	#2 Orange Grounding Cable
8ea	#2 Threaded Copper Ferrule
2ea	C-Clamp w/ Parking Stand
5ea	C-Clamp
1ea	Bronze Flat Face Clamp
8ea	6” Heat Shrink Tubing (Canusa CFM1100)
1ea	Storage Bag

Build to:

2ea	9' Line to Line lead w/ 1 CS & 1 C-Clamp
1ea	12' Lead Line to Pole Band w/ 2 C-Clamps
1ea	60' Pole Band to Ground w/1 C-Clamp and 1 Bronze Flat Face
1ea	Finished Product packaged in Bag for Delivery with all contents listed above

Pole Band ordered separately see Miscellaneous Components

C-Clamp

Code: 205884 (w/stand)

Code: 205883 (w/o stand)

Range: .19 – 1.25

Bronze Flat Face Clamp

Code: 205918

Range: .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: #2 – 5/8”

Torque: 25 ft-lb.

#2 cable with pressed ferrules on each end

9 ft #2 – Code: 206055
12 ft #2 – Code: 206062
60 ft #2 – Code: 206063

T Handle

Code: 205017

T-Handle 5/8 Thread

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#2 Bag Ground Set 2 — Code: 206156

Line Department

Specify Cable Length when ordering phase jumpers

Bag Ground Assembly

Rated Single 15 kA Double 30 kA

Components:

60' #2 Orange Grounding Cable
8ea #2 Threaded Copper Ferrule
2ea C-Clamp w/ Parking Stand
5ea C-Clamp
1ea Bronze Flat Face Clamp
8ea 6" Heat Shrink Tubing (Canusa CFM1100)
1ea Storage Bag

Build to:

3ea 15' Lead Line to Line Band w/ 2 C-Clamps

1 ea 60' Pole Band to Ground w/1 C-Clamp and 1 Bronze Flat Face

1 ea Finished Product packaged in Bag for Delivery with all contents listed above

Pole Band ordered separately see Miscellaneous Components

C-Clamp

Code: 205884 (w/stand)

Code: 205883 (w/o stand)

Range: .19 – 1.25

Bronze Flat Face Clamp

Code: 205918

Range: .25" – 1.5"

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: #2 – 5/8"

Torque: 25 ft-lb.

#2 cable with pressed ferrules on each end

15 ft #2 – Code: 206064
60 ft #2 – Code: 206063

T Handle

Code: 205017

T-Handle 5/8 Thread

#2 Bag Ground Set 3 — Code: 206144

Line Department

Specify Cable Length when ordering phase jumpers

Bag Ground Assembly

Rated Single 15 kA Double 30 kA

Components:

60' #2 Orange Grounding Cable
8ea #2 Threaded Copper Ferrule
2ea C-Clamp w/ Parking Stand
5ea C-Clamp
1ea Bronze Flat Face Clamp
8ea 6" Heat Shrink Tubing (Canusa CFM1100)
1ea Storage Bag

Build to:

2ea 6' Line to Line lead w/ 1 CS & 1 C-Clamp
1ea 12' Lead Line to Pole Band w/ 2 C-Clamps
1ea 60' Pole Band to Ground w/1 C-Clamp and 1 Bronze Flat Face
1ea Finished Product packaged in Bag for Delivery with all contents listed above

Pole Band ordered separately see Miscellaneous Components

C-Clamp

Code: 205884 (w/stand)

Code: 205883 (w/o stand)

Range: .19 – 1.25

Bronze Flat Face Clamp

Code: 205918

Range: .25" – 1.5"

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: #2 – 5/8"

Torque: 25 ft-lb.

#2 cable with pressed ferrules on each end

6 ft #2 – Code: 206093
15 ft #2 – Code: 206064
60 ft #2 – Code: 206063

T Handle

Code: 205017

T-Handle 5/8 Thread

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Tower Ground Set — Code: 203870

Line Department

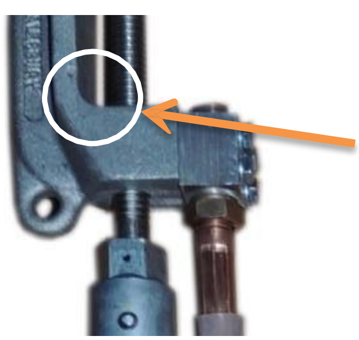
Tower Ground Set Assembly

Rated Single 30 kA Double 57 kA

Components:

16’	2/0 Yellow Grounding Cable
2ea	2/0 Threaded Copper Ferrule
1ea	Tower Ground Clamp
1ea	Bronze Flat Face Ground Clamp / includes snap
2ea	6” Heat Shrink Tubing (Canusa CFM1100)

Build to:
16 ft 2/0 Lead with Tower Ground Clamp (6ft long stick) on one end and Bronze Flat Face Ground Clamp on the other.



Note: Casting on this clamp must have a rounded corner as shown here

Tower Ground Clamp

Code: 209341

Range: .19” – 1.25”

Bronze Flat Face Clamp

Code: 205918

Range .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”

Torque: 25 ft-lb.

2/0 cable with pressed ferrules on each end

16 ft 2/0 – Code: 205807

Threaded Ferrule Adapter

Code: 209000

4-1/4” – 20 × 1.5” bolts

Torque: 96 in.-lb.

Tower Ground Set — Code: 201991

Line Department

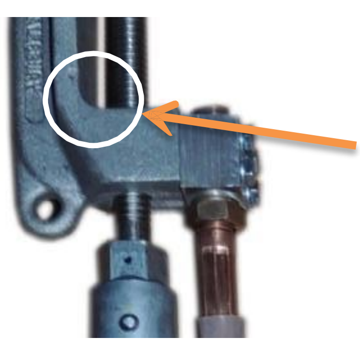
Tower Ground Set Assembly

Rated Single 15 kA Double 30 kA

Components:

16' #2 Orange Grounding Cable
2ea #2 Threaded Copper Ferrule
1ea Tower Ground Clamp
1ea Bronze Flat Face Ground Clamp/ includes snap
2ea 6" Heat Shrink Tubing (Canusa CFM1100)

Build to:
16 ft Lead #2 with Tower Ground Clamp (6 ft long stick) on one end and Bronze Flat Face Clamp on the other.



Note: Casting on this clamp must have a rounded corner as shown here

	**Tower Ground Clamp** Code: 209341 Range: .19" – 1.25"
	**Bronze Flat Face Clamp** Code: 205918 Range: .25" – 1.5"
	**Threaded Ferrule w/nut-lock and heat shrink tubing** Size: 2/0 – 5/8" Torque: 25 ft-lb.
	**#2 Orange with pressed ferrules on each end** 16 ft #2 – Code: 206738
	**Threaded Ferrule Adapter** Code: 209000 4-1/4" – 20 × 1.5" bolts Torque: 96 in.-lb.

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All Angle Ground Set

Code: 16 ft – 206735
Code: 22 ft – 206739
Code: 40 ft – 202952

Line, Substation and Generation

ALL Angle Ground Assembly

Rated Single 30 kA Double 55 kA

Specify correct cable length when ordering:
Available in 16 ft, 22 ft, 40 ft lengths

Components:

Various	2/0 Yellow Grounding Cable
2ea	2/0 Threaded Copper Ferrule
1ea	All Angle Clamp
1ea	Bronze Flat Face Ground Clamp
2ea	6” Heat Shrink Tubing (Canusa CFM1100)

Build to:

16, 22, 40 ft 2/0 lead with All Angle Clamp (6 ft long stick) on one end and Bronze Flat Face Clamp on the other.

Note: Do not operate all-angle clamps beyond a 75^0 angle

All Angle Clamps must have brass threaded portions

All Angle Salisbury

Code: 206745

Range: .25” - 2.5”

Bronze Flat Face Clamp

Code: 205918

Range: .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”

Torque: 25 ft-lb.

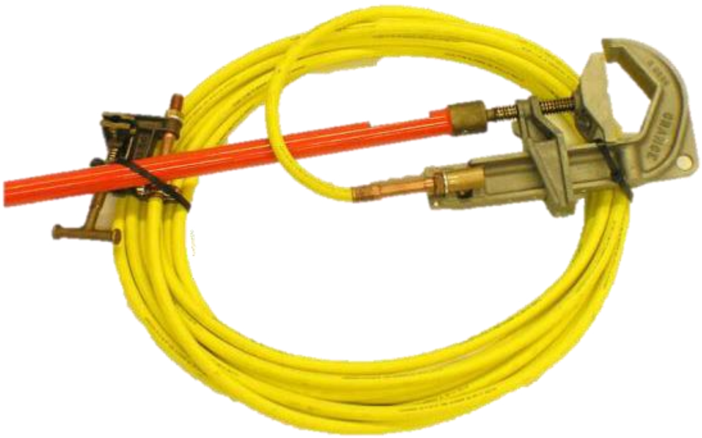
2/0 cable with pressed ferrules on each end

16 ft 2/0 – Code: 205807
22 ft 2/0 – Code: 202954
40 ft 2/0 – Code: 202721

Bus Bar Ground Set

Code: 22 ft – 206740
Code: 40 ft – 202953

Substation and Generation



Bus Bar Ground Assembly

Rated Single 30 kA Double 57 kA

Specify correct cable length when ordering
Available in 22 ft, 40 ft lengths

Components:

Various	2/0 Yellow Grounding Cable
2ea	2/0 Threaded Copper Ferrule
1ea	Bus Bar Clamp
1ea	Bronze Flat Face Ground Clamp
2ea	6” Heat Shrink Tubing (Canusa CFM1100)

Build to:

22 or 40 ft 2/0 lead with Bus Bar Clamp (6 ft long stick) on one end and Bronze Flat Face Clamp on the other.

6 ft stick

AB Chance Bus Bar

Code: 202720

Range: .50” – 4”

Bronze Flat Face Clamp

Code: 205918

Range: .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”

Torque: 25 ft-lb.

2/0 cable with pressed ferrules on each end

22 ft 2/0 – Code: 202954
40 ft 2/0 – Code: 202721

T Bar Adapter

Code: 209264

Size: 7/16 “– 5/8”

Torque: 20 ft-lb.

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Portable Truck Ground Set — Code: 202823

Substation and Generation

Portable Truck Ground Set

Rated Single 30 kA Double 57 kA

Components:

22’	2/0 Yellow Grounding Cable
2ea	2/0 Threaded Copper Ferrule
1ea	All Angle Clamp with Posi-Lock Adapter
1ea	Bronze Flat Face Clamp
2ea	6” Heat Shrink Tubing (Canusa CFM1100)

Build to:

22' 2/0 Lead with All Angle Clamp on one end and Bronze Flat Face on the other.

Note: Do not operate all angle clamp beyond a 75^0 angle

All Angle Posi Lock

Code: 202824

Range: .25” - 2.5”

Bronze Flat Face Clamp

Code: 205918

Range: .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”

Torque: 25 ft-lb.

2/0 cable with pressed ferrules on each end

22 ft 2/0 – Code: 202954

Posi-Lock Adapter

Code: 202832

Personal Ground Set

Code: 205954

Substation and Generation

Personal Ground Assembly

Bonding Only (Not Rated)

Components:

10”	2/0 Green Grounding Cable
2ea	2/0 Threaded Copper Ferrule
1ea	All Angle Clamp
1ea	Bronze Flat Face Ground Clamp
2ea	6” Heat Shrink Tubing (Canusa CFM1100)

Build to:

10 ft 2/0 Green Lead with All Angle Clamp (3ft long stick) on one end and Bronze Flat Face Clamp on the other.

Note: Do not operate all angle clamp beyond a 75^0 angle

3 ft stick

All Angle

Code: 205950

Range: .25” - 2.5”

Bronze Flat Face Clamp

Code: 205918

Range: .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”

Torque: 25 ft-lb.

2/0 Green cable with pressed ferrules on each end

10 ft 2/0 – Code: 206065

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Vehicle Ground Set — Code: 206067

40’ Vehicle Ground Assembly

Rated Single 30 kA Double 57 kA

Components:

40'	2/0 Green Grounding Cable
2ea	2/0 Threaded Copper Ferrule
2ea	Bronze Flat Face Clamp
2ea	6” Heat Shrink Tubing (Canusa CFM1100)

Build to:

40' lead with shrink wrapped ferrules and Bronze Flat Face Clamps on both ends

Bronze Flat Face Clamp

Code: 205918

Range: .25” – 1.5”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”

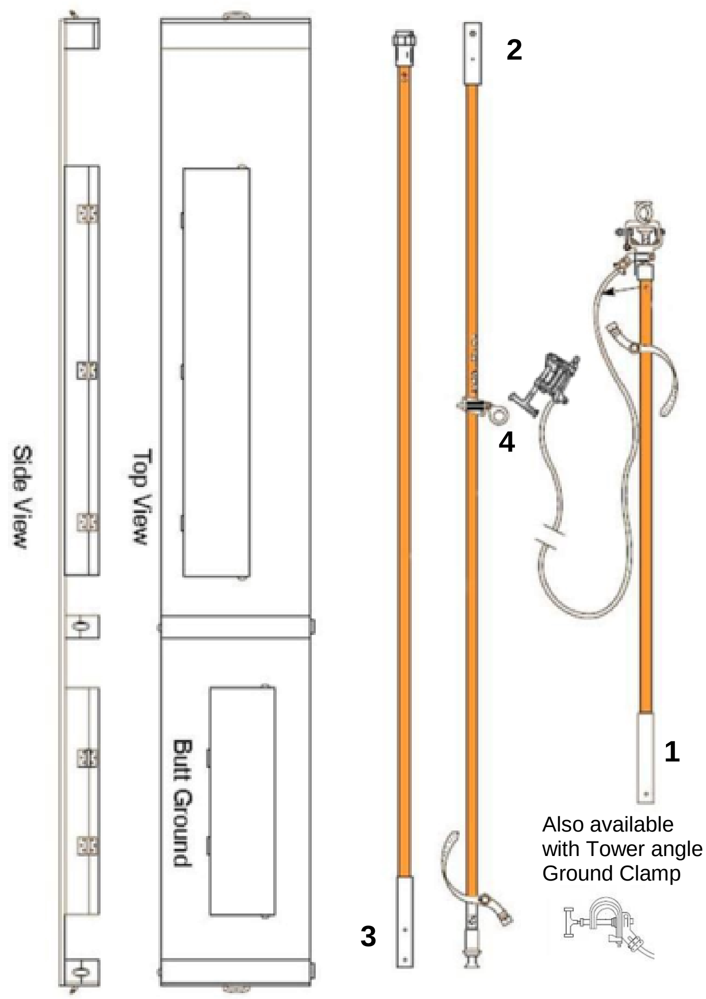
Torque: 25 ft-lb.

2/0 Green cable with pressed ferrules on each end

40 ft 2/0 – Code 206066

T-Line 500 kV Ground Set

Code: 205738



Rated Single 30 kA Double 55 kA

1.	27 ft 2/0 yellow with All Angle Stick (1) 27 ft 2/0 cable and clamp, all-angle	205738
2.	Ground stick (2) and wire tong band	201964
3.	Ground stick (3)	201963
4.	Wire tong band	201971
5.	Ground-storage board (See PG&E Line Construction Drawing L1-3267.)	

Contact your Sr. Transmission Specialist for board replacement and special grounds for river crossings

Note: Do not operate all-angle clamps beyond a 75^{0} angle

Chance All-Angle Stick

Code: 202719

Range: .25" – 1.5"

Bronze Flat Face Clamp

Code: 205918

Range: .25" – 1.5"

Tower Angle Ground Clamp

Code: 205696

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8"

Torque: 25 ft-lb.

2/0 Yellow cable with pressed ferrules on each end

27 ft 2/0 – Code 206726

35 ft 2/0 – Code 206732

40 ft 2/0 – Code 202721

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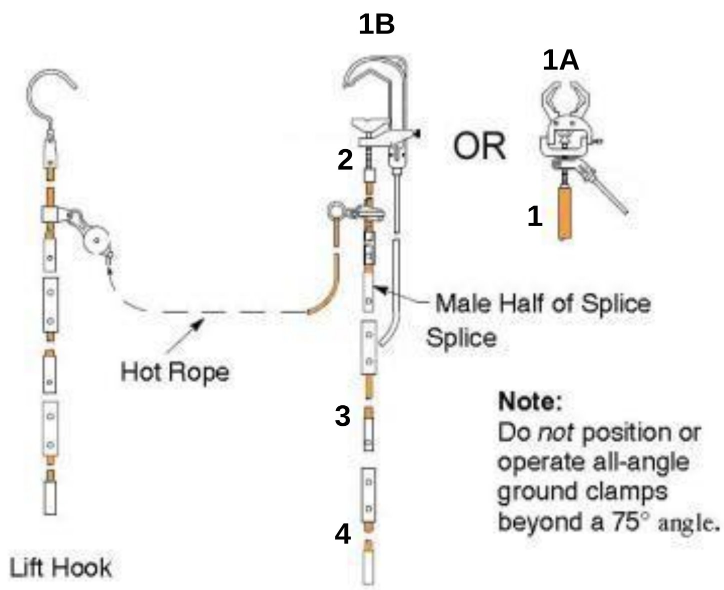
Substation 500 kV Ground Set

Code: 202724
Code: 202725

Substation and Generation



500 kV Ground Assembly

1A	All-Angle clamp full assembly **Single 30 kA Double 55 kA**	202724
1 B	Bus-Bar clamp full assembly **Single 30 kA Double 57 kA**	202725

1. All Angle on 6 ft Pole with 40' Yellow 2/0 cable — 202952
2. Bus Bar Clamp on 6 ft pole with 40' 2/0 cable — 202953
3. 10 ft Ext Pole 1/1/2" to 1 1/2" — 202731
4. 10 ft Ext Pole 1/1/2" to 1 1/4" — 202738
5. Wire-tong band swivel — 202740
6. Pole-band ring — 202777

Chance All Angle Stick

Code: 202719

Range: .25" -2.5"

Single 30 kA
Double 55 kA

AB Chance Bus Bar

Code: 202720

Range: .50" - 4"

Single 30 kA
Double 57 kA

Bronze Flat Face Clamp

Code: 205918

Range: .25" – 1.5"

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8"

Torque: 25 ft-lb.

2/0 Yellow cable with pressed ferrules on each end

40 ft 2/0 – Code: 202721

500 kV Lift Hook Assembly	Code: 205660

Substation and Generation

500 kV Lift Hook

1. Bus Bar Clamp on 6 ft pole with 40' 2/0 cable 202953
2. 10 ft Ext Pole 1/1/2" to 1 1/2" 202731
3. 10 ft Ext Pole 1/1/2" to 1 1/4" 202738
4. Collar, 1 ½ inch diameter 202783
5. Snatch Block 202822
6. 50 ft of spec 4-II hot rope 100056

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Small Conductor Ground		Code: 206068
Substation and Generation  **Small Conductor Ground** **Rated Single 30 kA No Double Rating** **Components:** 22' 2/0 Yellow Grounding Cable 2ea 2/0 Threaded Copper Ferrule 2ea Small C-Clamp 2ea 6" Heat Shrink Tubing (Canusa CFM1100) **Build Out:** 22' 2/0 Yellow Lead with small C-Clamp on each end		**Small C-Clamp** Code: 205979 Range: 3/16" – 3/4" Single 30 kA No Double
		**Threaded Ferrule w/nut-lock and heat shrink tubing** Size: 2/0 – 5/8" Torque: 25 ft-lb.
		**2/0 Yellow cable with pressed ferrules on each end** 22 ft 2/0 – Code: 202954
		**Posi-Lock, Small C Clamp Optional** Code: 204699 Single 30 kA, No Double

Switch Gear Ball Stud Ground Set — Code: 206069

Substation/Generation/Metering

Rated Single 30 kA Double 57 kA

Components:

- 16' 2/0 AllWire Yellow Grounding Cable
- 8ea 2/0 Threaded Copper Ferrule
- 1ea Connector, 4-way
- 4ea Ball Stud Clamp
- 8ea 6" Heat Shrink Tubing (Canusa CFM1100)
- 1ea Estex 2197-SL Bag (Code: 205897)

Build Out:

4 × 4' Leads with Ball Stud Clamp on one end built into Cluster Block, 3 leads w/common

Ball Stud Clamp

Code: 201500

Range: 1" ball
5/8" threaded

Aluminum Cluster Block

Code: 206081

Range: 1 to 3-5/8" thread

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8"

Torque: 25 ft-lb.

2/0 Yellow cable with pressed ferrules on each end

4 ft - 2/0 – Code: 206080

Ball Stud Clamp

Code: 201500

Range: 1" ball
5/8" threaded

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Switch Gear Flat Bronze Ground Set — Code: 206078

Substation/Generation/Metering

Rated Single 30 kA Double 57 kA

Components:

16' 2/0 All Wire Yellow Grounding Cable
8ea 2/0 Threaded Copper Ferrule
1ea Connector, 4 way
4ea Small Bronze Flat Clamp
8ea 6” Heat Shrink Tubing (Canusa CFM1100)
1ea Estex 2197-SL Bag (Code: 205897)

Build Out:

4 × 4' Leads with Small Bronze Flat Clamp on one end built into Cluster Block, 3 leads w/common

Small Flat Bronze

Code: 206043
Range: 3/16” – 1 3/8”

Aluminum Cluster Block

Code: 206081
Range: 1 to 3-5/8” thread

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8”
Torque: 25 ft-lb.

2/0 Yellow cable with pressed ferrules on each end

4 ft - 2/0 – Code: 206080

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Switch Gear Mushroom Ground Set   Code: 206079

Substation/Generation/Metering

Rated Single 30 kA, No Double Rating

Components:

16' 2/0 All Wire Yellow Grounding Cable
8ea 2/0 Threaded Copper Ferrule
1ea Connector, 4-way
4ea Mushroom Clamp
8ea 6" Heat Shrink Tubing (Canusa CFM1100)
1ea Estex 2197-SL Bag (Code: 205897)

Build Out:

4 × 4' Leads with Small Bronze Flat Clamp on one end built into Cluster Block, 3 leads w/common

Mushroom Knob

Mushroom Clamp

Mushroom Clamp

Code: 206051

Range: 1.5" mushroom 3/16 – 3/4"

Rating: Single 30 kA No Double rating

Aluminum Cluster Block

Code: 206081

Range: 1 to 3-5/8" thread

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 2/0 – 5/8"

Torque: 25 ft-lb.

2/0 Yellow cable with pressed ferrules on each end

4 ft - 2/0 – Code: 206080

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Switch Gear Single Cable Options/Sub/Gen/Metering	
	**Single Ball Stud Cable Assembled** Code: 206082 Range: 1” ball 5/8” threaded Fault Rating: Single 30 kA, Double 57 kA **8 ft Yellow 2/0 Cable w/ferrules** Code: 202951
	**Single Small Flat Bronze Cable Assembled** Code: 206084 Range: 3/16” – 1 3/8” Fault Rating: Single 30 kA, Double 57 kA **8 ft Yellow 2/0 Cable w/ferrules** Code: 202951
	**Single Mushroom Cable Assembled** Code: 206085 Range: 1.25” mushroom 3/16” –3/4” Fault Rating: Single 30 kA, No Double Rating **8 ft Yellow 2/0 Cable w/ferrules** Code: 202951

4/0 Large Bus Bar Ground

Code: 22 ft – 206741
Code: 40 ft – 206086

Substation and Generation

4/0 Large Bus Bar Ground

Rated Single 47 kA Double 63 kA

Available in 22 ft, 40 ft lengths
Specify cable length when ordering

Components:

Various	4/0 Red Grounding Cable
2ea	4/0 Threaded Copper Ferrule
1ea	Small Bronze Flat
1ea	Large Bus Bar Clamp
2ea	6” Heat Shrink Tubing (Canusa CFM1100)

Build Out:
22' 4/0 Red Lead with Small Flat Bronze Clamp on one end and Large Bus Bar Clamp on the other end.

Large Bus Bar
Code: 206104
Range: .398” – 6.625”

Small Flat Bronze
Code: 206043
Range: 3/16” – 1 3/8”

Threaded Ferrule w/nut-lock and heat shrink tubing

Size: 4/0 – 5/8”
Torque: 25 ft-lb.

2/0 Red Cable with pressed ferrules on each end

22 ft 4/0 – Code: 206087
40 ft 4/0 – Code: 206088

2/0 Bus Bar Jumper Code: 206742

Substation and Generation

2 ft 2/0 Cable Jumper – with C-Clamp w/stand on one and C-Clamp w/out stand on the other end.

Fault Rating: 30 kA

C-Clamp

Code: 205884 (w/stand)

Code: 205883 (w/o stand)

Range: .19 – 1.25

Underground Grounding Jumpers	
	**6 ft #2 Grounding Jumper w/Grounded Bushing** Code: 205968 Fault Rating: 15 kA
	**6 ft #2 Grounding Jumper w/ DB Elbow** Code: 205967 Fault Rating: 13 kA
	**6 ft #2 Grounding Jumper w/Grounding Stud for Stress Cone/ Split Bolt Connection** Code: 205969 Fault Rating: 15 kA

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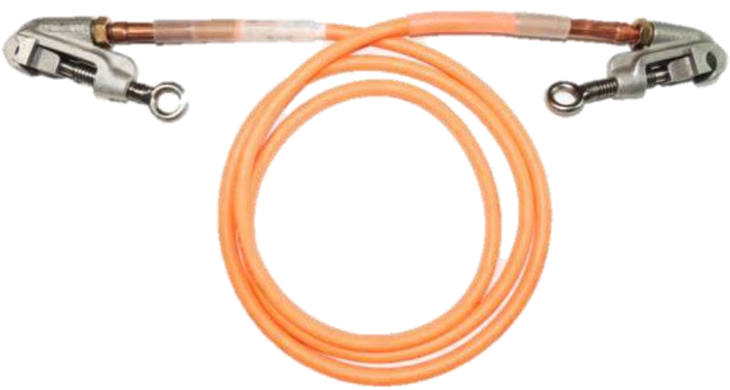
<table>
<tr><th colspan="2">Underground Grounding Jumpers, continued</th></tr>
<tr><td></td><td>6 ft #2 Grounding Jumpers – w/C-Clamp

Code: 205963

Range for Small C-Clamp: 3/16” – 3/4”

Fault Rating: 15 kA</td></tr>
<tr><td></td><td>6 ft #2 Cable w/ferrules (No Clamps)

Code: 206093

Fault Rating: 15 kA</td></tr>
<tr><td></td><td>6 ft 2/0 Grounding Jumper w / Adjustable Head

Code: 205978

Fault Rating: 29 kA</td></tr>
<tr><td></td><td>6 ft 2/0 Grounding Jumper – w/C-Clamps

Code: 205971

Range for Small C-Clamp: 3/16” – 3/4”

Fault Rating: 30 kA</td></tr>
</table>

Underground Grounding Jumpers, continued	
	**6 ft 2/0 Cable w/ferrules (No Clamps)** Code: 206154 Fault Rating: 30 kA

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Ground – Clamp Shunts

Code: 206744

Underground Flat Bronze Ground Set

Rated Single 15 kA, No Double Rating

Components:

- 16' #2 All Wire Orange Grounding Cable
- 8ea 2/0 Threaded Copper Ferrule
- 1ea Connector, 4-way
- 4ea Small Bronze Flat Clamp
- 8ea 6” Heat Shrink Tubing (Canusa CFM1100)
- 1ea Estex 2197-SL Bag (Code: 205897)

Build Out:
4 × 4' Leads with Small Bronze Flat Clamp on one end built into Cluster Block, 3 leads w/common

	**Small Flat Bronze** Code: 206043 Range: 3/16” – 1 3/8”
	**Aluminum Cluster Block** Code: 206081 Range: 1 to 3-5/8” thread
	**Threaded Ferrule w/nut-lock and heat shrink tubing** Size: 2/0 – 5/8” Torque 25 ft-lb.
	**#2 Orange cable with pressed ferrules on each end** 6 ft #2 – Code: 206093

Underground Components

	**Load Break Grounding Elbow, 25/35 kV** Code: 205132 Fault Rating: 15 kA		**Basic Insulated Cap with capacitance test point** Code: 303828 600 A
	**Grounding Stand-Off Load Break, 25 kV** Code: 205131 Fault Rating: 15 kA		**Load Break Insulated Stand-Off** Code: 300483 25 kV
	**Dead Break Grounding Elbow** Code: 205965 Fault Rating: 13 kA		**Dead Break Grounding Stand-Off** Code: 205966 Fault Rating: 25 kA
	**Dead Break Test Plug Elbow Receptacle** Code: 303503		**Dead Break Insulated Stand-Off** Code: 303515
	**Candled Load Break Insulated Elbow** Code: 301585 25 kV		**Load Break Insulated Stand-Off** Code: 301279 35 kV
	**Candle Load Break Insulated Elbow** Code: 304778 35 kV		

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Miscellaneous Components 1			
	**Grounding Clamp, Adjustable Head** Code: 205975 Fault Rating 29 kA		**C-Clamp w/parking stand** Code: 205884 Rating: 30 kA
	**Small C-Clamp** Code: 205979 3/16” – 3/4” Fault Rating: 30 kA		**C-Clamp** Code: 205883 Rating: 30 kA
	**Screw-in Grounding Plug** Code: 205974 5/8” × 11” Fault Rating: 30 kA		**Posi-Lock Ground Clamp** Code: 204699 Fault Rating: 30 kA
	**Screw-in Grounding Stud** Code: 205973 5/8” × 11” Fault Rating: 30 kA		**Mushroom Clamp** Code: 206051 Range: 1.5” mushroom 3/16” –3/4” Fault Rating: 30 kA
	**Screw-in Grounding Stud** Code: 205972 3/4” × 10” Fault Rating: 30 kA		**Grounding Stud /Split Bolt Connection** Code: 206103 Fault Rating: 15 kA
	**1735 Underground Grounding Stud** Code: 206743 Fault Rating: 35 kA 7/8” diameter copper with 5/8-11 female thread on one end and a 1” hex drive on the other end		

Miscellaneous Components 2

	**Fixed T- Handle** Code: 209328 Fault Rating: Single 30 kA Double 57 kA		**Small Flat Bronze** Code: 206043 Range: 3/16” – 1 3/8” Fault Rating: Single 47 kA Double 63 kA
	**Removable T-Handle** Code: 202964 Fault Rating: Single 30 kA Double 57 kA		**Bronze Flat Face Clamp** Code: 205918 Range: .25” – 1.5” Fault Rating: Single 30 kA Double 57 kA
	**Pole Grounding Band** Code: 206044 Fault Rating: 43 kA		**Cutout Grounding Clamp** Code: 330214 Fault Rating: 27 kA
	**Tower Angle Ground Clamp** Code: 205696 Fault Rating: Single 47 kA Double 63 kA		**Large Bus Bar** Code: 206104 .16”– 6.625” Fault Rating: Single 47 kA Double 63 kA
	**Ball Stud:** Code: 200948 **Covers:** Code: 201724 Fault Rating: Single 30 kA Double 57 kA		**Ball Stud Ground Clamp** Code: 201500 Fault Rating: Single 30 kA Double 57 kA

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Miscellaneous Components 3			
	**3 Phase Secondary Shunts** Code: 018047		**Single Phase Secondary Shunts** Code: 205051
	**Ground Rod** Code: 187010 3/4” × 5’		**Magnetic Bonding Clamp** Code: 206094
	**Temporary Ground** Code: 187009 5/8” × 5’		**Vehicle Frame Ground Kit** Code: 200694 18-inch 2/0 Green jumper **Lug Only** Code: 200952
	**Fuse Cut Out Ground Bar Extension** Code: 301416		**Pothead Grounding Lug** Code: 300008 **(90^0)** Code: 300007 **(Straight)** ½-inch 13unc Tin Plated Rating: Single 30 kA No Double Rating
	**Aluminum Cluster Block** Code: 206081 Range: 1 to 3-5/8” Rating: Single 30 kA Double 63 kA		**Slip Resistant Ground Mat** **58” × 58” Mat** Storage Bag and 6’ jumper Code: 203960 **58” × 120” Mat** Storage Bag and 6’ jumper Code: 203961 **120” × 120” Mat** Storage Bag and 6’ jumper Code: 203962

Miscellaneous Components 4

	**Quick Change to Universal** Code: 205549		**Universal to Quick Change** Code: 205773
	**Posi-Lock Adapters** Code: 202832		**Magnetic Hook for Blankets** Code: 205004
	**Ground Connection Coating** Code: 130479		**Silicon Wiping Cloth** Code: 205485
	**321 Dry Film Lubricant** Code: 500111		ESTEX 3000-27 - STRAP, WEB 1" × 27" Ground Cable Storage Strap Code: 2749988
	**Quick Change Keeper** Code: 205701		**Fuse Puller** Code: 205159 Range: 3/4” to 2” Supporting Ground Cables
	**Torque Wrench** Code: 2744360		**Open Head Spanner Accessory** **Size: 15/16** Code: 2744362 **Size: 13/16** Code: 2744361

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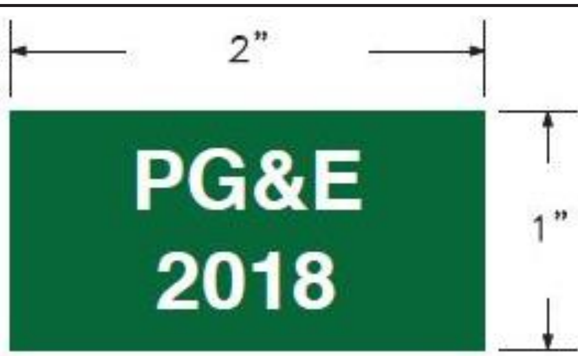
Miscellaneous Components 5	
	**Stick Extension 6' × 1-1/2", Fiberglass** Code: 205088
	**Stick Extension 4' × 1-1/2", Fiberglass** Code: 202722
	**Live Line Tool Sticker** Code: 2857969
	**External Frame Backpack** Code: 2622453 Dimensions: Rear Compartment: 26" T × 13" W × 8" D Front Pocket: 21" T × 13" W × 3.5" D

Miscellaneous Components 5, continued

	**Mid Span Tree-Wire Stripper** #4, 6/1 ACSR WS1-125: Code: 200370 4/0 Al Stranded WS2 -175: Code: 200377 397 A1 Stranded WS2 – 354: Code: 200380 Replacement Blades CB1: Code: 2862261 Replacement Blades CB2: Code: 2862262
	**Chance Electrostatic Grounding Device** Code: 2815803
	**Bond Wire Grounding Lug** 5/8" Bond Wire Grounding Lug: Code: 206197 3/4" Bond Wire Grounding Lug: Code: 206180

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Signs

Grounding in Steel Enclosures Sign

Dimensions: 10” × 7”

Magnetic Sign: 2814142

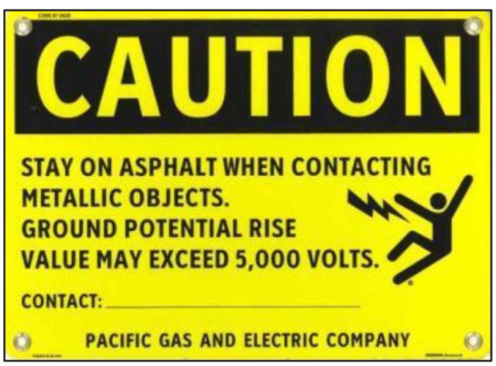
Plastic Hanging Sign: Code: 376935

Ground Potential Rise Sign

Dimensions: 14” × 10”

Magnetic Sign: Code: 2814128

Vinyl Decal: Code: 2813743



Surface Treatment Sign

Dimensions: 14” × 10”

Porcelain Enamel Sign: Code: 2814184

Cones and Barricading	
	**Barricade Kit** Code: 208950 **Barricade Kit Accessories:** Flag Cone Adaptors: Code: 204959 Barricade Kit Tape: Code: 2866350 Storage Bag: Code: 204956
	**Cones** **28-inch Cone w/PGE Logo** Code: 206391 **18-inch cone w/PGE Logo** Code: 206240
	**Flags** Orange Flag, 24" × 24" Code: 206779

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Running Grounds	Code: 205740
	**Running Ground** Code: 206095 Reference: Sherman & Reilly, Inc. Assembly Number R-6201-D (Steel Roller) or R-6201-A (Aluminum Roller)
	**Running Ground** Code: 205740 Reference: Sherman & Reilly, Inc. Assembly Number DG-4100 Rated at 30 kA

Roller and Stringing Blocks	
	**Lindsey 6800/10H** Code: 203855 Rating: 15 kA
	**Lindsey 5930** Code: 203857 Rating: 15 kA
	**Lindsey 5330** Code: 203858 Rating: 15 kA

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Bierer 500KV Audio Visual Detector (with 3 kV Trans and Batt.)

Code: 206042
Code: 240532

Substation and Generation / All Departments

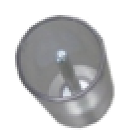
Substation & Generation Long Probe Version
Code: 206042

Distribution Short Probe Version
Code: 240532

Direct Contact / Manual Set / 0 to 500 kV Detector

The base unit when ordered will come with the following items:

- AV Meter
- 3 kV Test Transformer and 6-volt battery
- Bushing Adapter
- Universal Hot Stick Adapter
- Tip Probes (Straight, Hook and Wye)
- Manufactures Instruction Booklet
- Carrying Case

	**AV Detector** 0 to 500 kV 14-inch probe /Approved for Metalclad Switch Gear
	**3 kV Trans and Batt.** Alternate Source Code: 2715636
	**Bushing Adapter**
	**Stick Adapter** • Universal to Quick Change
	**Probe Tips** • Hook Tip • Straight Tip • “Y” Tip

Bierer 500KV Audio Visual Detector (without 3 kV Trans and Batt.)

Code: 206098
Code: 206099

Substation and Generation / All Departments

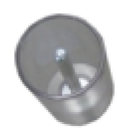
Substation & Generation Long Probe Version
Code: 206098

Distribution Short Probe Version
Code: 206099

Direct Contact / Manual Set / 0 to 500 kV Detector

The base unit, when ordered, will come with the following items:

- AV Detector
- Bushing Adapter
- Universal Hot Stick Adapter
- Tip Probes (Straight, Hook and Wye)
- Manufactures Instruction Booklet
- Carrying Case

	**AV Detector** 0 to 500 kV 14 inch probe /Approved for Metalclad Switch Gear
	**Bushing Adapter**
	**Stick Adapter** • Universal to Quick Change
	**Probe Tips** • Hook Tip • Straight Tip • “Y” Tip

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Bierer 40 KV Voltage Detector (with 3 kV Trans and Batt.)

Code: 240262

Electric Distribution

Bierer Voltage Detector (0 to 40 KV)

Analog Voltage Detector

The base unit when ordered will come with the following items:

- Analog Meter Probe
- 3 kV Test Transformer and 6-volt battery
- Universal Hot Stick Adapter
- Probes (Straight, Hook)
- Manufactures Instruction Booklet
- Carrying Case

Analog Detector

Test Device

- 3 kV Test Transformer and 6-volt battery

Code: 2715636

Stick Adapter

- Universal to Quick Change

Probes

- Straight Probe
- Hook Probe

Bierer 25KV Analog Detector Set/Phasing Meter (with 3 kV Trans & Batt.) — Code: 240268

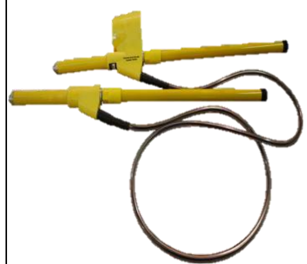
Electric Distribution

Bierer 81280 (0 to 25 kV)

Dual Application Meter (Analog Detector Set / Phasing Meter)

The base unit when ordered will come with the following items:

- Analog Meter Probe
- Reference Probe
- 3 kV Test Transformer and 6-volt battery
- Cable (Interconnect, Extension)
- Universal Hot Stick Adapter
- Probes (Straight, Hook)
- Manufactures Instruction Booklet
- Carrying Case



Analog Detector Set / Phasing Meter

0 to 25 kV

- Analog Meter Probe
- Reference Probe

Test Device

- 3 kV Test Transformer and 6-volt battery

Code: 2715636

Cable

- 8 ft extension cable
- 8 ft interconnect cable

Stick Adapter

- Universal to Quick Change

Probes

- Straight Probe
- Hook Probe

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Bierer Cordless Detector Set / Phasing Meter (with dual power test supply)

Code: 240620

Electric Distribution

PD800W Cordless Detector Phasing Set

Cordless Digital Phasing Tester

The base unit when ordered will come with the following items:

- Cordless Meter Probe
- Reference Meter Probe
- Dual Power Supply and 6-volt battery
- Bushing Adapter
- Universal Hot Stick Adapter
- Tip Probes (Straight, Hook and Wye)
- Manufactures Instruction Booklet
- Carrying Case

Meter Probe

- Cordless
- Reference

External Dual Power Supply

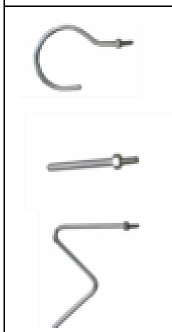
(operates in phasing, voltage detection, phase sequencing and phase angle indication)

Code: 2823035

Bushing Adapter

Stick Adapter

- Universal to Quick Change



Probe Tips

- Hook Tip
- Straight Tip
- “Y” Tip

HD Electric Digital Voltage Indicator (500T-01 / K34)

Code: 240531

All Departments

Direct Contact / Auto Set /0 to 500 kV Detector

- Underground Bushing Probe – IEP-DVI-5
- Voltage Indicator Tester – PT-DVI
- Adapter for Shotgun Stick – HSA-2500
- Carrying Bag – B-30
- Carrying Case – CS-DVI-5
- Small Overhead Hook Probe, 2” dia. opening – HP-DVI-2
- Large Overhead Hook Probe, 6” dia. opening – HP-DVI-6

AV Detector

0 to 500 kV

Probe Adaptor for Metal Capacitive Test Points

Stick Adapter

Probe Tips

- 2”
- 6”

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Grace Engineered Voltage Detectors

Substation and Generation

Clip-On Voltage Detectors < 43 kV

For use with remote racking devices when grounding switch gear

Note: Only applied when ground buggies are racked out and de-energized.

Assembled with alligator Clips at Davis Facility.

Grace Engineering R-1VL – Indicator

Voltage 2 kV and 15 kV, 1 pack each.

Code: 206100

Grace Engineering R-1VH – Indicator

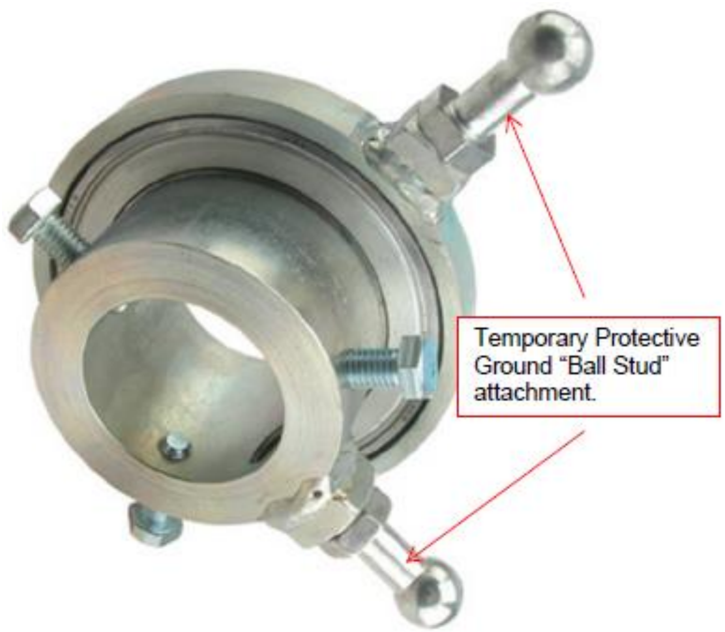
Voltage 15 kV and 43 kV, 1 pack each.

Code: 206101

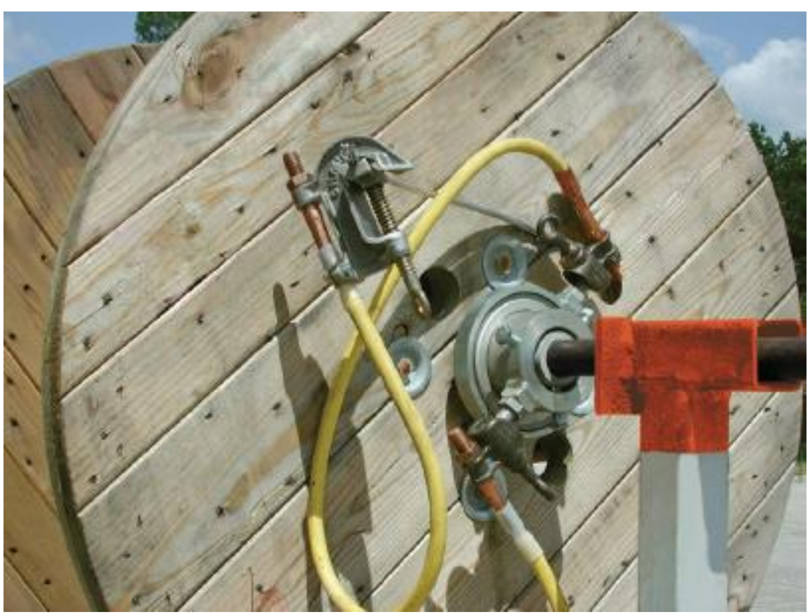
Rotating Ground Adapters

All Departments

Rotating Ground Adapter with Ball Stud connectors



Grounding Collar



Example of ground collar in use

Note: The temporary grounding jumper requires a ball stud ground clamp affixed to one end of the ground jumper which attaches to the rotating ground adapter.

Rotating Ground Adapter with Ball Stud connectors

Code: 2851396

Rating: 30,000 Amps.

Use: To ground conductor on a wire trailer as an alternative to running grounds.

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Insulated Cable Grounding Spikes

	**Manual Spiking Tool 1710** Code: 2868177
	**Hand Pump Operated Spike Salisbury 1715EPP** Code: 205982 1-inch to 3-inch Cable
	**Electric Pump Operated Spike 17150050** Code: 205983 0-inch to 3.5-inch Cable

Cable Locating Equipment	
	**PCT-2 Hipotronics Phase Tracer** ***Capital Tool process needed for ordering***
	**VCI-3 Voice Cable Identification System** ***Capital Tool process needed for ordering***
	**Storage Bag** Code: 206102 Color: Blue (printed with black PG&E logo) Size: 27" × 15" × 15" Net weight: 5 lb.

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APPENDIX A: GLOSSARY & ACRONYMS

Glossary

A

Anticipated Fault Current – The maximum short-circuit current that has a reasonable probability of occurrence.

Approved Grounding Jumper (Shunting) – A coded jumper rated for grounding 15,000 or 30,000 ampere circuits.

B

Backfeed – Electrical energy coming from the load direction.

Barricade – A physical obstruction or restraint created to prevent or control access of employees and the public to hazardous areas or equipment. Cones may be used as a minimum requirement. In addition, tape, flags, signs, and/or ropes may be used. Synonyms: work site barricades, isolation.

Barrier – A physical obstruction intended to prevent contact with energized lines or equipment.

Bonded – The electrical interconnection of conductive parts to maintain a common electrical potential.

C

Cable Spike – A destructive testing/grounding device that is used to prove that underground cable conductors are de-energized.

Capacitor – An electrical device capable of storing electrical energy.

E

Equipotential zone (equipotential zone grounding, EPZ) – A general term used to describe the application of temporary protective grounds to limit the potential across the worker's body. It is often associated with work site or single-point grounding, but also includes other applications of temporary grounding.

Exposure – Refers to any condition that could result in accidental contact with an energized conductor, de-energized circuits with different grounding requirements, or induced voltage.

F

Ferrule (hot stick) – A metal collar that is attached to the end of a hot stick. This ferrule provides a connection point to join hot sticks together.

Foreign Grounds – Any ground that is not tied to the equipotential zone (EPZ) or bracket ground scheme; for example, equipment grounds, riser grounds, transformer grounds, lightning-arrester grounds, and guy wires.

G

Ground Grid – A system of horizontal and vertical electrodes, consisting of a number of interconnected, bare conductors buried in the earth that provide a common ground for electrical devices or metal structures.

Ground Potential Rise (GPR) – The maximum voltage that a station ground grid can attain relative to a distant grounding point assumed to be the potential of remote earth.

J

Job Site – One (or more) locations where work is being performed.

L

Lightning – A flashing discharge of atmospheric electricity, caused by the movement of positive and negative electrical charges toward one another. The negative charged particles at a cloud base move downward and meet with rising positive charges from the earth.

Lines – May include metallic pulling lines (sock lines), messengers, guy wires, communication lines, and transmission, secondary, and primary conductors, including aerial cable and common-neutral conductors.

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M

Minimum Approach Distance (MAD) – MAD is the closest distance that a qualified employee, or any conductive object are permitted to approach an exposed energized conductor or apparatus. Suitable arc flash clothing and PPE must be worn during these practices.

Multi-Point Grounding – The combination of source grounds and a personal ground with pole bands at the worksite.

P

Personal Ground – A temporary protective ground that is installed to provide additional protection when used within an area protected by Multi-Point Grounding. Personal Grounds, by definition, follow the employee as work is performed, and are not to be left unattended.

Proximity – Any point that can be reached directly by an individual without changing location.

R

Rubber Insulating Gloves – These gloves provide personal protection for electrical workers. To be effective, the gloves must incorporate high dielectric and physical strength, along with flexibility and durability. Rubber insulating gloves are classified by the level of voltage and protection they provide.

S

Shunt – A temporary conductive path around an object or person.

Single Point Grounding – A general term used to describe the application of temporary protective grounds on all conductors at the work site to a common ground source, to establish an equipotential zone to limit the potential across a worker's body.

Source Grounds – Temporary protective grounds installed to protect from accidental energization by a power source. In a multi-point grounding scheme, these are the grounds installed between the work site and all possible sources of energy.

Station Ground Switches – A type of grounding device that is permanently installed at substations and used on the 500 kV lines, underground transmission lines, and network systems.

S continued

Step Potential – The voltage difference between two points on the earth's surface when separated by a distance of one pace, which is assumed to be approximately 3 feet.

Stringing Equipment – Stringing equipment includes any equipment that may be used for stringing, such as wire dollies, pay-out reels, tensioners, take-up trailers, take-up reels, and rope trucks.

W

Work Site – The immediate site(s) where a task will be conducted within a job site.

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Acronyms

A .... ampere
ACSR ..... aluminum conductor steel reinforced
AISI .... American Iron and Steel Institute
ANSI .... American National Standards Institute
ASTM ..... American Society for Testing and Materials
ATS .... Applied Technology Services
AWG ...... American wire gauge
BT .... battery test
Cal/OSHA .... California Occupational Safety and Health Administration
CT .... current transformer
EPZ .... equi-potential zone
ESS .... electrical strike system
FR .... flame resistant
ft/lbs. ...... foot pounds
HDD .... horizontal and directional drilling
HPFF ...... high pressure fluid filled
HPGF ..... high pressure gas filled
GPR .... ground potential rise
GTO .... grounding tailboard/observer form
IEEE .... Institute of Electrical and Electronic Engineers
kA .... kiloamperes
kV .... kilovolt
kcmil ...... thousand cubic mils
LED .... light emitting diode
MAD .... minimum approach distance
MOL .... man on line
MPR .... material problem report
NWP ....network protector
OCS...........other confined spaces
OHGW.......overhead ground wire
OPGW.......optical grounding wire
PCC...........provider cost center
PIC ....person in charge
PILC ....paper-in-lead cable
PPE ....personal protective equipment
QEW..........qualified electrical worker
RFI ....radio frequency induced
SAP ....Systems Applications and Products in Data Processing
SGGC........Substation and Generation Grounding Committee
SRM ....Supplier Relationship Management
SVL ....sheath voltage limiter
TGRAL ......Test Ground Rocker-Arm Line (oil switch)
TGRAM .....Test Ground Rocker-Arm Main (oil switch)
TPG ....temporary protective ground
UGC ....universal ground clamp
UNC...........unified course thread
V................volt
Vac............volts alternating current
WEM..........Western Electric Meter
XLPE ....cross-linked polyethylene

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APPENDIX B:
FORMS & MANUFACTURERS' OPERATING INSTRUCTIONS

CONTENTS

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Operating Instructions

AVPG&E: 0-to-500kV Audible Operating Instructions–Visual, Bierer Meters Manual

Bierer
METERS
Safety is number one.

AVPG&E
0 – to – 500kV
Audible-Visual

CAUTION

The equipment covered in these operating instructions should be used by qualified employees, trained in and familiar with the safety-related work practices, safety rules and other safety requirements associated with the use of this type of equipment These instructions are not intended as a substitute for adequate training, nor do they cover all details or situations which could be encountered in relation to the operation of this type of equipment.

WARNING

Use appropriate length live line tool for the voltages being worked and maintain minimum approach distances as outlined in OSHA 1910.269, Table R-6. Do not let live line tool fittings become grounded in any way. This will damage meter and may cause personal injury.

NOTICE

Before operating this equipment, read, understand and follow al instructions contained in this manual. Keep instructions wit equipment.

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Design and Function

The AVPG&E is a direct contact voltage indicator with an audible and visual alarm to indicate the presence of voltage, with an operating range from 120V secondary voltage to 500kV transmission voltage. Activation thresholds are greater than 50% of voltage rating on selector switch, dependent on proximity to energized or grounded objects.

Example: 69kV position activation threshold is +20kV p-to-g.

A 12 position switch is used to select various functions and voltage levels as follows:

Position	Description
Off	Unit Off for Storage and Transit
PROX	Proximity Voltage Detection
4	Direct Contact on 4kV system
12	Direct Contact on 12kV system
21	Direct Contact on 21kV system
34.5	Direct Contact on 34.5kV system
60	Direct Contact on 60kV system
70	Direct Contact on 70kV system
115	Direct Contact on Overhead 115kV lines
230	Direct Contact on Overhead 230kV lines
500	Direct Contact on Overhead 500kV lines
Test	Test basic meter function by sounding horn and lights

Note: In the test position the voltage indicator should give a loud audible alarm and bright visual indication. If not, replace the 9 volt battery behind the live line tool attachment threaded into the meter housing.

2

Direct Contact Voltage Indication all Positions

1. Turn selector switch to **Test** position to test voltage indicator for proper operation, See Note, page 2.

2. Attach voltage indicator to appropriate length live line tool for voltage being tested.

3. Turn selector switch to appropriate voltage range.

4. For Overhead application use the hook probe and make direct contact with the conductor. Audible-visual alarm indicates presence of voltage within the activation threshold and voltage range selected, See Chart, page 2.

5. For Underground application use the bushing adapter and plug unit into bushing insert on the transformer. Audible- visual alarm indicates presence of voltage within the activation threshold and voltage range selected, See Chart, page 2.

6. For Secondary application use the low voltage probe adapter and make direct contact to conductor. Audible- visual alarm indicates presence of voltage within the activation threshold and voltage range selected, See Chart, page 2.

7. No audible-visual alarm indicates the voltage is below the threshold values for the selected position, See Chart, page 2.

8. Turn the selector switch to the **Test** position to re-test the voltage indicator.

> **Note:** Always test voltage indicator before and after each use.

Alarms and results will vary due to field condition including, but not limited to, conductor proximity, size and orientation of system components in the area, both energized and grounded. As with all voltage detector devices, a false positive can occur when both voltage indicator electrodes (probe tip and live line tool attachment) are at the same potential. The AVPG&E should be used as a secondary means to confirm the status of a circuit after standard operating procedures such as visual open gaps, hold orders and tag outs render the circuit de-energized. If there is any doubt about the audible-visual alarm under any circumstances, the line or equipment shall be considered energized and proper safety precautions shall be taken.

Technical & Service
Bierer & Associates Inc.
Manufacturing & Repair
11142 Wilson Blvd.
Blythewood SC 29016
Tel: (803) 786-4839
Fax: (803) 786-5457

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Digital Voltage Indicators and Accessories, Operating & Instruction Manual, HD Electric Company

DIGITAL VOLTAGE INDICATORS
and ACCESSORIES

Operating & Instruction Manual

DVI-100

DVI-500

HD ELECTRIC COMPANY
1475 LAKESIDE DRIVE • WAUKEGAN, ILLINOIS 60085 U.S.A.
PHONE 847 . 473 . 4980 • FAX 847 . 473 . 4981 • website: www.HDElectricCompany.com

DIGITAL VOLTAGE INDIC ATORS

DESCRIPTION

The Digital Voltage Indicators, DVI-100 and DVI-500, are direct contact digital voltage indicators for overhead and underground power distribution systems up to 500kV line-to-ground (870kV line-to-line). The display is auto-ranging and indicates from 0.1kV (100 volts) to 9.9kV and from 10kV to 99kV for the DVI-100 and to 500kV for the DVI-500. An audible alarm beeps whenever the indicated voltage is 0.1kV or higher.

There are two versions available of each model. The DVI-100 and DVI-500 indicate voltage by directly contacting conductors on overhead and underground systems. The DVI-100T and DVI-500T with Test Point mode also indicate voltage on elbow test points.

An optional underground probe is available for underground or pad mount applications, or for any application up to 21kV line-to-ground where the DVI will be used in close proximity to grounded conductors or surfaces.

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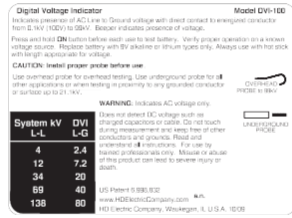
SAFETY

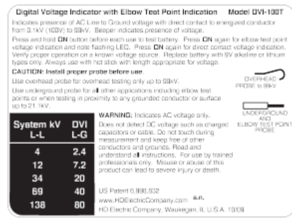
- Only trained, professional operating personnel should use the DVI. The voltages this instrument operates at are dangerous and lethal. Severe injury or death can occur if improperly used.
- Risk of electrocution is inherent in or around high voltage.
- Always use proper high voltage procedures, including personal protective equipment, when working near or around high voltage equipment or conductors.
- Do not exceed the DVI maximum voltage rating.
- Assemble the DVI with the proper contact probe for your application.
- The DVI must be used with a hotstick of the appropriate length for the voltage being measured per your company and OSHA published requirements.
- Do not touch the DVI during measurements. The DVI housing should be considered to be at the same voltage as the conductor under test.
- Prior to using, inspect the instrument for any physical damage, cleanliness and check for proper working order by pressing and holding the ON button. Do not proceed if the display does not indicate all 8's or if the beeper does not sound.
- Never allow another high voltage or grounded conductor to contact the instrument during use. Keep the DVI housing free and clear of all structures at all times.
  Bridging the DVI probe or housing from line-to-ground or line-to-line may cause a fault and arc.
- The DVI does not indicate voltages below 100 volts. Always use proper grounding procedures. A zero voltage reading on the DVI **does not** mean the line is dead or grounded.
- Grounded equipment or lines can appear to be live when in close proximity to energized conductors if not fully or properly grounded.
- Always test the DVI on a known voltage source before and after each use, or use the PT-DVI Proof Tester.

These important labels are affixed to the products. Read and understand before proceeding.

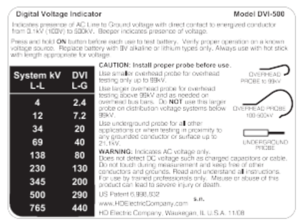
DVI-100



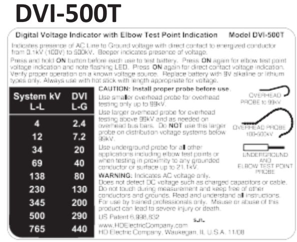
DVI-100T



DVI-500



DVI-500T



- **The DVI is a voltage indicator, not a voltmeter.** Do not attempt to make accurate voltage measurements for phasing or other applications with the DVI.
- The DVI is a direct contact device. The metal portion of the DVI probe must contact the metal conductor to be tested. Voltage indication on insulated conductors such as tree wire or spacer wire will be much lower than actual and may not indicate any voltage at all.
- DVI voltage readings are sensitive to geometry. Read and understand the Accuracy section of this manual before using the DVI.
- The DVI indicates AC voltage only. It does not detect DC voltage such as charged capacitors or cable.

HOW TO USE IT

Test the DVI battery and display by pressing and holding the ON button. Verify that the display reads all 8's and the beeper sounds. If needed, replace the 9V battery with an alkaline or lithium type.

Install the appropriate probe securely to the DVI. Use the overhead hook probes, the smaller hook can be used up to 99kV and the larger hook 100kV and above, for overhead applications with clearance sufficient to keep the DVI housing away from any other live or grounded conductor. Use the optional insulated underground probe for underground or pad mount applications including loadbreak bushings, metal clad switchgear or any other applications where grounded or other live conductors may be in close proximity to the conductor being tested. Some overhead applications such as fuse cutouts, switches, disconnects, terminations or measurements made near a pole or crossarm may call for use of the underground probe due to the close proximity of grounds. **Never allow the DVI to bridge between two energized conductors or from an energized conductor to ground.**

Always install the DVI on a hotstick with length appropriate for the voltage to be measured by way of the built-in universal spline, making certain it is securely attached.

Test the DVI on a known voltage source before and after each use, such as the PT-DVI Proof Tester.

Apply the DVI probe to the conductor to be tested making sure to make metal to metal contact.

All readings are in kV. Voltages below 0.1kV (100V) may indicate zero. A zero voltage reading does not mean the line is dead or grounded. Voltage in excess of 99kV line-to-ground for the DVI-100 and in excess of 500kV for the DVI-500 will cause the display to flash and may damage the unit.

ACCURACY

The DVI indicates voltage based on the electric field strength surrounding a conductor. Electric field strength can be greatly influenced by the geometry of a conductor and the presence of other nearby conductors. For best accuracy, keep the DVI at least three feet (one meter) away from inside or outside corners or points and position the face of the DVI away from other live conductors and towards ground. The following guidelines may be helpful:

- The DVI may read up to 25% higher than actual voltage when placed on outside corners or points.
- The DVI may read up to 25% lower than actual voltage when placed on inside corners.
- The DVI may read up to 25% higher than actual voltage if measurements are taken with a ground in close proximity.
- The DVI may read up to 25% higher or lower if other phases are nearby, such as from an overbuild.
- When checking for voltages on conductors believed to be grounded, make the measurement and keep the DVI as far away as possible from energized conductors and position the face of the DVI towards ground. When checking pole guy wires, make the measurement as close to ground as possible.

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For best overall accuracy, the following guidelines may be helpful:

Best overall accuracy is with a single energized conductor (Fig.1), midspan with no nearby grounds.

Expected accuracy is +/- 3%.

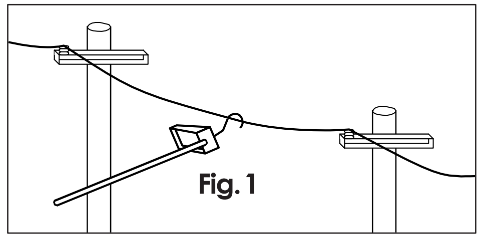


Fig. 1

In a typical overhead three phase system with horizontal spacing, the best accuracy is on the two outside conductors (Fig. 2).

Expected measurement accuracy on the two outside conductors is +/- 5%

On the center conductor, expected accuracy is +/- 10%.

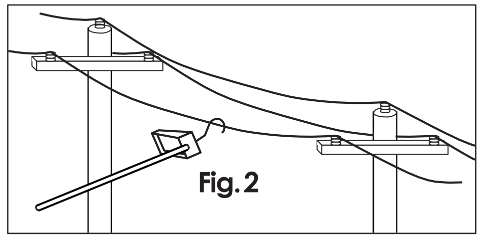


Fig. 2

In more complex situations with transmission or other higher voltage overbuild, accessory hardware such as fuses or disconnects or for measurements made on points such as terminations or endpoints, best accuracy is with the DVI as far away as possible from other live conductors or grounds, away from points or corners and facing the ground (Fig.3 & 4). Expected overall accuracy is +/- 25%.

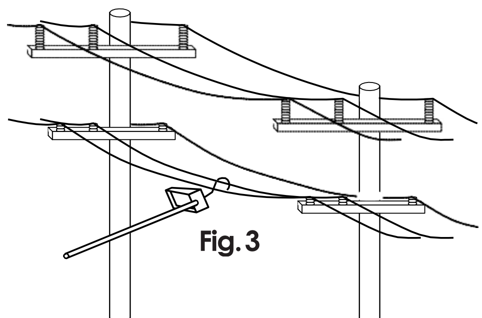


Fig. 3

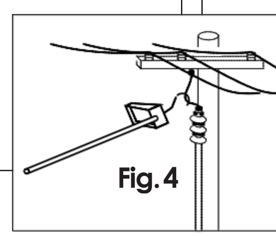


Fig. 4

For measurements made on grounded conductors, keep the DVI as far away as possible from energized conductors and face the DVI towards ground (Fig. 5).

Readings on grounded conductors with nearby energized conductors may indicate 0.1 to 0.2kV or more.

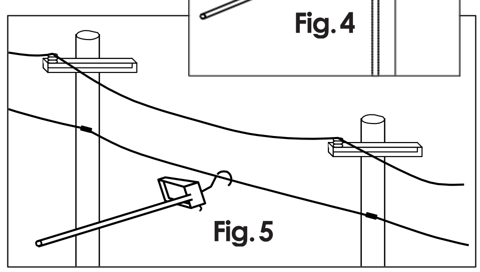


Fig. 5

For best accuracy with readings on pad mount equipment, livefront (shown) or deadfront, keep the DVI housing clear of adjacent grounds (Fig.6). DVI with IEP-DVI-5 probe shown.

Expected overall accuracy is +/- 10%.

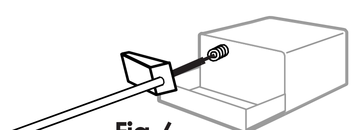


Fig. 6

5

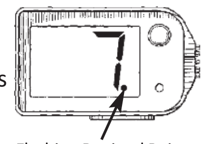
INDICATING VOLTAGE ON ELBOWTEST POINTS

DVI6100T AND DVI6500T ONLY

The DVI-100T and DVI-500T can be set to indicate voltages on elbow test points. For checking elbows and all other pad mount or underground equipment, first install the IEP-DVI-5 underground probe.

For checking elbow test point voltages, turn the DVI on by pressing the **ON** button. Press the **ON** button again for test point mode, indicated by the flashing decimal point.

All elbow test point voltage indications are in kV, calibrated for line voltage. For example, an elbow energized at 7.2kV will indicate 7 as shown here. Expected accuracy is +/- 10%. Variations among elbows from different manufacturers or vintages can be as much as +/- 25%.



Flashing Decimal Point

To cancel test point mode, press the **ON** button again. Test point mode will be automatically cancelledif the indicated voltages exceeds 99kV.

ACCESSORIES

IEP6DVI65 UNDERGROUND BUSHING PROBE

The IEP-DVI-5 Underground Bushing Probe is designed for direct insertion into exposed 15, 25 or 35kV loadbreak bushings (after connecting elbows have been removed and properly stored). The probe must be inserted directly into the bushing and remain free and clear of all surrounding surfaces. It is rated for use upto 21kV line-to-ground. This probe should also be used in metal clad switchgear or any other applications where grounded or other live conductors may be in close proximity to the conductor being tested. To assemble the IEP-DVI-5 probe on the DVI:

1. Inspect the IEP-DVI-5 probe for any mechanical defects and make certain it is clean and dry.
2. Screw the IEP-DVI-5 into the DVI. Make certain it is snug by hand tightening, but DO NOT OVERTIGHTEN.
3. Test the fully assembled DVI on a known voltage source, such as the PT-DVI Proof Tester, prior to using.

PT6DVI PROOF TESTER FOR DVI VOLTAGE INDICATORS

The PT-DVI Proof Tester is for use on the DVI with any available probes. This tester generates high voltage AC for testing the DVI. To use, turn on the DVI, hold the Tester in one hand and the DVI in the other. Apply the DVI probe to the metal end plate on the Tester. Press and hold the TEST button on the Tester. A properly operating DVI will indicate a voltage of 0.5-3kV depending on how the DVI and Tester are held. If the DVI does not indicate voltage,
do not use it and return it to HD Electric Company for service.

CAUTION: This Tester generates high voltage AC for testing DVI AC voltage indicators. There is no danger of electric shock when this tester is used as directed. Discontinue use & return to HDE for service if the housing is cracked or broken, or if the battery cover is lost.

WARNING: Do not use this tester except as directed. Do not use to test equipment other than specified DVIVoltage Indicators. Do not apply to energized circuits or equipment. Do not operate this Tester without the battery cover and do not open the housing. Refer all servicing to the factory. Failure to follow these instructions may lead to electric shock, severe injury or death

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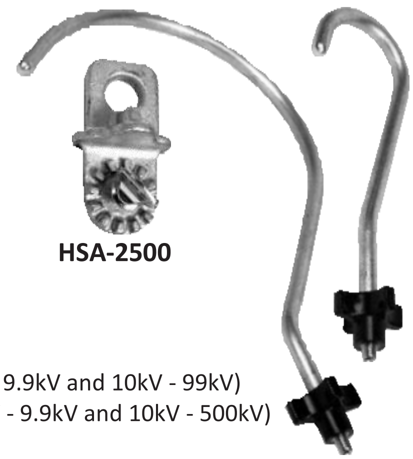
OTHER ACCESSORIES

The DVI-100 comes standard with (1) HP-DVI-2 small overhead hook probe and a CS-DVI carrying case. The DVI-500 comes standard with (1) HP-DVI-2 small overhead hook probe,
(1) HP-DVI-6 large overhead hook probe and a CS-DVI-5 carrying case. Both cases can accommodate the IEP-DVI-5 underground bushing probe, the PT-DVI Proof Tester and a
spare 9V battery.

ADAPTER FOR SHOTGUN STICK


HP-DVI-6 HP-DVI-2
HSA-2500

NHSAU2500O HOTSTICKS
A range of hotsticks are available in lengths starting at 4'. Contact HD Electric for more details.

SPECIFICATIONS

MODEL NUMBER: DVI-100, DVI-100T,
DVI-500 and DVI-500T

OPERATING VOLTAGE RANGES: DVI-100: 0 - 99kV (0.1kV - 9.9kV and 10kV - 99kV)
DVI-500: 0 - 500kV (0.1kV - 9.9kV and 10kV - 500kV)

OPERATING FREQUENCY: 60Hz (50Hz available)

OPERATING TEMPERATURE RANGE: -40F to +120F (-40° to 49°C)

DIMENSIONS: Display housing: 4.25"H x 7"W x 4.5"D (11 cm x 18 cm x 11 cm)
Overhead probes: HP-DVI-2: 8" long (20 cm) for conductors to 1" diameter HP-DVI-6: 12"long (30 cm) for conductors to 6"diameter

WEIGHT: 1.37 lb. (0.62 kg) with overhead probe

LED HEIGHT: DVI-100: 2.25"(6 cm)
DVI-500: 1.45"(3.7 cm)

ACCURACY: Laboratory calibrated to +/- 3%
Typical overhead line in compact overhead three phase +/- 10%
Otherapplications up to +/- 25%

BATTERY LIFE: About 100 readings with 9V alkaline

MAINTENANCE AND CARE

STORAGE U It is recommended for protection of the DVI that it and its accessories are stored in the carrying case provided.

CLEANLINESS U The molded housing is very rugged, but it should be kept clean and free of dirt, grease and any other foreign materials. If the housing surface integrity has been compromised in any way, remove from service and return to factory for repair or replacement.

DAMAGE U If you suspect any mechanical or electrical damage, do not use the DVI and arrange for repair by returning to the factory.

CALIBRATION & TESTING U Regular calibration of the DVI is not required. There is no accessible calibration adjustment.

SERVICE U Return to HD Electric Company for service.

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LIMITED WARRANTY AND LIMITATION OF LIABILITY

This warranty applies to all products sold by HD Electric Company (the "Products"); provided, however, that the term Products does not include any third party products purchased through HD Electric Company, for which no warranties are made (the "Third Party Products"). Third Party Products may be subject to a separate manufacturer's warranty; [should you have any question regarding whether a separate warranty applies, please contact HD Electric Company].

NOTICE: READ THIS LIMITATION OF WARRANTY AND LIABILITY BEFORE BUYING OR USING THE PRODUCTS CONTAINED HEREIN.

It is impossible to eliminate all risks associated with the use of the Products. Risks of serious injury or death, including risks associated with electrocution, arcing and thermal burns, are inherent in work in and around energized electrical systems. Such risks arise from the wide variety of electrical systems and equipment to which Products may be applied, the manner of use or application, weather and environmental conditions or other unknown factors, all of which are beyond the control of HD Electric Company.

HD Electric Company does not agree to be an insurer of these risks.

WHENYOU BUY OR USE THESE PRODUCTS, YOU AGREE TO ACCEPT THESE RISKS.

HD Electric Company warrants to the original purchaser that the Products (excluding any third party products purchased through HD Electric Company, for which no warranties are made) will be free from defects in material and workmanship, under normal use and regular service, and preventative maintenance for a period of one (1) year from the date of shipment (the"Warranty Period"). Should any failure to conform with this warranty be found during the Warranty Period, you must notify HD Electric Company of your claim within thirty (30) days of discovery, and within the Warranty Period. Your failure to give notice of claims of breach of warranty within the Warranty Period shall be deemed an absolute and unconditional waiver of claims for such defects. HD Electric Company will have no responsibility to honor claims received after the date the applicable Warranty Period expires.

Upon notice of your claim, HD Electric Company will provide a return authorization number, and further instructions on how to return the product for service. You must follow HD Electric Company's instruction. You are responsible for all Product removal, handling, re-installation, and shipping (both to and from HD Electric Company). Products returned for repair, as well as repaired or replacement Products shall be sent postage / freight prepaid. After receipt of a product which HD Electric Company determines is defective, HD Electric will, at its option, either (1) repair (or authorize the repair of) the Product or (2) replace the Product, subject to the following: The Products are made using parts sourced from a variety of manufacturers. Due to the rapidly changing technology environment, parts may become obsolete / unavailable over time (end of life). In the event that a Product cannot be repaired or replaced due to unavailability of parts, HD Electric Company will use commercially reasonable efforts to obtain substitute parts or conduct work around design, but cannot guarantee its ability to do so.

Items not found defective will be returned at your expense, or failing receipt of instruction from you on return of such items within five (5) business days of our notice to you that the product is not defective, HD Electric may dispose of the product at its discretion and with no liability to you. HD Electric Company's determination of defects is final. Products repaired or replaced during the Warranty Period shall be covered by the foregoing warranties for the remainder of the original Warranty Period or ninety (90) days from the date of delivery of the repaired or replaced Products, whichever is longer.

LIMITATIONS:
This warranty is void in the event of misuse, alteration, faulty installation, or misapplication of the product. This warranty does not cover failure of product or components due to any ACT OF NATURE; lightning, floods, hurricanes, tornadoes or any other such catastrophic events.

HD Electric Company does not warrant any third party products or associated hardware or their performance or suitability for use and application. Such items are provided"as-is".

All repairs must be authorized by HD Electric Company. Unauthorized repairs will not be reimbursed under any circumstances.

HD Electric Company is not required to make replacement or loaner equipment available while Products are being repaired or replaced, or to compensate you for any in/out labor charges or expenses associated with removal, handling or re-installation of the Products.

TO THE MAXIMUM EXTENT PERMITTED BY LAW, THIS WARRANTY AND THE REMEDIES SET FORTH ABOVE ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, REMEDIES AND CONDITIONS, WHETHER ORAL OR WRITTEN, EXPRESS OR IMPLIED. HD ELECTRIC EXPRESSLY DISCLAIMS ALL OTHER WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY AND NON-INFRINGEMENT.

IN NO EVENT SHALL HD ELECTRIC COMPANY BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES RESULTING FROM THE USE OR HANDLING OF THESE PRODUCTS. THIS SHALL INCLUDE BUT, NOT LIMITED TO, LOST PROFITS OR REVENUE, LOSS OF USE OF THE PRODUCTS, COST OF SUBSTITUTE PRODUCTS, FACILITIES OR SERVICES, OR DOWNTIME.

IN NO EVENT SHALL HD ELECTRIC COMPANY HAVE ANY LIABILITY FOR ANY THIRD PARTY PRODUCTS OR ASSOCIATED HARDWARE, OR CUSTOMER- OWNED SYSTEMS, EQUIPMENT OR SOFTWARE.

HD Electric Company must have prompt notice of any claim so that an immediate product inspection and investigation can be made. Buyer and all users shall promptly notify HD Electric Company of any claims, whether based on contract, negligence, strict liability, or other tort or otherwise be barred from any remedy.

HD Electric Company is committed to ongoing review and improvement of its product lines, and thus reserves the right to modify product design and specifications without notice.

HD Electric Company products are available through HD sales representatives worldwide.

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DVI IM-100f US Patent 6,998,832 US Patent D510,882

8

Analog Voltage Detector and Phasing Tester Operating Instructions 81280 & 83280, Bierer

Analog Voltage Detector and Phasing Tester

Operating Instructions

81280 & 83280

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Limitation of Warranty and Liability

Bierer & Associates Inc. warrants this product to be free from defects in workmanship and material, under normal use and service conditions for a period of one year from date of shipment.

Due to continuous product improvement and development, Bierer & Associates Inc. reserves the right to modify product designs and specifications without notice.

It is impossible to eliminate all risks associated with the use of high voltage electrical devices including this device. Risks of serious injury or death are inherent in working around energized electrical systems. Such risks include but are not limited to variations of electrical systems and equipment, manner of use or applications, weather and environmental conditions, operator mentality, and other unknown factors that are beyond the control of Bierer & Associates Inc.

Bierer & Associates Inc. do not express or imply to be an insurer of these risks, and by purchasing or using this product you **AGREE TO ACCEPT THESE RISKS.** IN NO EVENT SHALL Bierer & Associates Inc. BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT.

SAFETY MESSAGE DEFINITIONS per ANSI Z535

These instructions contain important safety messages to alert the user to potentially hazardous situations, how to avoid the hazard, and the consequences of failure to follow the instruction.

The safety alert symbol ⚠ identifies a safety message. The signal word following the symbol indicates:

⚠ **DANGER** A hazardous situation which, if not avoided, **will** result in death or serious injury and equipment damage.

⚠ **WARNING** A hazardous situation which, if not avoided, **could** result in death or serious injury and equipment damage.

⚠ **CAUTION** A hazardous situation which, if not avoided, **could** result in minor or moderate injury and equipment damage.

NOTICE Important safety message relating to equipment damage only.

2

PRODUCT SAFETY INFORMATION

WARNING

1. Meter assembly, interconnect cable assembly, and live line tool adapters shall be considered **non-insulating**. Do not let live line tool fittings come in contact with energized or grounded conductors. **The live line tool adapters, fittings, and handles supplied with meters shall not be used on any other devices.**
2. Use appropriate length live line tools for voltage being worked and maintain minimum approach distances as outlined in OSHA 1910.269, Table R-6.
3. All Phasing Meters and Voltage Detectors manufactured during and after 2007 will have a limit mark engraved on the high voltage probe(s) 2.5 inches from the tip to indicate to the user the physical limit that should not be exceeded when approaching and contacting an electrical conductor or other electrical test points. Zero Ohm insulated adapters (81280IE) should be used if limit mark will be exceeded.
4. This equipment should be used only by qualified employees, trained in and familiar with the safety-related work practices, safety rules and other safety requirements associated with the use of this type of equipment.
5. These instructions are not intended as a substitute for adequate training, nor do they cover all details or situations which could be encountered when operating this type of equipment.
6. Before operating this equipment, read, understand and follow all instructions contained in this manual. Keep instructions with equipment.

INSPECTION & MAINTENANCE BEFORE USE

WARNING

1. Prior to using any high voltage test equipment, a careful inspection should be made to ensure the unit is free from any contaminants such as dirt, grease, etc. and that there are no apparent physical damages.
2. High voltage probe assemblies shall be wiped clean prior to each use with a silicone impregnated cloth and kept clean and free of contaminants. This will prevent tracking on the outside of the probe and meter error.
3. Always confirm internal battery voltage before and after each use.

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The Voltage Detector and Phasing Tester:

WARNING

- see "Product Safety Information", page 3.
- see "Inspection & Maintenance", page 3.

1. For voltage sensing and phasing on overhead and underground systems.
2. For voltage sensing and phasing at capacitive test points.
3. Five-position switch selects function **C** voltage sensing on capacitive test points

CP	phasing between capacitive test points
L	voltage sensing on overhead and underground systems
LP	phasing on overhead and underground systems
BT	internal battery test.

4. Bushing and elbow adapters for URD use.
5. Adapters are available for use with live line tools:

Q	Quick Change – Standard on both probes	
U	Universal – Adapters for use with hotsticks.	PN: 3403
GA	Grip All – Adapters for use with shotgun sticks.	PN: 3402

6. Available in two models: 300 V to 25 kV and 300 V to 35 kV.
7. A second probe and series lead is furnished for use when phasing or measuring line-to-line or line-to-ground voltages.
8. The carrying case incorporates a 3 kV test device for testing the instrument for correct operation before and after each use.

Obsolete

BATTERY TEST

The battery test tells the operator whether the meter probe's internal battery is fully charged.

Turn the selector switch on the back of the meter to position BT (Battery Test) and hold to the right. The meter should show a full scale deflection. If there is less than full deflection, the meter probe battery should be changed.

(If the battery test fails, you can replace the 9 volt battery located behind the attachment point for the hot stick located on the main meter face.)

WARNING – Battery Test

-see "Inspection and Maintenance", item 3, page 3.

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SENSING ON CAPACITIVE TEST POINTS

1 Turn the Selector switch to position C (Capacitive Sensing).

2 Fasten the meter probe to appropriate live line tool.

3 Turn on the test device.

4 To test the meter probe on the test device (provided in the carrying case) depress the button on the test device with the meter probe end. **The meter should show a full**

5 Test the meter probe on the Capacitive point.

- No meter deflection indicates de-energized source.
- Any meter deflection indicates voltage present.

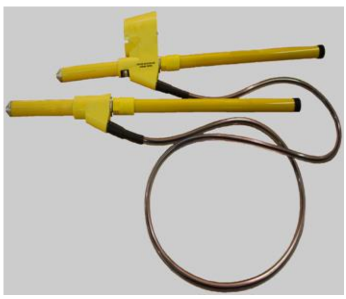
6 Retest meter on test device to confirm that it is working.

WARNING

- see "Product Safety Information", page 3.
- see "Inspection & Maintenance", page 3.

PHASING ON CAPACITIVE TEST POINTS

1 Turn the Selector switch to position CP (Capacitive Phasing).



2 Connect the meter probe to the second probe with the interconnect cable.

3 Turn on the test device.

4 To test the meter probe on the test device provided, depress the button of the test device with the meter probe and place the second probe end on the other terminal. **The meter should show a full scale deflection.** If not, check all batteries or send for repair.

5 While depressing the button with the meter probe, have the second probe make contact with the meter probe end. **The meter should deflect toward zero**.

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6 Place the meter probe end to a capacitive test point.

7 While touching the meter probe to the test point, have the second probe make contact with the meter probe end. The meter should deflect toward zero.

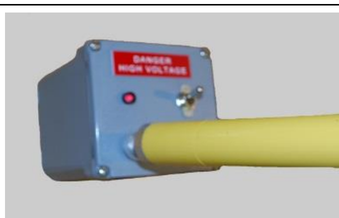
8 Leave the meter probe on the first capacitive test point and contact the second probe to another capacitive test point. **In Phase** is represented by the meter deflecting toward zero. **Out of Phase** is represented by a meter reading or deflection

SENSING ON DIRECT LINE

1 Turn the Selector Switch to position L

2 Fasten the meter to appropriate live line tool.

3 Turn on the test device



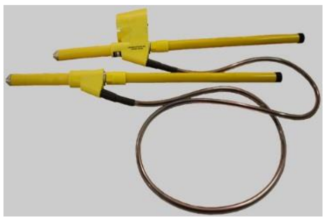
4 To test the meter probe on the test device provided in the carrying case, depress the button on the test device with the meter probe end. **The meter should show at least a 3 kV deflection.** If not, check all batteries or send for repair.

5 Place the meter probe end on the conductor under test.

- Meter deflection indicates voltage is present.
- No deflection means line is de-energized.

PHASING ON DIRECT LINE

1 Turn the selector switch to position **LP** (Line Phasing).



2 Connect the meter to the second probe with the series lead

3 Turn on the test device

4 To test the meter probe on the test device provided, depress the button of the test device with the meter probe, and place the second probe end on the other terminal. **The meter should show a reading of at least 2.5 kV.** If not, check all batteries or send for repair

5 While depressing the button with the meter probe, have the second probe make contact with the meter probe end. **The meter should deflect toward zero**.

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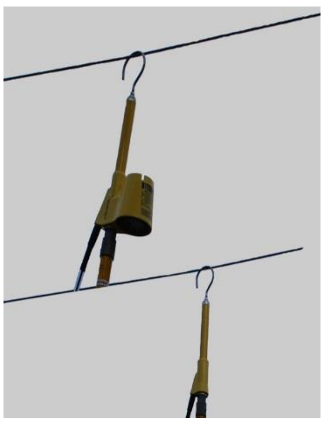
6 Place the meter probe end on one of the conductors

7 Have the second probe make contact with the same conductor as the meter probe end. Again, the meter probe should deflect toward zero.



8 Leave the meter probe on the first conductor and contact the second probe on another conductor. **In Phase** is represented by the meter deflecting toward zero. **Out of Phase** is represented by a meter reading or deflection

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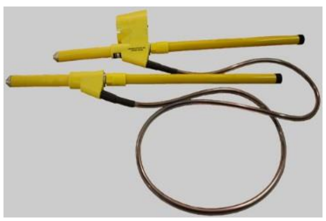
LINE-TO-LINE AND LINE-TO-GROUND VOLTAGE

1 Turn the selector switch to position **LP** (Line Phasing).



2 Connect the meter to the second probe with the interconnect cable.

3 Turn on the test device

4 To test the meter probe on the test device, depress the button of the test device with the meter probe end, and place the second probe end on the other terminal. **The meter should show a reading of at least 2.5 kV.** If not, check all batteries or send for repair.

5 To measure line-to-line voltage, use the meter probe, series lead, and second probe combination to make contact between lines and take a reading. To measure voltage line-to-ground, use the meter probe, interconnect cable and second probe combination to make contact between the line and ground and take the reading.

VOLTAGE CHECK OR INDICATION, URD

1 Set the selector switch to L

2 Attach insulating handle to meter probe.

3 Turn on the test device

4 To test the meter probe on the test device provided in the carrying case, depress the button on the test device with the meter probe end. **The meter should show at least a 3 kV deflection.** If not, check all batteries or send for repair.

5 Attach URD bushing adapter to meter probe. Plug meter probe with URD bushing adapter into desired bushing.

6 If line voltage is present, meter will indicate approximate line to ground voltage.

7 If line voltage is not present, there will be no meter reading or deflection.

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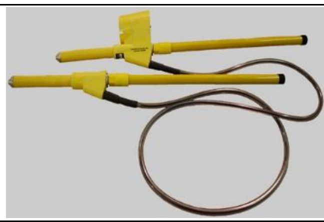
PHASE-TO-GROUND VOLTAGE CHECK, URD

1 Set the selector switch to LP (Line Phasing).



2 Connect the meter to the second probe with the interconnect cable and attach insulating handles to both probes.

3 Turn on the test device

4 To test the meter probe on the test device provided, depress the button of the test device with the meter probe, and place the second probe end on the other terminal. **The meter should show a reading of at least 2.5 kV.** If not, check all batteries or send for repair.

5 While depressing the button with the meter probe, have the second probe make contact with the meter probe end. The meter should show a **Zero** reading

6 Attach URD bushing adapter to meter probe.

7 Plug meter probe with URD bushing adapter into desired bushing. Touch second probe to good electrical ground connection. If line voltage is present, meter will indicate nominal phase to ground voltage. If no line voltage is present, there will be no meter reading or deflection

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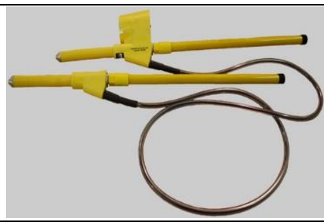
PHASE-TO-PHASE VOLTAGE CHECK, URD

1 Set the selector switch to LP (Line Phasing).



2 Connect the meter to the second probe with the interconnect cable and attach insulating handles to both probes.

3 Turn on the test device

4 To test the meter probe on the test device provided, depress the button of the test device with the meter probe, and place the second probe end on the other terminal. **The meter should show a reading of 2.5 kV.** If not, check all batteries or send for repair.

5 While depressing the button with the meter probe, have the second probe make contact with the meter probe end. The meter should show a **Zero** reading

6 Attach both URD bushing adapters to probes. Plug meter probe with URD bushing adapter and second probe with URD bushing adapter into bushings to be tested. If both phases are present, meter will indicate nominal phase-to-phase voltage. If neither phase is present, there will be no meter reading or deflection.

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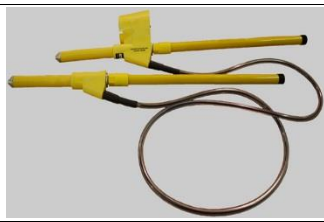
URD PHASING

1 Set the selector switch to LP (Line Phasing).



2 Connect the meter to the second probe with the interconnect cable and attach insulating handles to both probes.

3 Turn on the test device

4 To test the meter probe on the test device provided, depress the button of the test device with the meter probe, and place the second probe end on the other terminal. **The meter should show a reading of 2.5 kV.** If not, check all batteries or send for repair.

5 While depressing the button with the meter probe, have the second probe make contact with the meter probe end. **The meter should show a Zero reading**

6 Attach both URD bushing adapters to probes. Test for phase-to-ground voltage on bushings to be phased. Nominal phase-to-ground voltage should be present on both bushings before phasing

7 Plug meter probe with URD bushing adapter and second probe with URD bushing adapter into bushings to be phased**. In Phase** is represented by near zero meter reading or deflection.

8 **Out of Phase** is represented by a meter reading or deflection.

PARTS AND ACCESSORIES

CAT. NO.	DESCRIPTION	WEIGHT
8128TEALB	15 - 35 kV Elbow Adapter ½"	1 lb (0.45 kg)
8128TBALB	15 - 35 kV Bushing Adapter ½"	1 lb (0.45 kg)
81280LHM	Hook Adapter	1 lb (0.45 kg)
81280LPM	Probe Adapter	1 lb (0.45 kg)
PA165UGA	Universal/Grip All Adapter	1 lb (0.45 kg)
10022CHL	Handle with Threaded Ferrule and Cap (2 required)	1 lb(0.45 kg)
10022HHSL	Handle with Threaded Ferrule and Ferrule with Stud (4 required)	1 lb (0.45 kg)
PA25S	25 kV Voltage Meter with Quick Change	2 lbs(0.91 kg)
PA35S	35 kV Voltage Meter with Quick Change	2 lbs(0.91 kg)
PA25P	Second Probe with Quick Change	1 lb (0.45 kg)
PA25T	3 kV Power Supply	3 lbs (1 .36 kg)
PA25B	Box with Foam Padding	7 lbs (3.17 kg)
81280FL	8' (2.44 m) Lead Extension	2 lbs(0.91 kg)
81280ML	8' (2.44 m) Lead, Standard	2 lbs(0.91 kg)
81280B1	6 Volt Battery	2 lbs(0.91 kg)

Technical & Service
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REV. ED. 100405

PD Series™ Cordless Phasing Tester: Operating Instructions PD800W™ (BIERER)

BIERER

PD Series™ Cordless Phasing Tester

Operating Instructions

PD800W™

Patent No. 6,617,840 and 6,734,658

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Limitation of Warranty and Liability

Bierer & Associates Inc. warrants this product to be free from defects in workmanship and material, under normal use and service conditions for a period of one year from date of shipment.

Due to continuous product improvement and development, Bierer & Associates Inc. reserves the right to modify product designs and specifications without notice.

It is impossible to eliminate all risks associated with the use of high voltage electrical devices including this device. Risks of serious injury or death are inherent in working around energized electrical systems. Such risks include but are not limited to variations of electrical systems and equipment, manner of use or applications, weather and environmental conditions, operator mentality, and other unknown factors that are beyond the control of Bierer & Associates Inc.

Bierer & Associates Inc. do not express or imply to be an insurer of these risks, and by purchasing or using this product you **AGREE TO ACCEPT THESE RISKS.** IN NO EVENT SHALL Bierer & Associates Inc. BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT.

SAFETY MESSAGE DEFINITIONS per ANSI Z535

These instructions contain important safety messages to alert the user to potentially hazardous situations, how to avoid the hazard, and the consequences of failure to follow the instruction.

The safety alert symbol ⚠ identifies a safety message. The signal word following the symbol indicates:

⚠ **DANGER** A hazardous situation which, if not avoided, **will** result in death or serious injury and equipment damage.

⚠ **WARNING** A hazardous situation which, if not avoided, **could** result in death or serious injury and equipment damage.

⚠ **CAUTION** A hazardous situation which, if not avoided, **could** result in minor or moderate injury and equipment damage.

NOTICE Important safety message relating to equipment damage only.

PRODUCT SAFETY INFORMATION

WARNING

1. Meter assembly and live line tool adapters shall be considered **non-insulating**. Do not let live line tool fittings come in contact with energized or grounded conductors. **The live line tool adapters, fittings, and handles supplied with meters shall not be used on any other devices.**
2. Use appropriate length live line tools for voltage being worked and maintain minimum approach distances as outlined in OSHA 1910.269, Table R-6.
3. All Phasing Meters and Voltage Detectors manufactured during and after 2007 will have a limit mark engraved on the high voltage probe(s) 2.5 inches from the tip to indicate to the user the physical limit that should not be exceeded when approaching and contacting an electrical conductor or other electrical test points. Zero Ohm insulated adapters (81280IE) should be used if limit mark will be exceeded.
4. This equipment should be used only by qualified employees, trained in and familiar with the safety-related work practices, safety rules and other safety requirements associated with the use of this type of equipment.
5. These instructions are not intended as a substitute for adequate training, nor do they cover all details or situations which could be encountered when operating this type of equipment.
6. Before operating this equipment, read, understand and follow all instructions contained in this manual. Keep instructions with equipment.

INSPECTION & MAINTENANCE BEFORE USE

WARNING

2. Prior to using any high voltage test equipment a careful inspection should be made to ensure the unit is free from any contaminants such as dirt, grease, etc. and that there are no apparent physical damages.
3. High voltage probe assemblies shall be wiped clean prior to each use with a silicone impregnated cloth and kept clean and free of contaminants. This will prevent tracking on the outside of the probe and meter error.
4. Always confirm internal battery voltage before and after use.

3

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DESIGN and FUNCTION

WARNING – Limit Mark
-see "Product Safety Information", item 3, page 3.

The cordless PD800W is designed to operate similar to a conventional phasing tester, but is easier to use because it does not require an interconnect cable. The unit consists of a Reference Probe (transmitter) and a Meter Probe (receiver) and will operate reliably at distances up to 100 feet. The phasing tester is useable from 120V to 800kV. Each unit has a five-position switch for the following functions:

Off – Unit off for storage or transport.

Deg – Phase angle measurement in degrees for use on Secondary, URD and Overhead. Direct contact from 120V to 69kV **(including capacitive test points).** Non-contact from 69kV to 800kV

URD – Phasing Underground Residential Distribution with Voltage Indications. Direct contact from 4kV to 35kV **(not for capacitive test points).**

OH – Phasing Over-Head conductors with voltage indications Direct contact from 4kV to 69kV.

T – Tests basic meter function and displays the internal 9V battery voltage.

Voltage indications and degree readings are supplemented with phase indicator lights on the Meter Probe for dual confirmation of the phase relationship between the Reference Probe and Meter probe.

0° - indicates an in-phase condition.
120° - indicates out-of-phase condition of 120 degrees.
240° - indicates an out-of-phase condition of 240 degrees.
"DY"- blinking light indicates a Delta/Wye transformation (30 degree phase shift) in conjunction with one of the other three phase indicator lights.

Note 1: For best results, always position the Reference Probe and Meter Probe perpendicular to the conductors being tested and away from all other conductive surfaces such as adjacent phases, neutrals and grounded structures. Maintain a minimum distance of two feet between the body of the probes and all other conductors or grounded surfaces. Maintain a minimum distance of two feet between your hands and the body of the probe regardless of the voltage being tested. Never hold the tester with rubber gloves when in use.

Note 2: When phasing on **URD** transformer bushings use 8128TBALB Bushing Adapters on both the Reference and the Meter Probe.

BATTERY REPLACEMENT

The threaded live line tool fitting on the face of the meter probe is furnished with two flat edges for use with a wrench or slip joint pliers to remove and install the fitting from the meter housing. To remove, turn the live line tool fitting in a counterclockwise direction and install in a clockwise direction.

WARNING

- **When in operation the selector switches on the Reference Probe and Meter Probe must be in the same position. Failure to do so could produce false readings, resulting in equipment damage and/or personal injury. Always check the selector switch on both units before and after each use.**

METER SET-UP and TESTING

WARNING

- see "Product Safety Information", page 3.
- see "Inspection & Maintenance", page 3.

Testing the Meter Probe:
The Meter Probe completes a self-check each time the selector switch is moved from one position to another. It displays the number 510 +/ - 5 (full scale) and blinks 0, 120, 240 phase sequence indicator lights followed by a blinking **D** (Delta/ Wye Transformation) indicator light.

Test:
The internal 9V battery voltage may be checked by turning the rotary selector switch to the **T** position and holding for several seconds until the indicator lights stop blinking. If the battery voltage displayed is less than 8 volts, shown on the meter as 80, the battery should be replaced. A standard 9 volt battery is located behind the live line tool attachment.

Testing the Reference Probe:
Turn the Meter Probe selector switch to the **URD** or **OH** position. The results of the Reference Probe self-checks will be displayed on the Meter Probe. Each time the selector switch on the Reference Probe is moved from one position to another, the number 510 will be displayed on the Meter Probe for several seconds.

Test:
The internal 9V battery is checked by turning the selector switch to the **T** position and holding for several seconds. The internal battery voltage of the reference will be displayed on the Meter Probe. If the battery voltage displayed on the Meter Probe is less than 8V, shown on meter as 80, the battery should be replaced. A standard 9 volt battery is located behind the live line tool attachment.

WARNING

- **When in operation the selector switches on the Reference Probe and Meter Probe must be in the same position. Failure to do so could produce false readings, resulting in equipment damage and/or personal injury. Always check the selector switch on both units before and after each use.**

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PHASE ANGLE MEASUREMENTS
Direct Contact from 120V to 69kV including Capacitive Test Points

WARNING – see "Meter Set-Up & Testing", page 6.

1. Attach the Reference and Meter Probe to the appropriate length live line tool for the voltage being tested. Minimum 2 feet **(See Note 1 Pg. 5)**
2. Set the selector switch on both probes to the **Deg** position.
3. With the Reference Probe, touch all conductors one at a time to verify all of the phases are energized. **(See Note 2 on Page 5).**
4. The **White** phase indicator light will be on if there is at least 120 volts present on the conductor.
5. Touch both the Reference Probe and the Meter Probe to a single (the same) energized conductor. The Meter Probe should indicate near zero degrees on the digital display and show a zero degree indication light. A **0°** light on the meter probe indicates an in phase condition. **(See Note 2 on Page 5).**
6. Leave the Reference Probe on the first energized conductor. Touch the Meter Probe to another energized conductor.
7. If the conductors are in phase, the Meter Probe should indicate near zero degrees on the digital display and show a zero degree indication light.
8. If the conductors are out of phase, the Meter Probe will indicate either of the following:
   a. Nominal 120 degrees and a **120** degrees indicator light or
   b. Nominal 240 degrees and a **240** degrees indicator light.

WARNING – see "Meter Set-Up & Testing", page 6.

Delta/ Wye Transformation
The PD800W provides an additional feature of flagging a Delta Wye Transformation with a blinking yellow indicator light labeled "DY".
Expected phase angles when phasing a three-phase system are 0 degrees, 120 degrees, and 240 degrees. The PD800W continuously monitors all phase angles between the Reference Probe and the Meter Probe when used in either the **Deg, URD,** or **OH** mode. If the phase angle deviates more than +/ - 20 degrees from any of the three expected values of 0, 120, or 240 degrees the **Yellow** "DY" light will blink.

PHASE ANGLE MEASUREMENTS
Non-Contact from 69kV to 800kV

WARNING – see "Meter Set-Up & Testing", page 6.

1. Attach the Reference and Meter Probe to appropriate length live line tools for the voltage being tested. Minimum 2 feet **(See Note 1 on pg. 5)**
2. Select the **OH** position on the Reference Probe.
3. Bring the Reference Probe to a distance from each conductor that is close to the minimum approach distance for the voltage being tested to verify all conductors are energized. **(See OSHA 1910-269, Table R-6 for a minimum approach distance).**
4. The **White** phase indictor light will be on if the electric field present at the minimum approach distance equals at least 600 volts.
5. **Reset the selector switches on both probes to the Deg position.**
6. Bring both the Reference Probe and Meter Probe close to the minimum approach distance of a single (the same) conductor. The Meter Probe should indicate near zero degrees on the digital display and show a **0°** indication light.

NOTE 3: On lines 69kV to 600kV the Reference Probe may be suspended from the conductor with optional insulated support hook attachment PD800SH2. Above 600kV use PD800SH4. Meter Probe must be used in non-contact mode as described above in No. 6.

7. Leave the Reference Probe in position with the first conductor. Bring the Meter Probe close to the minimum approach distance of another energized conductor.
8. If the conductors are in phase, the Meter Probe should indicate near zero degrees on the digital display and show a **0°** indication light.
9. If the conductors are out of phase, the Meter Probe will indicate either of the following:
   a) Nominal 120 degrees and a **120** degrees indicator light or
   b) Nominal 240 degrees and a **240** degrees indicator light

WARNING – see "Meter Set-Up & Testing", page 6.

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TESTING PHASE SEQUENCE

Phase sequence will be either: **(1 - 2 - 3) or (3 - 2 - 1)**
(A - B - C) or (C - B -A)

Phase sequence is the order in which the voltages of a three phase system rise and fall. Only two sequences are possible, sometimes referred to as Clockwise or Counter Clockwise rotation. However, three different physical connections are possible to achieve each sequence. Any one of the phases of a three-phase system may be assigned the status of leading phase. This convention is currently left to the discretion of the electric utility.

Sequence: **(1 - 2 - 3) or (A – B – C)**		**A - B - C -** A - B - C - A - B - C
	(B – C – A)	B - C - **A - B - C** - A - B - C - A
	(C – A – B)	C - A - B - C - **A - B - C** - A - B

Sequence: **(3 - 2 - 1) or (C – B – A)**		**C - B - A** - C - B - A - C - B - A
	(B – A – C)	B - A - **C - B - A** - C - B - A - C
	(A – C – B)	A - C - B - A - **C - B - A** - C – B

WARNING – see "Meter Set-Up & Testing", page 6.

1. Attach the Reference Probe and the Meter Probe to the appropriate length live line tools for the voltage being tested.
2. Set the selector switches on both probes to the **Deg** position.
3. Touch or approach "1" ("A") phase with the Reference Probe.
4. Touch or approach "2" ("B") phase with the Meter Probe.
5. Sequence (1 - 2 - 3)
   (A - B - C) will be indicated by an nominal 120 degrees on the digital display and a **120** degree indicator light.
6. Sequence (3-2-1)
   (C - B -A) will be indicated by a nominal 240 degrees on the digital display and a **240** degree indicator light.

WARNING – see "Meter Set-Up & Testing", page 6.

VOLTAGE INDICATIONS URD and OH
Direct Contact from 4kV to 69kV
(Does not include Capacitive Test Points)

By design, the PD800W consists of two individual direct contact voltage detectors which communicate with each other via a radio link. When used to display voltage in the **URD** or **OH** positions, the readings are a composite of the actual voltage on the line and the capacitive coupling between the live line tool fitting (quick change, universal, or grip all) to other potentials in the vicinity.

If the live line tool fitting is close to another phase, ground or other voltage source, the reading will be higher than normal. If the live line tool fitting is close to conductors or equipment of the same phase, the reading will be lower than normal. In the PD800W, the phase to phase voltage indications are derived from the two phase to ground voltages present on the Reference Probe and the Meter Probe. The resulting phase to phase reading will be proportional to the phase to ground readings.

Example: If due to field conditions both the Reference Probe and Meter Probe sense 9kV phase-to-ground on a 7.2 kV phase to ground system, the phase-to phase indication would be 16 kV rather than 12 kV. In this example, the meter is simply indicating that the two conductors are out of phase. The out of phase condition will be confirmed with the presence of a **Blue** or **Red** indicator light.

Note 4: Higher than normal reading in the **OH** position can sometimes be lowered closer to normal by retesting in the **URD** position, especially when used in close proximity to neutrals and other grounded surfaces.

Inspect and Test the Unit. Attach the Reference Probe and/or the Meter Probe to the appropriate length live line tool for the voltage being tested. Minimum 2 feet. **(See Note 1 on Page 5)**

1. **Phase-to-Phase Voltage Indication - Direct Contact from 4kV to 69kV Does not include Capacitive Test Points**
   Normal phase-to-phase voltage indications may be obtained in the **URD** or **OH** position by touching one energized phase conductor with the Reference Probe and one energized phase conductor with the Meter Probe. **(See Note 1 on Page 5)**

2. **Zero-Voltage Indication - Direct Contact from 4kV to 69kV**
   Does not include Capacitive Test Points
   Normal zero-voltage indication may be obtained in the **URD** or **OH** position by touching the Reference Probe and Meter Probe to energized conductors of the same phase and voltage. **(See Note 1 on Page 5)**

3. **Phase-to-Ground Voltage Indication - Direct Contact from 4kV-to-69kV**
   Does not include Capacitive Test Points
   The Meter Probe may be used in the **URD** or **OH** position as a stand-alone digital voltage detector to obtain a phase-to-ground voltage indication by touching the energized conductor directly. When using the Meter Probe in this manner, the Reference Probe must be switched off and should be stored in the padded box.

4. **Reference Probe as a Voltage Detector - Direct Contact from 240V to 69kV**
   Including Capacitive Test Points
   The Reference Probe may be used as a stand-alone voltage detector by touching the energized conductor or capacitive test point directly. The **White** indicator light will be on if the voltage is equal to or greater than the threshold values below **(See Note 1 on Page 5).**
   a) **Deg** position: 240V
   b) **URD** or **OH** position: 800V

Use (a) above for capacitive test points and voltages up to 480V and use (b) above for voltages 600V-to-69kV

VOLTAGE INDICATIONS URD and OH (cont'd.)
Direct Contact from 4kV to 69kV
(Does not include Capacitive Test Points)

5. **Non-Contact from 69kV to 800kV**
   The Reference Probe may be used as a non-contact stand-alone voltage detector. The presence of an electric field at the minimum approach distance will cause the **White** indicator light to come on. **(See OSHA 1910.269, Table R-6 for minimum approach distance).**

Deg Electric field greater than 120V at the minimum approach distance.

URD or **OH** Electric field greater than 800V at the minimum approach distance.

FCC INSTRUCTIONS TO THE USER

This equipment (Reference Probe) has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not used in accordance with this instruction manual may cause interference to radio communications. Operation of this equipment in a residential area is likely to cause interference in which case the user is encouraged to try to correct the interference by one or more of the following measures:

1. Reorient or relocate the equipment.
2. Increase the separation between the equipment and the radio service that is experiencing the interference.
3. Consult the dealer or an experienced radio technician for help.

The user is cautioned that changes or modifications made to the equipment or antenna could void the user's authority to operate this equipment.

FCC COMPLIANCE INFORMATION STATEMENT

Trade Name:	Cordless Phasing Tester
Model Number:	Bierer PD800W
Compliance Test Report Number:	B31202D2
Compliance Test Report Dates:	12/01/03 & 12/02/03
Responsible Party:	Bierer & Associates, Inc.
Address:	11142 Wilson Blvd., Blythewood, SC 29016
Telephone:	803-786-4839

This equipment (Meter Probe) has been tested and found to comply with limits for a Class B, RF Receiver pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular situation. If the unit does cause harmful interference to radio or television, please refer to the three steps listed above under "FCC Instructions to the User".

PARTS & ACCESSORIES

PART NO.	DESCRIPTION
8128TBALB	15 -25kV Bushing Adapter
8128LHM	Hook Probe Adapter
8128LPM	Straight Probe Adapter
3403	Quick Change to Universal Adapter
3402TH5811	Quick Change to Grip All Adapter
10022CHL	Handle w/Threaded Ferrule and Cap (2 required*)
10022HHSL	Handle w/Threaded Ferrule and Ferrule w/Stud (2 or 4 required*)
PD800ANT	Antenna for Reference or Meter Probe
PD800SH2	Support Hook 2 ft., 69kV to 600kV
PD800SH4	Support Hook 4 ft., above 600kV

*Nominal one inch in diameter and two feet in length; handle assemblies may be two, four or six feet in length.

Limit Mark

All Phasing Meters and Voltage Detectors manufactured after 2007 will have a limit mark engraved on the high voltage probe(s) 2.5 inches from the tip to indicate to the user the physical limit that should not be passed when approaching and contacting an electrical conductor or other electrical test points.

Technical & Service

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Blythewood SC 29016
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Email: rickkennerly@bellsouth.net

Notes____

REV. ED. 090122

Analog Voltage Detector 0-40kV Operating Instructions: VDA040CTM, BIERER Meters

Bierer
METERS
Safety is number one.

Analog Voltage Detector 0-40kV
Operating Instructions
VDA040C™

MADE IN USA

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Bierer & Associates Inc. warrants this product to be free from defects in workmanship and material, under normal use and service conditions for a period of one year from date of shipment.

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It is impossible to eliminate all risks associated with the use of high voltage electrical devices including this device. Risks of serious injury or death are inherent in working around energized electrical systems. Such risks include but are not limited to variations of electrical systems and equipment, manner of use or applications, weather and environmental conditions, operator mentality, and other unknown factors that are beyond the control of Bierer & Associates Inc.

Bierer & Associates Inc. do not express or imply to be an insurer of these risks, and by purchasing or using this product you **AGREE TO ACCEPT THESE RISKS.** IN NO EVENT SHALL Bierer & Associates Inc. BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT.

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⚠ **WARNING** A hazardous situation which, if not avoided, **could** result in death or serious injury and equipment damage.

⚠ **CAUTION** A hazardous situation which, if not avoided, **could** result in minor or moderate injury and equipment damage.

NOTICE Important safety message relating to equipment damage only.

2

PRODUCT SAFETY INFORMATION

WARNING

1. Meter assembly, interconnect cable assembly, and live line tool adapters shall be considered **non-insulating**. Do not let live line tool fittings come in contact with energized or grounded conductors. **The live line tool adapters, fittings, and handles supplied with meters shall not be used on any other devices.**
2. Use appropriate length live line tools for voltage being worked and maintain minimum approach distances as outlined in OSHA 1910.269, Table R-6.
3. All Phasing Meters and Voltage Detectors manufactured during and after 2007 will have a limit mark engraved on the high voltage probe(s) 2.5 inches from the tip to indicate to the user the physical limit that should not be exceeded when approaching and contacting an electrical conductor or other electrical test points. Zero Ohm insulated adapters (81280IE) should be used if limit mark will be exceeded.
4. This equipment should be used only by qualified employees, trained in and familiar with the safety-related work practices, safety rules and other safety requirements associated with the use of this type of equipment.
5. These instructions are not intended as a substitute for adequate training, nor do they cover all details or situations which could be encountered when operating this type of equipment.
6. Before operating this equipment, read, understand and follow all instructions contained in this manual. Keep instructions with equipment.

INSPECTION & MAINTENANCE BEFORE USE

WARNING

1. Prior to using any high voltage test equipment, a careful inspection should be made to ensure the unit is free from any contaminants such as dirt, grease, etc. and that there are no apparent physical damages.
2. High voltage probe assemblies shall be wiped clean prior to each use with a silicone impregnated cloth and kept clean and free of contaminants. This will prevent tracking on the outside of the probe and meter error.
3. Always confirm internal battery voltage before and after each use.

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DESIGN and FUNCTION

WARNING – Limit Mark

-see "Product Safety Information", item 3, page 3.

The VDA040C is a combination capacitive/direct contact, capacitive type voltage detector for use on voltages up to 40 kV Line-to-Ground (69 kV Phase-to-Phase), and is over-voltage protected to 66 kV Line-to-Ground (115 kV Phase-to-Phase).

NOTE: Meter scale indicates **Line-to-Ground** values. Not calibrated to read Phase-to-Phase.

Each unit has a five position switch for the following functions:

C Capacitive Voltage Detection

URD Voltage Detection, URD Equipment

OH Voltage Detection, Overhead Lines

X4 Meter Scale Times "X" 4

T Meter Test

WARNING

Meter should deflect full scale in the **"T"** position. Deflection below full scale indicates low battery. Replaceable 9V battery is located behind the live line tool attachment threaded into the meter housing.

As with all voltage detectors, readings can be affected by a variety of field conditions. For example, if the live line tool attachment is close to another phase, ground or voltage source, the readings may be high. If the live line tool attachment is close to the same phase, readings may be low.

If there is any doubt about the meter reading under any circumstances, the line or equipment shall be considered energized and appropriate safety precautions taken, i.e., confirm visual open gaps, tag outs, hold orders and sources of induced voltage.

4

Voltage Detection in the "C" Position

In the **"C"** position, the VDA040C can be used as a non-contact proximity voltage detector on bare overhead primary conductors. It can also be used in direct contact with secondary voltages and capacitance test points to indicate the presence of voltage.

1 Test Voltage detector for proper operation by turning selector switch to the **"T"** position. Meter should deflect full scale. (See Warning page 4).

2 Turn the selector switch to the **"C"** position.

3 From the ground, hold the VDA040C by the live line tool attachment and point the unit toward the energized line. Any meter deflection indicates the presence of voltage. (See **WARNING** statement page 4).

4 If voltage is not present, meter should read zero volts. (See **WARNING** statement page 4).

5 Re-test voltage detector by turning the selector switch to the **"T"** position.

NOTE: Use of the VDA040C in the **"C"** position on primary voltages with an insulated live line tool or from an insulated aerial device, is **NOT** recommended since the readings may be diminished and could result in false de—energized readings

WARNING

DO NOT make contact with any energized conductors or equipment when holding unit by hand.

If there is any doubt about the meter reading in the **"C"** position, the line or equipment shall be considered energized, and appropriate safety precautions taken. To confirm the presence of nominal voltages, induced voltage prior to installing ground, re-test the line or equipment using the direct contact methods described on the following pages.

WARNING

Unit shall be tested before and after each use on a known voltage source. Failure to do so could result in false negative indications.

Battery Replacement

A standard 9 volt battery is located behind the 5/8" x 11 threaded live line tool fitting on the meter housing. Two flat edges are furnished for use with a wrench or slip joint pliers to remove and install the fitting from the probe housing.

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Voltage Detection in the "C" Position Secondary Voltages and Capacitance Test Points

1 Test Voltage detector for proper operation by turning selector switch to the **"T"** position. Meter should deflect full scale. (See **Warning** page 4).

2 Turn the selector switch to the **"C"** position.

3 Attach voltage detector to appropriate length live line tool for voltage being tested.

4 Make direct contact with line or equipment under test.
Any meter deflection indicates the presence of voltage.

5 If no voltage is present, meter should read zero volts.

6 Re-test voltage detector by turning the selector switch to the **"T"** position.

WARNING

DO NOT make contact with any energized conductors or equipment when holding unit by hand.

Readings should take into account proximity to other phases and grounded surfaces and be consistent with previous experience on the same voltage and circuit configuration with this voltage detector. If there is any doubt about the meter reading in the "C" position, the line or equipment shall be considered energized and appropriate safety precautions taken.

WARNING

Unit shall be tested before and after each use on a known voltage source. Failure to do so could result in false negative indications.

6

Voltage Detection in the "URD" Position

1. Test Voltage detector for proper operation by turning selector switch to the **"T"** position. Meter should deflect full scale. (See **Warning** page 4).
2. Thread appropriate adapter, bushing or elbow into meter.
3. Attach voltage detector to appropriate length live line tool for voltage being tested.
4. Turn the selector switch to the "URD" position.
5. Make direct contact with URD equipment under test.If equipment is energized, meter should read approximate Line-to-Ground voltage. For voltages above 10 kV, Line-to-Ground meter will read full scale.
6. If URD equipment is de-energized, meter should read zero volts
7. Re-test voltage detector by turning the selector switch to the "T" position

WARNING

DO NOT make contact with any energized conductors or equipment when holding unit by hand.

Readings should take into account proximity to other phases and grounded surfaces and be consistent with previous experience on the same voltage and circuit configuration with this voltage detector. If there is any doubt about the meter reading in the **"URD"** position, the line or equipment shall be considered energized and appropriate safety precautions taken.

WARNING

Unit shall be tested before and after each use on a known voltage source. Failure to do so could result in false negative indications.

7

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Voltage Detection in the "OH" Position

1 Test Voltage detector for proper operation by turning selector switch to the **"T"** position. Meter should deflect full scale. (See **Warning** page 4).

2 Turn the selector switch to the **"OH"** position.

3 Attach voltage detector to appropriate length live line tool for voltage being tested.

4 Make direct contact with line or equipment under test. If equipment is energized, meter should read approximate Line-to-Ground voltage. For voltages above 10 kV Line- to-Ground, use the **"X4"** position.

5 If no voltage is present, meter should read zero volts. Readings other than zero volts may indicate the presence of induced voltage.

6 Re-test voltage detector by turning the selector switch to the **"T"** position

WARNING

DO NOT make contact with any energized conductors or equipment when holding unit by hand.

Readings should take into account proximity to other phases and grounded surfaces and be consistent with previous experience on the same voltage and circuit configuration with this voltage detector. If there is any doubt about the meter reading in the **"OH"** position, the line or equipment shall be considered energized and appropriate safety precautions taken.

WARNING

Unit shall be tested before and after each use on a known voltage source. Failure to do so could result in false negative indications.

8

Voltage Detection in the "X4" Position

1. Test Voltage detector for proper operation by turning selector switch to the **"T"** position. Meter should deflect full scale. (See **Warning** page 4).
2. Turn the selector switch to the **"X4"** position.
3. Attach voltage detector to appropriate length live line tool for voltage being tested.
4. Make direct contact with line or equipment under test. If equipment is energized, meter should read approximate Line-to-Ground voltage. (Actual reading times (X) 4 = voltage present).
5. If line or equipment is de-energized, meter should read zero volts. Readings other than zero volts may indicate the presence of induced voltage. (Actual reading times (X) 4 = induced voltage present).
6. Re-test voltage detector by turning the selector switch to the **"T"** position

WARNING

DO NOT make contact with any energized conductors or equipment when holding unit by hand.

Readings should take into account proximity to other phases and grounded surfaces and be consistent with previous experience on the same voltage and circuit configuration with this voltage detector. If there is any doubt about the meter reading in the **"X4"** position, the line or equipment shall be considered energized and appropriate safety precautions taken.

WARNING

Unit shall be tested before and after each use on a known voltage source. Failure to do so could result in false negative indications.

9

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PARTS & ACCESSORIES

PART NO.	DESCRIPTION
8128TBALB	15 -25kV Bushing Adapter
8128LHM	Hook Probe Adapter
8128LPM	Straight Probe Adapter
81280IE	Insulated Extension Adapter
PA165UGA	QC to Universal/Grip All combo Adapter
10022CHL	1 Handle w/Threaded Ferrule and Cap
10022HHSL	1 Handle w/Threaded Ferrule and Stud

*Nominal one inch in diameter and two feet in length; handle assemblies may be two, four or six feet in length.

Limit Mark

All Phasing Meters and Voltage Detectors manufactured after 2007 will have a limit mark engraved on the high voltage probe(s) 2.5 inches from the tip to indicate to the user the physical limit that should not be passed when approaching and contacting an electrical conductor or other electrical test points.

Technical & Service
Bierer & Associates Inc.
Manufacturing & Repair
10730 Farrow Rd.
Blythewood SC 29016
Tel: (803) 786-4839
Fax: (803) 786-5457
www.BiererMeters.com

Bierer METERS
Safety is number one.

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Forms

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Pacific Gas and Electric Company®

Application for Work

Obsolete

62-3470 (Rev 03/01)
ECCO

APPLICATION FOR: **SWITCHING LOG #**

☐ CLEARANCE	☐ LOAD TRANSFER	☐ NOTIFICATION	☐ TEST PROGRAM
☐ NON-TEST	☐ HOT WASH	☐ CUSTOMER WORK	☐ EMERGENCY
☐ RELAY WORK	☐ DEAD WASH	☐ AUTO-TEST	☐ OTHER

CONTROL CENTER:____________ **Received By:**____________ **Date:**__________ **Time:** __________

Requested By:__________ Phone:__________ Pager:__________ Cell:__________ Fax:__________

Requested For:__________ Phone:__________ Pager:__________ Cell:__________ Radio:__________

Start Date: __________ Time: __________ **Switching Time** From: __________ To: __________

End Date: __________ Time: __________ **Switching Time** From: __________ To: __________

Line or Apparatus: ____________________

Clearance Limits: ____________________

Purpose:____________________

Work Location: ____________________

Crew Special Setups Required for Work:

1. If it is a T-Line clearance, requires nearest Tower number with line name or GIS coordinate.
2. If it is a substation clearance, requires bus number.
3. To mitigate High Fault Duties, requires what are the additional equipment will be taken out.

1. Example T-Line clearance: Pittsburg - Eastshore 230kV line Tower # 4/20 or GIS coordinate = Lat:37.71 and Long=-121.99 degrees
2. Example, Substation: Moraga 115kV Bus 1 Section D
3. Example (Mitigation High Fault Duties) : Pittsburg 230V Bus 2 Section D clearance, Bank 12 will be outl

Phasing/Rotation Required: Yes ☐ No ☐ Location:__________ Emergency Restoration Time: __________

Weather: Not a factor ☐ Clear Weather Only ☐ Light Precipitation ☐ Accounting Order #__________ PM# __________

Customer Shut Down Time(s): From:________ To:________ From:________ To:________ NTFD By: __________

Additional Clearance/Equipment Required:____________________ LOG# __________

Operations Special Setups Required For Switching or Work ____________________

Operation Engineer	Sent for Review	Date:	Review Complete	Date:	By:
Protection Engineer	Sent for Review	Date:	Review Complete	Date:	By:
Control Center OK	Yes ☐ No ☐	Date:			By:
CAISO via TOC	Sent for Approval	Date:	**Approved/Disapproved**	Date:	By:

Adjacent CCNTR Notified:	By:	Date:	Time:
Concerned Parties			

Switchman Requested:	**By:**	**Switchman Location/Date/Time:**	**Date sent:**

Obsolete

Remarks and additional information

SKETCH OR DETAIL OF PROPOSED WORK

(Indicate phasing location)

Obsolete

ELECTRIC OPERATIONS PRE-JOB TAILBOARD FORM

Maintain this record in accordance with GOV-7101 ERIM Standard. *Check or fill out all that apply.*

Work Location:______________________________ **Date:**____________ **Time:**____________

GPS Latitude:__________ **Longitude:**__________ **Job#:**__________ **LR/LC/EC Tag#:**__________

Person in Charge:______________ **Contact#:**__________ **Tailboard Presenter:**______________

T&D Supervisor: ______________ **Contact#:**__________ **Circuit:** ______________

Control Center:______________ **Contact#:**__________ **Circuit Feeding Normal** Yes ☐ No ☐

Emergency Placard Updated/Reviewed ☐ **Location:**__________ **Switching Log#:**______________

SSD#:__________ **Physical location:** ______________________________

ASSD#:__________ **SCADA** Yes ☐ No ☐ **OIS#:**______________ **Meter#:**______________

Clearance Points: ______________________________

Section 1 - Scope of Work ☐ Transmission ☐ Distribution ☐ Tower

Contractor Onsite Yes ☐ **No** ☐ **Contractor(s):**______________________________

Environmental released to construction (ERTC) in job package? Yes ☐ No ☐ **ERTC reviewed?** Yes ☐ N/A ☐

Grounding Required Yes ☐ No ☐ **Hot Stick Yes** ☐ No ☐ **Rubber Glove** Yes ☐ No ☐ **Bare hand** Yes ☐ No ☐

Identify the work to be done:______________________________

____

____

____

Section 2 – Hazards Associated with the Work

Situation/Resolutions - Controls:______________________________

____

____

____

Section 3 – Employee Responsibilities, PPE Requirements

☐PPE ☐ 4-core stretches/warm-up ☐ Human Performance Tools ☐ Employee Readiness ☐ Worksite Protection

☐ Special PPE Requirements:______________________________

Section 4 – Electric Operations Critical Items Checklist

Rubber Glove	☐ Rubber gloves/rubber protective equipment inspection. Expiration date(s):______________
☐ Observer(s):______________	
☐ Boom/Bucket Liners, dielectric sticker. Expiration date:__________	☐ Aerial lift boom inspected, cleaned and operate lower controls
Energized Pole Setting/Boom Proximity Projects	
☐ Observer(s):______________	☐ Conductor height: __________Ft.
☐ Vehicle Grounded	☐ Daily Boom inspection
Non-test established? Yes ☐ **No** ☐ **If No, why?** ______________	
Tool and Equipment Inspections	☐ Fall arrest/climbing gear inspected (includes Vertical Life Lines)
☐ Rigging tools (ropes, slings, hoists, link sticks, etc.)	☐ Hot sticks, dielectric test stickers. Expiration date:__________

Section 5 – Helicopter Tailboard Checklist N/A ☐

Helicopter Contractor:______________	**Landing Zone Lead:**______________
☐ Total Weight of human cargo load, tools, rope, and sky chairs not to exceed 600 lbs. when attached to HEC parachute. Weight:__________	☐ Inspect HEC rope, A-frames, belly band and parachute.
	☐ Pilot(s) to review with crew correct use and operation of grapple, snap hook, and remote hook.
☐ Length of Ropes ________Ft. __________Ft.	☐ Pilot(s) to review emergency shutdown of engines, battery, and use of rotor brake.
☐ Helicopter training qual. cards reviewed	
☐ Helicopter manual on-site and appropriate section(s) reviewed	☐ Pilots to verify the Helicopter Safe Working Distances. • Helicopter horizontal safe work distance (1/2 of rotor diameter) • Helicopter Vertical Safe Working distance (10 feet marker below skid)
☐ Radio communication – Helicopter/LZ/Crew Members	
☐ Confirm all load weights with pilot(s).	

Section 6 – Change in Scope Yes ☐ No ☐

If the scope of the job changes, document changes and re-tailboard:

____

____

Obsolete

ELECTRIC OPERATIONS GROUNDING TAILBOARD FORM

IS GROUNDING REQUIRED? Yes ☐ No ☐ *CHECK OR FILL OUT ALL THAT APPLY.*

Circuit(s) name:______________________________

Clearance limits:______________________________ **Switch Log #:**____________________

Person reporting on/off:____________________ **Grounding Observer(s):**____________________

Section 1 – General Practices ☐ Distribution ☐ Transmission ☐ Overhead ☐ Underground ☐ Substation ☐ Tower

☐ Verify the size of grounds to be used and check their condition (live line tool annual test stickers must be current).

☐ Discuss the type of grounding procedure being utilized.

☐ Discuss vehicle/equipment grounding requirements, including number of grounds to be used.

☐ Determine and communicate the grounding source which will be utilized: (discuss any difference of potential hazards that may exist).
☐ Station Ground Grid ☐ Common Neutral ☐ Anchor Rod(s) ☐ Temporary Ground Rods

☐ Discuss and ensure all other potential sources have been addressed (e.g., capacitor, backfeed, induction, microwave, radio tower, lines crossings, parallel lines, elevated neutral).

☐ Communicate that the line will be tested de-energized with an approved voltage tester.
☐ AV Tester ☐ Volt Detector ☐ Direct line ☐ UG Cap Test Point

☐ Discuss/identify Minimum Approach Distance (MAD) required while performing testing/grounding procedures.

Section 2 – Observer Responsibilities *Exception: UG Distribution designated observer may assist with the grounding operation.*

☐ Verify the circuit was tested de-energized	☐ Use 3-way communication and stop all unsafe acts
☐ Ensure ground source connection is a clean bare metal surface	☐ Observe only one employee at a time grounding in the proper sequence
☐ Verify employees know and maintain MAD	☐ Ensure no contact is made with TPG cables when grounding
☐ Maintain a clear line of sight of employees performing grounding	☐ Ensure TPG cables are not coiled or crossed and are away from work area

Section 3 – Circuit Voltage/Grounding Option & Method

1 - Enter the voltage for each circuit to be grounded:
2 - Enter the number that corresponds with the grounding option for each circuit being grounded below the circuit voltage: **(1)** Conductor Size. **(2)** Max. Available System Fault Currents and Clearing times [1- 2/0 TPG or 2 – 2/0 for exception circuit (Distribution), 2 – 2/0 TPGs (Transmission). **(3)** Fault Duty Mitigation. **OR** Enter the fault duty for the Maximum Fault Duty & Clearing Time, at the Work Site (Transmission) or at the SSD (Distribution).
3 - Enter the corresponding letter for the grounding method to be used below the grounding option/fault duty: **(A)** Multi-Point, **(B)** Single-Point, **(C)** Bracket Grounding Option 1 (Distribution only). **(D)** Double Open/Distribution Bracket Grounding Option 2. **(E)** Sub-Station Double Lock.

1 – Circuit Voltage (kV):	____ kV	____kV	____kV	____kV	____kV	____kV	____kV
2 – Grounding Option or Fault Duty:	____A	____A	____A	____A	____A	____A	____A
3 – Grounding Method	____	____	____	____	____	____	____

Section 4 – Initial Installation & Changes in Number of Protective Grounds

#of Grounds Initially Installed:__________ Location(s):______________________________
______________________________ Date:________ Time:_______

Location of Grounds Added: ____________________ #Added:__________
Location of Grounds Removed:____________________ #Removed:__________
Revised Total:________ Date:________ Time:_______

By:__________________ Observer:__________________ Reason for Change:______________________________

Section 5 – Final Removal of Protective Grounds

☐ All Personnel & Grounds in Clear | Total # of grounds removed:__________ | Total removed EQUALS the last total from Section 4 Yes ☐ No ☐

Confirmed By:______________________________ Date:__________ Time:__________

Signature Section

Each employee (including all contractors or others apart of job not employed by PG&E) in attendance at the tailboard briefing must sign below, verifying their understanding of the job & REQUIRED work procedures which MUST be used to mitigate the worksite hazards. If attendees do not have a Lan ID they must print their company's name. ALL Lan IDs/company name must be legible.

Signature:	LANID:	Signature:	LANID:
Signature:	LANID:	Signature:	LANID:
Signature:	LANID:	Signature:	LANID:
Signature:	LANID:	Signature:	LANID:
Signature:	LANID:	Signature:	LANID:
Supervisor Name:	**Supervisor Signature:**		**LANID:**
Review Date:	**Record Retention Removal Date:**	**Headquarters Filed:**	

The person in charge of the project is required to turn in this completed form at the end of each work period to their supervisor.

Substation Grounding Tailboard/Observer Form

Obsolete

The person in charge of the project is required to turn this completed form in at the end of each work period to their supervisor.
Discuss Section 2 with Crew and Observer. Update Section 4 as needed to record the number of grounds applied within your clearance

Person in Charge:	**Date:**	**Circuit Name & Line #(s):**
Person Reporting On:	**Grounding Observer(s):**	**Work Location/ Worksite:**
Check or Fill out all that apply	**Switch Log # :**	

SECTION 1 – GENERAL PRACTICES Distribution Transmission Overhead Underground Substation Generation.

Tap Line Clearance ☐Yes ☐No | Grounding Manual On Site ☐

- ☐ 1. Ensure PIC is reported on and each employee knows the clearance points and that each location has been verified open and tagged MOL.
- ☐ 2. Verify and discuss the fault duty of the circuit section being grounded (see Section 3 below).
- ☐ 3. Verify the type and size of grounds to be used and check their condition (are live line tool annual test stickers current, if applicable?)
- ☐ 4. Discuss the type of grounding procedure being utilized: ☐Single Point ☐Multi-Point ☐Bracket Grounding- Rubber Gloves
- ☐ 5. Discuss vehicle/equipment grounding requirements, including number of grounds to be used.
- ☐ 6. Determine and communicate the grounding source which will be utilized: (discuss any difference of potential hazards that may exist)
  ☐ Station Ground Grid ☐ Common neutral ☐ Anchor rod(s) ☐ Temporary ground rods ☐ Other
- ☐ 7. Discuss and ensure all other potential sources have been addressed (e.g., Capacitor, back feed, induction, microwave, radio tower, line crossings, differential of potential, parallel line, elevated neutral, etc.).
- ☐ 8. Communicate that the line will be tested de-energized with an approved voltage tester. ☐ AV Tester ☐ Volt Detector ☐ UG Cap test point
- ☐ 9. Review Emergency protocols in the event of an incident.
- ☐ 10. Discuss the specific locations where the ground/shunts will be installed. Include both the physical location and/or the place in the circuit.

Ground Locations (Shunts Substation and Power Gen Only):

- ☐ 11. Discuss best location(s) on structure to establish fall protection anchor point(s) while performing testing/grounding procedures.
- ☐ 12. Discuss/identify location(s) on structure to maintain Minimum Approach Distance (MAD) while performing testing/grounding procedures.

SECTION 2 – OBSERVER RESPONSIBILITIES *** Exception: UG Distribution designated observer may assist with the grounding operation.**

- ☐ 1. Verify the circuit was tested de-energized.
- ☐ 2. Ensure ground source connection is a clean bare metal surface.
- ☐ 3. Verify employees know and maintain MAD.
- ☐ 4. Maintain a clear line of site of employees performing grounding.
- ☐ 5. Use 3-way communication and stop all unsafe acts.
- ☐ 6. Observe only one employee at a time grounding in the proper sequence.
- ☐ 7. Ensure no contact with TPG cables when grounding.
- ☐ 8. Ensure TPG cables are not coiled or crossed and are away from work area.

SECTION 3 – FAULT DUTY Substation Distribution Circuits that doesn't have differential protection is considered "SLOW" See Section 5.2 Table A

If mitigating the fault current by (A) Double Open,(B) Double Lock,(C) Conductor Size or (D) T/D Section 4.2 – Option"s" 1 - 4, insert the option letter in the box listed below in the appropriate fault duty section. If option 4 is used the fault duty must be listed below.

Circuit Voltage and MAD	kV	MAD	kV	MAD	kV	MAD	kV	MAD
Maximum Circuit Fault Duty		A ☐		A ☐		A ☐		A ☐

SECTION 4 – INITIAL INSTALLATION & CHANGES IN NUMBER OF PROTECTIVE GROUNDS

Number of Grounds Initially Installed Initial Total: ______________		Date: __________________ Time:_________
Number of Grounds Added or Removed Location:	ADDED / REMOVED	ECC Notified (Power Gen Only): ___________Time: ________ Tailboard Performed ☐
By:________________________ Observer:____________________ New Total: _______________		Reason for Change:
Number of Grounds Added or Removed Location:	ADDED / REMOVED	ECC Notified (Power Gen Only): ___________Time: ________ Tailboard Performed ☐
By:________________________ Observer:____________________ New Total: _______________		Reason for Change:
Number of Grounds Added or Removed Location:	ADDED / REMOVED	ECC Notified (Power Gen Only): ___________Time: ________ Tailboard Performed ☐
By:________________________ Observer: ___________________ New Total: _______________		Reason for Change:

SECTION 5 – FINAL REMOVAL OF PROTECTIVE GROUNDS

☐ Final Walk Down Performed (Substation) ☐ All Personal Grounds / Shunts Removed ☐ All Personnel & Grounds in the Clear	Total Number of Grounds Removed: *Total removed EQUALS the last total from Section 4:* _________ Date: ____________________ Time: ____________
Person Reporting Off (include Lan ID):	**Confirmed By:**

Substation Grounding Tailboard/Observer Form

Obsolete

TD-2345M-F01

Each employee in attendance after attending the grounding tailboard briefing shall sign below, verifying their understanding of the job and required work procedures which shall be utilized to mitigate the worksite hazards.

EMPLOYEE NAME:	SIGNATURE:	LAN I.D.:

Supervisor Name: ____________________________ **Supervisor Signature:** ______________________

LAN I.D.___________ **Review Date**______________

Maintain this record in the PIC field folder at the headquarters of the PIC
Headquarters Filed__________________________

Record Retention Removal Date_______________________

Remove Record from File 5 Years from Start Date

Note: If the scope of the job changes, document and re-tailboard: (scope changes require new tailboard form.)

____

____

____

____

____

Protective Grounds Tracking Log

Extended Grounding Tracking Log – INITIAL INSTALLATION & CHANGES IN NUMBER OF PROTECTIVE GROUNDS

Number of Grounds Added or Removed Location: By:______________________ Observer:____________________New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only); Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:
Number of Grounds Added or Removed Location: By:______________________ Observer:____________________New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only) ; Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:
Number of Grounds Added or Removed Location: By:______________________ Observer:____________________New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only) ; Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:
Number of Grounds Added or Removed Location: By:______________________ Observer:____________________New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only) ; Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:
Number of Grounds Added or Removed Location: By:______________________ Observer:____________________ New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only) ; Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:
Number of Grounds Added or Removed Location: By:______________________ Observer:____________________New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only) ; Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:
Number of Grounds Added or Removed Location: By:______________________ Observer:____________________New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only) ; Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:
Number of Grounds Added or Removed Location: By:______________________ Observer:____________________New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only) ; Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:
Number of Grounds Added or Removed Location: By:______________________ Observer:____________________New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only) ; Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:
Number of Grounds Added or Removed Location: By:______________________ Observer:____________________New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only) ; Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:
Number of Grounds Added or Removed Location: By:______________________ Observer:____________________New Total: ________________	ADDED / REMOVED	ECC Notified (Power Gen Only) ; Date:______________Time: ________ Tailboard Performed ☐ Reason for Change:

Obsolete

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APPENDIX C:

UNDERGROUND IDENTIFICATION TOOLS AND DEVICES

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1 Cable Identification Tools

1.1 PTC-2 Hipotronics – Phase Tracer

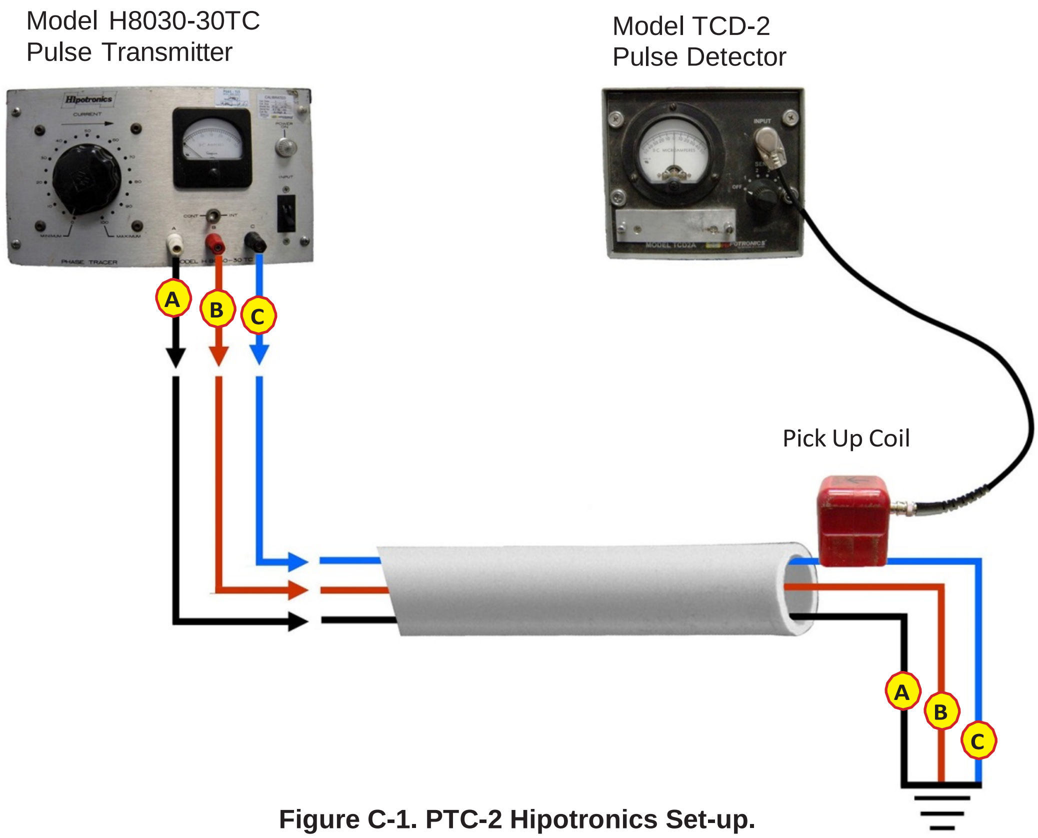

Figure C-1. PTC-2 Hipotronics Set-up.

- Device can be used on all types of underground cable.
- Requires 120V source to operate.
- Read and understand manufacturer's instructions.
- Ground the presumed sources.
- Install transmitter leads on one end of the grounded cable and then remove these grounds. If grounds cannot remain installed during this task, Class 2 rubber gloves with approved protectors must be worn while installing the leads.
- Leave ground(s) on all conductor(s) at the opposite end of the cable run from the transmitter. See Figure C-1 above.
- Turn transmitter on and use pick-up coil at worksite to identify correct cable(s) to be spiked. Mark the cable(s) for future reference.
- Spike cable at worksite.
- Install grounds, as required, before commencing work.

1.2 VCI-3 — Voice Cable Identification System

- Device can be used on all types of underground cable.
- The VCI-3 is battery operated.
- Read and understand the manufacturer's instructions.

1. Transmitter Operation

Figure C-2. VCI-3

a. Turn the instrument on by pressing the I/O key.

b. Press and hold the REC key. Record a vocal message while speaking from a maximum of 12 inches away from the speaker/microphone and holding the REC key depressed.

c. Release the REC key. The recorded message should be played back a few seconds later. After approximately 2 minutes the voice recording mutes locally to conserve battery.

d. Connect either the magnetic sensor clamps or alligator clips, whichever is required.

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1.2 (continued)

2. Installation of Transmitter Using Magnetic Sensor Clamps

a. Install the induction clamps over an unshielded part of the cable (below the concentric neutral or tape shield). Clamps can also be installed on cable heads, directly on ground returns, or directly on portable grounds.

b. Install each clamp with the arrow pointing in the same direction, towards the worksite (see Figure C-3 below).

Figure C-3. Induction Clamp

c. Install the clamps according to the order of the phases already identified, if known; otherwise install them in the most logical order.

d. Proper operation requires that the ground leads of the 3 cables are connected together. This will assure that all resistance values are identical. Connections must be relative to ground and not relative to another phase.

1.2 (continued

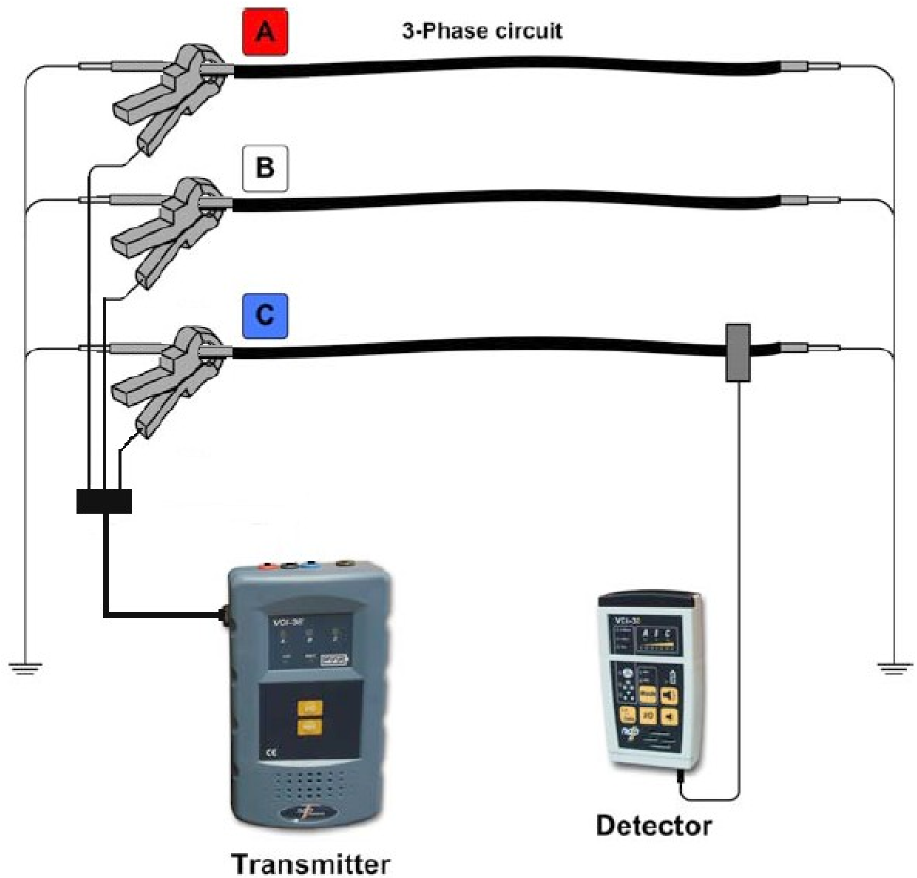

Figure C-4. Clamp-On Method.

3. Installation of Transmitter using Direct Mode (alligator clips)

a. Install the alligator clips on bare conductor.

- Install the clips according to the order of the phases already identified, if known; otherwise install them in the most logical order.
- One option is to disconnect the grounds from the ground bus and attach the clips to ground heads, insuring they are kept separate and insulated from each other (rubber blanket).

b. Ground only the end of the cable opposite the Transmitter, unlike the Magnetic Sensor Clamp mode.

c. Proper operation requires that the ground leads of the 3 cables are connected together. This will assure that all resistance values are identical. Connections must be relative to ground and not relative to another phase.

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1.2 (continued)

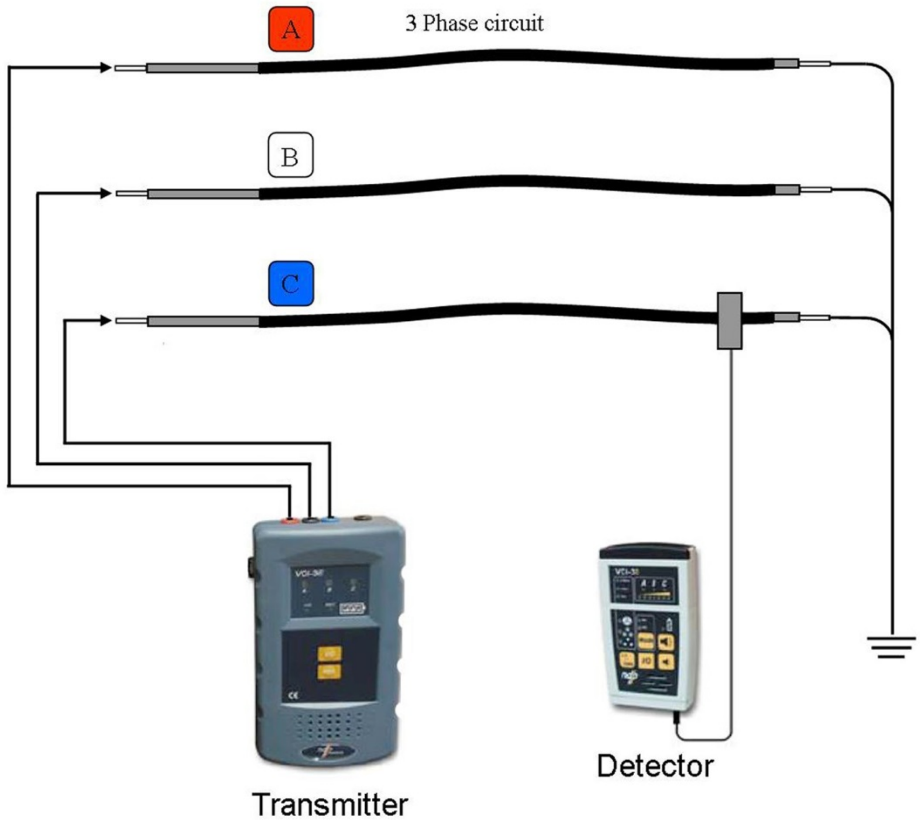


Figure C-5. VCI-3 Direct Connect Method.

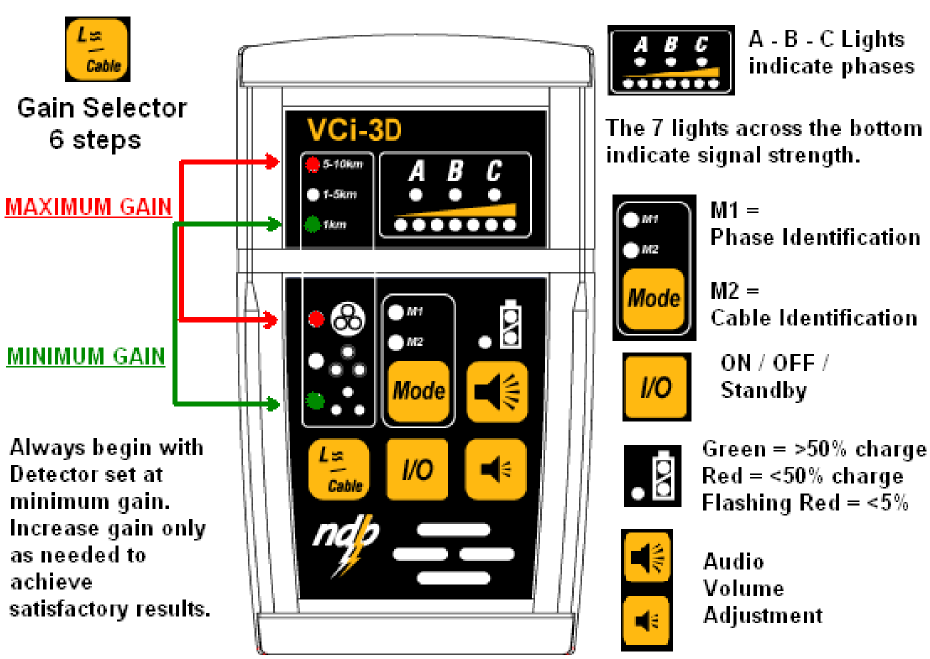


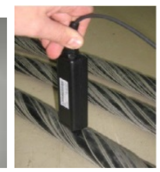
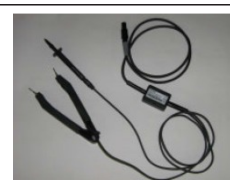
Figure C-6. Close-Up.

1.2 (continued)

4. Detector Operation for Cable Identification.

a. Attach one of the four option probes to the Detector, prior to turning the detector on (see Table C-1 below).

Table C-1

1	Clamp type sensor	
2	Straight probe for common 1/C cables. Probe must be positioned in-line with cable to be identified.	 
3	V-shaped differential probe for tripolar shielded cables, PILC 3/C type cables. (Most sensitive probe.)	
4	Compass probe for open-ended cables. The red probe is associated with the identifying phase.	

b. Turn on the detector; push the I/O key once to put the instrument in standby mode, the I/O indicator will flash.

c. To start detection, push the I/O key a second time, the I/O indicator remains lit.

d. Ensure detector is set on minimum gain setting.

e. Place the detector probe on the cable to be identified and wait a few seconds.

- Place the probe in the proper cable orientation, per Table C-1 above.
- The switch located on the probe allows a signal boost when detection is required on shielded cables such as on lead PILC type cables.

f. Increase the gain incrementally by pushing the L=/Cable as needed to receive a satisfactory signal.

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1.2 (continued)

CAUTION

Use the appropriate length of cable setting, as setting the detector on maximum can cause false signals.

Avoid over-gaining the unit, i.e., setting the detector on max gain, signal saturation, when not required.

g. Cable Detection / Phase Indicator LEDs are in two groups: Identification (upper 3 LEDs, green – yellow – red) and signal strength (7 LEDs, all yellow).

- Individual corresponding A-B-C LEDs will light for phase identification, while all A-B-C LEDs light to confirm cable identification. Signal strength is indicated by the 7 yellow lights. One lit LED represents a signal at the limit of detection, while seven lit LEDs equals a signal that is saturated. Adjust the gain accordingly.

h. The indicator corresponding to the phase will light once the phase is detected in M1 mode or all 3 will light if in M2 mode to identify cable. A sound will be generated (four tones).

i. Afterwards the system returns to standby mode until the I/O key is pushed again.

j. To turn OFF the instrument, push the I/O key until two tones can be heard.

5. Install grounds as required before commencing work.

2 TGRAM[1] and TGRAL[2] Oil Switches

2.1 Installing Grounds

1. Ensure that all the switches associated with the circuit section to be cleared are in the "OFF" or "OPEN" position.

2. Place protective barrier on the switch, covering the test bushings. Refer to TD-2908P-01, "Distribution Switching Procedures."

3. Shine a flashlight in the inspection window. Visually ensure that the contacts of the internal test-ground bushing are clear.

4. Visually ensure that the test-ground bushings are not grounded.

5. FOR TGRAL SWITCHES ONLY, remove the nonmetallic bushing covers that protect the test-ground bushings. Using a hot stick and rag, clean the test bushings and ensure they are free of contaminates.

WARNING

Test ground bushings may be energized.

6. Disengage the appropriate stop block by removing the padlock, pulling the pin, and rotating the stop block to one side. This provides a space for the handle of the switch being grounded when the switch is moved from the "OFF" to the "Test Ground" position.

7. Place the switch to be grounded in the "Test Ground" position.

8. Test the test-ground bushing de-energized using an approved voltage detector.

9. Install grounds on the test-ground bushings as depicted in the following figures.

   a. Figure C-7, "TGRAM with Adjustable-Head Ground Clamps Installed on the Test-Ground Bushings" on Page C-9.

   b. Figure C-8, "Standard Ground Clamp Installed on a TGRAL With the Test-Ground Outlet's Bushing Lug Removed" on Page C-9.

      - Attach the clamp end of the adjustable-head grounding jumpers to an approved ground source.

      - Attach adjustable-head grounding jumpers to the test-ground bushings.

10. Use the standard ground clamp when the test-ground outlet's bushing lug has been removed from a TGRAL switch, as shown in Figure C-8 on Page C-9.

[1] Test Ground Rocker-Arm Main
[2] Test Ground Rocker-Arm Line

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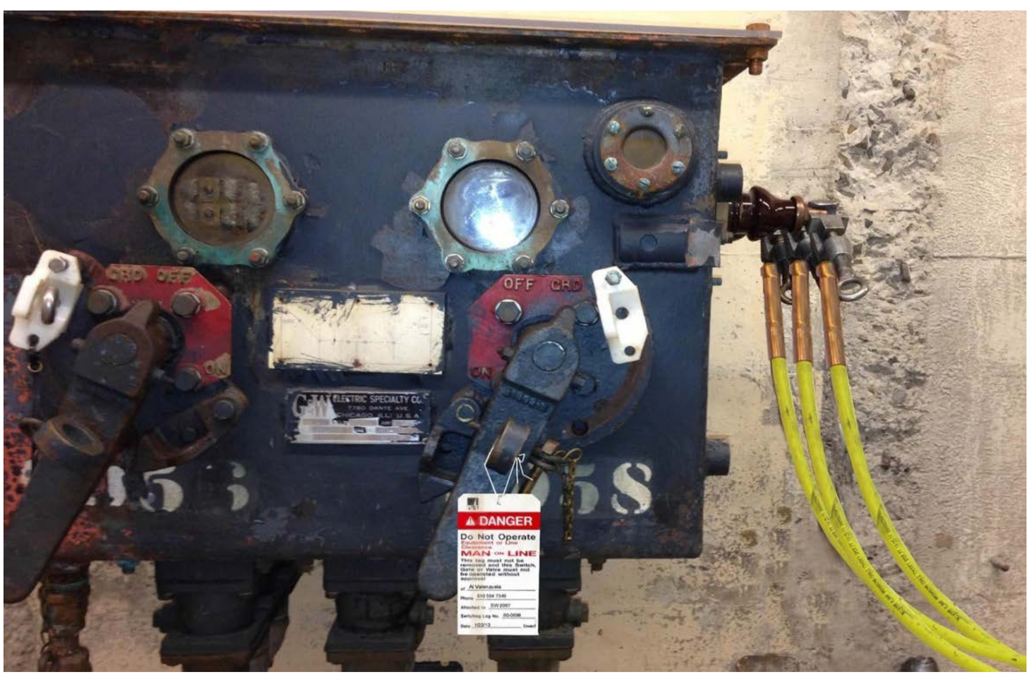
2.1 (continued)

Figure C-7. TGRAM With Adjustable-Head Ground Clamps Installed on the Test-Ground Bushings.



FigureC-8. Standard Ground Clamp Installed on a TGRAL with the Test-Ground Outlet's Bushing Lug Removed.

2.2 TGRAM and TGRAL Oil Switches — Removing Grounds

1. Ensure the switch is in the “Test Ground” position.
2. Remove the grounds from the test-ground bushings.
3. Ensure that the stop block is blocking the ON/CLOSED position to prevent accidental closing.
4. Place the switch in the OFF/OPEN position.
5. Re-engage the Test/Ground stop block by rotating it back to its blocking position. Then reinstall the pin and the padlock.
6. Test the test-ground bushings de-energized using an approved voltage detector.
7. FOR TGRAL SWITCHES ONLY, reinstall the nonmetallic bushing covers.

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3 Grounding Fused, D&W Type Underground Cutouts

3.1 Special Procedures and Precautions

Take the following special procedures and precautions when working on the load side of fused, D&W cutouts (SEE Figure C-9 below).

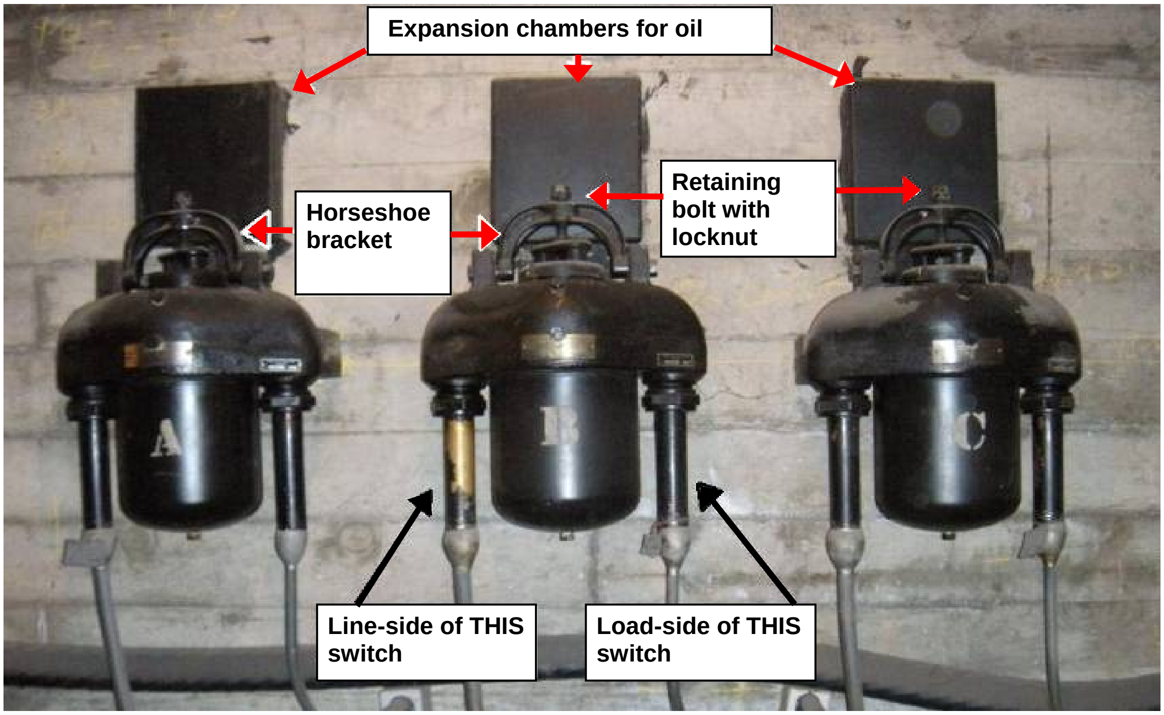

Figure C-9

1. Source side switches, disconnects or separable connectors must be utilized for de-energizing 12kV, D&W type cutouts prior to operation.

2. Only trained qualified electrical workers are authorized to operate 4kV fused, D&W type, cutouts energized. They must understand the hazards related to the operation and understand the purpose and results of the switching operation being performed.

3. IF source side switches or separable connectors are not available or practical,

   THEN follow the procedures in Sections 3.2 and 3.3 for 4kV D&W cutouts only.

4. D&W cutouts do not contain provisions for testing the line side or the load side cables energized or de-energized without following special procedures in Section 3.2 on Page C-12.

NOTE
Consider the use of source side clearance points in lieu of utilizing the D&W cutouts as a clearance point.

Obsolete

3.2 Instructions for Installing the 4kV Grounding Bushing (SEE Figure C-10 below)

Figure C-10. Typical 4kV Grounding Bushing

1. Before use, INSPECT the 4kV grounding bushing for cracks, contaminants, missing parts, etc.

2. WEAR appropriate personal protective equipment (PPE), including approved 100 cal. switching suit, safety glasses and Class 2 rubber gloves with approved protectors.

3. LOOSEN the lock nut and retaining bolt.

4. ROTATE the fuse holder in the D&W cutout into the "Off" (open) position.

5. LOOSEN the retaining bolt and lower the horseshoe bracket (SEE Figure C-9 on Page C-11).

a. CHECK the retaining bolt to ensure the bolt is fully withdrawn; otherwise the grounding bushing will not fully rotate to the "On" (closed) position (Figure C-11 below).

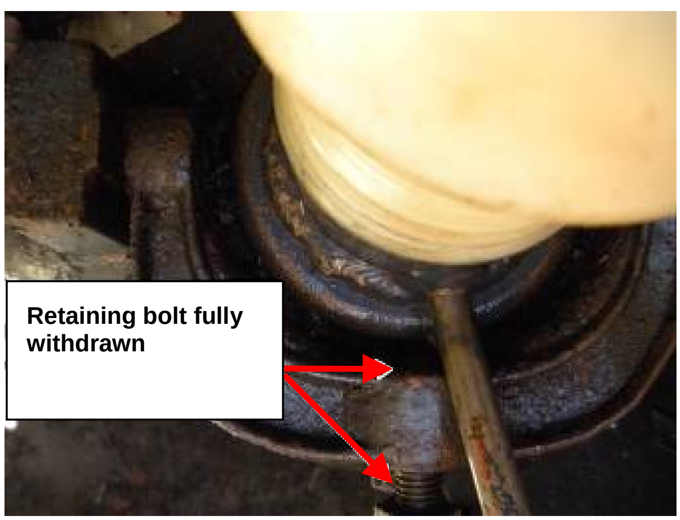

Figure C-11

6. REMOVE the fuse and holder, CONTAIN any excess oil with clean dry rags, AND PLACE the fuses in a clean plastic bag.

3.2 (continued)

7. ENSURE that the internal contact link is mounted on the proper side of the grounding plug in order to make contact with the cable intended to be grounded.

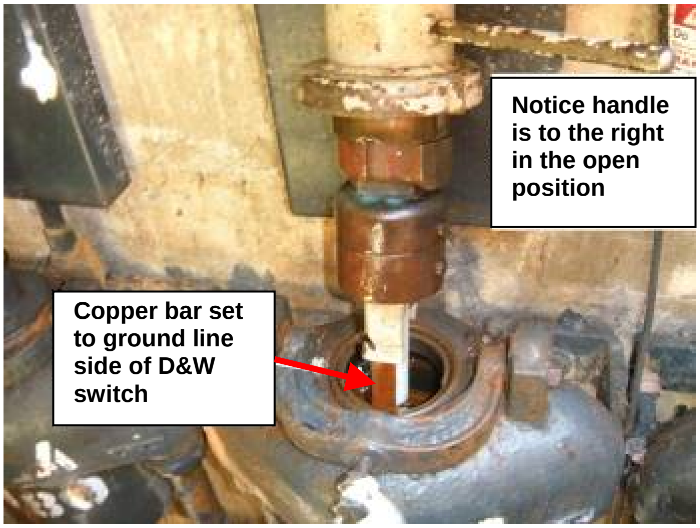

Figure C-12

8. To reposition the copper bar, LOOSEN the retaining knurled and hex nuts, position the bar on the correct side to be grounded and retighten the nuts (SEE Figure C-13 below).

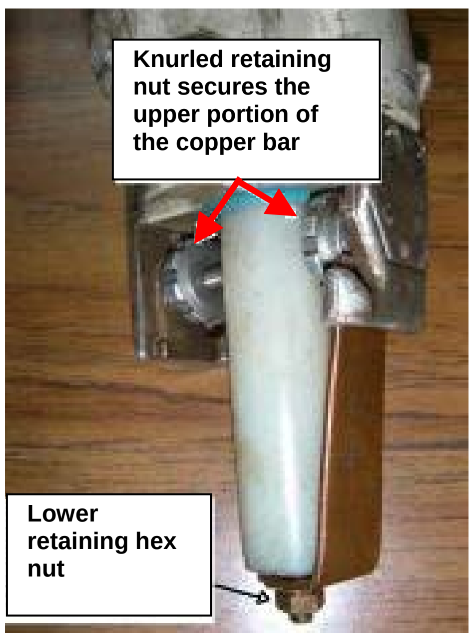

Figure C-13

9. Carefully INSERT the 4kV grounding bushing with the handle pointing to your right in the "Off" (open) position. This is the only way that it will drop into the switch housing; in the open position.

10. Carefully LOWER the bushing down into the switch until it comes to a rest and is flush with the top of the switch.

3.2 (continued)

11. IF space does not allow you to insert the Grounding Bushing as one complete unit,

THEN you MAY INSERT the lower half. Then place the upper half onto the lower, using a shotgun (SEE Figure C-14 below).

Figure C-14

12. ROTATE the 4kV grounding bushing to the "On" (closed) position (SEE Figures C-15 and C-16 below and Figure C-17 on Page C-15).

Figure C-15. "Off" Position (Open)

Figure C-16. "On" Position (Closed)

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3.2 (continued)

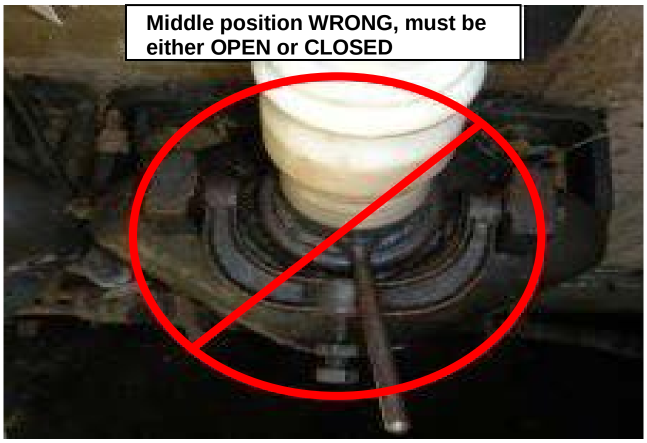

Figure C-17. Incorrect Position

13. To verify the copper bar is in the correct position, ATTACH an approved voltage detector to an approved Live Line tool AND TEST the metal rod at the top of the Grounding Bushing de-energized (SEE Figure C-18 below).

Figure C-18

3.3 Installation and Removal of Grounds

To install or remove Grounds, FOLLOW the approved method of testing and grounding procedures, per the PGM, Section 6 (SEE Figure C-19 below).

Figure C-19