EVERSOURCE	WORK METHOD STANDARD ELECTRIC OPERATIONS ORGANIZATION

Protective Grounding Inside Substations

Document Number:	Issued Date:	Revised Date:	Revision:	Applicability:
WMS 89.06-234	31-May-20	15-Sept-22	3	CT/WMA/NH

***** This Document Supersedes procedure TD 703 *****

Scope:

This work standard covers the safe work practices for applying Temporary Protective Ground (TPG) cables. TPG cables are used 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. This standard also includes the process of ground cable selection and installation based on the maximum fault current and clearing times.

Gas Insulated Substations (GIS) and equipment have specific operating and grounding procedures, which include equipment grounding, thus are excluded from this work standard's scope.

Safety:

Providing a work environment, free of recognized hazards is a value at Eversource. Therefore, prior to the start of any work, ensure that you are familiar and knowledgeable with all Eversource Safety Rules, Policies and Procedures that are applicable to the work and tasks at hand and perform a job brief at the job site, prior to commencing work. PPE requirements to protect the worker shall be followed as required in the Eversource Employee Safety Manual.

Rev No.	Description	Date
3	New fault current numbers updating the Attachments to allow operations to use the higher rating grounding cable.	September 15, 2022
2	Added the requirement to use the Substation Grounding Plan form OP-4899 and provided an example of the form in Appendix D	January 11, 2021
1	Updated Attachments 1 and 2.	June 17, 2020

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1.0 Introduction

1.1 The electric utility industry has three accepted work method practices allowing qualified workers to perform work within the Minimum Approach Distances (MAD) of energized or de-energized lines and equipment. These include insulation, isolation, and the use of Temporary Protective Grounds (TPGs).

1.2 The development of an equipotential zone (EPZ) for personal protection is the primary work method covered by this standard. It is required that whenever work is performed on substation equipment, all three phases of the equipment to be worked on shall be isolated and grounded.

1.3 Workers are best protected by properly installing worksite grounds, otherwise referred to as TPGs.

1.3.1 TPG's consist of a clamp, ferrule, cable, and heat shrink tubing to make up the general term of a "cable assembly".

1.3.2 For the remainder of this standard, the terms TPG and ground cable assembly will be used interchangeably.

2.0 Reference Documents

ASTM F2249-18	Standard Spec for In-Service Test Methods for Temporary Grounding Jumper Assemblies.
ASTM F855-14	Temporary Protective Grounds on De-energized Electric Power Lines.
CAT 3001	Substation Grounding Material Catalog.
ESOP 100	Switching and Tagging.
FIST	U.S. Bureau of Reclamation Facilities Instructions, Standards, and Techniques Volume 5-1, "Personal Protective Grounding for Electric Power Facilities".
IEEE 80	Guide for Safety in AC Substation Grounding.
IEEE 1246	Guide for TPG Systems Used in Substations.
OP-4899	Grounding Plan Form.
OSHA 1910.269(n)	Grounding for Protection of Employees.
WMS 84.05-234	Maintenance & Testing of Hot Line Tools & Equipment.
WMS 88.11-234	Substation Work Area Identification.
WMS 89.07-234	Vehicle & Equipment Grounding in Substations.
WMS 89.11-234	Maintenance & Testing of Personal Protective Grounding Equipment.
WMS 91.11-234	Testing for Potential on Substation Equipment.

3.0 Bill of Materials

3.1 Refer to **CAT 3001** Substation Grounding Material Catalog for the approved ground cable assembly materials, live-line, and cleaning tools.

4.0 Definitions

4.1 Bonding – The practice of intentionally electrically connecting all non-current-carrying metal parts to form a safe low impedance path to any current likely to be imposed on it.

4.2 Cradle-to-Cradle – The moment the aerial platform leaves its lowest position to the point when it returns to its lowest position. Applies to all aerial devices with or without cradles.

4.3 Equipotential zone / equipotential grounding (EPZ) – For the purposes of protective grounding, a near identical state of electrical potential.

4.4 Grounding– Intentionally connecting to earth through a ground connection.

4.5 Grounding Plan – The process to which the TPG quantity, length, and locations are discussed and determined.

4.6 Personal Ground – Personal Grounds are additional grounds installed at the work location to lower or "clamp" the voltage across the worker.

4.7 Phase-to-Ground (Parallel) Grounding – The installation of TPGs from each phase to ground. The ground attachment point can be a common point for all three TPG ground connections or can be a different point for one or more TPG ground connections, but a low-resistance connection between any separated TPG ground connection point is required.

4.8 Phase-to-Phase (Chain) Grounding – The installation of TPGs from phase to phase to phase with an additional TPG connecting from one of the three phases to ground. "Balanced Chain Grounding" utilizes the "B" phase to ground. "Un-Balanced Chain Grounding" utilizes either the "A" or "C" phase to ground.

4.9 Temporary Protective Ground (TPG) – Cable and clamp assembly designed to limit the voltage exposure at the worksite to a safe value in the event where the line or equipment being worked upon is accidentally energized. They also provide a parallel path for fault current to flow.

4.9.1 TPGs are used for:

.1.1. System Operator Grounds.

.1.2. Worker Grounds.

.1.3. Personal Grounds.

4.10 Ultimate Rating (Capacity) – A calculated maximum symmetrical current that a TPG is capable of carrying for a specified time without fusing or melting.

5.0 General

5.1 Work on de-energized equipment and circuits shall be performed with TPGs installed on each phase.

5.2 Eversource Engineering has specified the required cable quantity based on fault current and clearing times.

5.3 There are two grounding practices, "Phase-to-Phase" or "Phase-to-Ground" grounding. "Phase-to-Phase" grounding is the preferred method to reduce circulating currents.

5.4 In accordance with **ESOP 100**, there are two types of grounds either of which may be used for worker protection.

5.4.1 System Operator Grounds – Grounds whose installation, removal or operation is directed and tracked by the System Operator.

5.4.2 Worker Grounds – Grounds whose installation or removal is directed and tracked by the Clearance Holder.

5.5 Worker Grounds shall be the preferred grounding method for TPGs in the work zone. This shall comply with the developed Grounding Plan.

5.6 During testing, ground cable assemblies may be removed per ESOP 100 and in accordance with the Grounding Plan. Throughout testing, the worker SHALL use insulated equipment or insulated tools and ensure isolation from any live electrical hazards.

5.7 Eversource utilizes a color-coded system to help identify installed ground cables from a distance, as described in Section 6.0 “Ground Selection”. The principles and methods described herein are applicable to any appropriately rated assembly, regardless of the color.

6.0 Ground Selection

6.1 The minimum acceptable ground cable size is 4/0 AWG.

> **NOTE:** 2/0 yellow ground cables are NOT allowed to be used for grounding in Eversource substations.
>
> 2/0 red cable assemblies are ONLY allowed for bonding in Eversource substations.

6.2 Approved TPG assemblies:

6.2.1 Grade 5 Assembly - Yellow 4/0 AWG ground cable with minimum Grade 5 clamps.

.1.1. Substations not included/listed in Attachments 1 thru 3 tables, require a minimum one Grade 5 (yellow cable) TPG assembly.

6.2.2 Grade 5H Assembly - Blue (with white stripe) 4/0 AWG cable with minimum Grade 5H clamps.

.2.1. For CT/WMA grounding requirements see Attachments 1 and 2.

.2.2. For NH grounding requirements see Attachment 3.

6.2.3 Grade 6H Assembly: Blue (with white stripe) 4/0 cable with minimum Grade 6H Clamps.

> **NOTE:** A TPG assembly rating is limited to the lowest component rating.
>
> Example: If the ground cable is Grade 6H and one of the clamps selected is a Grade 5H clamp, the TPG assembly is limited to Grade 5H.

6.3 The shortest ground cable SHALL always be used:

6.3.1 The maximum TPG ground length shall not exceed 25 feet.

6.4 When two (2) or more ground cable assemblies are required, they SHALL be:

6.4.1 Equal length.

6.4.2 Equal rating for the cable, clamps and ferrules.

6.5 Grounding equipment and their applications are provided in **CAT 3001**.

7.0 Worksite & TPG Preparation

7.1 A Grounding Plan is required prior to the start of work. See Appendix C for the Grounding Plan Process.

7.1.1 The Grounding Plan shall include but not limited to the following:

.1.1. Identifying the work zone

.1.2. The source paths into the work zone

.1.3. Quantity of ground cable assemblies for each phase per location

.1.4. Clamp selection types and cable rating (colors)

.1.5. Ground-point locations

.1.6. Ground-point attachments

.1.7. Ground cable assembly lengths

.1.8. Evaluate the need for additional personal protective ground in work zone (15 feet from source grounds)

.1.9. Determine if any vehicle/equipment to be grounded

7.2 Grounding Plans shall be documented using the Eversource Grounding Plan **Form OP-4899** to ensure optimal grounding is achieved for each grounding scenario. Refer to Appendix D.

7.2.1 A schematic or one-line sketch shall be attached to the grounding plan.

7.3 Vehicles or equipment shall be connected to ground as specified in **WMS 89.7-234**.

NOTE:	Aerial Devices shall be grounded prior to bonding any part of the aerial device and/or the working personnel enters the aerial device. Bonding cable assemblies shall be used to bond non-insulated aerial devices. An additional Personal Ground is not needed when working in a bonded aerial device.

7.4 Clearance shall be given by the System Operator as specified under the provisions of the applicable Eversource switching authority. Refer to **ESOP 100**.

7.5 Before installing a ground cable assembly, test equipment leads, or dead-line potential fuse, test the equipment for potential to prove it is de-energized per **WMS 91.11-234**.

7.5.1 Equipment and lines to be grounded shall be tested with an approved testing device using a live, dead, live process, and when found absent of any voltage shall be grounded immediately following the testing.

7.5.2 Refer to Substation Grounding Section in the Eversource Safety Manual.

CAUTION: If any potential test indicates potential is present, verify potential is ONLY due to induction prior to installing grounds.

7.6 Prior to the installation of ground cable assemblies, visually inspect and clean each assembly as detailed in **WMS 89.11-234**.

7.6.1 If any damage is found, return grounding assembly for repair and testing.

7.7 Perform visual inspection to make sure the ground leads to the ground grid are intact to the equipment and/or structure being grounded to.

7.8 It is recommended that ground attachment points have paths to the ground grid through multiple ground leads.

7.8.1 For structures that are grounded by 4/0 or larger leads, a minimum of 3 leads are recommended.

7.8.2 For structures that are grounded by 2/0 leads, a minimum of 4 leads are recommended.

7.8.3 To create more paths to the ground grid, temporary jumpers may be considered as part of the Grounding Plan.

CAUTION: If the station ground grid lead to the structure is not intact, STOP, and contact your Supervisor.

8.0 TPG Installation and Removal Requirements

CAUTION: Always use the shortest grounding cables in order to minimize cable slack, reduce the dangerous forces developed by fault currents and to limit worksite exposure voltage.

8.1 When installing or removing ground cable assemblies, the worker(s) must be constantly aware of:

8.1.1 Approach/Egress path to live parts.

8.1.2 Proximity and clearance to live parts in the vicinity to the work area.

8.1.3 Proper work positioning to prevent injury.

8.2 Grounding and bonding assemblies, installed or removed, shall be tracked.

8.3 The preferred ground connection points shall be connecting to the Steel/Aluminum Structures using:

8.3.1 A permanent engineered solution using a bolted ball stud.

8.3.2 A temporary I-beam Clamp or other specialty clamp that allows for temporary connection.

8.3.3 The shortest 4/0 ground cable per Attachments 1 thru 3.

8.4 Ground cable assemblies should be visible from the worksite, wherever practical.

8.5 Ground cable assemblies should be installed as close to the worksite as practical.

8.6 All source paths into work zone shall be grounded. This should require a minimum of two sets of grounds.

8.6.1 In cases where a second set of grounds cannot be achieved, (e.g. Placing grounds on equipment leads), consult with Supervision.

8.6.2 An additional Personal Ground shall be installed as close as possible to the worker:

.2.1. When the source ground location distance exceeds 15 feet from the worker.

.2.2. When only one source path into work zone.

CAUTION: For TPGs to provide proper protection, continuity must be maintained between the point of connection and the work location.

Any device capable of transforming voltage or producing a voltage drop shall not to be considered as maintaining continuity for the purpose of personnel safety. Such devices include transformers, fuses, reactors, resistors, circuit breakers, disconnect switches and line traps.

If the situation does not allow for other options, stop and consult supervision.

In situations where grounding cannot be achieved, refer to **ESOP 100**.

8.7 Approved live-line tools and rubber gloves SHALL be used to install and remove ground cable assemblies, test equipment leads, or dead-line potential fuses from the live end.

8.7.1 Rubber gloves SHALL be worn, at a minimum, when removing and installing the cold end of the ground assembly and while bonding.

8.7.2 If field conditions do not permit the use of live-line tools, contact Eversource Supervision.

8.7.3 Ensure live-line tools in use have been tested and labeled per **WMS 84.05-234**.

8.8 When ground cable(s) are coiled or on reels, they SHALL be completely removed from the reels or holders, unwound and straightened or laid out in an “S” shape on the ground with no crossover, to reduce the possibility of induced voltages.

NOTE: When two (2) or more ground cable assemblies are required on each phase, they shall be physically installed facing the same direction and no more than three (3) inches of each other at both ends.

8.9 Remove contaminants from all connection points in order to minimize ground connection point resistance.

8.9.1 The use of a wire brush on the end of a live-line tool is preferred.

8.9.2 Contaminants may also be removed by repeatedly tightening and loosening the clamp or by partially tightening the clamp and manipulating it back and forth.

CAUTION: 1) When installing a ground cable assembly with the live-line tool, the worker shall NOT touch or hold the ground cable.

2) Grounding assemblies shall NOT be extended by connecting multiple assemblies (i.e. Daisy Chain) under any circumstance.

8.10 When grounding from a non-insulated aerial device:

8.10.1 Verify the MAD is not being encroached or violated.

8.10.2 An additional qualified person (Spotter), other than the person(s) applying the ground, shall be designated to observe the MAD to exposed lines and equipment while operating the aerial device.

.2.1. This person shall provide timely warnings before the MAD is reached.

8.10.3 It is REQUIRED to wear FULL PPE cradle-to-cradle per Eversource Safety Manual.

.3.1. FULL PPE shall be worn from the stopped, lowest position before going cradle-to-cradle.

8.11 Equipment and job site configurations dictate the safest way to apply TPGs. The preferred method for applying Substation TPGs is the Balanced "Phase-to-Phase" Grounding method.

NOTE: In some cases, the Phase-to-Phase Grounding method requires longer grounds than the Phase-to-Ground method. When this occurs, the method utilizing the shortest ground cable assemblies is preferred.

8.11.1 Balanced "Phase-to-Phase" Grounding of Figure 1 should be used on devices that share a common grounded enclosure or structure, such as a three-phase, single-tank transformer or a three-phase circuit breaker.

NOTE: For All Grounding Methods: If more than one ground cable is required per phase, install all required cable assemblies on Phase 1 FIRST prior to installing grounds on Phase 2 and 3.

8.11.2 Application of Balanced "Phase-to-Phase" Grounding (Refer to Figure 1):

.2.1. First Cable: Attach one end of the cable to a ground end source. Attach the other end to the Middle Phase B.

.2.2. Second Cable: Attach one end of the cable to the first phase grounded. Attach the other end of this cable to Phase A or Phase C.

.2.3. Third Cable: Attach one end of the cable to the second phase grounded. Attach the other end of this cable to final phase to be grounded (Phase A or Phase C).

8.11.3 Removing grounds for the Balanced "Phase-to-Phase" method:

.3.1. Remove the ground assembly clamp(s) from Phase A.

.3.2. Remove the ground assembly clamp(s) from Phase C.

.3.3. Remove the ground assembly clamps from Phase B.

.3.4. Finally remove the ground assembly clamp(s) at the grounded point.

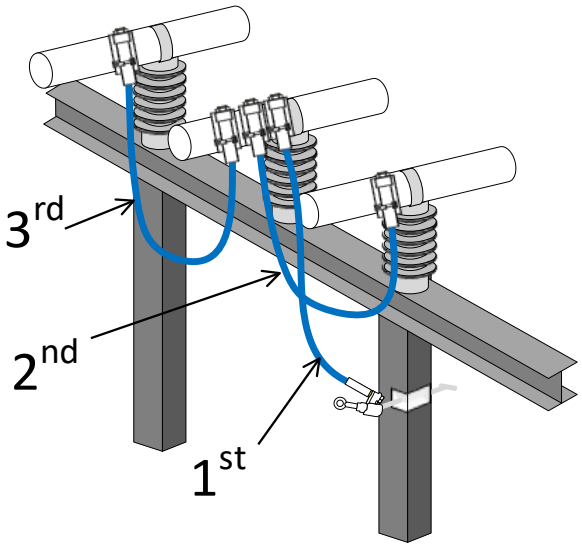


Figure 1 – Example of "Phase to Phase" (Balanced Chain Grounding) Grounding Application

8.12 If the Balanced "Phase to Phase" Grounding method cannot be performed, the following can be followed:

8.12.1 Application of Un-Balanced "Phase-to-Phase" Grounding (Refer Figure 2):

.1.1. First Cable: Attach one end of the cable to a ground end source. Attach the other end to the first phase to be grounded (Phase A or C).

.1.2. Second Cable: Attach one end of the cable to the first phase grounded. Attach the other end of this cable to Phase B.

.1.3. Third Cable: Attach one end of the cable to Phase B. Attach the other end of this cable to the final phase to be grounded (Phase A or C).

8.12.2 Removing grounds for the Un-Balanced "Phase-to-Phase" method:

.2.1. Remove the ground assembly clamp(s) from the first phase (either Phase A or C).

.2.2. Remove the ground assembly clamp(s) from Phase B.

.2.3. Remove the ground assembly clamps from the final phase (either Phase C or Phase A).

.2.4. Finally remove the ground assembly clamp(s) at the grounded point.

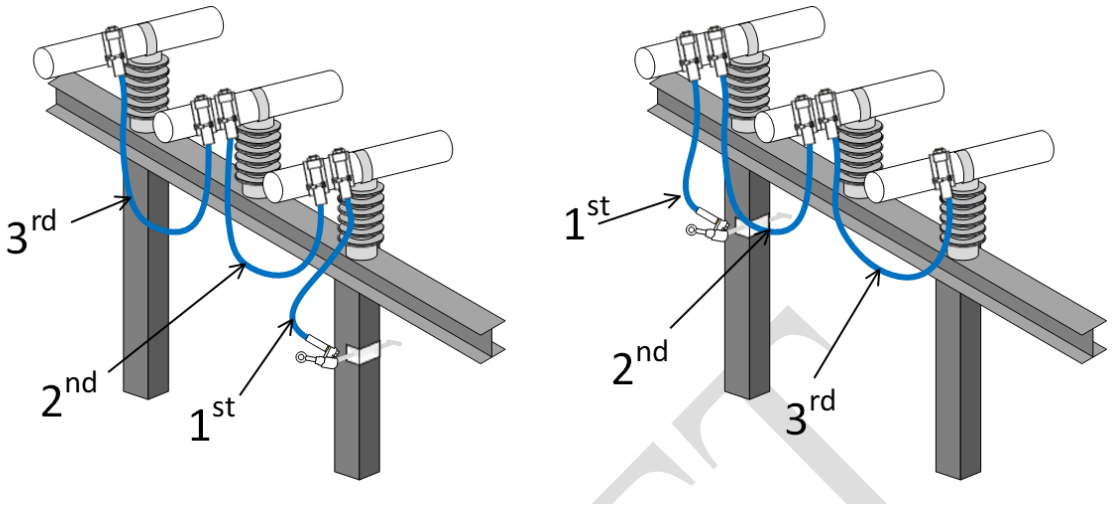


Figure 2 – Examples of "Phase to Phase" (Un-Balanced Chain) Grounding Applications

8.12.3 Application of "Phase-to-Ground" (Parallel) Grounding (Refer to Figure 3):

.3.1. First: Attach one end of each grounding cable to the ground end source.

.3.2. Second: Attach the other end of each grounding cable to the equipment-grounding point for each of the three (3) phases.

8.12.4 Removing ground for the "Phase-to-Ground" (Parallel) Grounding:

.4.1. First: Remove each grounding cable from the equipment-grounding point connections.

.4.2. Second: Remove each grounding cable from the ground end source.

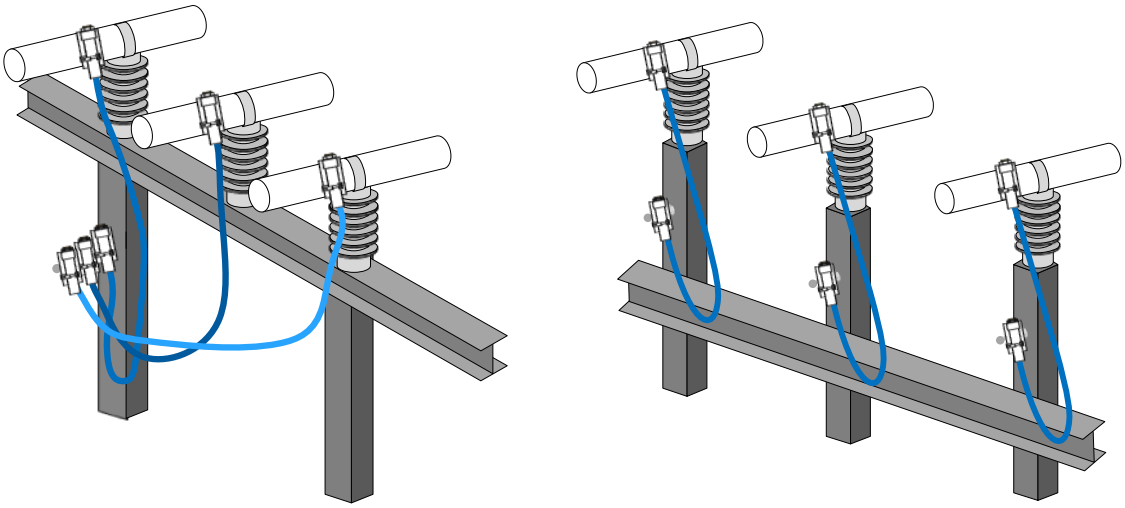


Figure 3 – "Phase-to-Ground" (Parallel) Grounding

Attachment 1 – CT & WMA: 69 kV & Above TPG Requirements

Substation*	Voltage (kV)	Clearing Time (cycles)**	Max Fault (amps)	# of TPGs***	Grade***
AGAWAM 16C	115	24	38596	1	Grade 6H
BARBOUR HILL 23J	115	24	31030	1	Grade 5H
BERLIN 6A	115	24	28762	1	Grade 5H
BUNKER HILL 12B	115	24	29477	1	Grade 5H
CDEC TAP and CDEC 51L	115	24	33217	1	Grade 5H
DEVON ALL BUSES and Tap	115	24	51621	2	Grade 5H
E. DEVON 8G	115	24	52103	2	Grade 5H
E. HRTFORD 32G	115	24	29141	1	Grade 5H
Ely Ave & Ely JCT	115	24	34924	1	Grade 5H
FLAX HILL 24A	115	24	29362	1	Grade 5H
FROST BRIDGE 8R and ALL TAPS	115	24	37256	1	Grade 6H
GLENBROOK 1K & TAP	115	24	39351	1	Grade 6H
HADDAM 11C	115	24	30051	1	Grade 5H
LUDLOW 19S	115	24	34743	1	Grade 5H
MANCHSTER 3A	115	24	48007	2	Grade 5H
MILFORD 43G	115	24	49729	2	Grade 5H
MOUNTVILL E4J	115	24	48228	2	Grade 5H
N. BLOOMFIELD 2A	115	24	33419	1	Grade 5H
NORWALK 9S and TAP-9X	115	24	44885	2	Grade 5H
NORWALK HABOR 6J	115	24	37722	1	Grade 6H
NW. HARTFORD 2N	115	24	30827	1	Grade 5H
PLUMTREE 30G	115	24	32021	1	Grade 5H
QUAD 1 &2 REACTOR	115	24	47203	2	Grade 5H
RVRSID TAPs	115	24	35555	1	Grade 5H
RVRSIDE 2R	115	24	28104	1	Grade 5H
S. AGAWAM 42E	115	24	28814	1	Grade 5H
S. MEADOW 1A	115	24	37932	1	Grade 6H
SHAWS HILL 24H	115	24	28441	1	Grade 5H
SILVER	115	24	28160	1	Grade 5H
SONO 24P	115	24	28985	1	Grade 5H
SOUTH END 1G	115	24	34696	1	Grade 5H
SOUTHINGTON 4C	115	24	48390	2	Grade 5H
STONY BROOK 54B	115	24	30238	1	Grade 5H
SW. HARTFORD 47N& RX	115	24	34332	1	Grade 5H
TOWANTIC 3P	115	24	39439	1	Grade 6H
UNCASVILLE 1Q	115	24	37548	1	Grade 6H
W. SPRGFIELD 8C	115	24	29287	1	Grade 5H
MILLSTONE 15G	345	15	37823	1	Grade 5H
SCOVILL ROCK 22P	345	15	36916	1	Grade 5H

See NOTES on next page

Attachment 2 – CT & WMA: 34.5 kV & Below TPG Requirements

Substation*	Voltage (kV)	Clearing Time (cycles)**	Max Fault (amps)	# of TPGs***	Grade***
BERLIN	13.80	72	22331	1	Grade 5H
BLOOMFIELD	23.00	72	26336	1	Grade 6H
BRISTOL	4.80	72	19183	1	Grade 5H
EAST HARTFORD	23.00	72	23108	1	Grade 6H
EAST NEW BRITAIN	13.80	29	27962	1	Grade 5H
FARMINGTON	23.00	61	28652	1	Grade 6H
FRANKLIN DRIVE	13.20	29	28551	1	Grade 5H
GLENBROOK	13.20	72	25941	1	Grade 6H
MANCHESTER	23.00	28	30000	1	Grade 5H
NEWINGTON	23.00	72	25369	1	Grade 6H
NORTHWEST HARTFORD	23.00	31	27733.4	1	Grade 5H
NORWALK	4.80	81	44387	3	Grade 6H
RIVERSIDE DRIVE	23.00	72	27083	1	Grade 6H
ROCKY HILL	23.00	72	25543	1	Grade 6H
ROCKY RIVER	13.80	72	19072	1	Grade 5H
SOUTH END	13.20	72	23976	1	Grade 6H
SOUTH MEADOW	23.00	35	39455	2	Grade 5H
SOUTHWESTHARTFORD	23.00	72	22976	1	Grade 5H
TUNNEL	23.00	72	24317	1	Grade 6H
VAN DYKE	11.00	72	20860	1	Grade 5H
WILLIAMS STREET	13.20	72	21518	1	Grade 5H
WILLIMANTIC	4.80	67	36292	2	Grade 6H
WEST SPRINGFIELD	13.80	29	55440	2	Grade 6H

NOTES:

* Substations that are not included in the above tables have the minimum TPG requirement of one (1) Grade 5 (yellow cables).

** The assumed default clearing time is 72 cycle for distribution unless listed in the table.

*** Lower TPG cable Grades can be used with the conditions below:

Requirement	Replacement with Lower Grade
1 assembly of 6H	2 assemblies of 5H
2 assemblies of 6H	3 assemblies of 5H
1 assembly of 5H	2 assemblies of Grade 5
2 assembly of 5H (only for 35 kV & below)	3 assemblies of Grade 5
2 assembly of 5H (above 35 kV)	No lower Grade available.

**** Tertiary winding is not listed because it is limited by grounding the primary and the secondary windings.

Attachment 3 – NH: 115 kV & Above TPG Requirements

NOTE: Distribution sites in NH have low fault currents, and the minimum TPG requirement is one (1) assembly of Grade 5 (yellow cable).

Substation*	Voltage (kV)	Clearing Time (cycles)**	Max Fault (amps)	# of TPGs***	Grade***
DEERFIELD B1 & B2	115	24	32183	1	Grade 5H
MERRIMACK	115	24	33172	1	Grade 5H
SCOBIE DIST	115	24	43890	2	Grade 5H
SCOBIE POND	115	24	47028	2	Grade 5H
SCOBIE R1R2	115	24	46985	2	Grade 5H
T120	115	24	45668	2	Grade 5H
TB30 SEC.	115	24	46068	2	Grade 5H
TB90 SEC.	115	24	45748	2	Grade 5H

NOTES:

* Substations that are not included in the above tables have the minimum TPG requirement of one (1) Grade 5 (yellow cables).

** The assumed default clearing time is 72 cycle for distribution unless listed in the table.

*** Lower TPG cable Grades can be used with the conditions below:

Requirement	Replacement with Lower Grade
1 assembly of 6H	2 assemblies of 5H
2 assemblies of 6H	3 assemblies of 5H
1 assembly of 5H	2 assemblies of Grade 5
2 assembly of 5H (only for 35 kV & below)	3 assemblies of Grade 5
2 assembly of 5H (above 35 kV)	No lower Grade available.

Appendix A – General Considerations for Placement of TPGs

1.0 General

1.1 For TPGs to provide proper protection, continuity must be maintained between the point of connection and the work location. See Figure A1.

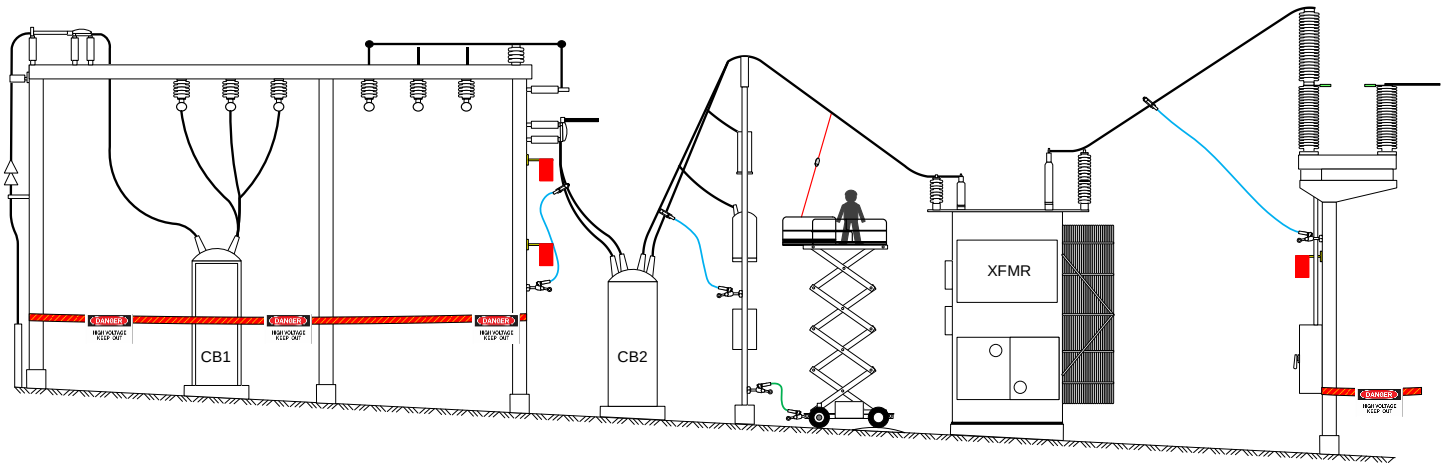


Figure A1 – View of Substation Equipment Layout

2.0 Power Circuit Breakers and Transformers

2.1 Turn ratio transformers are capable of transforming low voltages to high voltages, even when they are not connected to the normal power source.

2.1.1 Low voltages may come from continuity checking instruments, insulation checking apparatus, and electric arc welders.

2.2 TPGs shall be installed on both sides (all terminals) of circuit breakers and transformers while workers are inside the equipment tanks or on top of equipment, or within the minimum approach distance (MAD) of deenergized current carrying components, such as conductors and bushing terminals.

2.2.1 Circuit breaker bushing CT leads should be shorted unless normal burden load (connected meters, relays, etc.) is confirmed.

2.2.2 TPGs between the breaker and its free standing CTs shall be installed to prevent creation of an electrical loop that can cause circulating current and spurious operation of protective devices.

2.3 TPGs shall be in place before oil is drained from the tanks or the tanks are opened.

2.4 Bushing leads may be disconnected from bushing terminals, as necessary, to permit equipment testing that require the equipment terminals to be ungrounded, provided the TPGs remain connected to the bushing leads. The grounds should be re-established as soon as testing is completed, or a separate set of shorting leads installed for prolonged work conditions.

3.0 Disconnect Switches and Bus

3.1 Work on disconnect switches and bus conductors shall be performed with visible TPGs installed at the worksite.

3.2 TPGs are applied on both sides of the device when maintaining circuit switchers, or other devices that can have a circuit disconnection not visible to the worker.

4.0 Instrument and substation service transformers

4.1 Back-feeding voltage through voltage transformers and/or substation service (SSVT, CCVT, CVT, CCPD, VT, PT) is extremely hazardous due to the high turn ratio.

4.1.1 Opening secondary disconnect switches and removing fuses minimize the hazards from secondary back-feed during cases where the primary side cannot be grounded.

4.1.2 Attached ground switches shall not be solely relied upon due to potential lack of maintenance and possible failures.

5.0 Insulated High-Voltage Cable

5.1 Work on cable terminations or potheads shall be done with single-point grounding installed at the worksite end of the cable, or as otherwise provided in Section 5.3 below.

5.2 The non-working end of cable shall remain ungrounded and treated as if energized, unless all three of the following conditions apply; then both ends of the cable may be worked on with single-point grounding only at one end:

1) The non-working end of cable terminates within the same station.

2) The high-voltage cable does not exceed 30 feet in length.

3) The predicted exposure voltage is acceptable.

5.3 If the conditions of Section 5.2 in Appendix A are met, both ends of a high-voltage cable may be grounded and worked on simultaneously.

5.3.1 Double-isolation grounding may be applied to one or both ends for multi-point cable grounding. Full-size TPGs (4/0) shall be connected to the cable terminals (potheads).

5.4 When high-voltage cable is to be spliced, double-isolation grounding should be applied to both ends of the cable as shown in Figure A2, but do not ground the actual cable conductor at either end.

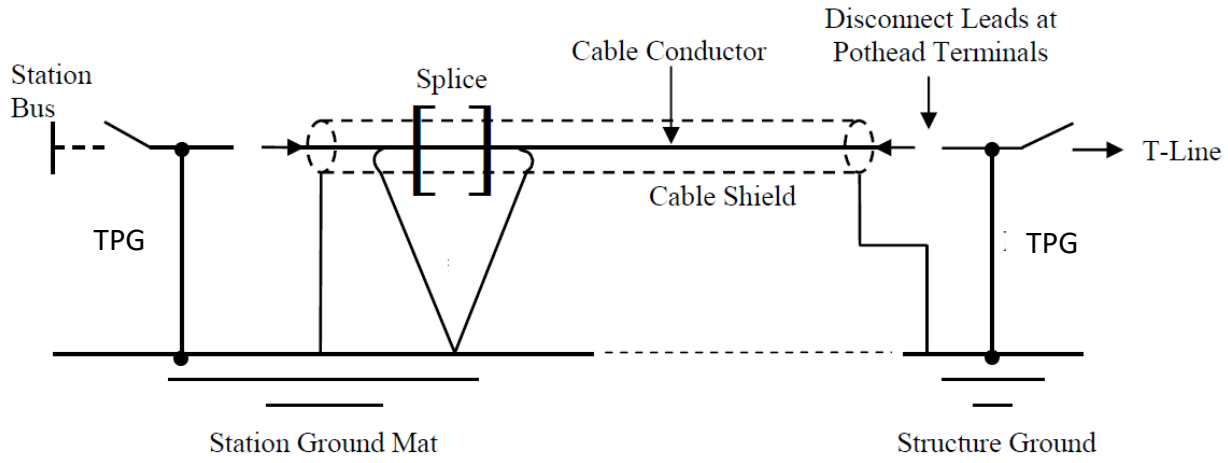


Figure A2 – Grounding During Splicing Cable

5.5 Install additional grounds to the cable shield and conductor on both sides of the splice at the worksite, if feasible.

CAUTION: The worksite grounds shall have an ampacity equal to or greater than the cable conductor or shield.

5.6 Worksite grounds shall remain in place until the conductor is joined.

NOTE:	If the shield and conductor cannot be grounded at the splice, and one end of the cable terminates external to the station, then treat the shield and conductor as if energized and use appropriate isolation/insulation protection for electric shock at the worksite (splice).

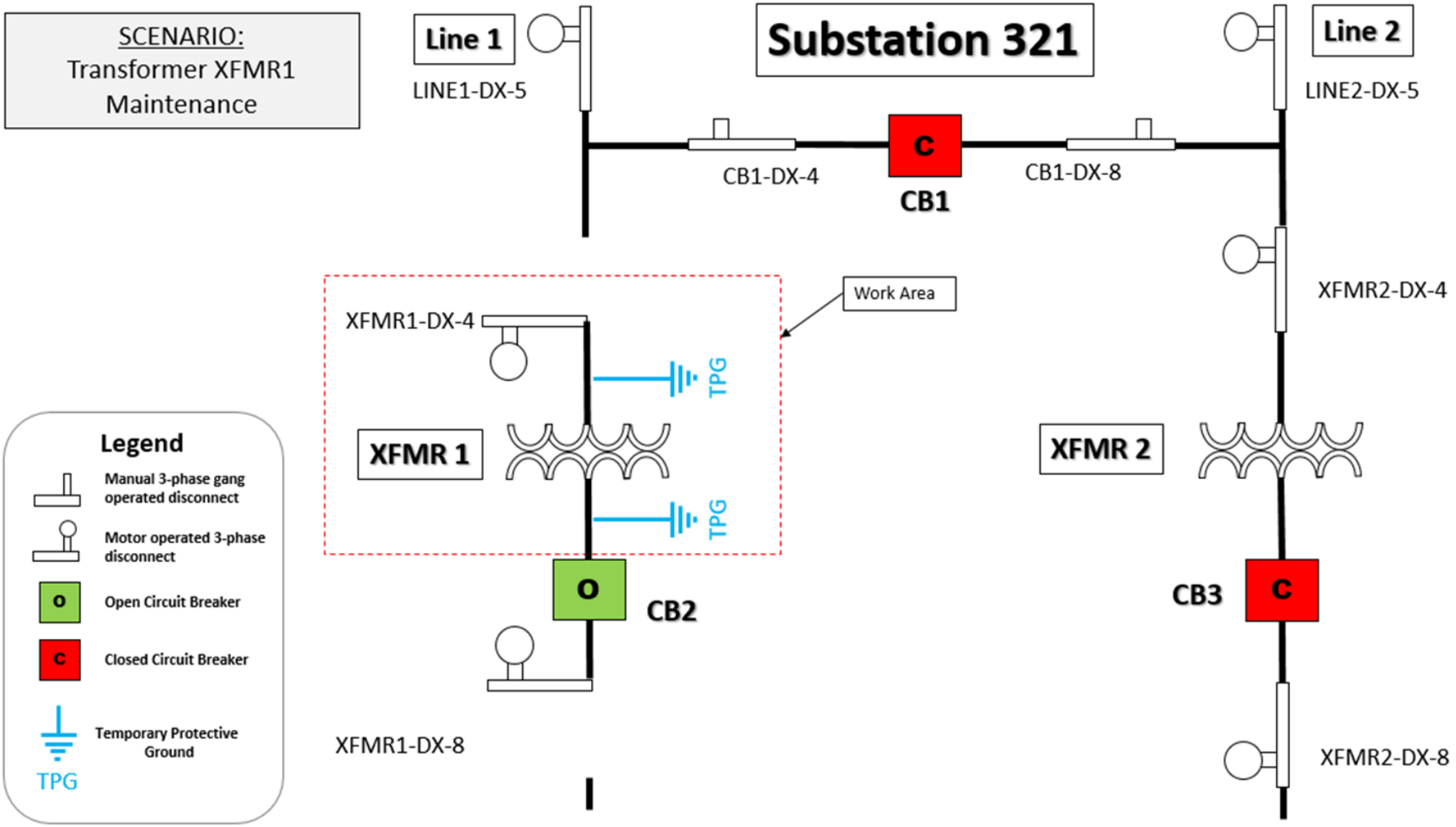
6.0 Capacitor Banks

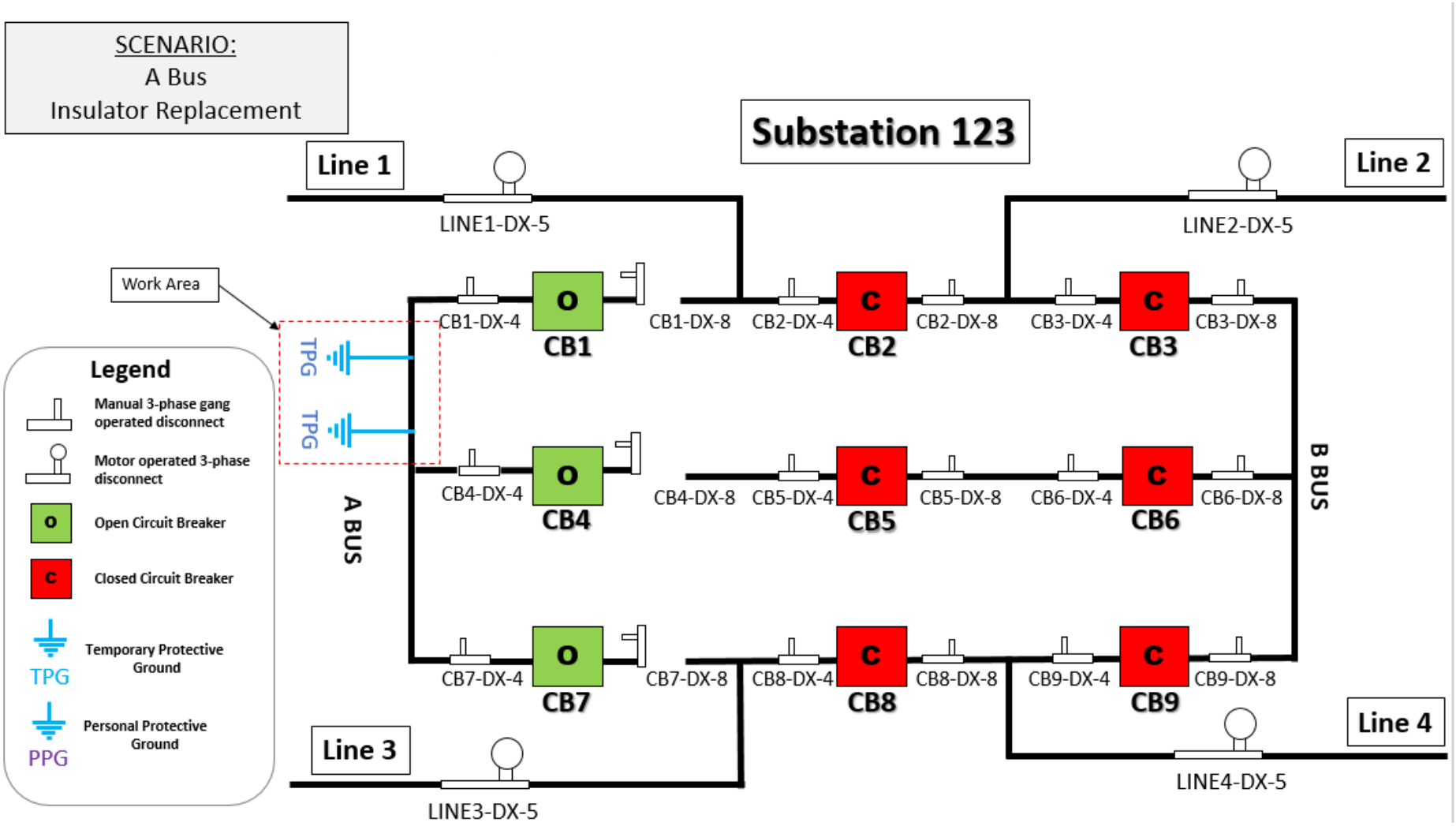
6.1 TPGs shall be applied to capacitor banks after a minimum of 5-minute waiting period once the bank has been electrically isolated.

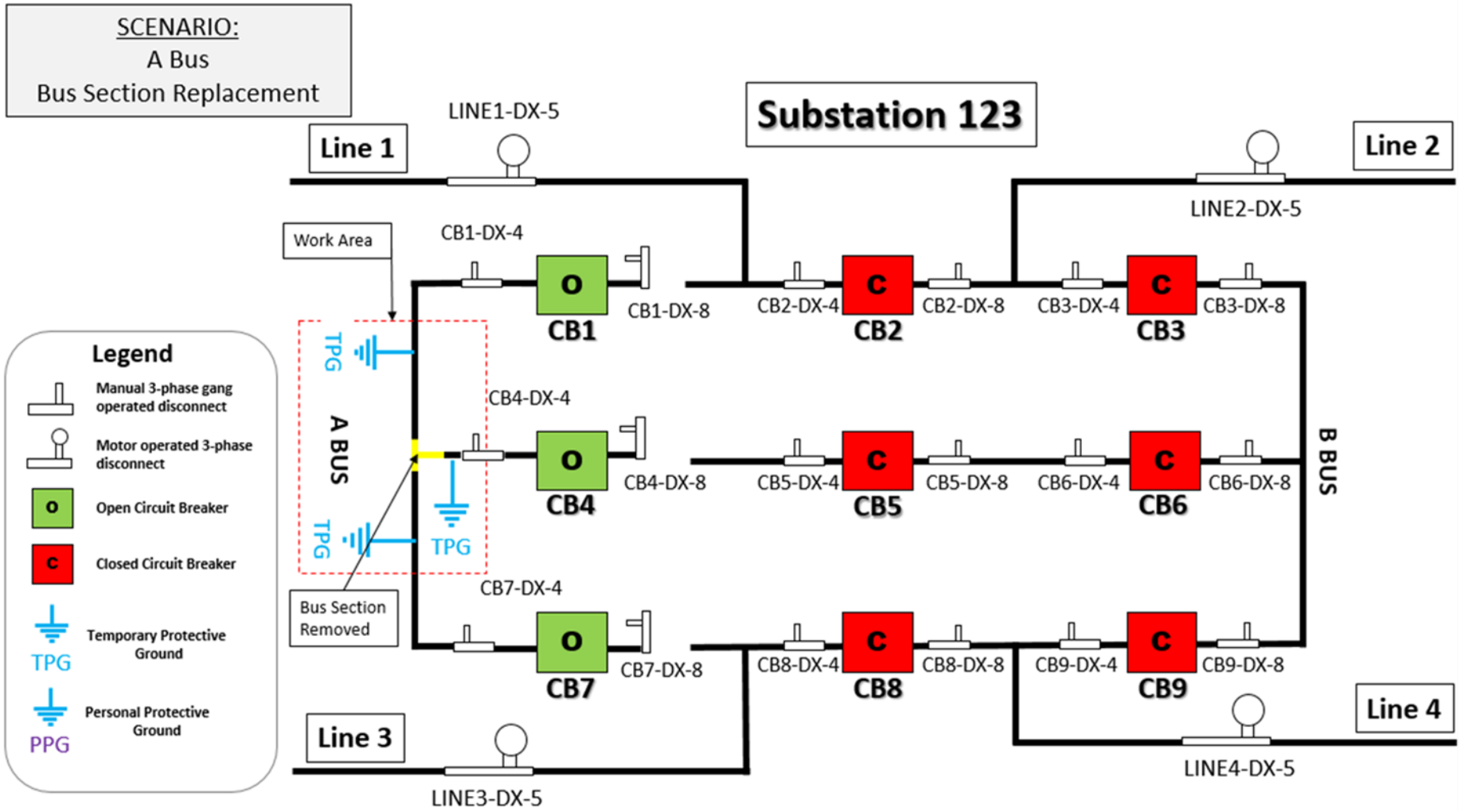
6.2 Close capacitor grounding switches, if available.

6.3 TPGs shall be applied to all phase terminals of the bank, and the neutral when wye connected.

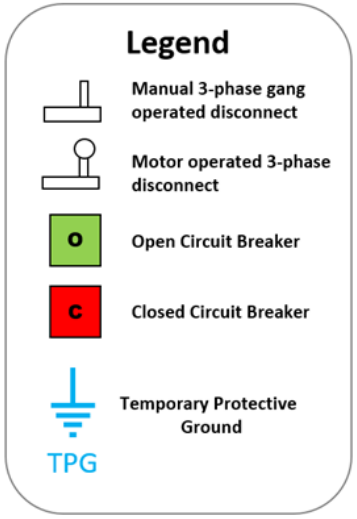
Appendix B – Grounding Scenarios

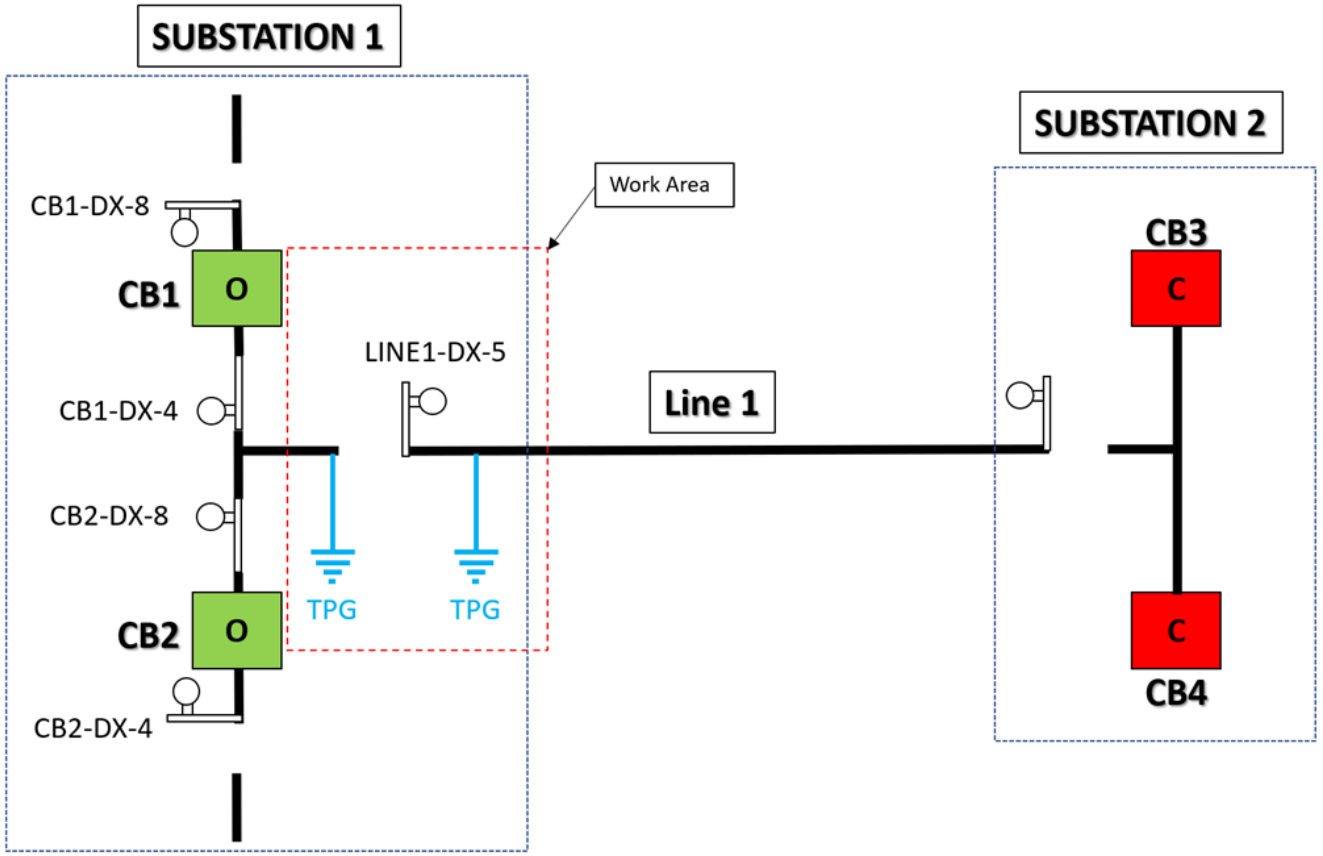



SCENARIO:
A Bus
Insulator Replacement
Substation 123
Line 1
Line 2
Line 3
Line 4
LINE1-DX-5
LINE2-DX-5
LINE3-DX-5
LINE4-DX-5
Work Area
TPG
TPG
A BUS
B BUS
CB1-DX-4
CB1-DX-8
CB2-DX-4
CB2-DX-8
CB3-DX-4
CB3-DX-8
CB4-DX-4
CB4-DX-8
CB5-DX-4
CB5-DX-8
CB6-DX-4
CB6-DX-8
CB7-DX-4
CB7-DX-8
CB8-DX-4
CB8-DX-8
CB9-DX-4
CB9-DX-8
O
C
CB1
CB2
CB3
CB4
CB5
CB6
CB7
CB8
CB9
Legend
Manual 3-phase gang operated disconnect
Motor operated 3-phase disconnect
Open Circuit Breaker
Closed Circuit Breaker
Temporary Protective Ground
TPG
Personal Protective Ground
PPG

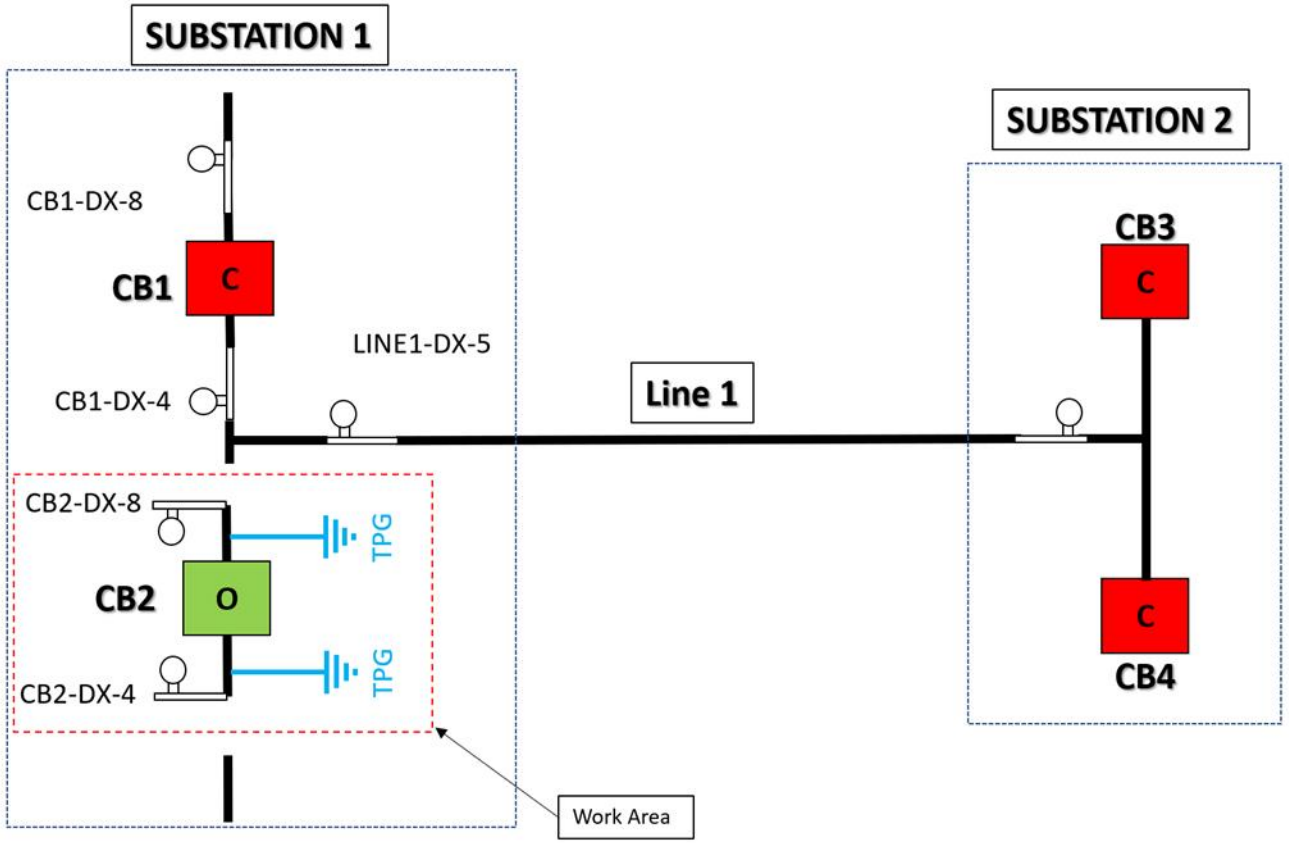

SCENARIO:
A Bus
Bus Section Replacement
Substation 123
Line 1
LINE1-DX-5
Line 2
LINE2-DX-5
Line 3
LINE3-DX-5
Line 4
LINE4-DX-5
Work Area
CB1-DX-4
CB1-DX-8
CB2-DX-4
CB2-DX-8
CB3-DX-4
CB3-DX-8
CB4-DX-4
CB4-DX-8
CB5-DX-4
CB5-DX-8
CB6-DX-4
CB6-DX-8
CB7-DX-4
CB7-DX-8
CB8-DX-4
CB8-DX-8
CB9-DX-4
CB9-DX-8
CB1
CB2
CB3
CB4
CB5
CB6
CB7
CB8
CB9
A BUS
B BUS
TPG
TPG
TPG
Bus Section Removed
Legend
Manual 3-phase gang operated disconnect
Motor operated 3-phase disconnect
Open Circuit Breaker
Closed Circuit Breaker
Temporary Protective Ground
Personal Protective Ground
PPG

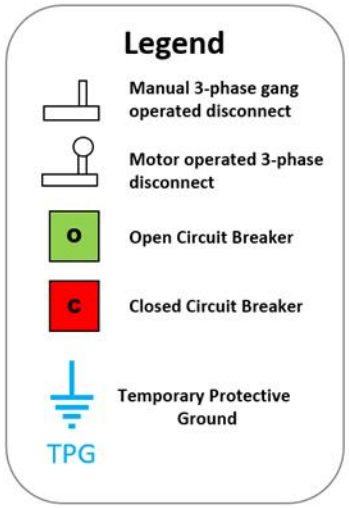
SCENARIO:
Line Switch
Maintenance



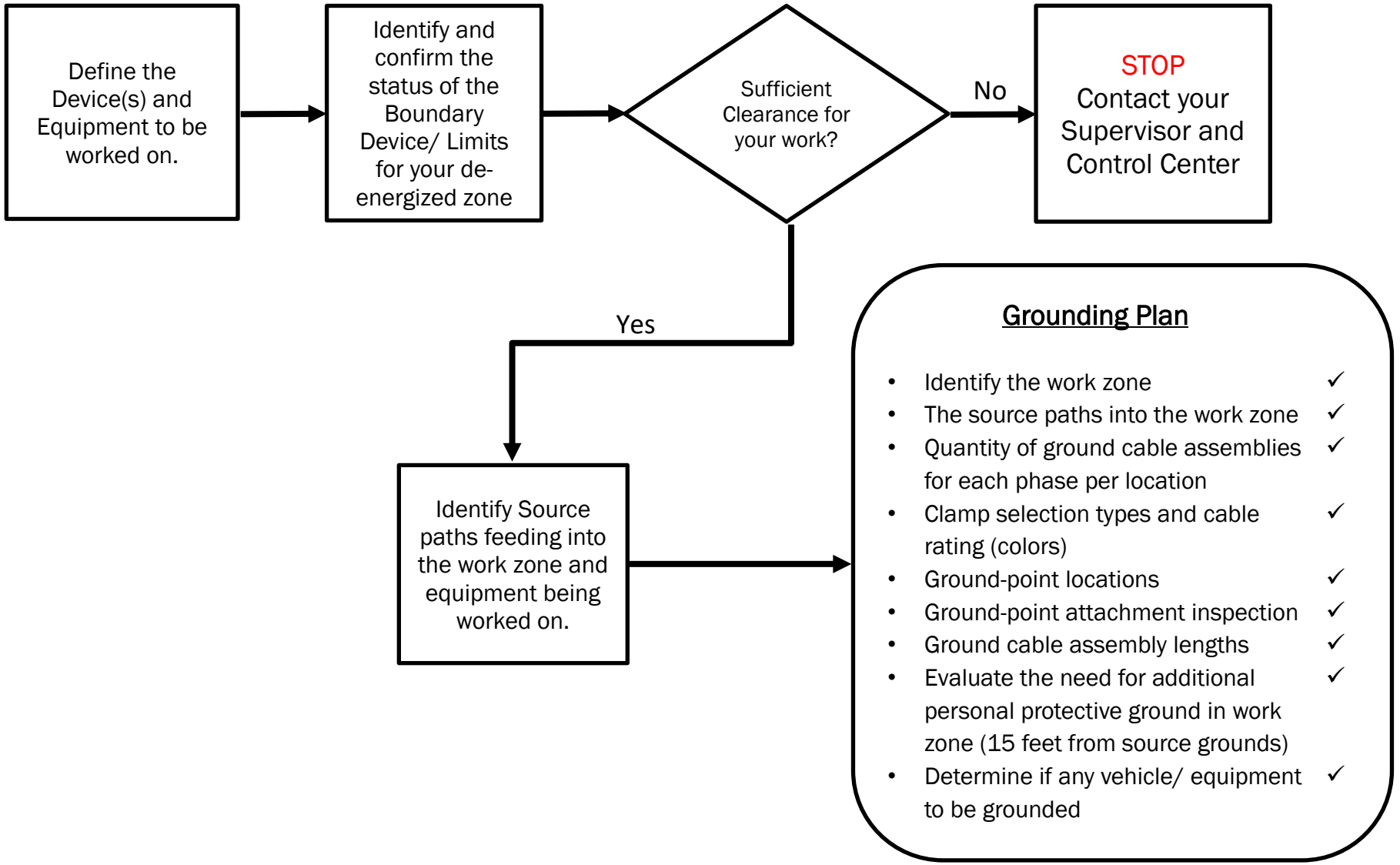


SCENARIO:
CB2 Breaker
Maintenance





Appendix C – Grounding Plan Process



Appendix D – Grounding Plan Form

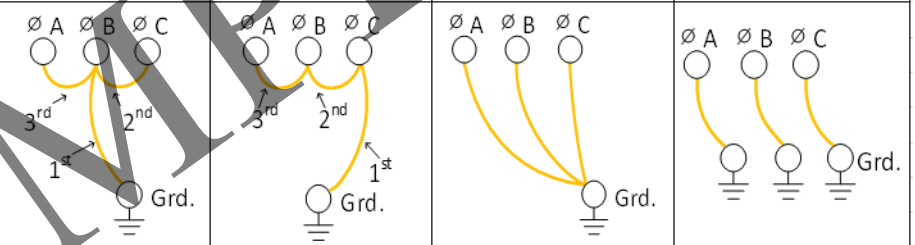
Grounding Plan Substation Operations	**Supervisor Review** NAME:_____ DATE: _____	EVERSOURCE

LOCATION	**CREW INFORMATION**	**RELEVANT PROCEDURES**	
Work Location / Address:	**Clearance Holder:**	Substation Grounding	Substation Work Area Identification
City / Town:	**Crew Size:**	Vehicle & Equipment Grounding	
Nearest Intersection / Landmark:	**Switching Control #**		Care of Live Line Tools
Time: **Date:**	**Logged in:** IVR or Called Dispatch	Maintenance & Testing of Substation Grounding Equipment	

JOB DESCRIPTION AND WORK BEING PERFORMED USING THIS GROUNDING PLAN

FIELD INFORMATION

Bus Voltage (kV)	**# TPG Per Phase:** 1 2	**Balanced**	**Un-balanced**	**Phase-to-Ground**	**Ph-to-Gnd Short Cable**
Ground Points Cleaned: YES N/A	**If >1 Max Fault Current:** (A)				
Clamp Rating: Grade 5 Grade 5H Grade 6H					
Cable Rating: Grade 5 (Yellow) Grade 6H (Blue)					
TPG Assembly Rating: Grade 5 Grade 5H Grade 6H					
TPG Inspected: YES N/A	**TPG Date Satisfactory:** YES NO				
Threaded Ferrules: YES N/A	**Noncompliant TPG Removed:** YES N/A				
Vehicle Grounded: YES N/A	**Cable Uncoiled:** YES N/A				
Lift Bonded: YES N/A	**Mobile Bond Used:** YES N/A				
Station Diagram Marked-up & Attached?: YES NO N/A					
Additional PPG Needed in the Work Zone: YES NO N/A					



NOTE: If the Boundary or work scope has changed engage Supervision to re-evaluate the Grounding Plan.

NOTE: When two (2) or more ground parallel cable assemblies are required on each phase, they shall be physically installed facing the same direction and no more than three (3) inches of each other.

PERSONAL PROTECTION & WORK AREA IDENTIFICATION

Identify the Work Zone / Zone of Protection and list the devices, locations and tags used for the isolation of the Work Zone.

Identify and list the Source Paths to the Work Zone and list the known Source Voltages.

JOB SAFETY

Equipment and lines shall be tested with an approved testing device using a live, dead, live process.	Approved live-line tools and rubber gloves SHALL be used to install and remove ground cable assemblies, test equipment leads, or dead-line potential fuses from the live end. Rubber gloves will be worn at a minimum when removing and installing the cold end. If field conditions do not permit the use of live line tools, contact Eversource Supervision.	IF a Grounding Plan cannot be executed because of Substation Design, Safety must be consulted and a JOB SAFETY ANALYSIS **SHALL** be performed. Consult Supervision