EVERSOURCE	TD703 Revision 7 **Temporary Protective Grounds for Personnel Protection in Substations**		
TD PROCEDURE			
Issue Date: 03/08/2017	**Effective Date:** **03/08/2017**	**Owner Department**: Station Operations **Subject Matter Expert:** Jorin Grori	**Applicability:** CT, Western MA, NH

All changes to TD procedures are controlled by TD 001
"Writing, Revising, and Publishing Transmission and Distribution Procedures."

This procedure replaces and supersedes the following procedures (in whole or in part), as described in Section 3 "Summary of Changes":

- TD703,"Temporary Protective Grounds for Personnel Protection in Substations", Rev. 6 dated 12/21/2015

Roll Out Instructions:
Prior to initial use of this procedure, each individual using this procedure is required to attend training on this procedure delivered during Bi-Monthly Safety Meeting or similar.

Approvals:

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Procedure applicable only to states for which an approval signature appears above.

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1. INTRODUCTION

1.1 Objective

This procedure covers the safe work methods to protect workers from voltages and currents that might develop at a de-energized worksite within a substation, during operation, maintenance and construction of Eversource's lines and equipment. The development of a Single Point Ground to establish an Equipotential Zone (EPZ) for personal protection is the primary work method covered by this procedure; however the use of insulation or isolation work methods may be used as an alternative when approved by Eversource management, safety and engineering in some isolated incidences.

1.2 Applicability

This procedure is applicable to Eversource- CT, Western MA and NH electric personnel involved in Construction, Repair, or Maintenance of Substation Equipment.

1.3 References

Unless otherwise specified:

- Forms are available through Lotus Notes Forms Catalog or Forms Catalog on the intranet.

Procedures are available in the:

- Lotus Notes Field Documentation Database
- Lotus Notes Regulated Businesses Policies & Procedures database
- Distribution Engineering Standards Bookshelf

Development References
Documents used to develop this procedure and the process it controls:

- TD 001 "Writing, Revising, and Publishing TD Procedures"
- ASTM F 855-15, "Standard Specifications for Temporary Protective Grounds to Be Used on De-energized Electric Power Lines and Equipment"
- ASTM F 2249-03, "Standard Specification for In-Service Test Methods for Temporary Grounding Jumper Assemblies Used on De-Energized Electric Power Lines and Equipment
- IEEE C2-2012, "National Electrical Safety Code"
- IEEE 80-2000, "IEEE Guide for Safety in AC Substation Grounding"
- IEEE 1246-2011, "IEEE Guide for Temporary Protective Grounding Systems Used in Substations"
- U.S. Bureau of Reclamation Facilities Instructions, Standards, and Techniques (FIST) Volume 5-1, "Personal Protective Grounding for Electric Power Facilities and Power Lines", July 2005
- 29CFR1910.269(n), "Grounding for Protection of Employees"

- 29CFR1926.954, “Grounding for Protection of Employees”

Supporting References
Documents that support performance of activities directed by this procedure:

- Employee Safety Manual
- Eversource System Material Standards
- Eversource System Tool and Equipment Standards
- TD 211 “When to Wear Arc Rated Flame Resistant Clothing”
- TD 216 "Hot-Sticks Used in Lived Line Operations (Maintenance, Inspection, and Testing)”
- TD 800, “Switching and Tagging”
- TD 852, “Lockout/Tagout: Electrical Equipment and Other Equipment Related Energy Sources”
- TD 855, “Grounding for Personal Protection on Overhead Distribution Lines”
- TD 858, “Testing of Temporary Protective Grounds”
- SH 6051, "Test Method For Temporary Protective Grounding (TPG) Assemblies" (PSNH only)
- M8-MT-3003 “Temporary Protective Grounding for Personal Protection on Overhead Lines, 23 kV and Above”
- Transmission Supervisor Briefing Sheet SBST-06-09, “Revision to Substation Access Training Requirements”

Supporting Programs and Databases
Programs and databases that support performance of activities directed by this procedure:

- None

1.4 Discussion

The electric utility industry has three accepted work methods allowing qualified employees to work within the Minimum Approach Distance (MAD) of energized or de-energized lines and equipment. They are:

- Insulation
- Isolation
- The use of Personal Protective Grounding

Insulation - Workers can insulate themselves from any possible potential difference between lines and equipment, and ground using insulated rubber gloves, insulated tools, and insulated platforms (live-line bare-hand work method).

Isolation - Workers can use the isolation method when working on lines and equipment by first grounding the lines and equipment using an approved method, then removing the grounds and isolating the lines and equipment (ground, isolate then remove grounds). To use the isolation method, the lines and equipment must have:

- Been de-energized under the provisions of the applicable Switching Authority (PSNH SH-6054 - T&D Switching and Tagging, or TD-800 Switching and Tagging).
- No possibility of contact with another energized source.
- No hazards of induced voltage possible.

NOTE

The isolation method may be an acceptable work method in some isolated incidences; however approval from Eversource's management, safety and engineering is required to use the isolation method within substations.

Personal Protective Grounding - Workers can install personal protective grounding at the work site to limit the voltage difference between any two accessible points within the work site to a safe value.

Personal protective grounding limits the voltage difference between any two accessible points within the work site to a safe value if the lines or equipment being worked is accidentally re-energized. Personal protective grounding also provides a means for fault current to flow during accidental re-energization, allowing protective devices to trip. An additional function of personal protective grounding is to protect workers from the potential development of electric field induction and magnetic field induction.

Single-Point protective grounding establishes an Equipotential Zone. Single-Point protective grounding requires personal protective grounding equipment to be installed in a way that limits the voltage difference between any two accessible points within the work site to a safe value, if the lines and equipment being worked is accidentally re-energized.

1.4.1 Temporary Protective Grounds

Temporary Protective Grounds limit the voltage rise at the work site to a safe value in those cases where the equipment or line being worked upon is accidentally energized. They also provide a means for fault current to flow in case of accidental energization, allowing upstream protective devices to trip. An additional function of protective grounds is to protect against capacitive or inductively coupled voltage from adjacent parallel energized lines or capacitive coupled voltage from adjacent equipment.

NOTE

When working on Gas Insulated Switchgear, refer to TD-800 Switching and Tagging for dispatching of permanently installed ground switches.

1.4.2 Personal Protective Grounding Equipment

- Specified by Eversource has been chosen based on Eversource engineering fault current and clearing time studies. Refer to Attachment 3 for grounding cable fusing limitations.

- SHALL be visually inspected before use. This includes visually checking the grounding assemblies for broken or loose fittings, and chafed or cut insulation. The grounding clamp jaws shall be clean and the cable ferrules check for tightness each day before use. The grounding clamp jaws should be wire brushed before each use. If any damage is found, repair or replace the grounding assembly. Temporary protective grounding equipment shall be kept clean and in approved bags.

- SHALL be tested for resistance every two years. Temporary protective grounding equipment subjected to fault current shall be removed from service, inspected for damage and tested to determine if any part of the grounding assembly has been damaged. If any part is found damaged, the entire ground assembly shall be discarded.

1.4.3 Mechanical and Electrical Capabilities

Temporary Protective Grounds must have adequate electrical and mechanical capacity to withstand the maximum available fault current for the full time over which that current may be encountered, i.e., fault-clearing time. All temporary protective grounding equipment shall be rated at grade 5, or higher, as specified in ASTM F855, and constructed using 4/0 AWG copper grounding cable, threaded ferrules and appropriate grounding clamps. Only Eversource approved temporary protective grounding equipment SHALL be used when grounding Eversource equipment.

CAUTION

Any temporary ground assembly subjected to fault current meeting or exceeding it's Withstand Rating shall be discarded (Refer to Attachment 3).

1.4.4 Grounding Attachment Points

All Personal Protective Grounding Procedures used within Eversource substations, shall use the substation ground grid as the ground source. All new steel structures and a number of existing steel structures, within Eversource substations, have been installed or retrofitted with specific ground connection point(s). These ground connection points, if using individual phase grounding per Attachment 5, are located to accommodate eight (8) foot or twelve (12) foot grounding assemblies, and are connected to the substation ground grid.

Substation steel structures, that have not been retrofitted, can be upgraded using commercially available threaded stud grounding sockets. These grounding connection points must be connected to the substation ground grid with 4/0 copper cable. Where specific grounding connection points are not available, grounding assemblies shall be connected to a single stub connected to the ground grid.

Some Eversource substations have fault current levels and clearing times which may exceed the maximum withstand rating of a single 4/0 ground assembly. When personal protective grounding methods are used in these identified substations, two 4/0 grounding cables per phase are required (Refer to Attachment 4), they shall be of equal length, size and grounding components and be physically connected as close to each other as practicable to minimize the effects of circulating currents.

NOTE

Where physical clearances allow, use of the phase-to-phase grounding practice is recommended to further reduce the effects of circulating currents when using two cables per phase.

1.4.5 Ground Assembly Cable Length

Two standard lengths for grounding cable have been selected for use in those substations where grounding attachments are installed if using the individual phase grounding per Attachment 5:

- Twelve-foot lengths are for 345 KV systems
- Eight-foot lengths on 115 KV and below systems

Three important factors contribute to the determination of grounding-cable lengths:

- Minimizing cable slack reduces the severe and dangerous cable movements which can result from the forces developed by fault currents.
- Shorter cables reduce the cable weight workers must handle.
- Shorter cable length reduces the electrical resistance and thus lessens the voltage drop across the grounding cables.

There are, however, locations where grounding attachments have not been installed or the physical arrangement of a substation makes it impossible or impractical to use the standard cable lengths. For these locations, longer cables may be prepared whose length shall not exceed thirty (30) feet. Care must be taken to securely tie the cables to the structure to minimize cable movement under fault conditions. The limitations for length of grounding cable apply to all grounds including those for vehicles. Under no circumstance should ground assemblies be coiled while in use.

NOTE

There may be circumstances requiring Temporary Protective Grounds in excess of thirty (30) feet. In these instances, double 4/0 grounds are required to minimize exposure of personnel to excessive step- or touch-potential. Cables used under these circumstances shall not exceed fifty (50) feet. **IF double 4/0 grounds are required for current-carrying capabilities per** Attachment 4 **cables greater than thirty (30) feet in length SHALL NOT be used.**

CAUTION

Under no circumstance should ground assemblies be coiled while in use.

1.4.6 Grounding Method (Refer to Attachment 1)

Obtain a clearance as specified in Eversource's Clearance and Switching Procedures.

Using an Eversource approved voltage detector, test the phase conductors to ensure they are de-energized .

Wire brush the ground connection point. Wire brush the location on the conductor where the conductor end of the grounding assembly will be installed using a wire brush on a proper length live-line tool.

Install one end of a proper length grounding assembly to the ground grid connection point at or as close as possible to the work site. Install the other end of grounding assembly to the phase conductor using live-line tools at or as close as possible to the work site. If the work will require, or it could be expected that workers could enter the MAD of the ungrounded phase conductor(s), the other phase conductor(s) shall also be grounded.

Remove grounding jumpers after the work is complete in the reverse order.

This procedure recognizes the Single Point as the accepted grounding method that should be used to establish a safe work environment. It is required that whenever work is performed on substation equipment, all three phases of the equipment to be worked on shall be removed from service and grounded in accordance with this method. Single-point grounding refers to the application of a single set (one- or two- per phase, as required per Attachment 4) of temporary protective grounds installed in the immediate vicinity of the equipment on which work is to be performed.

1.4.7 General Requirement

When lines and equipment that were energized, or may be energized, at over 50 volts are removed from service for operation, maintenance or construction, they SHALL be considered energized until a clearance has been issued and the lines and equipment have been TESTED AND GROUNDED AS SPECIFIED IN THIS PROCEDURE or if less than 600V as specified in TD 852, "Lockout/Tagout: Electrical Equipment and Other Equipment Related Energy Sources".
Conductors and devices SHALL be tested and grounded only after proper clearances have been issued as specified the appropriate Switching Authority procedures (PSNH SH-6054 - T&D Switching and Tagging, or TD-800 Switching and Tagging). An Eversource approved voltage detector, rated for the system voltage, shall be used to verify the line or equipment is de-energized.
Do not ground through fuses, power circuit breakers, switches, power transformers and other types of devices.

When working on Gas Insulated Switchgear, refer to TD-800 Switching and Tagging procedure for dispatching of permanently installed ground switches.

2. INSTRUCTIONS

Prior to the start of any work:

- Ensure that all employees are properly trained and qualified to perform this work, and that all appropriate PPE and safety requirements are met, including but not limited to those defined in the following documents:
  - TD211, "When to Wear FR Clothing"
  - Eversource Employee Safety Manual.
- Job Setup includes preparing work zones and defining requirements for various jobs as necessary. All arrangements should be completed or setup prior to beginning the job. Setup tasks include scheduling for switching, if applicable.

2.1 Ground Assembly Clamps

Supv. – TS Const. & Maint.

Supv. – S/S Const. & Maint.

Supv. – Substation Operations

2.1.1 SELECT grounding clamps appropriate for the particular work site. The following is a selection of standard clamps approved for use by Eversource personnel (a complete listing is available in the Eversource System Tool and Equipment Standards):

- All-Angle Clamp
  - Stock Code 0188789, for switchgear-grounding studs and conductor sizes up to 954 kcmil ACSR (1.2" O.D.)
  - Stock Code 0188786, for conductor sizes up to 2-1/2 IPS (2.88" O.D.)
- Bus Clamp
  - Stock Code 0188791, for conductor sizes up to 4.5" O.D.
  - Stock Code 0436298, for conductor sizes up to 6-3/8" O.D. (can accept two 4/0 ground cables for high current applications)
- C-Type Clamp
  - Stock Code 0142987, for conductor sizes up to 2" O.D.
  - Stock Code 0436288, for conductor sizes up to 2" O.D.
  - Stock Code 0436260, for conductor sizes up to 3" O.D (can accept two 4/0 ground cables for high current applications)
- Flat-Face Clamp
  - Stock Code 0187884, for flat bus or structural steel sizes up to 1-1/2" thick.
  - Stock Code 0188455, T-handle, for structural steel or grounding conductor sizes up to 1-1/2" thick, <u>ground end only</u>.

- Socket Clamp
  - Stock Code 0184279, for 1" diameter ball stud.
  - Stock Code 0188220, for 1" diameter ball stud.
  - Stock Code 0436295, T-Handle, for 1" diameter ball stud, ground end only.

2.2 Assembly of Temporary Protective Ground(s) using Eversource Standard Components

Assigned Qualified Employee

NOTE

A selection of standard components approved for use in Substations by Eversource personnel are described in Appendix I. Additional components may be added to the System Tool and Equipment Standards as they become available. Other components may be used by non-Eversource personnel if they can be demonstrated to meet the performance requirements of Section 1.4.2.

2.2.1 SELECT ferrule appropriate for clamp to be used.

NOTE

Ferrules are normally supplied with an internal coating of conductive grease. If this is not present, apply a light coating of corrosion-resistant conductive grease (**s/c 0183394**) to the interior of the barrel

2.2.2 CUT copper grounding cable to desired length.

2.2.3 STRIP insulation from conductor approximately 1-1/2 to 1-3/4 inches from end of cable.

NOTE

This will provide a gap between the insulation and ferrule for inspection of the conductor after assembly (Refer to Appendix I, Figure I-1).

2.2.4 INSERT conductor within the ferrule so that the strands are visibly past the inspection hole, twisting in the direction of the cable lay as necessary.

2.2.5 APPLY first crimp to ferrule crimp-barrel below inspection hole allowing sufficient room for second crimp (see Appendix I, Figure I-1), using Burndy Y35 Crimping tool and appropriate die (ref. Appendix I) or company approved equivalent.

2.2.6 INSPECT to ensure cable conductor remains visible within ferrule inspection hole.

NOTE

If conductor is not visible within ferrule inspection hole, ferrule must be cut off and discarded.

2.2.7 ROTATE ferrule 90° in crimping tool jaw and APPLY second crimp.

2.2.8 INSPECT to ensure cable conductor remains visible within ferrule inspection hole.

NOTE

If conductor is not visible within ferrule inspection hole, ferrule must be cut off and discarded.

2.2.9 APPLY a five- to six-inch section of heat shrink tubing over ferrule crimp barrel and cable, ensuring ferrule inspection hole is completely covered.

2.2.10 TEST Temporary Protective Ground per Section 2.3.

2.3 Inspection, Maintenance and Testing of Temporary Protective Grounds:

Supv. – TS Const. & Maint

Supv. – S/S Const. & Maint

Supv. – Substation Operations

2.3.1 ENSURE that cables are properly sized. ASTM F 855 size 4/0 AWG copper cable shall be used in all Eversource substations supplied at any voltage.

2.3.2 ENSURE that:

- Cables are properly terminated with compression ferrules (see Section 2.2).
- There are no soldered-ferrule terminations, solder-bonded-open-stranded terminations, or broken, frayed or discolored stranding.
- The cable is not kinked, twisted, scuffed, or cut.
- The ground-clamp serrated jaws, clamping-jaw pins, and operator operate properly and are not excessively worn.
- Clamps at both equipment or bus end and grounding end are properly rated for use (i.e., ASTM F 855 Grade 5 or higher).
- Grounding-cable connection to grounding clamp is tight.
- Stick-type units are clean and without cracks. Test, if necessary (Refer to **TD 216**).
- The Temporary Protective Ground assembly has a label indicating that it has been tested within 2 years in accordance with TD858.

2.3.3 REPAIR or REPLACE immediately any grounding cables that are not compliant with Section 2.3.1 and 2.3.2

2.3.4 TEST any new, repaired, modified or suspect Temporary Protective Ground using a company approved test set in accordance with manufacturer's instructions or as otherwise required per applicable company procedures.

2.4 Practices for Attaching Temporary Protective Grounds on Electrical Equipment.

NOTE

Under no circumstances shall temporary protective grounds be applied until the conditions of the switching authority having jurisdiction have been met.

Assigned Qualified Employee

2.4.1 General (to be used for any practice):

a. INSPECT all temporary protective ground assemblies to be used (See Section 2.3).

b. TEST for no potential at exact locations where temporary protective grounds are to be installed, using an Eversource-approved testing device appropriate for the normal operating voltage (Refer to Attachment 6).

CAUTION

If any Potential test indicates that potential is present, immediately STOP all work and contact the Authority having Jurisdiction (e.g., CONVEX, ESCC, SOC, etc.) to determine the source of potential. *Work shall not proceed until all sources of potential are identified.* If potential has been determined to be result of induction, performing single point grounding will mitigate the issue.

c. CLEAN structural grounding stud with serrated edges of grounding clamp by manipulating the clamp, or with a stiff wire brush. If the connection is made directly to the substation ground grid, CLEAN the wire with a wire brush rather than the serrated jaw of the clamp. If grounding to steel structure, ENSURE that steel surface is properly cleaned.

NOTE

Live-line tools shall be used whenever Temporary Protective Ground(s) are being applied or removed for equipment grounding purposes. (*Exception*: When attaching or detaching a T-handle clamp, Class 2 or higher-rated rubber gloves shall be used.)

NOTE

A T-Handle ground clamp can not be utilized on a grounding stud, bus, or cable terminal on the first phase or any other phase. A T-Handle ground clamp can only be used on a ground end source unless a live-line tool is being utilized to install and remove the T-Handle clamp.

Tightly ATTACH the grounding clamp to the structural grounding stud, or ground-grid wire, or steel structure.

NOTE

When attaching directly to structural steel or ground-grid wire, grounding clamps shall be physically placed as close together as possible to minimize circulating current effects.

d. TIGHTEN the ground clamp locking bolt.

e. CLEAN equipment-grounding stud, bus, or cable terminal with serrated edges of the grounding clamp by manipulating the clamp or using a wire brush with a live-line tool.

f. *Tightly* ATTACH the grounding clamp to the equipment-grounding stud, bus, or cable terminal.

CAUTION

Ensure that temporary protective grounds are not coiled in any manner when installed. Slack cable shall be restrained or supported to prevent excessive movement under fault conditions.

2.4.2 Individual-Phase Grounding Practice

NOTE

Individual-phase grounding uses cables to connect each phase to the ground terminal separately (Refer to Attachment 5, Figure 1).

a. Connecting Grounds

CAUTION

Test for no potential on ALL phases prior to applying any ground(s).

1) First: ATTACH one end of each grounding cable to ground.

2) Second: ATTACH the other end of each cable to the equipment-grounding point of each of the three phases.

b. Removing Grounds

1) First: REMOVE the equipment-grounding connections.

2) Second: REMOVE the grounding terminal connections.

2.4.3 Phase-to-Phase Grounding Practice

NOTE

Phase-to-Phase grounding uses cables to connect ground-phase-phase-phase (See Attachment 5, Figure 2).

a. Connecting Grounds

CAUTION

Test for no potential on ALL phases prior to applying any ground(s).

1) First Cable: ATTACH one end of the cable to a ground end source. ATTACH the other end to the nearest phase to be grounded.

2) Second Cable: ATTACH one end of this cable to the first phase grounded. ATTACH the other end of this cable to the second phase to be grounded.

3) Third Cable: ATTACH one end of the cable to the second phase grounded. ATTACH the other end of this cable to the third phase to be grounded.

NOTE

If using phase to phase grounding method attach to the middle phase for step 1 and attach to the outer phases for step 2 and step 3.

b. Removing Grounds

1) Removal is carried out by always disconnecting the ungrounded end of each cable first and working from the last phase grounded back toward the equipment-grounding connection of the first grounding cable

2.5 Practices for Attaching Temporary Protective Grounds on Vehicles and Other Equipment:

Assigned Qualified Employee

NOTE

In substations where fault energy levels require the use of two grounding cables per phase, two cables shall also be used for vehicle grounds and bonds connected in accordance with Section 2.5.1 or 2.5.2.

NOTE

Personal Protective Equipment (PPE) requirements for connecting or disconnecting Vehicle Grounds or Bonds shall be determined by the Employee Safety Manual or other referenced document as applicable.

2.5.1 Vehicle Grounding (general requirements):

a. Workers shall connect parked vehicles that are actively engaged in performing maintenance activities to the substation ground grid, using grounding cable(s) sized per 1.4.2, if the vehicle is able to come within the minimum approach distance for non-qualified workers of energized equipment.

b. Vehicle Grounding Cables shall be completely removed from any reels or holders and laid to minimize inductive effects.

CAUTION

Under no circumstances shall an installed ground cable be coiled.

c. When applying grounds, attachment shall be made to the vehicle or equipment ground point first, then to the substation ground grid to prevent arcing near the vehicle or equipment. Ground points shall be cleaned with a stiff wire brush before applying grounds.

2.5.2 Platform Bonding (aerial devices):

a. After grounding is completed, if work is to be performed from an UNINSULATED aerial device or work platform, a bond shall be installed from the platform to the conductor(s) or device(s) being worked on prior to handling the conductor(s) or device(s).

b. The bond may be established using a suitable Temporary Protective Ground installed directly between the conductor(s) or device(s) and the platform as soon as practicable after positioning, and should remain in place as long as work is being performed.

c. The bonding cable(s), if used, will be used in addition to any required grounding cable(s).

2.5.3 Special operations (oil handling): While performing oil handling operations on oil-insulated equipment (e.g., transformers, regulators, and circuit breakers), the following precautions shall be observed in addition to Section 2.5.1:

a. Apparatus tanks, shielded hoses, pumping or filtering equipment, drums, tank cars, trucks, and portable storage tanks shall be solidly bonded through a common ground to the substation ground grid.

NOTE

Shielded hoses are *required* whenever oil handling operations are being performed to prevent a buildup of static electricity and the resultant explosion hazard.

b. Exposed conductors (e.g., transformer or circuit breaker bushings, or coil ends of a transformer with the bushing physically removed) shall be connected to the same grounding system as the vehicle and processing equipment.

CAUTION

When returning to work on a partially completed oil filtering operation after shutdown for any reason, all switching, bonding, and grounding should be checked before resuming the operation.

3. SUMMARY OF CHANGES

Changes to TD Procedures are controlled by TD 001 "Writing, Revising, and Publishing Transmission & Distribution Procedures."

Revision 1 – Effective 04/01/2004

Procedure extensively revised as part of TD Procedure Upgrade Project initiated in June 2002, which included:

- Upgrading to new T&D procedure format
- Accommodating processes and NU organization in place at time of upgrade
- Reviewing applicable regulations and policies, and revising procedure based on that review
- Updated lists of Facilities Requiring Two Grounding Cables per Phase
- Updated approved materials, specified TPG assembly instructions, and incorporate requirements for vehicle and equipment grounding.

Revision 2 – Effective 01/23/2009

- The TD Procedure was substantially re-written due to evaluation by Tri-State Committee.
- Provided further clarification regarding single-point vs. source grounding technique.
- Updated lists of Facilities Requiring Two Grounding Cables per Phase.
- Updated approved materials.
- Revised requirements for vehicle and equipment grounding.
- Incorporated recommendation for bonding of vehicles.

Revision 3 – Effective 11/30/2011

- Updated approvers and SME
- Section 1.3 References: Updated references to Accident Prevention Manual to NU Safety & Health Handbook, replaced TD856 with M8-MT-3003 and added TD858 to Supporting References
- Section 2.3.2 added bullet about testing temporary protective ground
- Updated 'exceptions' on footnote 2 of Attachment 3
- Updated values for maximum available fault current and added additional locations to table in Attachment 4
- Added Attachment 7 Substation Signage

Revision 4 – Effective 02/01/2013

- Updated Section 1.3 Development References ASTM F 855-04 to ASTM F 855-09. Updated Supporting References to add SH 6051, "Test Method For Temporary Protective Grounding (TPG) Assemblies" (PSNH only)
- Updated values for maximum available fault current, added additional locations (Farmington 1C bus voltage 23kV bus voltage and Rockville 14W 4.8 kV bus voltage) and removed locations (Southington 4C 4.8kV bus voltage and Tunnel 12S 23 kV bus voltage) in table in Attachment 4
- Section 1.4.4 added statement that the limitations for length of grounding cable apply to all grounds including those for vehicles.
- Revised titles to sections 2.4 and 2.5
- Revised section 2.4.1 added Note about T-Handle clamps
- Section 2.5.2 a to require a bond rather than recommend

Revision 5 – Effective 6/18/2014

- Updated approvers and department names to reflect current organization.
- Section 1.1. Clarified to a higher detail the objective of this procedure.
- Updated Section 1.3 IEEEC2 2007 to IEEE C2 2012.
- Added TD852 to Section 1.3 Supporting References.
- Section 1.4 has been re-written to follow electrical industry standards.
- Attachment 1 Definitions. Added new definitions and re-defined some of the old definitions.
- Attachment 3 Note: PSNH has determined that 4/0 CU grounds can be applied at all distribution substations changed to: PSNH has determined that **a single** 4/0 CU grounds can be applied at all distribution substations.
- Attachment 4 Updated table.
- All references to CONVEX OI #6401 have been replaced by TD-800 Switching and Tagging.

Revision 6 – Effective 12/21/2015

- Updated approvers to reflect current organization.
- Updated template and NU references in support of rebranding
- Updated name of NU Safety & Health Handbook to Employee Safety Manual
- Updated Supporting References document titles for TD001, TD211, & TD216
- Removed US Western Area Power Authority System Maintenance Manual from Development References
- Attachment 4 – Updated table

Revision 7 – Effective 03/08/2017

- Updated approvers to reflect current organization.
- Updated applicability to clarify Eversource service area
- Section 1.3 Development References – updated
- Updated title of TD852 throughout document
- Corrected ‘ground mat’ to ‘ground grid’ throughout document
- Reviewed and clarified standard lengths
- Added note to step 2.4.3 for phase to phase grounding
- Attachment 3 – added values for 34.5 345kV
- Attachment 4 – updated table

Editorial Change - Revision 7 – Effective 03/17/2017

- Attachment 4 – updated Bus Voltage for Berlin 6A, Southington 4C, and Waterside 22M

Attachment 1
Definitions

Barrier – An insulating device rated for the voltage involved (line hose, plastic cover-up).

Barricade – A physical obstruction made from cones 28 inches or taller, A-frame type barricades, or other structures connected with continuous barricade tape providing a warning and limiting access to a potentially hazardous area.

Bond – A reliable connection to assure the required electrical conductivity between conductive parts required to be electrically connected.

Bonding – An electrical interconnection of conductive parts to maintain a common electrical potential.

Bonding jumper – A jumper used to bond conductive parts together (switch handle to a temporary ground mat, jumper across an open neutral, etc.).

Bracket grounding - A grounding method where temporary protective ground sets are installed on both sides of a worksite.

Clearance - The certification by the Switching Authority that a specified line or equipment is de-energized from all normal sources of electrical energy, a clearance tag has been placed at all clearance points, and the transfer of authority from the system operator to the clearance holder has been completed.

De-energized - Disconnected from all intentional sources of electrical supply by opening switches, jumpers, taps, elbows or other means. De-energized lines and equipment could be electrically charged or energized through various means, e.g. induction from energized circuits, portable generators or lighting. De-energizing lines and equipment does not allow workers to enter MAD unless the work methods in this procedure are followed.

Electric field induction (capacitive coupling) - The process of generating a voltage or current in an isolated conductive object or electric circuit by means of time-varying electric fields.

Magnetic field induction (electromagnetic coupling) - The process that employs both electric and magnetic fields to generate a circulating current between two grounded sites of a line due to the proximity of an adjacent or nearby energized line.

Energized - Electrically connected to a source of potential difference, or electrically charged so as to have a potential different from that of the earth.

Equipotential Zone (EPZ) - The state of maintaining a near identical electrical potential between two or more items, as compared to the nominal voltage present.

Exposure voltage - The voltage impressed across a worker's body, either hand-to-hand, or hand-to-foot, when the worker comes in contact with objects at the worksite that are not at the same potential.

Attachment 1
Definitions
(Sheet 2 of 2)

Ground (Ground source) – Earth, or a conductive body of relatively large extent that serves in place of earth. Ground normally provides a reference to zero (0) volts, no voltage, for electrical circuits. Under fault conditions ground may raise in voltage to a level above zero volts near an intentional or accidental connection of an electrical circuit to ground.

Grounded (Grounding) – A means of connecting an electrical circuit or electrical equipment to ground (see the definition of ground) whether intentional or accidental.

Insulated aerial manlifts – Mechanical equipment employing insulated booms, tested for the voltage involved, used to position workers in an elevated position.

Minimum air insulation distance (MAID) - The shortest distance in air between an energized line or equipment, and a worker's body at different potential. This distance does not take into account a floating electrode in the gap, or any factor for inadvertent movement.

Minimum approach distance (MAD) - The minimum air insulation distance (MAID) plus a factor for inadvertent movement.

Personal protective grounding – Grounds installed in a method that bonds the de-energized lines and equipment with all other conductive objects within the worksite, including the structure, limiting the exposure voltage to a safe value.

Qualified employee (Workers) - One knowledgeable in the construction and operation of the electric power generation, transmission, and distribution equipment involved, along with the associated hazards. An employee must have the training required by OSHA 1910.269(a)(2)(ii) in order to be considered a qualified employee.

Temporary Protective Grounding Equipment – A system of ground clamps, ferrules, cluster bar(s) and cables designed and suitable for carrying fault current as specified in ASTM F855.

Mechanical equipment - manlifts, digger/derricks, boom trucks, tankers, trailers, pulling and tensioning equipment used in stringing conductors, cable pulling equipment, etc.

Withstand Rating – The current a temporary protective ground should conduct for a specified time to allow the protective devices to clear the fault without being damaged sufficiently to prevent being operable. The TPGs are generally rated by this value. Any temporary protective grounding equipment subjected to current in excess of this value should not be reused.

Ultimate Capacity (capability, fusing limitation) – A calculated maximum symmetrical current that temporary protective grounding equipment is capable of carrying for a specified time without fusing or melting the cable.

Attachment 2
Acronyms
(Sheet 1 of 1)

Supv. – TS Const. & Maint. – Supervisor, Transmission Substation Construction & Maintenance

Supv. S/S Const. & Maint. – Supervisor, Substation Construction & Maintenance

Supv. – Substation Operations – Supervisor – Substation Operations

Attachment 3
Ground Cable Fusing Limitations

(Sheet 1 of 1)

\Bus Voltage (kV)	Type of Substation	Fault Clearing Time[1]	Protective Ground Cable Size[2]	Max. Current Single Cable (Amps.)	Max. Current Two Cables (Amps.)
345	Standard Bulk Transmission	0.25 sec. (15 cycles)	4/0	43,000	77,400
230	Bulk Transmission Terminal	0.833 sec. (50 cycles)	4/0	24,000	43,200
115 or 69	Bulk Transmission & Bulk Distribution	0.40 sec. (24 cycles)	4/0	34,900	62,800
34.5 or less	Bulk Distribution (supplied at 345 kV)	1.2 sec. (72 cycles)	4/0	20,100	36,200
34.5 or less	Bulk Distribution (supplied at 115 kV)	1.2 sec. (72 cycles)	4/0	20,100	36,200
34.5 or less	Distribution S/S (supplied at 34.5 kV or less)	1.2 sec. (72 cycles)	4/0	20,100	36,200

[1] The fault-clearing times designated above are based on broad-application worst-case relay and/or breaker-failure situations. If other fault-clearing times are substantiated, maximum current single cable ratings may be adjusted by calculation on a case-by-case basis.

[2] PSNH has determined that a single 4/0 CU grounds can be applied at all distribution substations, 34.5 kV and below, based on site specific analysis. Exceptions are Front Street and Keene Substations. Protection & Control Engineering should be consulted before grounds are applied at these Substation locations.

Attachment 4
Facilities Requiring Two Grounding Cables Per Phase

(Sheet 1 of 2)

The following substation busses are known to have available fault current in excess of single 4/0 ground assembly capabilities, and require all grounding locations at the specified voltage(s) to be equipped with two 4/0 grounding cables of equal length per phase when establishing an equipotential work zone. EXCEPTION: Where grounds are applied to a Potential Transformer, Station Service Transformer, or similar device, and the grounds are applied solely to provide protection against inadvertent backfeeding of the device (e.g., no other source is present at that location), single 4/0 grounding cables per phase may be used.

CAUTION

If physical restrictions prevent the application of two 4/0 grounding cables per phase when performing work on any of the facilities identified below, other protective measures must be taken to reduce the available fault current below the maximum single cable current limitations identified in Attachment 3. Consult with the respective Manager – Distribution Substation Maintenance or Manager – Transmission Substation Maintenance for instructions on a case-by-case basis

NOTE

Where physical clearances allow, Phase-to-Phase Grounding practices are recommended when using double 4/0 grounds

Location	Bus Voltage (kV)	Maximum Available Fault Current (Amp)
Agawam 16C	115	39,498
Black Rock 11H	13.8	24,700
Black Rock 11H	4.8	28,167
Bloomfield 3B	23	35,275
Berlin 6A	13.8	22,581
Card 11F (5X Tertiary)*	34.5	49,431
Devon 7R	115	51,917
Devon Railroad 26M	115	51,392
Devon Tap	115	51,795
Deerfield (TB14 Tertiary)*	13.8	66,135
East Devon 8G	115	52,126
East Hartford 32G	23	23,411
East New Britain 7L	13.8	26,585
Enfield 12C	4.8	28,249
Farmington 1C	23	26,941
Franklin Dr	13.2	25,805
Franklin Dr	4.16	28,842
Glenbrook 1K	115	41,725
Glenbrook 1K (Statcom)*	14.6	63,293
Glenbrook 1K*	13.2	37,173
Glenbrook 1K (1X & 2X Tertiary)	7.26	32,190
Ludlow 19S	115	35,231
Stony Brook 54B	115	35,140

Attachment 4
Facilities Requiring Two Grounding Cables Per Phase

(Sheet 2 of 2)

Location	Bus Voltage (kV)	Maximum Available Fault Current (Amp)
Manchester 3A	115	47,242
Manchester 3A	23	23,548
Montville 4J	115	51,963
Montville 4J (16X Tertiary)	6.6	22,983
Northwest Hartford 2N	23	28,437
Norwalk 9S	115	43,626
Norwalk 9S*	4.8	452,072
Norwalk 9S	27.6	35,217
Norwalk Harbor 6J	115	37,435
Rockville 14W (6X Tertiary)	4.8	36,414
Rocky Hill 3R	23	26,459
Rocky River 12Y	13.8	25,205
Riverside Drive 2R	23	21,496
Scobie Pond (TB30 Tertiary)*	13.8	70,557
Scobie Pond	115	46,679
South End 1G	13.2	35,707
South End 1G (1X & 2X Teritary)	7.97	20,483
South Meadow 1A*	23	40,099
South Naugatuck 21L	4.8	23,344
Southington 4C	115	38,256
Southington 4C*	13.8	40,055
Southington 4C(3X Tertiary)*	34.5	51,569
Southwest Hartford 47N	23	23,323
Uncasville 1Q	115	36,385
Waterside 22M	13.2	27,288
Weston 21M (2X Tertiary)*	5.04	34,935
Weston 21M	27.6	20,724
West Springfield 8C*	13.8	53,213
Williams 9L	13.2	21,183
Willimantic 14S	4.8	35,162
Windsor Locks 14K	4.8	26,022

* Requires additional protective measures (e.g., switching) to reduce fault current magnitude or duration below the grounding cable limits identified in Attachment 2. Acceptable grounding requirements must then be established on a case-by-case basis. Consult with the respective Manager – Distribution Substation Maintenance or Manager – Transmission Construction & Maintenance for instructions.

NOTE

There may be other facilities requiring two cables per phase for adequate grounding. If in doubt, consult with the Transmission or Distribution Substation Engineering (CT, Western MA), or Transmission Substation Engineering or Engineering & Design (NH) as applicable.

Attachment 5
Figures
(Sheet 1 of 1)

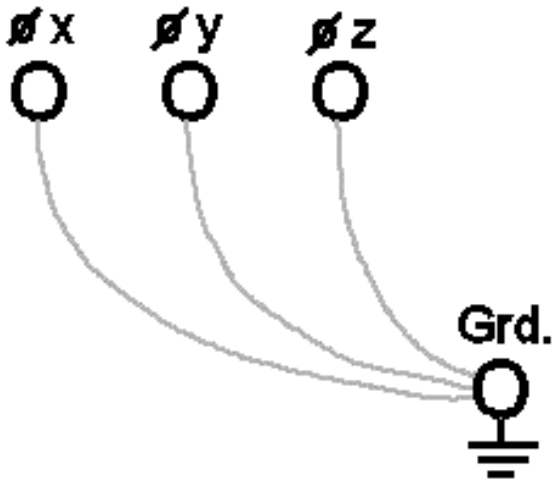

Figure 1.

Individual-Phase Grounding

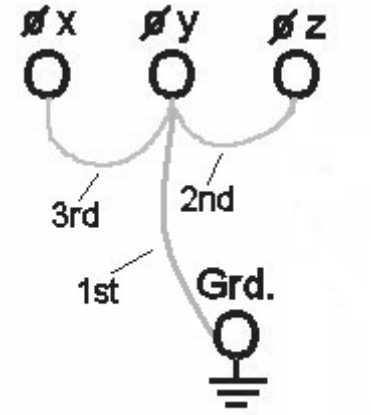

Figure 2.

Phase-to-Phase Grounding

Attachment 6
Approved Potential Testers

(Sheet 1 of 1)

The following is a list of Eversource-Approved Potential Testers recommended for use in substations. A complete list of Eversource-Approved Potential Testers is available in the System Tool and Equipment Standards.

Stock Code	Mfg./Cat #	Voltage Range	Illustration
0188094 0188095	A.B. Chance C403-0979 A. B. Chance XT403–2293	1KV – 40KV 69KV – 345KV	
0188096	A.B. Chance C403-3375	69KV – 500KV	
0187394 0443314	Salisbury 4244 Salisbury 4556	240V – 230KV 240V – 230KV	

Attachment 7
Substation Signage
(Sheet 1 of 1)

*** XXX,XXX determined by Substation Equipment**

Appendice 1

Standard components for temporary protective ground assemblies suitable for use in substations

(Non-mandatory Information)

(Sheet 1 of 2)

Clamps:

A) All-Angle Clamp, s/c 0188789

B) All-Angle Clamp, s/c 0188786

C) Bus Clamp, s/c 0188791

D) Bus Clamp, s/c 0436298

E) Bus Clamp, s/c 0436289

F) C-Type Clamp, s/c 0142987

G) C-Type Clamp, s/c 0142987

H) C-Type Clamp, s/c 0436288

I) C-Type Clamp, s/c 0436260

J) Flat-Face Clamp, s/c 0187884 with T-Handle, s/c 0188455

K) Socket Clamp, s/c 0184279 with T-Handle, s/c 0436295

L) Socket Clamp, s/c 0188220

Appendice 1

Standard components for temporary protective ground assemblies suitable for use in substations

(Non-mandatory Information)

(Sheet 2 of 2)

Additional Materials:

Stock Code	Description
0193446	FERRULE, Compression, Plain, Unshrouded, ASTM F855 Type I, Tinned Copper, 4/0, For Use On Grounding Cable (Fits Clamp Types A, B, C, D, F)
0436350	FERRULE, Compression, 5/8”-11 UNC Thread, Unshrouded, ASTM F 855 Type VI, Tinned Copper, 4/0, with Hex Nut & Lockwasher, For Use On Grounding Cable (Fits Clamp Types E, G, H, I)
0183394	GREASE, Rust Preventive, Conductive
0177775	CABLE, Covered, yellow, 4/0 AWG, CU, ASTM F855 Type I, for Temporary Protective Grounds
0143551	CABLE, Covered, clear, 4/0 AWG, CU, ASTM F855 Type III, for Temporary Protective Grounds, Outdoor Use Only
0193433	TUBING, Heat Shrink, For Grounding Cable Ferrule, 5" Long, 0.6 To 1.55” Diameter
0192948	TUBING, Heat Shrink, For Grounding Cable Ferrule, 25’ Reel, 0.6 To 1.55” Diameter

Figure I-1 –
Ground Cable Assembly