Northeast Utilities System TD PROCEDURE	TD 703 Rev. 2 Temporary Protective Grounds For Personnel Protection In Substations		
Issue Date: 01/21/09	**Effective Date:** **01/23/09**	Owner Department: Transmission Maintenance & Work Management SME Name, Department: Gregg Sauer Operational Engineering	Applicability: CT, 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. 1

Roll Out Instructions:
Prior to initial use of this procedure, each individual using this procedure is required to review these requirements with immediate supervision.

Approvals:

Transmission:_____
Name: Dwayne M. Basler
Title: Director - Transmission Maintenance & Work Management

CL&P_____
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Title: Director – Operations

PSNH: _____
Name: Steve M. Johnson
Title: Director – Energy Delivery

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

Ensure you are using the current revision by verifying it against the controlled electronic copy located on the Distribution Engineering Standards Bookshelf or the Regulated Businesses Policies and Procedures Lotus Notes Database.

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1. INTRODUCTION

1.1 Objective

This procedure establishes specifications and instructions for installation of temporary protective grounds in order to provide maximum safety for personnel while they are working on de-energized lines or equipment in substations.

1.2 Applicability

All personnel involved in Construction, Repair, or Maintenance of Substation Equipment.

1.3 References

Unless otherwise specified:

- Forms are available through Lotus Notes NU Forms Catalog or NU Forms Catalog on the NUNet at: http://nunotes2.nu.com/apps/Enterprise/nuforms/NUFORMS.NSF?OpenDatabase
- Procedures are available at the following locations:
    - Lotus Notes UG Policies and Procedures database
    - System Engineering Standards Bookshelf on the NUNet at: http://rbgit-prod.nu.com/standards/standard.pdf

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

- TD 001 “Writing, Revising, and Publishing Transmission & Distribution Procedures”
- ASTM F 855-04, “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 C2-2007, “National Electrical Safety Code”
- IEEE 80-2000, “IEEE Guide for Safety in AC Substation Grounding”
- IEEE 100, “The Authoritative Dictionary of IEEE Standards Terms
- IEEE 1246-2002, “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
- U.S. Western Area Power Authority Power System Maintenance Manual, Chapter 1, “Personal Protective and Vehicle Grounding”,
- 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:

- Convex Operating Instruction # 6401, “Protective Switching and Tagging Procedures”
- CL&P Accident Prevention Manual, “Electric Facilities”, “Protective Grounding”
- MA Accident Prevention Manual, Section 2.3, “Grounding for Protection of Personnel”
- NUSCo Accident Prevention Manual, Section 2.3, “Grounding for Protection of Personnel”
- PSNH Safety Manual, Section 3, “Electrical”, and Section 4, “Lockout\Tagout”
- Northeast Utilities System Material Standards
- Northeast Utilities System Tool and Equipment Standards
- TD 211 “When to Wear FR Clothing”
- TD 216 "Live Line Tool (Hot Stick) Use, Care, Maintenance, and Inspection”
- TD 800, “Distribution System Protective Work Clearances”
- TD 855, “Grounding for Personal Protection on Overhead Distribution Lines”
- TD 856 “Temporary Protective Grounding for Personal Protection on Overhead Lines, 69 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

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 capacitively coupled voltage from adjacent equipment.

NOTE

When working on Gas Insulated Switchgear, refer to CONVEX OI #6401 for dispatching of permanently installed ground switches.

1.4.2 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.

CAUTION

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

a. Cable

ASTM F 855 Copper Ground Cable size 4/0 AWG shall be used in all NU substations supplied at all voltages. This cable was chosen based on the theoretical maximum available fault current and fault duration to which NU substations can be subjected (Refer to Attachment 3)..

In substations where fault energy levels may exceed the capability of a single ground assembly, two cables of equal length per phase shall be used.

b. Ground Assembly Components

All clamps and fittings used on Temporary Protective Grounds in all NU substations shall be rated ASTM F 855 grade 5 or higher.

1.4.3 Grounding Attachment Points

New installations shall include attachment points which accommodate the standard lengths of grounding cable

The grounding cable attachment points are commercially available grounding studs welded to the bus or bolted to the equipment. In grounding operations, each of the studs is connected to the substation grounding grid by the grounding cables.

At locations where grounding studs are not installed, grounding cables should be attached to the conductor, bus, or cable and the substation ground grid or, if necessary, a steel structure.

Where two 4/0 grounding cables per phase are required (Refer to Attachment 4), they shall be of equal length 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.

1.4.4 Length of Cable

Two lengths of grounding cable have been selected for use in those substations where grounding attachments are installed:

- 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.

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

Do not, under any circumstances, coil grounding cables while installed

1.4.5 Grounding Method (Refer to Attachment 1)

This procedure recognizes two accepted grounding methods that may be used at the discretion of the clearance-holder 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 one or both of these methods:

a. Source grounding:

Source grounding refers to the application of two or more sets (one- or two- per phase, as required per Attachment 4) of temporary protective grounds, installed at locations separating the work zone from any adjacent energized equipment or source of potential. This method is applicable in cases where the work zone covers a relatively large area within the substation and/or there are multiple independent sources of energy.

When using this method, it is common (though not necessary) to apply the ground set at the nearest available point to the open connection. In any case where source grounding is used, the work zone shall be considered to extend up to, but not beyond, the point at which the grounds are applied (e.g., "working between grounds").

b. Single-point grounding:

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. This method has limited application in instances where work is to be performed in a relatively small area and in cases where use of source grounding is not practicable.

2. INSTRUCTIONS

2.1 Ground Assembly Clamps

Supv. – TS Const. & Maint.

Supv. – S/S Const. & Maint.

Supv. – Dist. Maint.

2.1.1 SELECT grounding clamps appropriate for the particular work site. The following is a selection of standard clamps approved for use by NU personnel (a complete listing is available in the NU 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 <u>end only</u>.

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

Assigned Qualified Employee (AQE)

NOTE

A selection of standard components approved for use in Substations by NU personnel are described in Appendix I. Additional components may be added to the NU System Tool and Equipment Standards as they become available. Other components may be used by non-NU 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. – Dist. Maint.

2.3.1 ENSURE that cables are properly sized. ASTM F 855 size 4/0 AWG copper cable shall be used in all NU 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**).

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.

NOTE

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

AQE

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 NU-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*

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.)

d. *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

e. TIGHTEN the ground clamp locking bolt.

f. 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.

g. *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.

2.4.1 Phase-to-Phase Grounding Practice

NOTE

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

c. 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 ground. 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.

d. Removing Grounds

1) Removal is carried out by reversing the steps in Paragraph 2.4.1.c, 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 Vehicle and Equipment Grounding and Bonding:

AQE

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 Accident Prevention Manual, 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 mat, 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, it is recommended that a bond 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

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

- 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.

End of Section

Attachment 1
Definitions

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.

Ground – A conducting connection, whether intentional or accidental, by which an electrical circuit or equipment is connected to earth.

Method – For purposes of this procedure, the term "Grounding Method" shall refer to the philosophy or strategy used to determine the appropriate locations within a substation for connecting Temporary Protective Grounds to establish an equipotential work zone.

Practice – For purposes of this procedure, the term "Grounding Practice" shall refer to the physical interconnections between lines, busses, or terminals and the system ground necessary to establish a ground installation.

Temporary Protective Ground(s) (TPG, "Portable Grounds", "Worker's Grounds", "Grounding Cables", Ground Assembly") – An assembly of approved components used to establish a grounding connection to de-energized lines or equipment.

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. A TPG subjected to current in excess of this value should not be reused.

Ultimate Capacity (capability, fusing limitation) – A calculated maximum symmetrical current that a temporary protective ground 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

AQE – Assigned Qualified Employee

Supv. – Dist. Maint. – Supervisor – Distribution Maintenance

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)	[values pending review]	4/0	[values pending review]	[values pending review]
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 4/0 CU grounds can be applied at all distribution substations, 34.5 kV and below, based on site specific analysis. Exceptions are Bridge Street 115 - 4.16 kV, Brook Street 34.5 - 4.16 kV, Brook Street 34.5 - 13.8 kV, 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

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 2. 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)
Black Rock 11H	13.8	27,000
Black Rock 11H	4.8	26,100
Bloomfield 3B	23	20,900
Card 5A (-5X Tertiary)*	34.5	92,500*
Devon 7R	115	51,900
Devon Railroad 26M	115	48,600
Deerfield (TB14 Tertiary)*	13.8	64,400*
East Hartford 32G	23	20,700
East New Britain 7L	13.8	24,200
Enfield 12C	4.8	26,900
Forestville 12A	13.8	23,100
Franklin Drive 1B	13.2	24,600
Franklin Drive 1B	4.16	27,500
Glenbrook 1K	115	37,700
Glenbrook 1K (Statcom)*	14.6	61,000*
Glenbrook 1K	13.2	24,000
Ludlow 19S	115	43,300
Manchester 3A	115	40,300

Attachment 4
Facilities Requiring Two Grounding Cables Per Phase

(Sheet 2 of 2)

Location	Bus Voltage (kV)	Maximum Available Fault Current (Amp)
Manchester 3A	23	22,900
Montville 4J	115	49,400
Northwest Hartford 2N	23	23,700
Noera 13H	4.8	35,000
Norwalk 9S	115	38,500
Norwalk 9S*	4.8	48,100*
Norwalk Harbor 6J	115	43,900
Rocky Hill 3R	23	22,500
Rocky River 12Y	13.8	23,200
Riverside Drive 2R	23	20,700
Scobie Pond (TB30 Tertiary)*	13.8	69, 000*
South End 1G	13.2	22,000
South Meadow 1A	23	33,100
South Naugatuck 21L	4.8	24,000
Southington 4C	115	35,600
Southington 4C	13.2	23,900
Southington 4C	4.8	24,400
Southwest Hartford 47N	23	20,500
West Springfield 8C*	13.8	53,600*
Willimantic 14S	4.8	33,400
Windsor Locks 14K	4.8	24,300

* 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 (CL&P, WMECo), or Transmission Substation Engineering or Engineering & Design (PSNH) as applicable.

Attachment 5
Figures
(Sheet 1 of 1)

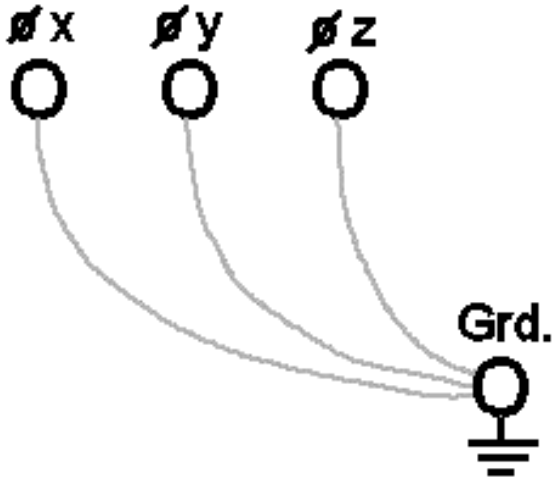

Figure 1.

Individual-Phase Grounding

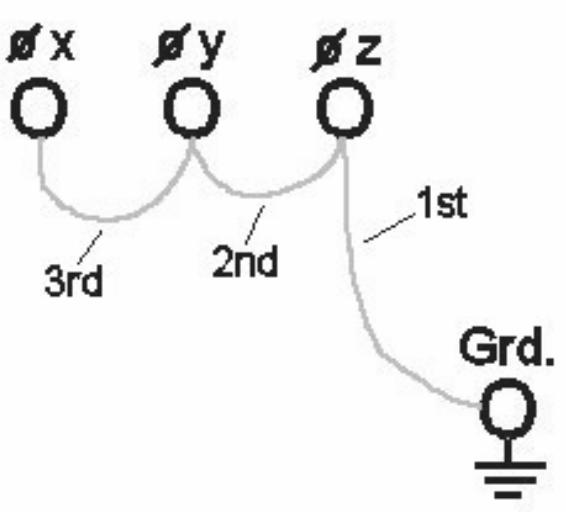

Figure 2.

Phase-to-Phase Grounding

Attachment 6
Approved Potential Testers

(Sheet 1 of 1)

The following is a list of NU-Approved Potential Testers recommended for use in substations. A complete list of NU-Approved Potential Testers is available in the NU 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	

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

(Non-mandatory Information)

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

Appendix I
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