

# Protective Grounding for Overhead Distribution Lines 35 kV & Below

**Document Number:**

WMS 89.01-1

**Issued Date:**

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**Revision:**

0

**Applicability:**

CT / WMA / NH

**\*\*\* This Document Supersedes TD855 \*\*\*****Scope:**

This work standard covers the safe work practices for installing Temporary Protective Grounding (TPG) assemblies on Overhead (OH) Distribution lines 35 kV and below.

**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
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Reviewed by: Signature on FileJonathan Duffy  
Director, SafetyDate: 23-Dec-22Approved by: Signature on FileJennifer Hebsch  
Director, System Resiliency and Standards EngineeringDate: 28-Feb-23Approved by: Signature on FileBarry Lashley  
Director, Electric OperationsDate: 12-Dec-22Approved by: Signature on FileJay Yergeau  
Director, Electric OperationsDate: 20-Dec-22Approved by: Signature on FileKevin Saulnier  
Director, Electric OperationsDate: 16-Feb-23Approved by: Signature on FileDavid Velez  
Director, Electric OperationsDate: 10-Jan-23

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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 TPG assemblies.
- 1.2 The development of an equipotential zone (EPZ) for personal protection is the primary work method covered by this procedure. It is required that whenever work is performed on OH Distribution lines under a clearance, as specified in **ESOP 100**, all phases of the equipment to be worked on shall be de-energized, isolated, and grounded.
- 1.3 The primary purpose of protective grounding is to protect the worker against injury from electric shock by limiting the voltage difference between any two accessible points at the work site to a safe value under the following conditions:
  - 1.3.1 A device accidentally closing into grounded line section.
  - 1.3.2 An energized line accidentally contacting the deadline.
  - 1.3.3 Electromagnetically induced voltages caused by load or fault currents in an adjacent line.
  - 1.3.4 Electrostatic voltages caused by capacitive coupling to adjacent lines.
  - 1.3.5 Back feed from emergency or auxiliary power supplies or other unexpected sources.
  - 1.3.6 Lightning strikes.
- 1.4 Workers are best protected by properly installing worksite grounds, otherwise referred to as TPGs.
  - 1.4.1 TPG's consist of two clamps, ferrules, cable, and heat shrink tubing to make up the general term of a "cable assembly".
  - 1.4.2 For the remainder of this standard, the terms TPG and ground cable assembly will be used interchangeably.
- 1.5 When it is not practical to install a cluster bar and ground cable assembly, the line must be treated as energized and all appropriate insulate & isolate work practices employed.
- 1.6 This procedure includes the process of ground cable selection and installation based on maximum fault current and clearing times.
  - 1.6.1 A list of all circuits and the minimum required ground cable size is listed in Attachment 1.
- 1.7 Appendix A shows various field scenarios and how to apply ground cables.

## 2.0 Reference Documents

ASTM F855 Temporary Protective Grounds on De-energized Electric Power Lines  
ASTM F2249 Standard Spec for In-Service Test Methods for Temporary Grounding Jumper Assemblies  
CAT 3000 Transmission & Distribution Grounding Material  
DTR 16.201 Grounding Application Guide  
DTR 16.700 Grounding & Bonding Pole-mounted Equipment  
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  
OG-3B Requirements for Work on the EMA Electric Distribution System  
OP-5087 OH Grounding Plan Form  
OSHA 1910.269(n), Grounding for Protection of Employees  
WMS 89.03 Vehicle & Equipment Grounding for Transmission  
WMS 84.05 Maintenance & Testing of Hot-line Tools & Equipment  
WMS 89.05 Applying Personal Protective Grounding for Transmission Lines, 115 kV & Above  
WMS 89.06 Protective Grounding Inside Substations  
WMS 89.11 Maintenance & Testing of Personal Protective Grounding Equipment  
WMS 91.11 Testing for Voltage

## 3.0 Bill of Materials

3.1 Refer to **CAT 3000** Transmission & Distribution 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 create a safe low impedance path, for any current likely to be imposed on it.
- 4.2 Cluster Bar (Chain Binder) – A terminal that is clamped to a structure, below the workers feet, that provides a means for the attachment and bonding of TPGs and/or bonding cables to the structure.
- 4.2.1 When a ground stud is available on a steel structure, a cluster bar is not required. The ground stud performs the same function as a cluster bar.

**CAUTION:** The cluster bar and grounding jumper are important parts of personal protective grounding. They are used at the work location to minimize the voltage difference in the aerial work zone (whether working from an aerial device or on a pole). If the cluster bar is not used, the grounding jumpers alone will not provide personal protection.

**CAUTION:** Bracket Grounding by itself does not create an Equipotential Zone.

- 4.3 Bracket Grounding – Two or more sets of grounding jumpers installed on all sides and as close as practical to the work area.
- 4.4 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.
- 4.5 Equipotential zone / equipotential grounding (EPZ) – For the purposes of protective grounding, a near identical state of electrical potential.
- 4.6 Ground to Ground – The moment the worker leaves the ground to climb a pole, prior to commencing work, to the time when they return back on the ground.
- 4.7 Grounding – The practice of intentionally connecting to earth through a ground connection.
- 4.8 Grounding Plan – The process to which the TPGs quantity, length and locations are discussed and determined.
- 4.9 Known Source of Voltage – The one side of an energized primary switch or device in the open position, which if placed in the closed position, would energize a work zone. A generator identified on an Eversource primary circuit print supplying primary voltage (including wind and solar) is a Known Source of Voltage.
- 4.10 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 points are required.
- 4.11 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.
- 4.12 Single Point Grounding – The application of temporary protective grounds only in the immediate vicinity of an electrically continuous worksite. The location of the TPGs must be close enough to the worksite to prevent a hazardous differential in potential across a worker at the worksite.
  - 4.12.1 Establishes an equipotential safe working zone by the application of TPGs.
- 4.13 System Operator Ground – A ground whose installation, removal or operation is directed and tracked by the System Operator.
- 4.14 Temporary Protective Grounding (TPG) – A cable, ferrule and clamp assembly designed to limit the voltage difference between any two accessible points at the worksite to a safe value and having enough current withstand rating.
  - 4.14.1 TPGs can be used for system operator grounds, personal grounds, worker grounds, and ground cable assemblies.
- 4.15 Ultimate Rating (Capacity) – A calculated maximum symmetrical current value that a TPG cable is capable of carrying, for a specified time, without fusing or melting.
- 4.16 Worker Ground – Grounds whose installation or removal is directed and tracked by the Clearance Holder.

- 4.17 Zone of Protection – An area isolated from all Known Sources of Voltage whereby the perimeter limits are in their protective position and the work area is subsequently grounded.

## 5.0 General

- 5.1 Eversource Engineering has specified the required cable quantity based on fault current and clearing times.
- 5.2 There are two (2) grounding practices, “Phase-to-Phase ” or “Phase-to-Ground” grounding.
- 5.2.1 The preferred is “Phase-to-Phase” grounding, to reduce circulating currents.
- 5.3 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.
- 5.4 The lines and equipment can be worked without grounds if the following conditions can be met:
- 5.4.1 The lines and equipment have been de-energized, following proper switching and tagging procedures.
- 5.4.2 The possibility of contact with an energized source is not present.
- 5.4.3 The hazard of induced voltage is not present.

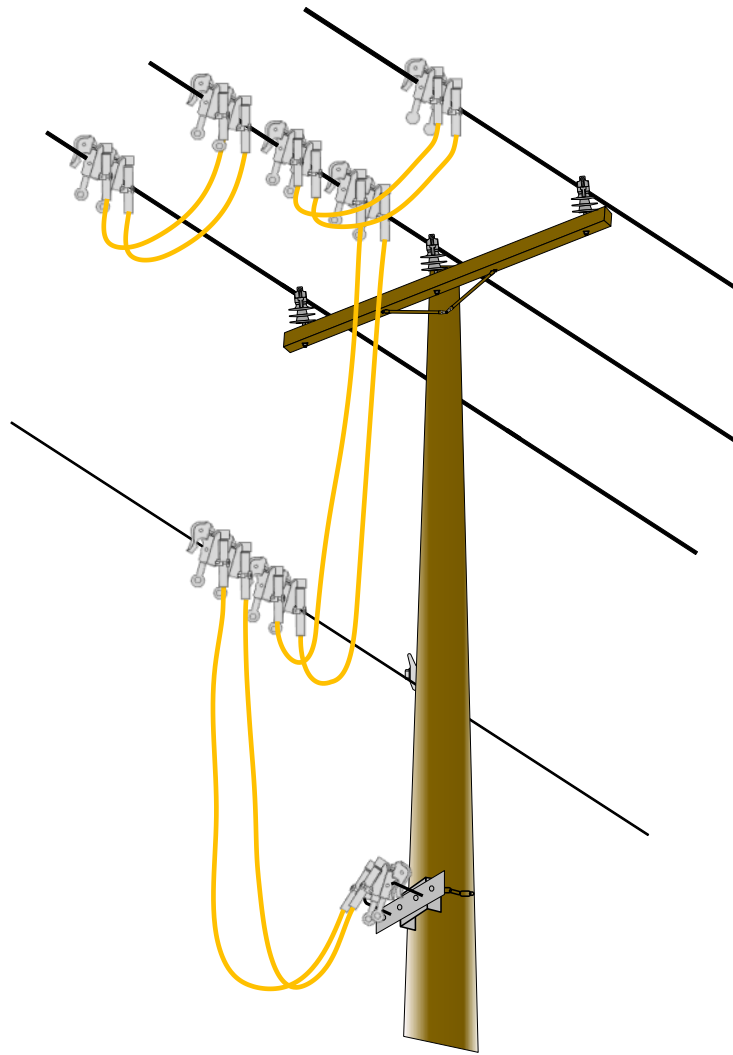
**NOTE:** The preferred method is to install grounds, whenever possible.

## 6.0 Ground Selection

**CAUTION:** Prior to selecting TPGs, verify the ground cable requirement (quantity and grade) based on Attachment 1.

- 6.1 When two (2) or more ground cable assemblies are required to meet the available fault current, as defined in the Attachments, they SHALL be:
- 6.1.1 Equal length.
- 6.1.2 Equal rating for the cable, clamps and ferrules.
- 6.1.3 Assembled using uniform components (same manufacturer, type, rating, etc.). Refer to Figure 1.

**Example:** Double ten (10) foot TPG assemblies from phase to phase, and the double TPG assemblies from the neutral to the cluster bar could be 15 feet.



**Figure 1 – Multiple Grounds**

**NOTE:** The shortest ground cable SHALL always be used.

- 6.2 Approved grounding equipment and their applications are provided in Material Catalog **CAT 3000**.
- 6.3 If situations arise where it is impractical to apply ground cable assemblies at a work location, bracket grounds **MUST** be installed as close as practical to the work location (see “Work with Bracket Grounds” Section 11.0).

## **7.0 TPG Preparation**

- 7.1 The grounding plan shall be determined prior to the start of work, refer to Form OP-5087 “OH Distribution Grounding Plan”.
- 7.2 Vehicles or equipment shall be connected to a ground source as specified in Work standard **WMS 89.03**.
- 7.3 Clearance shall be given by the System Control Center as specified under the provisions of the applicable Eversource switching authority. Refer to **ESOP 100**.
- 7.4 Prior to installing TPGs, test the equipment for potential to prove it is de-energized per Work standard **WMS 91.11**.



7.5 Prior to the installation of ground cable assemblies, visually inspect and clean each assembly as detailed in Work standard **WMS 89.11**.

7.5.1 If any damage is found, return the ground cable assembly for repair and testing.

**NOTE:** All switching and tagging for transmission and distribution shall be performed in accordance with Eversource System Operating Procedure **ESOP 100**.

7.6 Prior to working on OH Distribution lines as de-energized:

7.6.1 Contact the System Operator if the line must be removed from service.

7.6.2 Refer to applicable **ESOP 100** requirements.

## **8.0 Installation & Removal**

8.1 All ground cable assemblies installed and removed shall be tracked per **ESOP 100**.

**CAUTION:** Always use the shortest length ground cable, in order to minimize cable slack, reducing the severe and dangerous forces developed by fault currents.

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

8.2.1 Approach/Egress path to live parts.

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

8.2.3 Proper work positioning to prevent injury.

8.3 Approved live-line tools **SHALL** be used to install and remove ground cable assemblies, from both the live and cold ends.

8.3.1 Verify all live-line tools have been tested and labeled per Work standard **WMS 84.05**.

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

8.4 When a ground cable is coiled or on a reel, it **SHALL** be completely removed from the reel or holder.

8.4.1 Unwind and straighten the cable or lay it out in an “S” shape on the ground without crossover, to reduce the possibility of induced voltages.

8.5 Clean all connection points to remove contaminants.

8.5.1 If a wire brush cannot be used, then clean the connection point by the sequence of “tightening-loosening-tightening” the clamp repeatedly.

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

A ground cable assembly shall NOT be extended by connecting multiple assemblies together (a.k.a. daisy chain) under any circumstance.

8.6 The preferred method is to install single point grounds at the pole to be worked on.

8.6.1 If field conditions do NOT permit, then the grounds can be installed on the adjacent pole.

.1.1. The pole being worked on in this case would only require a cluster bar and a ground lead to the neutral.

.1.2. If the grounds are located more than one section away, a personal ground lead to the phase being worked on would be required.

**NOTE:** When two (2) or more ground cable assemblies are required on each phase, they shall be physically installed:

- Facing the same direction.

- No more than 3 inches apart from each other.

8.7 Order of ground connections are listed below:

8.7.1 System neutral

8.7.2 Static/shield wire

8.7.3 Steel structures that are grounded

8.7.4 Equipment ground rod

8.7.5 Guy anchor rod

8.7.6 Temporary screw ground rod

8.7.7 Temporary driven ground rod

8.8 Attach at least one (1) approved, high visibility, non-conductive, "Ground Flag" in each location where ground cables are installed.

8.9 A cluster bar is to be attached on ALL poles that are to be climbed, or when working from an aerial lift, where the pole is within reaching distance of the worker.

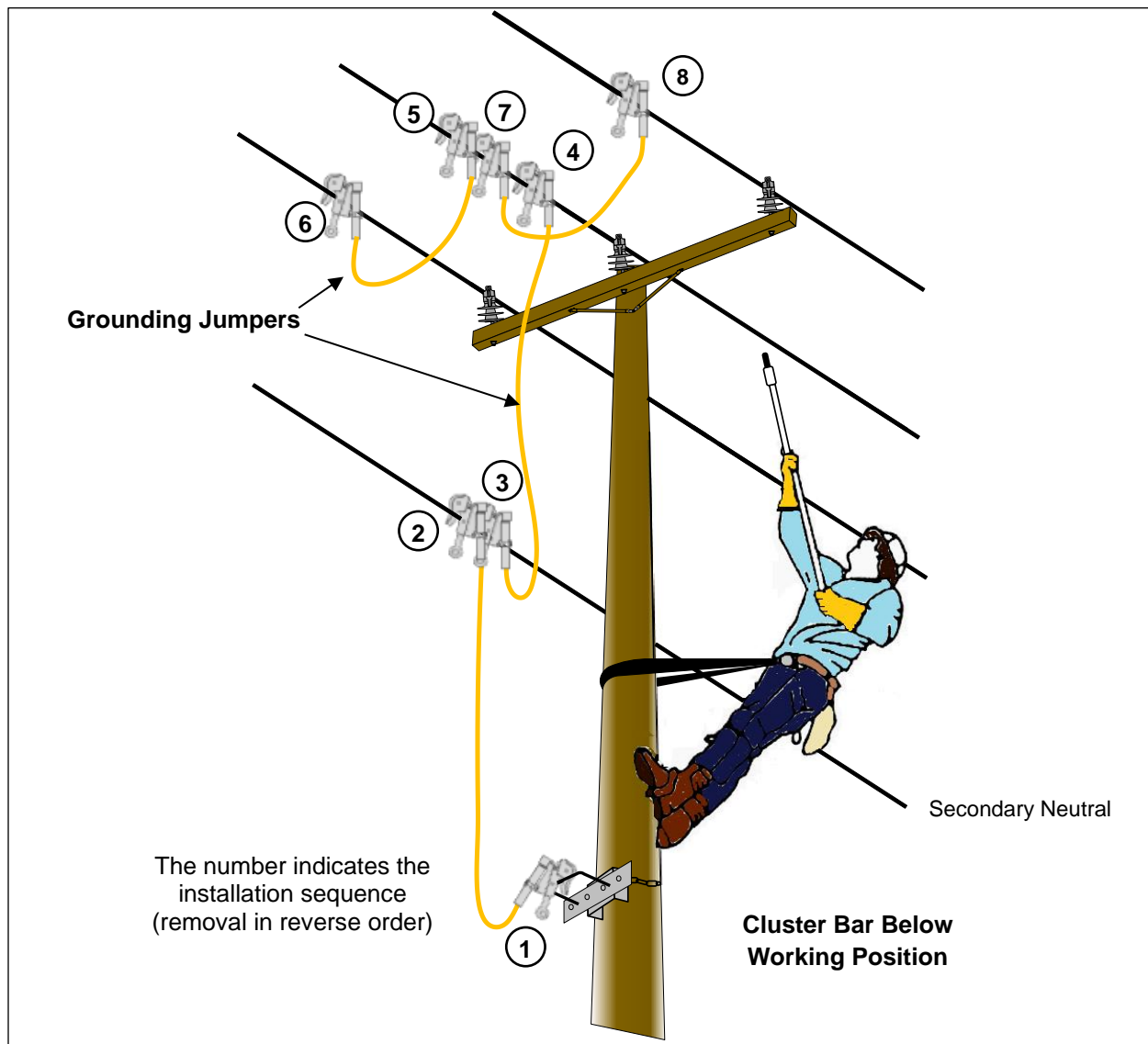
8.9.1 The cluster bar is connected to the system neutral and/or to a grounded phase conductor.

8.9.2 The cluster bar shall be attached on the pole below the working position, leaving adequate working space above it.

8.9.3 When a worker is climbing and will be physically working from the structure, a cluster bar shall be positioned approximately 3 feet below the worker's feet as shown in Figures 2 and 3.



**Figure 2 – Equipotential Grounding Point of Work for Wye or Delta System  
w/o Secondary or System Neutral Wire**



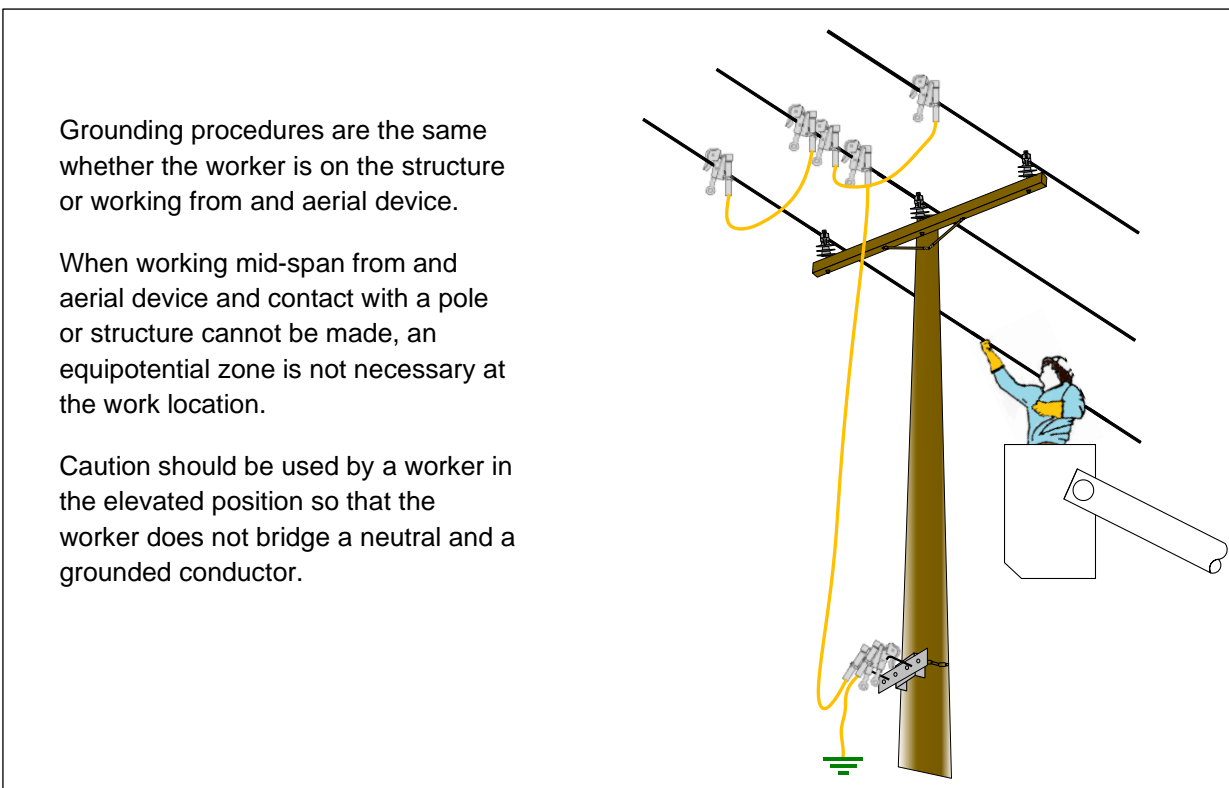
**Figure 3 – Equipotential Grounding Point of Work for Delta System with Secondary Neutral**

**NOTE:** The worker should avoid contact with neutrals, equipment, grounds or down grounds.

## 9.0 Work with an Aerial Device or on a Pole

**NOTE:** ALL requirements from the “Installation & Removal” section of this standard SHALL be followed.

- 9.1 Prior to the start of work complete the Grounding Plan, refer to OP-5087.
- 9.2 When work is being performed:
  - 9.2.1 Verify the MAD is not being encroached or violated.
  - 9.2.2 When it is determined necessary, an additional qualified person (Spotter), other than the person(s) performing work, SHALL be designated to observe the MAD to exposed lines and equipment while operating the aerial device.
    - .2.1. The Spotter shall provide timely warnings before the MAD is reached.
  - 9.2.3 It is REQUIRED to wear FULL PPE cradle-to-cradle or ground-to-ground per Eversource Safety Manual.
  - 9.2.4 The position of the cluster bar should be below the neutral conductor, refer to Figure 4.
    - .4.1. When work is being performed from an aerial lift and the pole is NOT within reaching distance of the worker, a cluster bar is NOT required.
    - .4.2. Connect the cluster bar to the common neutral or shield wire, if present, on Wye or Delta systems.
    - .4.3. If there is no common neutral or shield wire, install a grounding jumper from a suitable ground element to the cluster bar as shown in Figure 2.



**Figure 4 – Equipotential Grounding**

## 10.0 Work with Temporary Screw Grounds & Rods

10.1 When it is necessary to use temporary screw grounds or temporary driven ground rods:

10.1.1 Location should be out of the immediate work area to reduce tripping risks and the hazard of step and touch potentials.

10.1.2 Soil condition should be considered to obtain an effective ground.

.2.1. Low lying areas with permanent moisture shall be used whenever they can be found near the work area.

.2.2. Loose loam and sandy soil shall be set to maximum depth.

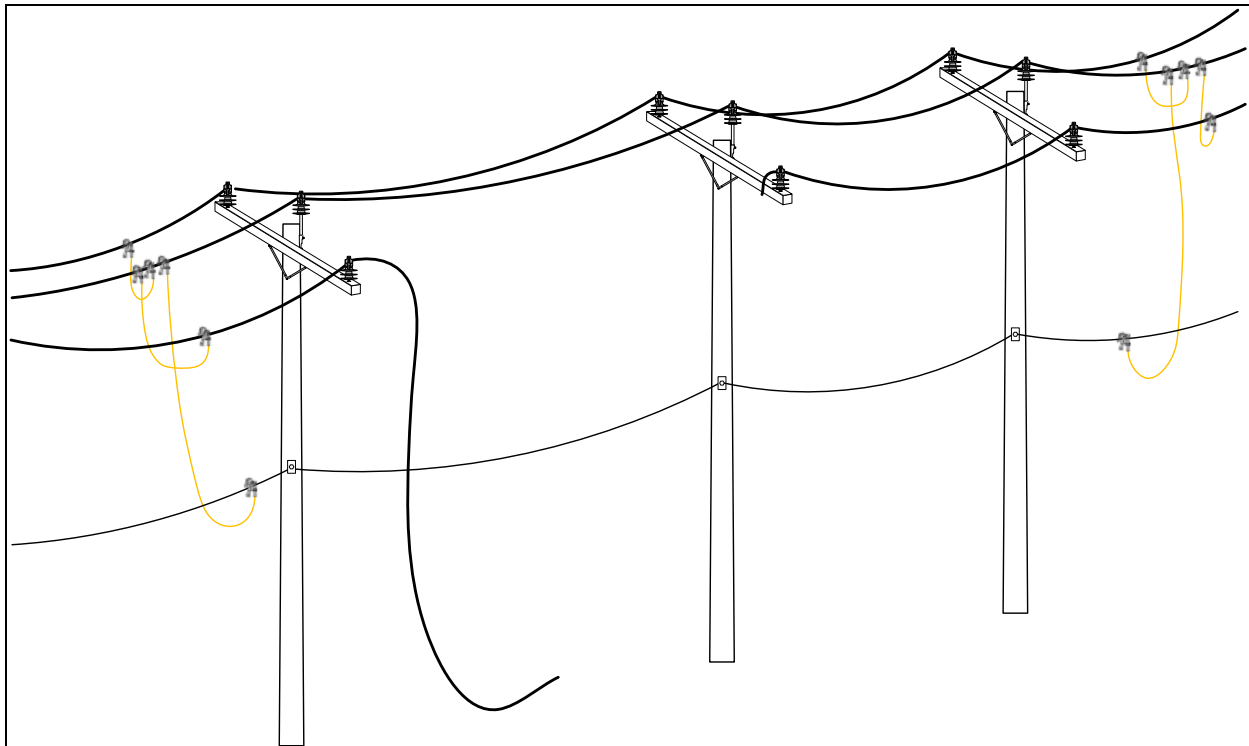
.2.3. If maximum depth is difficult in gravel, hardpan, or other soil conditions, they shall be set at an angle so that as much of its surface area as possible is in contact with the earth.

## 11.0 Work with Bracket Grounds

**NOTE:** ALL requirements from the “Installation & Removal” section of this standard shall be followed.

11.1 Bracket Grounding involves the installation of grounds at two locations, one on each side of the work location (typically a downed conductor).

11.2 Bracket grounds shall be located as close as practical to the work location (the next pole, tower or structure), see Figure 5.



**Figure 5 – Bracket Grounding Downed Conductor**

## 12.0 Phase-to-Phase Method

**NOTE:** The phase identifications (A, B, & C) used in this section are for explanation and figure reference purposes ONLY.

- 12.1 Equipment and jobsite configurations dictate the safest way to apply TPG assemblies. The preferred method for applying OH Distribution TPGs is the Balanced “Phase-to-Phase” Grounding method.

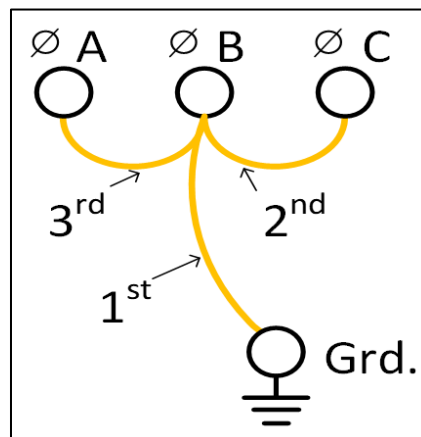
**NOTE:** For All Grounding Methods: If more than one (1) ground cable is required per phase, install all required cable assemblies FIRST (i.e. to Phase 1) prior to installing grounds on Phase 2 and 3.

### 12.1.1 Application of Balanced “Phase-to-Phase” Grounding (Refer to Figure 6):

- .1.1. First Cable: Attach one end of the cable to a ground end source. Attach the other end to the Middle Phase B.
- .1.2. 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.
- .1.3. 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).

### 12.1.2 Removing grounds for the Balanced “Phase-to-Phase” method:

- .2.1. Remove the ground assembly clamp(s) from Phase A.
- .2.2. Remove the ground assembly clamp(s) from Phase C.
- .2.3. Remove the ground assembly clamps from Phase B.
- .2.4. Finally remove the ground assembly clamp(s) at the grounded point.



**Figure 6 – Example of “Phase to Phase”  
(Balanced Chain Grounding) Grounding Application**

- 12.2 If the Balanced “Phase to Phase” Grounding method cannot be performed, the following can be followed:

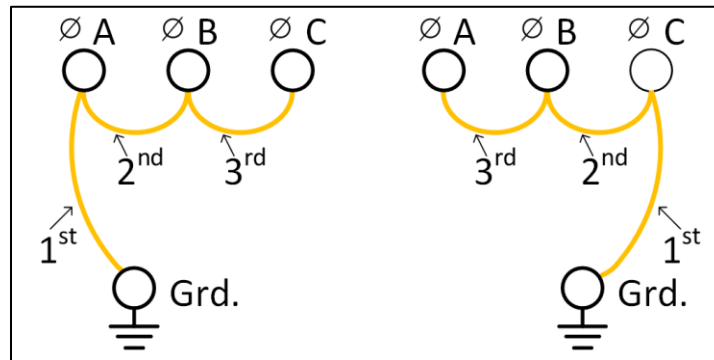
### 12.2.1 Application of Un-Balanced “Phase-to-Phase” Grounding (refer to Figure 7):

- .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).

12.2.2 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.



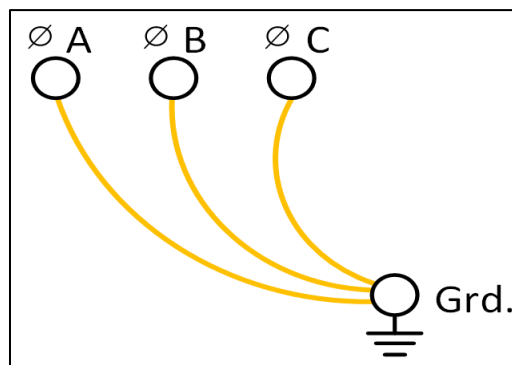
**Figure 7 – Examples of “Phase to Phase” (Un-Balanced Chain) Grounding Applications**

12.2.3 Application of “Phase-to-Ground” (Parallel) Grounding (Reference Figure 8):

- .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.

12.2.4 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.



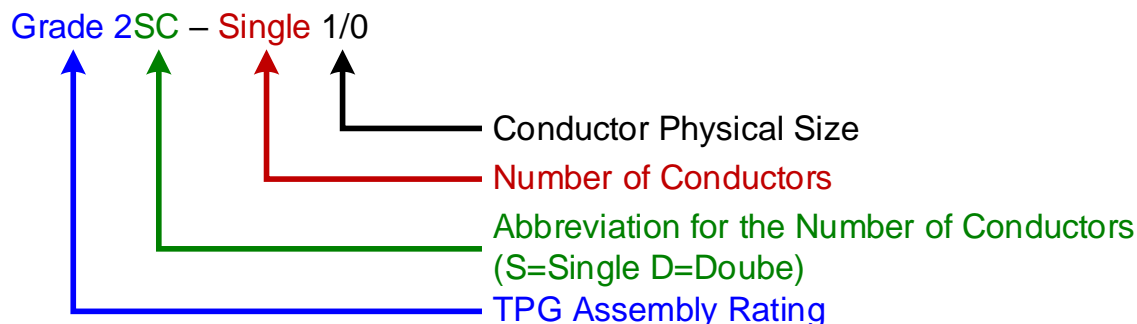
**Figure 8 – “Phase-to-Ground” (Parallel) Grounding**



## Attachment 1 – OH Grounding Requirements per Line

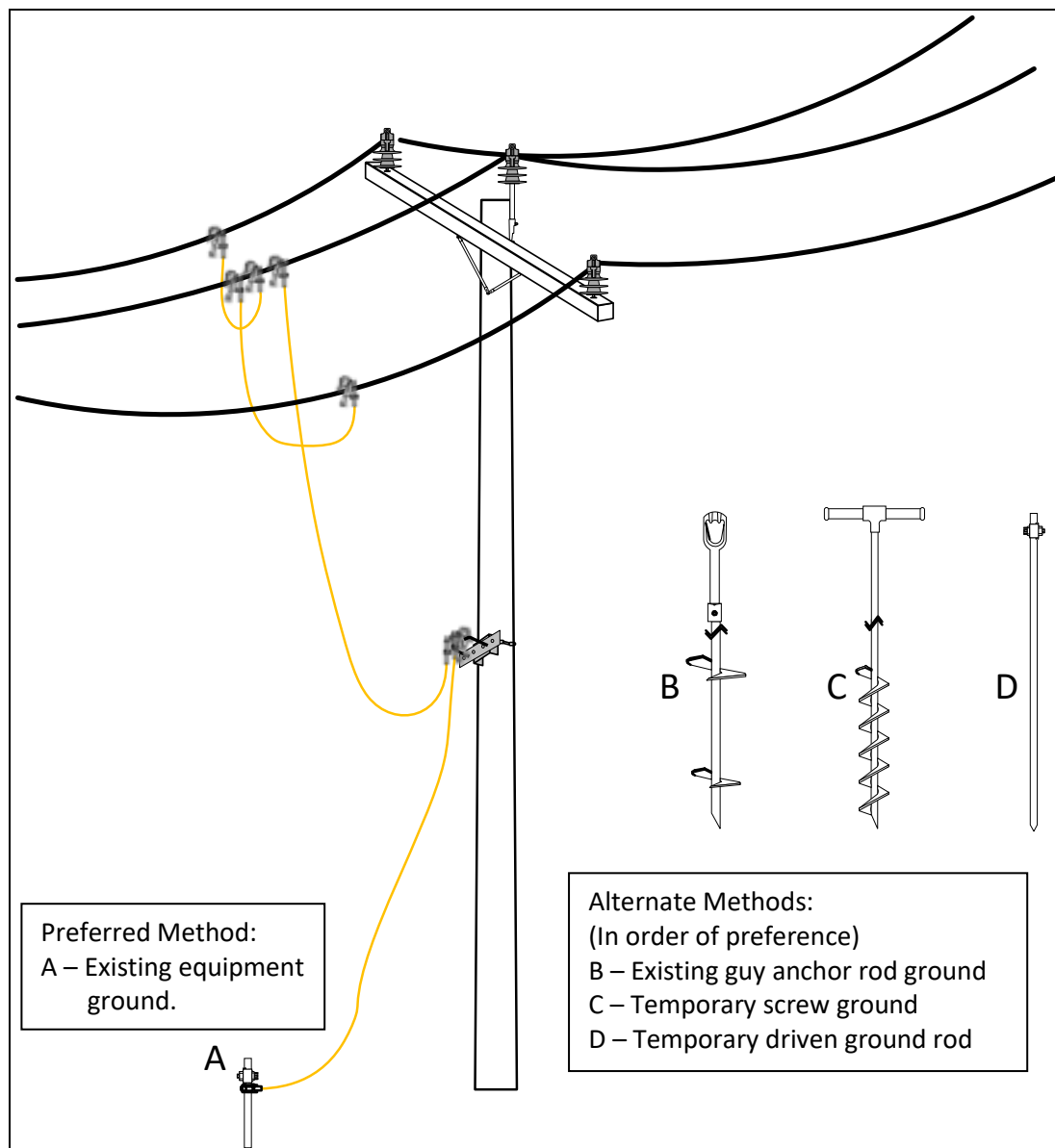
**NOTE:** When an OH distribution feeder is not included/listed in the grounding database (see link below) refer to the applicable Substation Grounding document (**WMS 89.06**) for the appropriate TPG selection.

1. The OH distribution grounding database is a comprehensive list of TPG requirements on the Eversource distribution feeders.
2. Prior to applying TPG to a distribution feeder, the “database” shall be used to determine the correct TPG assembly.
3. To make the appropriate TPG selection, utilize the known feeder information and locate the Grounding Requirements in the “database”:
  - a Substation Number – Substation that the feeder originates from.
  - b Feeder - The feeder (line) number that is to be grounded.
  - c Operation Company – The state where the feeder is located.
  - d Division – The area within the operating company where the feeder is located.
  - e AWC – An “Area Work Center” within the division.
  - f Voltage (kV) – Feeder voltage.
  - g Grounding Requirement – The minimum acceptable ground cable that is allowed to be applied to the feeder.
4. “Grounding Requirements” explained:

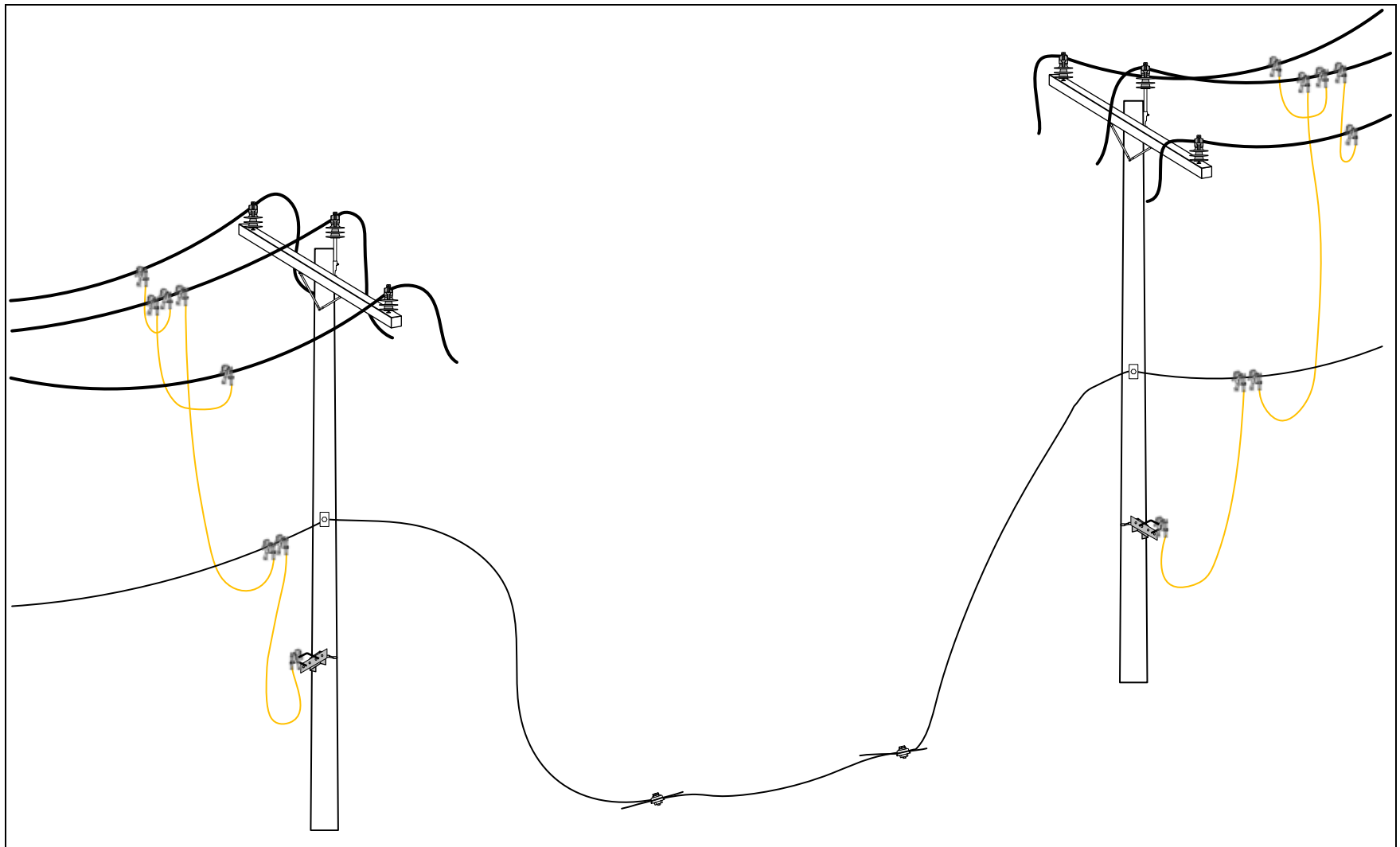


5. “Grounding Requirements” examples:
  - a Grade 3HSC – Single 2/0 H Rated: This is a single 2/0 cable with Grade 3H rated clamps and ferules.
  - b Grade 5HDC – Double 4/0 H Rated: This is two (2) 4/0 cables with Grade 5H rated Clamps. When TPG cables are doubled up, the assemblies should be identical (length and clamp type).
  - c Grade 6HSC – Single 4/0 H Rated: This is a single 4/0 6H cable with Grade 6H rated clamps.
6. To Access the TPG Database, [CLICK HERE](#)

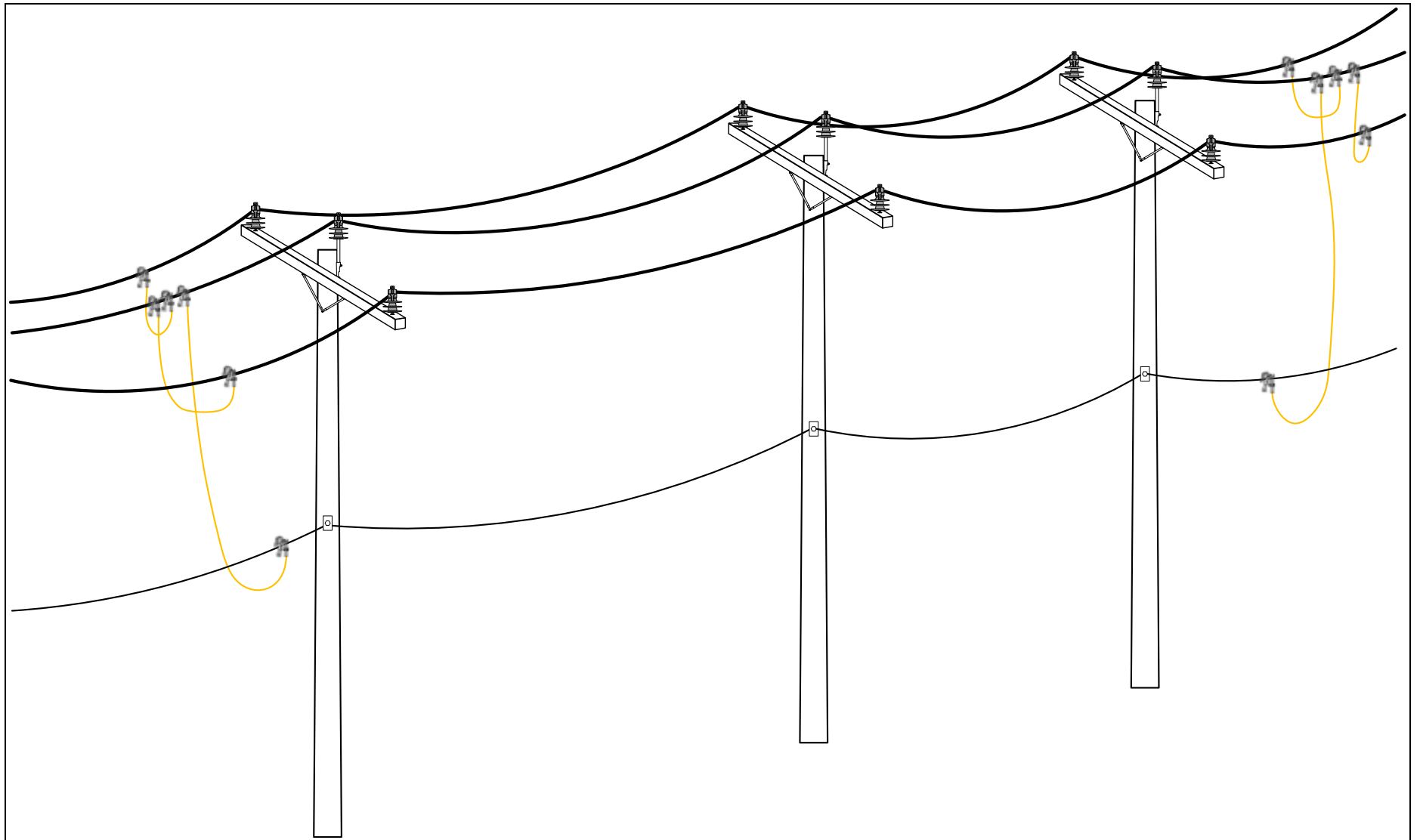
## Appendix A – Examples of Distribution Grounding



**Figure A1 – Delta Uni-Grounding and Ground point Selection**

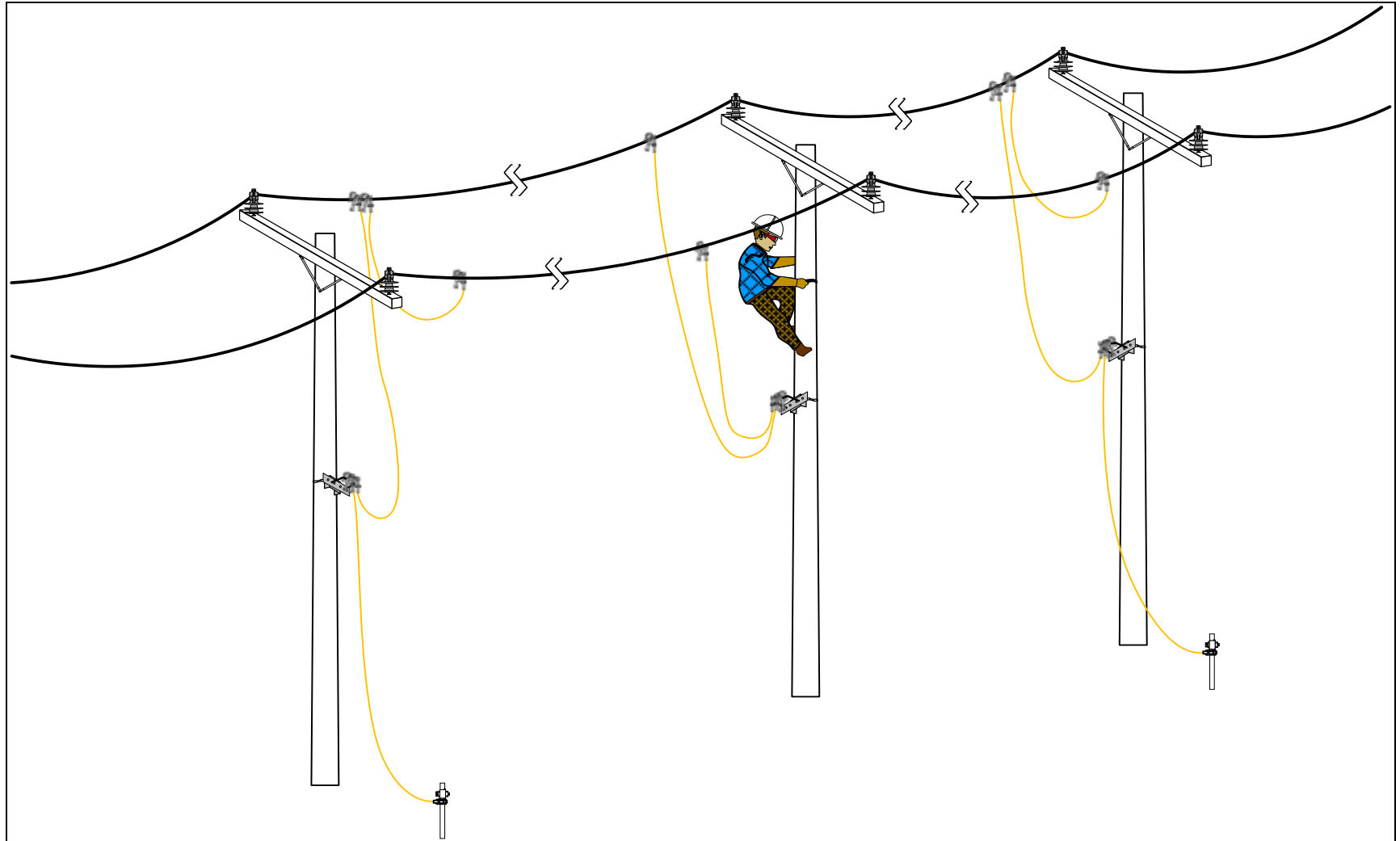


**Figure A2 – Grounding of a Broken Primary and Neutral Conductors**



**Figure A3 – Multiple Structure Bracket Grounding with Common Neutral**

**NOTE:** When grounding a system, single point grounding is the preferred method. Use multipoint grounding only when it is deemed necessary by the grounding plan.



**Figure A4 – Bracket Grounding of Multiple Spans with Personal Jumper at Worksite**

## Appendix B – Example of OP-5087 OH Grounding Plan Form (2 pages)

OH Grounding Plan OP-5087 Transmission & Distribution		Supervisor Review NAME: _____ DATE: _____		EVERSOURCE	
LOCATION		CREW INFORMATION		RELEVANT PROCEDURES	
Work Location / Address:		Clearance Holder:		Distribution OH Grounding	Vehicle & Equipment Grounding
City / Town:		Crew Size:		Transmission OH Grounding	
Nearest Intersection / Landmark:		Switching Control #:		Care of Live Line Tools	Material Catalog Books
Time:	Date:			Maintenance & Testing of Grounding Equipment	
JOB DESCRIPTION OF WORK BEING PERFORMED & GROUNDING REQUIREMENT(S) FROM WMS					
Feeder/Line #:		Grounding Requirement in WMS:			
Description of Work:					
FIELD INFORMATION					
System Voltage (kV)	# TPG Per Phase:	1	2	Balanced	Un-balanced
Ground Points Cleaned: YES NO					
Clamp Rating: (write-in)					
Cable Rating: (write-in)					
TPG Assembly Rating: (circle)	Grade 2 2H 3 3H 5 5H 6H				
TPG Inspected: YES NO	TPG Date Satisfactory: YES NO				
Threaded Ferrules: YES NO	Noncompliant TPG Removed: YES NO				
Vehicle Grounded: YES NO	Cable Uncoiled: YES NO				
Vehicle Bonded: YES NO	Mobile Bond Used: YES NO			Cluster Bar Used: YES NO	If No, Live-Line methods shall be used.
System Diagram Marked-up & Attached?: YES NO N/A		NOTES: (1) When two (2) or more ground cable assemblies are required on each phase, the clamps shall be physically installed facing the same direction and no more than three (3) inches of each other.			
Additional Bonding Needed in the Work Zone: YES NO N/A		(2) If the Boundary or work scope has changed engage Supervision to re-evaluate the Grounding Plan.			
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 methods SHALL be used to install and remove ground cable assemblies, from both the live and cold ends. If field conditions do not permit the use of live line tools, contact Eversource Supervision.		If a Grounding Plan cannot be executed because of the System Design, Safety must be consulted and a JOB SAFETY ANALYSIS <u>SHALL</u> be performed. Consult Supervision.	