

Personal Protective Grounding of Overhead Transmission Lines



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2. Scope

This work practice covers the use of personal protective grounds on the Seattle City Light (SCL) 115 and 230 kV overhead transmission systems. Some in the trade at SCL refer to 115 kV and 230 kV nominal transmission systems as “120/240.”

The following topics are outside the scope of this work practice:

- Grounding theory
- Switching and clearance procedures
- Worker training and certification requirements
- Grounding equipment and tool purchasing specifications
- Grounding equipment and tool maintenance procedures
- Traveling grounds
- Voltage detector operation
- Provisions covered under WAC 296-45-325
- Protection of workers outside the established equipotential zone
- Mitigating hazards associated with electric field and electromagnetic field induction
- Insulated and non-insulated people lift equipment.

3. Application

This work practice is directed at qualified persons who apply personal protective grounds on the SCL 115 and 230 kV overhead transmission system.

The objective of this work practice is to make the workplace as free from recognized hazards as reasonably possible. Following these rules may sometimes require that employee safety receive a higher priority than speed and work performance.

4. Definitions

Cluster bar – A terminal that is temporarily attached to a structure that provides a means for the attachment and bonding of grounding and bonding cables to the structure. Typically used with grounding jumpers to establish an equipotential zone. *Syn: cluster support, pole chain binder.*

Electric field induction - The process of generating voltages or currents to ground or both in a conductive object or electric circuit by means of time-varying electric fields. *Syn: capacitive coupling.*

Electromagnetic field induction - The induction process that includes both electric and magnetic fields and generates a circulating current between two grounded ends of a line due to the proximity of an adjacent or close energized and loaded line. *Syn: electromagnetic coupling.*

Equipotential - An identical state of electrical potential for two or more items. Also, for the purposes of protective grounding, a near identical state of electrical potential. *Syn: equal potential.*

Equipotential zone - Created by applying personal protective grounds, which provide a work space where all material and hardware within the worker’s reach is energized at the same potential if the lines accidentally become energized. *Syn: equal potential zone (EPZ).*

Grounding jumper - A system of ground clamps and covered cables suitable for carrying fault current. *Syn: ground set, ground.*

Optical ground wire (OPGW) – A dual-functioning cable designed to replace traditional static wires on overhead transmission lines with the added benefit of containing optical fibers which can be used for telecommunication purposes.

Overhead ground wire (lightning protection) – Multiple grounded wire or wires placed above phase conductors for the purpose of intercepting direct strokes in order to protect the phase conductors from the direct strokes. *Syn:* **earth wire, shield wire, skywire, static wire.**

Personal protective ground – A cluster bar installed on the pole below the work position, and a grounding jumper installed between the neutral and the cluster bar. The objective of personal protective grounds is to create an equipotential zone.

Personal protective grounding – Combines working grounds and personal protective grounds in a way that reduces the potential voltage difference at the worksite (voltage across the worker) to a safe level. *Syn:* **worksite grounding, single-point grounding, equipotential grounding, equal potential grounding.**

Qualified person – A person who is familiar with the construction of, or operation of such lines and/or equipment that concerns his/her position and who is fully aware of the hazards connected therewith, or, one who has passed a journey status examination for the particular branch of the electrical trades with which he/she may be connected. Refer to WAC 296-45-035 for the complete, legal definition.

Working grounds – Grounding jumpers installed between the phase conductors and system neutral conductor, at or near the worksite. The objective of working grounds is to ensure the circuit opens in the fastest available clearing time. If the system is three-phase, the grounding method must short circuit all three phases. *Syn:* **grounds.**

5. Introduction

Voltage may appear at a worksite due to accidental energization either through the isolating device or due to contact with another energized circuit. Voltages or currents may be present due to electric or magnetic induction from adjacent energized circuits or due to a direct or indirect lightning stroke.

When a hazard exists that is not covered by this work practice, the lead worker and employees are expected, in good faith, to mutually discuss the hazard and agree how to perform the work with the greatest degree of safety.

Experience has proven that the majority of injuries and deaths are preventable. Most injuries and deaths are not due to defective equipment but are due to failure on the part of the employees and those in authority to observe safety rules and failure to use safety devices. This work practice is a compilation of experience and common sense.

In general, the safest way to ground transmission lines and equipment is to create an equipotential zone by using personal protective grounds (a combination of working grounds and personal grounds). This limits the voltage across and the current that flows through the worker to minimum levels. Workers are best protected when personal protective grounds are installed at the worksite. However, there will be situations where this is impractical or impossible. In these situations, personal protective grounds shall be installed as close to the worksite as possible.

Workers on the ground may be exposed to higher step and touch potential when personal protective grounds are used. While work is in progress, ground personnel can protect themselves by staying away from the pole or temporary ground rod, where step and touch potential are higher.

Personal protective grounds also are intended to protect the worker from induced voltages created by parallel lines or static charge. This grounding method also insures the quickest operation of protective devices (relays and circuit breakers or fuses).

6. General Procedures

6.1 General

To work on exposed energized live parts, or near enough to them to expose any employee to any hazard they present, the provisions of WAC 296-45-325 shall apply.

To work lines or equipment as de-energized, the lines or equipment shall be de-energized under the provisions of WAC 296-45-335 and grounded as specified in this work practice. For specific exceptions to this rule, refer to Section 6.12 of this document.

It is SCL standard practice to always cover the distribution underbuild when work is performed on the transmission line above; in some situations the underbuild is also de-energized and grounded.

It is SCL standard practice to de-energize and ground both sides of a double circuit transmission structure when work is planned on just one side.

6.2 Equipotential Zone

Temporary protective grounds shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to hazardous differences in electrical potential.

6.3 Protective Grounding Equipment

Protective grounding equipment shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.

Grounding jumpers shall have approved ferrules and grounding clamps that provide mechanical support for jumper cables independent of the electrical connection.

Protective grounds shall have an impedance low enough to cause immediate operation of protective devices in case of accidental energizing of the lines or equipment.

CAUTION! In no case shall a grounding cable or grounding jumper be connected directly to another grounding cable or jumper (otherwise known as "daisy chaining").

6.4 Testing

Before any ground is installed, lines and equipment shall be tested and found absent of nominal voltage, unless a previously installed ground is present.

Grounding equipment shall be given a visual inspection and all mechanical connections shall be checked for tightness before each use.

The surface to which the ground is to be attached shall be cleaned before the grounding clamp is installed. The grounding clamp shall be a self-cleaning type (serrated jaw) clamp.

6.5 Order of Connection

When a ground is to be attached to a line or to equipment, the ground-end connection shall be attached first, and then the other end shall be attached by means of a live-line tool.

6.6 Order of Removal

When a ground is to be removed, the grounding device shall be removed from the line or equipment using a live-line tool before the ground-end connection is removed.

6.7 Additional Precautions

When work is performed on a cable at a location remote from the cable terminal, the cable may not be grounded at the cable terminal if there is a possibility of hazardous transfer of potential should a fault occur.

6.8 Removal of Grounds for Test

Grounds may be removed temporarily during tests.

During the test procedure, insulating equipment shall be used. Workers shall be isolated from any hazards in case the previously grounded lines and equipment become energized.

6.9 Conductor Separation

In cases where the conductor separation at any pole or structure is so great as to make it impractical to apply shorts on all conductors, and where only one conductor is to be worked on, only that conductor which is to be worked on needs to be grounded.

6.10 Ground Personnel

In cases where ground rods or pole grounds are utilized for personal protective grounding, personnel working on the ground should maintain sufficient distance from such equipment or utilize other approved procedures designed to prevent "touch-and-step potential" hazards.

6.11 Static Wires

CAUTION! Ground overhead ground wires as if they were conductors. Do not use an overhead ground wire as a ground.

6.12 Exceptions

If it can be demonstrated the installation of a ground is impracticable or that the conditions resulting from the installation of a ground would present greater hazards than working without grounds, the lines and equipment may be treated as de-energized provided **all** of the following conditions are met:

A) The lines and equipment have been de-energized under the provisions of WAC 296-45-335.

B) There is no possibility of contact with another energized source. For example:

- No energized lines, such as double circuits or overbuild, are installed on same pole.
- No energized lines cross the line to be worked.
- The wind is not blowing broken tree limbs in the air.
- The unexpected failure of an insulator, mounting hardware, tool, or piece of equipment will not result in energizing the line to be worked.
- The unexpected failure or inadvertent movement of a barrier board, insulating blanket, or guard will not result in energizing the line to be worked.

C) The hazard of induced voltage is not present. For example, there are no transmission lines or other distribution lines parallel to the line to be worked.

In general, there are very few situations in which ungrounded lines or equipment may be worked as if they were de-energized. Tying in new wire installed on new insulators, arms, and poles for a circuit extension not connected to the existing system in any way is one such situation.

7. Tools and Equipment

7.1 General

DANGER! The electromagnetic forces on grounding cables during a fault increase with increasing cable length. These forces can cause the cable to move violently during a fault and can be high enough to damage the cable or clamps and cause the cable to fail. In addition, flying cables can injure workers. Consequently, cable lengths should be as short as possible, and grounding cables that might carry high fault current should be in positions where the cables will not injure workers during a fault.

CAUTION! Maintenance of grounding equipment is essential. Corrosion in the connections between grounding cables and clamps and on the clamp surface can increase the resistance of the cable, thereby increasing potential differences.

The following tools and equipment are required to implement personal protective grounding. They are available from the Tool Room:

- Protective ground assemblies, consisting of self-cleaning clamps, ferrules, and flexible
- 4/0 AWG stranded copper, jacketed cable. See Figures 7a, 7b, and 7e.
- Cluster bar (cluster support, pole chain binder). See Figure 7c.
- Ball stud attachment point. See Figure 7d.
- Socket type clamp. See Figure 7e.
- Multi-range voltage detector. See Figure 7f.

Figure 7a. Protective Ground Assembly

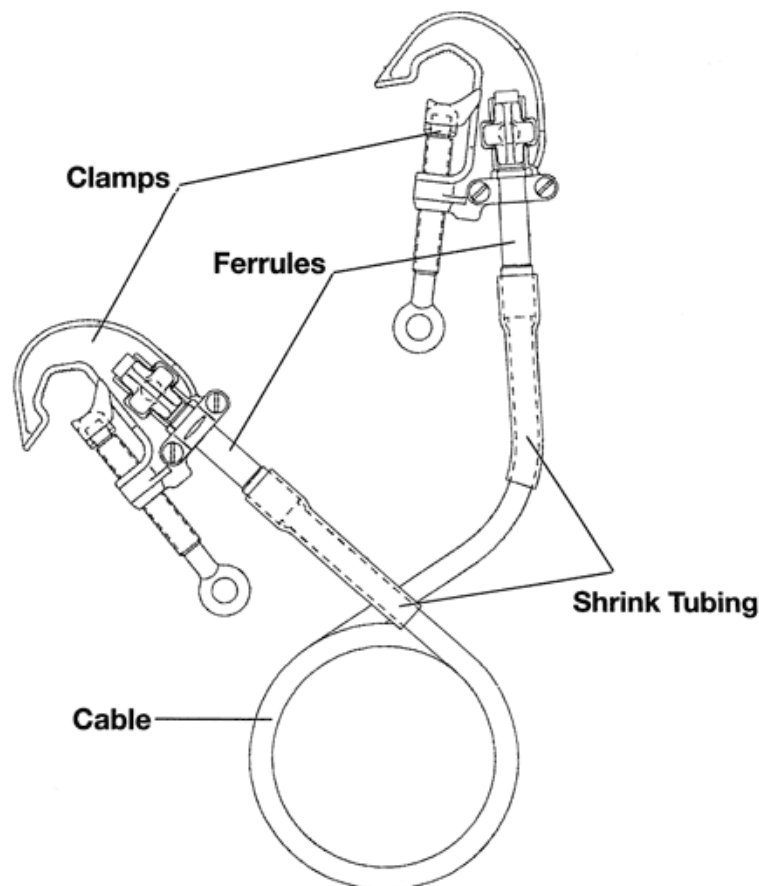


Figure 7b. Tower Grounding Clamp, Example



Figure 7c. Cluster Bar



Figure 7d. Ball Stud Attachment Point



Figure 7e. Socket Type Clamp

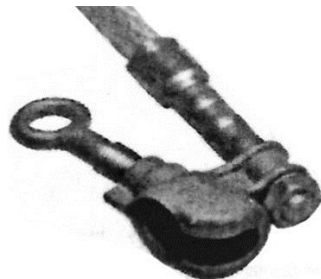


Figure 7f. Multi-Range Voltage Detector



7.2 Single Wood Pole Structures

For single wood pole structures without distribution underbuild, a typical ground set will consist of three working ground cables and a cluster bar. Each working ground shall have a C-type clamp as shown in Figure 7a on each end.

For single wood pole structures with distribution underbuild, a typical ground set will consist of four working ground cables and a cluster bar. Each working ground shall have a C-type clamp as shown in Figure 7a on each end.

In each of the above cases, the length of the bottom phase working ground shall be the distance from the bottom phase conductor to the cluster bar plus three feet.

If one or more static wires or OPGWs are present, additional working grounds will be required.

7.3 H-Frame Wood Pole Structures

For H-frame wood pole structures, a typical ground set will consist of six working ground cables and two cluster bars.

The length of each working ground shall be the distance from the phase conductor to the cluster bar plus three feet. Each working ground shall have a C-type clamp as shown in Figure 7a on each end.

If one or more static wires or OPGWs are present, additional working grounds will be required.

7.4 Steel Monopoles

For single circuit steel monopoles, a typical ground set will consist of three working ground cables.

For double circuit steel monopoles, a typical ground set will consist of six working ground cables.

In each of the above cases, the length of each working ground shall be the distance from the phase conductor to the grounding lug on the structure plus three feet. Most monopoles are not equipped with attachment points. These will need to be attached by the Steel Shop before any grounding can be performed. See Figure 7d for an example of a ball-type attachment point. Each working ground shall have a C-type clamp as shown in Figure 7a on one end and a socket-type clamp as shown in Figure 7e on the other.

If a static wire or OPGW is present, an additional working ground will be required.

7.5 Steel Lattice Towers

For steel lattice towers, a typical ground set will consist of six working ground cables. Most steel lattice towers are double circuit.

In the above case, the length of each working ground shall be the distance from the phase conductor to the tower leg plus three feet. Each working ground shall have a C-type clamp as shown in Figure 7a on one end and a tower clamp as shown in Figure 7b on the other.

For steel lattice towers with bundled conductors, a typical ground set will consist of twelve working ground cables. Most steel lattice towers are double circuit.

For bundled conductor cases, the length of six working grounds shall be the distance from the phase conductor to the tower leg plus three feet. The length of the six sub-conductor working grounds shall be three feet. Each sub-conductor working ground shall have a C-type clamp as shown in Figure 7a on each end.

If one or more static wires or OPGWs are present, additional working grounds will be required.

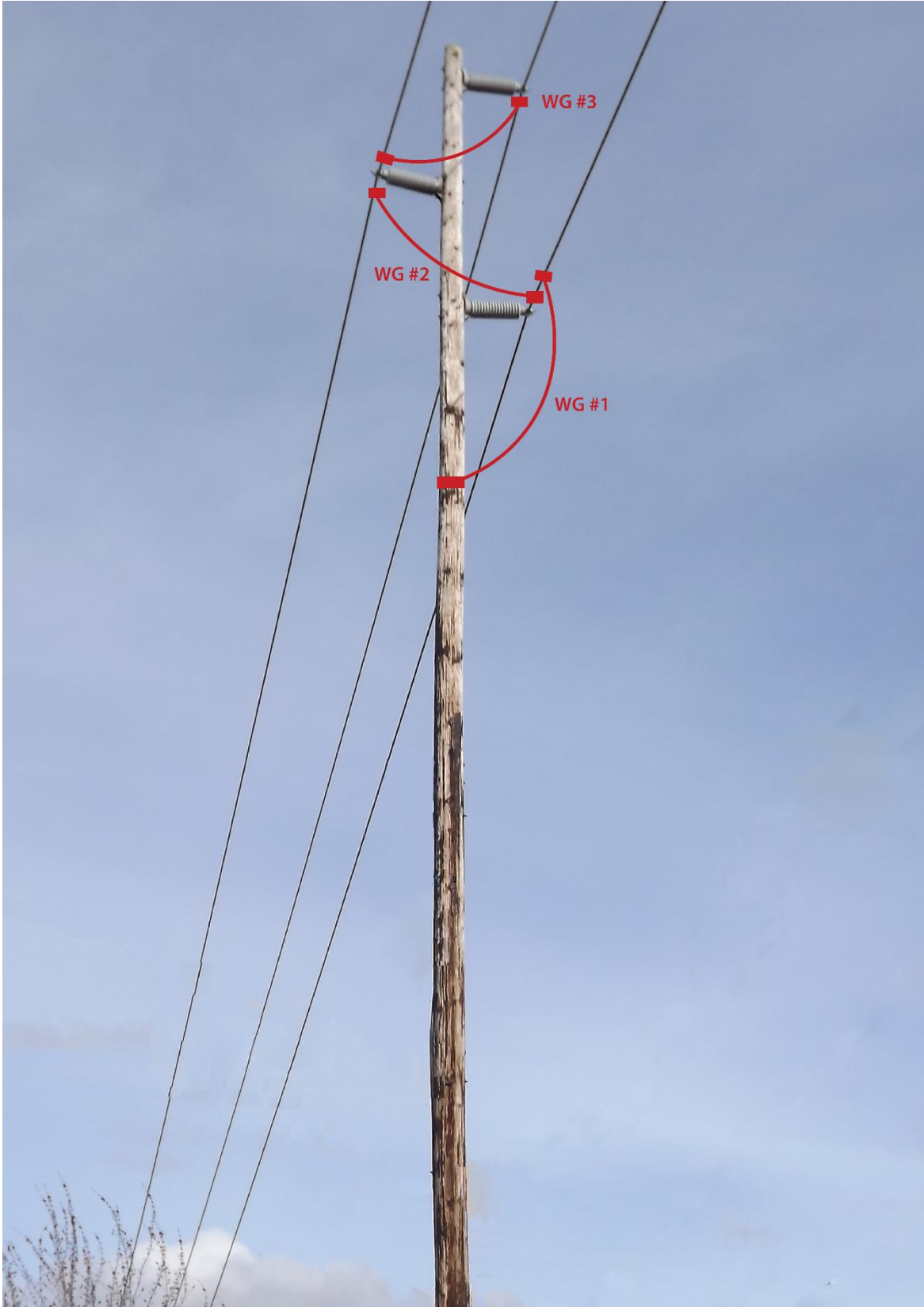
8. Detailed Procedures

8.1 115 kV Single Wood Pole without Distribution Underbuild

Follow these steps to apply personal protective grounds to 115 kV single wood poles without distribution underbuild (Figure 8.1).

Step	Action
1	Identify the line.
2	Obtain a clearance.
3	Isolate the line. Obtain visible openings on the source side (and the load side if possible) of the line or equipment.
4	Test the line or equipment to be sure it is de-energized.
5	Make grounding connections in the following order: <ol style="list-style-type: none">Verify pole ground (if any) is in good condition. Repair if necessary.Install the cluster bar on the pole just below the work area. Leave adequate working space above it.Bond pole ground to cluster bar.Clamp one end of working ground (WG) #1 to the cluster bar.Clamp the other end of WG #1 to the bottom phase.Clamp one end of WG #2 to the bottom phase.Clamp the other end of WG #2 to the middle phase.Clamp one end of WG #3 to the middle phase.Clamp the other end of WG #3 to the top phase.
6	Remove the grounds in the reverse order.

Figure 8.1. 115 kV Single Wood Pole without Distribution Underbuild

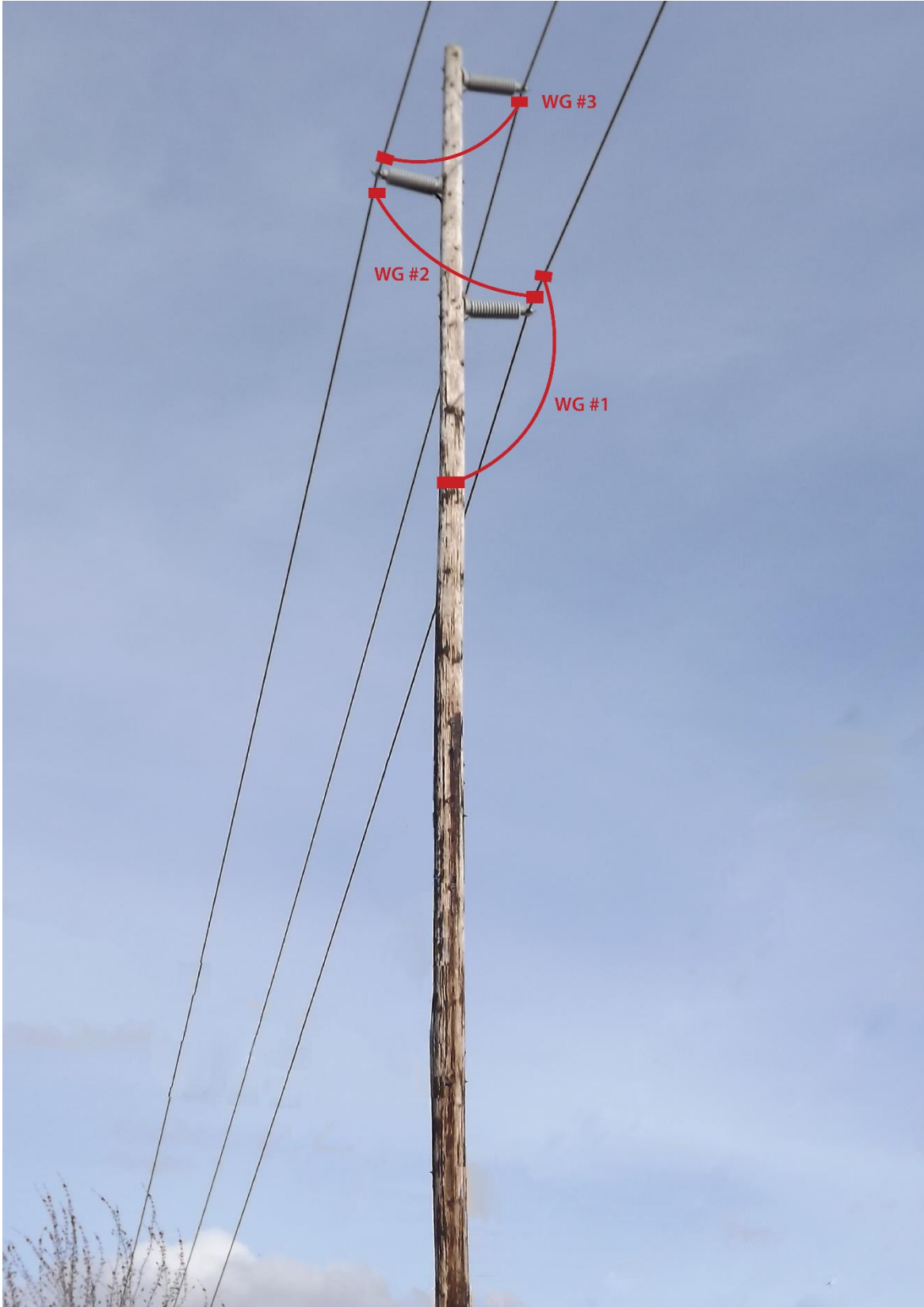


8.2 115 kV Cedar Falls Line (no system neutral nearby)

Follow these steps to apply personal protective grounds to the 115 kV Cedar Falls Line (Figure 8.2).

Step	Action
1	Identify the line.
2	Obtain a clearance.
3	Isolate the line. Obtain visible openings on the source side (and the load side if possible) of the line or equipment.
4	Test the line or equipment to be sure it is de-energized.
5	Make grounding connections in the following order: <ol style="list-style-type: none">Verify pole ground (if any) is in good condition. Repair if necessary.Install the cluster bar on the pole just below the work area. Leave adequate working space above it.Bond pole ground to cluster bar.Clamp one end of working ground (WG) #1 to the cluster bar.Clamp the other end of WG #1 to the bottom phase.Clamp one end of WG #2 to the bottom phase.Clamp the other end of WG #2 to the middle phase.Clamp one end of WG #3 to the middle phase.Clamp the other end of WG #3 to the top phase.
6	Remove the grounds in the reverse order.

Figure 8.2. 115 kV Cedar Falls Line (no system neutral nearby)



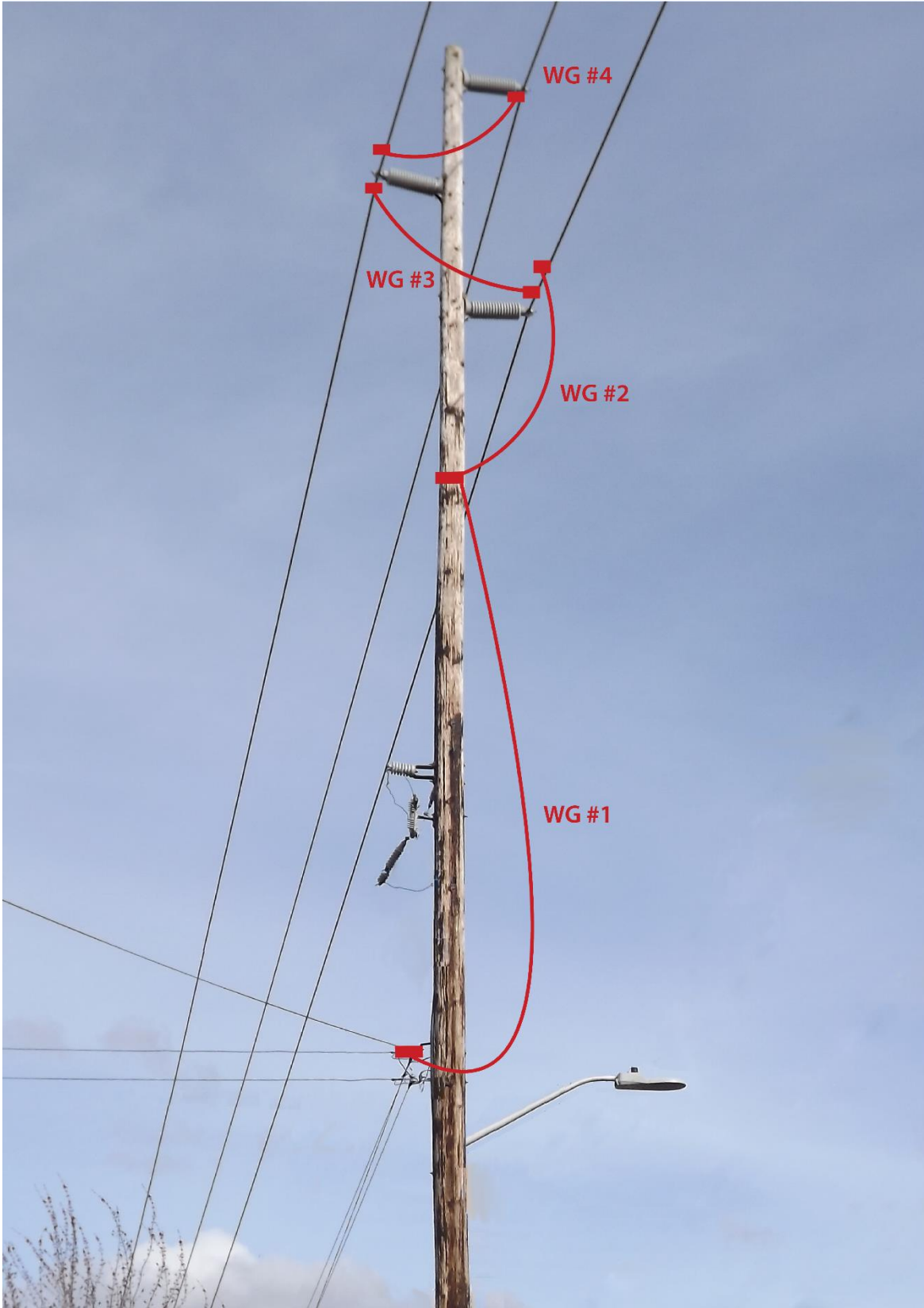
8.3 115 kV Single Wood Pole with Distribution Underbuild

Follow these steps to apply personal protective grounds to 115 kV single wood poles with distribution underbuild (Figure 8.3).

Step	Action
1	Identify the line.
2	Obtain a clearance.
3	Isolate the line. Obtain visible openings on the source side (and the load side if possible) of the line or equipment.
4	Test the line or equipment to be sure it is de-energized.
5	Make grounding connections in the following order: <ol style="list-style-type: none">Verify pole ground (if any) is in good condition. Repair if necessary.Cover underbuild with appropriately-rated insulating barriers. Underbuild shall be covered whether it is energized or not.Install the cluster bar on the pole just below the work area. Leave adequate working space above it.Bond pole ground to cluster bar.Clamp one end of working ground (WG) #1 to the cluster bar.Clamp the other end of WG #1 to the system neutral.Clamp one end of WG #2 to the cluster bar.Clamp the other end of WG #2 to the bottom phase.Clamp one end of WG #3 to the bottom phase.Clamp the other end of WG #3 to the middle phase.Clamp one end of WG #4 to the middle phase.Clamp the other end of WG #4 to the top phase.
6	Remove the grounds in the reverse order.

Note: Insulating barriers are not shown in Figure 8.3.

Figure 8.3. 115 kV Single Wood Pole with Distribution Underbuild

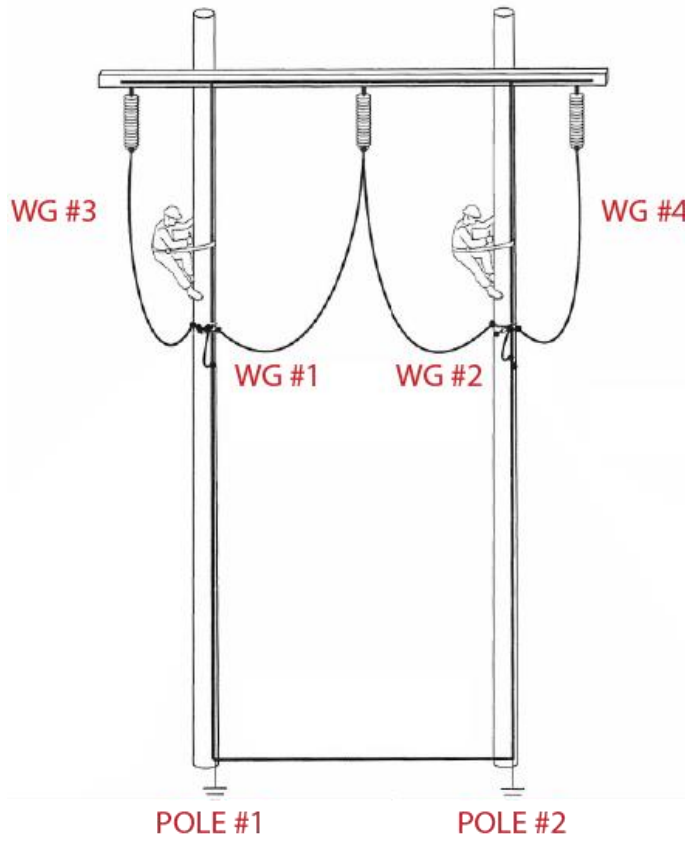


8.4 115 kV and 230 kV H-Frame Wood Pole Structures

Follow these steps to apply personal protective grounds to 115 kV and 230 kV H-Frame wood pole structures (Figure 8.4).

- | Step | Action |
|-------------|---|
| 1 | Identify the line. |
| 2 | Obtain a clearance. |
| 3 | Isolate the line. Obtain visible openings on the source side (and the load side if possible) of the line or equipment. |
| 4 | Test the line or equipment to be sure it is de-energized. |
| 5 | Make grounding connections in the following order: <ol style="list-style-type: none">a) Verify pole grounds (if any) are in good condition. Repair if necessary.b) Install a cluster bar on each pole just below the work area. Leave adequate working space above it.c) Bond each pole ground to its respective cluster bar.d) Bond pole grounds #1 and #2 together.e) Clamp one end of working ground (WG) #1 to the cluster bar on pole #1.f) Clamp the other end of WG #1 to the middle phase.g) Clamp one end of WG #2 to the cluster bar on pole #2.h) Clamp the other end of WG #2 to the middle phase.i) Clamp one end of WG #3 to the cluster bar on pole #1.j) Clamp the other end of WG #3 to an outside phase.k) Clamp one end of WG #4 to the cluster bar on pole #2.l) Clamp the other end of WG #4 to the opposite outside phase. |
| | If a static wire or OPGW is present, continue with steps m through p: <ol style="list-style-type: none">m) Clamp one end of WG #5 to the cluster bar on pole #2.n) Clamp the other end of WG #5 to the static wire or OPGW on pole #1.o) Clamp one end of WG #5 to the cluster bar on pole #2.p) Clamp the other end of WG #6 to the static wire or OPGW on pole #2. |
| 6 | Remove the grounds in the reverse order. |

Figure 8.4. 115 kV and 230 kV H-Frame Wood Pole Structures



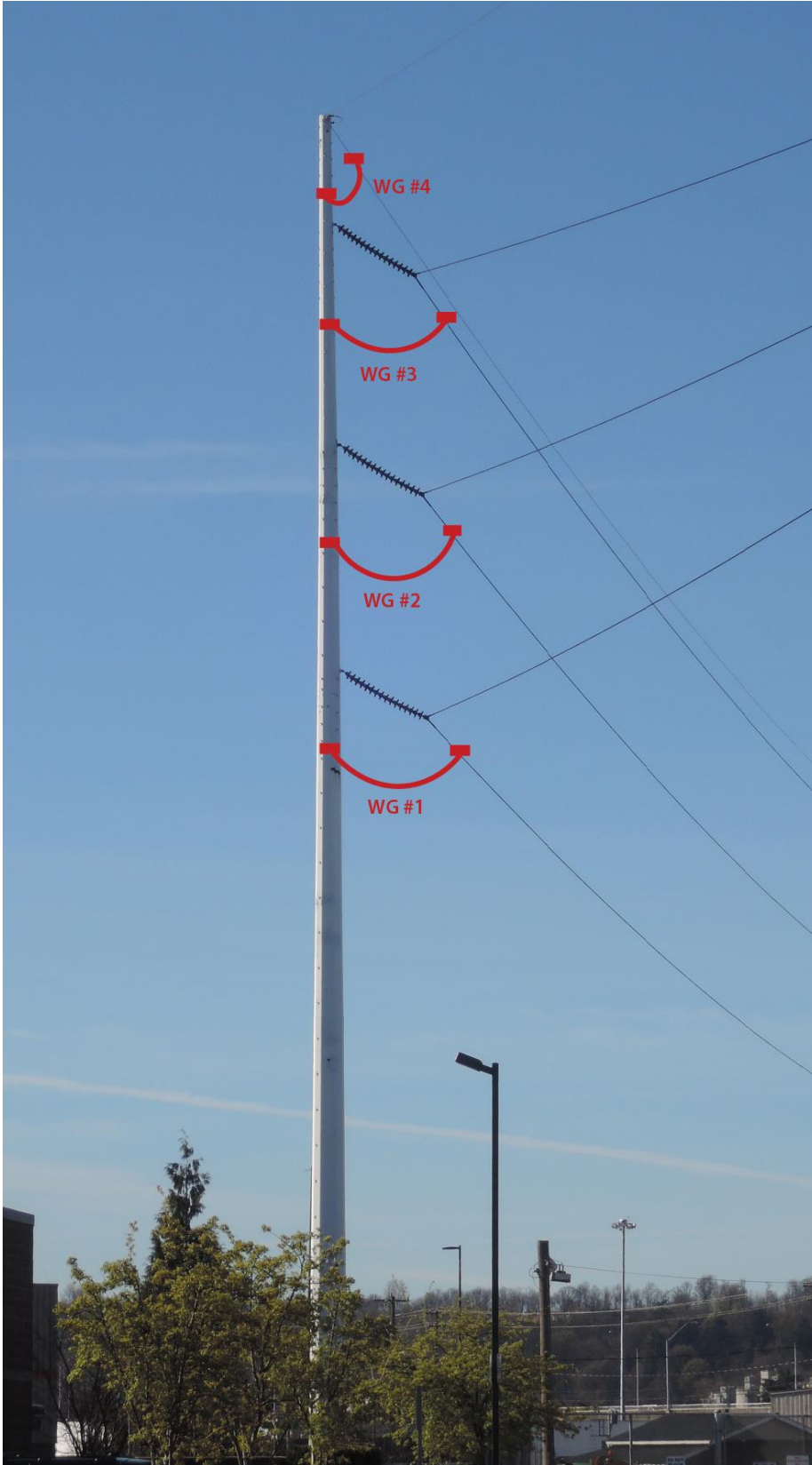
8.5 115 kV and 230 kV Steel Monopoles without Distribution Underbuild

Follow these steps to apply personal protective grounds to 115 kV and 230 kV steel monopoles without distribution underbuild (Figure 8.5).

- | Step | Action |
|-------------|--|
| 1 | Identify the line. |
| 2 | Obtain a clearance. |
| 3 | Isolate the line. Obtain visible openings on the source side (and the load side if possible) of the line or equipment. |
| 4 | Test the line or equipment to be sure it is de-energized. |
| 5 | Make grounding connections in the following order: <ol style="list-style-type: none">Verify pole ground (if any) is in good condition. Repair if necessary.Clamp one end of working ground (WG) #1 to the pole attachment point.Clamp the other end of WG #1 to the bottom phase.Clamp one end of WG #2 to the pole attachment point.Clamp the other end of WG #2 to the middle phase.Clamp one end of WG #3 to the pole attachment point.Clamp the other end of WG #3 to the top phase. |
| | If a static wire or OPGW is present, continue with steps h and i: <ol style="list-style-type: none">Clamp one end of WG #4 to the pole attachment point.Clamp the other end of WG #4 to the static wire or OPGW. |
| 6 | Remove the grounds in the reverse order. |

Note: Pole shown in Figure 8.5 has an OPGW.

Figure 8.5. 115 kV and 230 kV, Steel Monopoles without Distribution Underbuild



8.6 115 kV and 230 kV Double Circuit Steel Monopoles with Distribution Underbuild

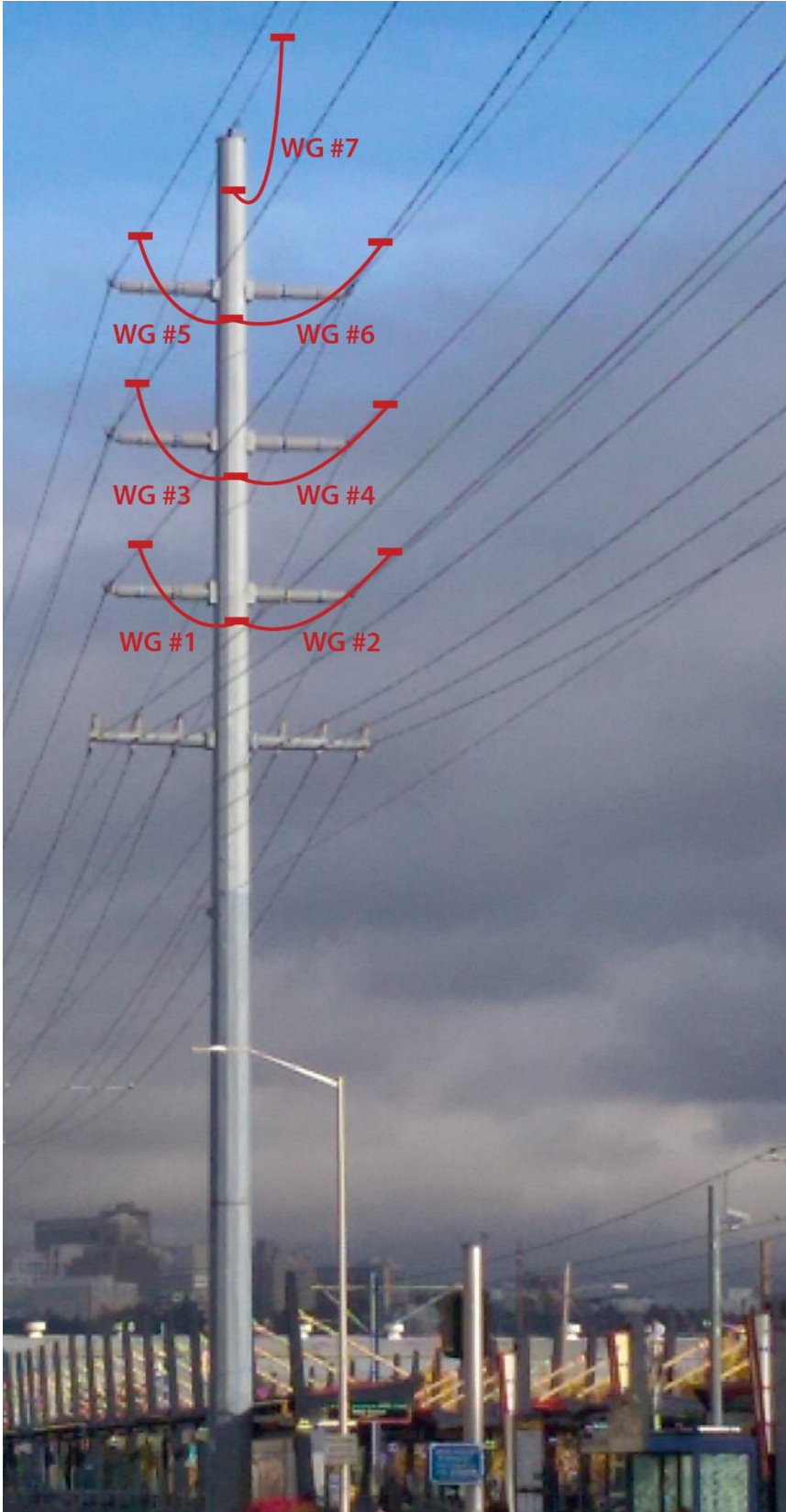
Follow these steps to apply personal protective grounds to 115 kV and 230 kV double circuit steel monopoles with distribution underbuild (Figure 8.6).

- | Step | Action |
|------|---|
| 1 | Identify the line. |
| 2 | Obtain a clearance. |
| 3 | Isolate the line. Obtain visible openings on the source side (and the load side if possible) of the line or equipment. |
| 4 | Test the line or equipment to be sure it is de-energized. |
| 5 | Make grounding connections in the following order: <ol style="list-style-type: none">Verify pole ground (if any) is in good condition. Repair if necessary.Cover underbuild with appropriately-rated insulating barriers. Underbuild shall be covered whether it is energized or not.Clamp one end of working ground (WG) #1 to the pole attachment point.Clamp the other end of WG #1 to the bottom phase of circuit #1.Clamp one end of WG #2 to the pole attachment point.Clamp the other end of WG #2 to the bottom phase of circuit #2.Clamp one end of WG #3 to the pole attachment point.Clamp the other end of WG #3 to the middle phase of circuit #1.Clamp one end of WG #4 to the pole attachment point.Clamp the other end of WG #4 to the middle phase of circuit #2.Clamp one end of WG #5 to the pole attachment point.Clamp the other end of WG #5 to the top phase of circuit #1.Clamp one end of WG #6 to the pole attachment point.Clamp the other end of WG #6 to the top phase of circuit #2. |
| | If a static wire or OPGW is present, continue with steps o through p: <ol style="list-style-type: none">Clamp one end of WG #7 to the pole attachment point.Clamp the other end of WG #7 to the static wire or OPGW. |
| 6 | Remove the grounds in the reverse order. |

Notes:

- Pole shown in Figure 8.6 has an OPGW.
- Insulating barriers are not shown in Figure 8.6.

Figure 8.6. 115 kV and 230 kV Double Circuit Steel Monopoles with Distribution Underbuild



8.7 115 kV and 230 kV Double Circuit Steel Lattice Towers

Follow these steps to apply personal protective grounds to 115 kV and 230 kV double circuit steel lattice towers (Figure 8.7).

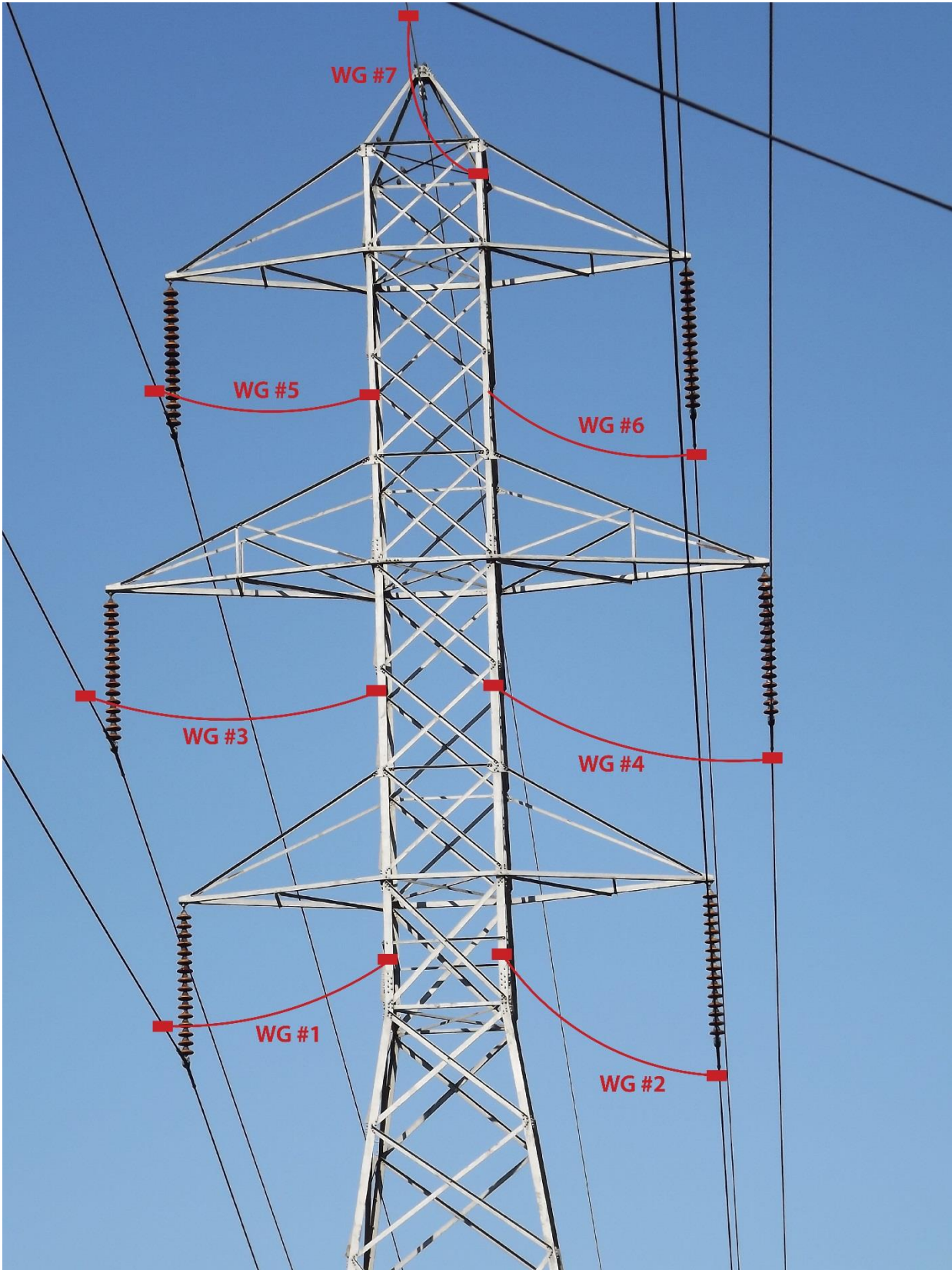
- | Step | Action |
|-------------|---|
| 1 | Identify the line. |
| 2 | Obtain a clearance. |
| 3 | Isolate the line. Obtain visible openings on the source side (and the load side if possible) of the line or equipment. |
| 4 | Test the line or equipment to be sure it is de-energized. |
| 5 | Make grounding connections in the following order: <ol style="list-style-type: none">Verify tower grounds (if any) are in good condition. Repair if necessary.Clamp one end of working ground (WG) #1 to the tower attachment point at the same elevation of the conductor to be groundedClamp the other end of WG #1 to the bottom phase of circuit #1Clamp one end of WG #2 to the tower attachment point at the same elevation of the conductor to be groundedClamp the other end of WG #2 to the bottom phase of circuit #2Clamp one end of WG #3 to the tower attachment point at the same elevation of the conductor to be grounded.Clamp the other end of WG #3 to the middle phase of circuit #1.Clamp one end of WG #4 to the tower attachment point at the same elevation of the conductor to be grounded.Clamp the other end of WG #4 to the middle phase of circuit #2.Clamp one end of WG #5 to the tower attachment point at the same elevation of the conductor to be grounded.Clamp the other end of WG #5 to the top phase of circuit #1.Clamp one end of WG #6 to the tower attachment point at the same elevation of the conductor to be grounded.Clamp the other end of WG #6 to the top phase of circuit #2. |

If a static wire or OPGW is present, continue with steps n through o:

- Clamp one end of WG **#7** to the tower attachment point.
 - Clamp the other end of WG **#7** to the static wire or OPGW.
- 6 Remove the grounds in the reverse order.

Note: Tower shown in Figure 8.7 has an OPGW.

Figure 8.7. 115 kV and 230 kV Double Circuit Steel Lattice Towers



8.8 115 kV Double Circuit Steel Lattice Tower with Bundled Conductor

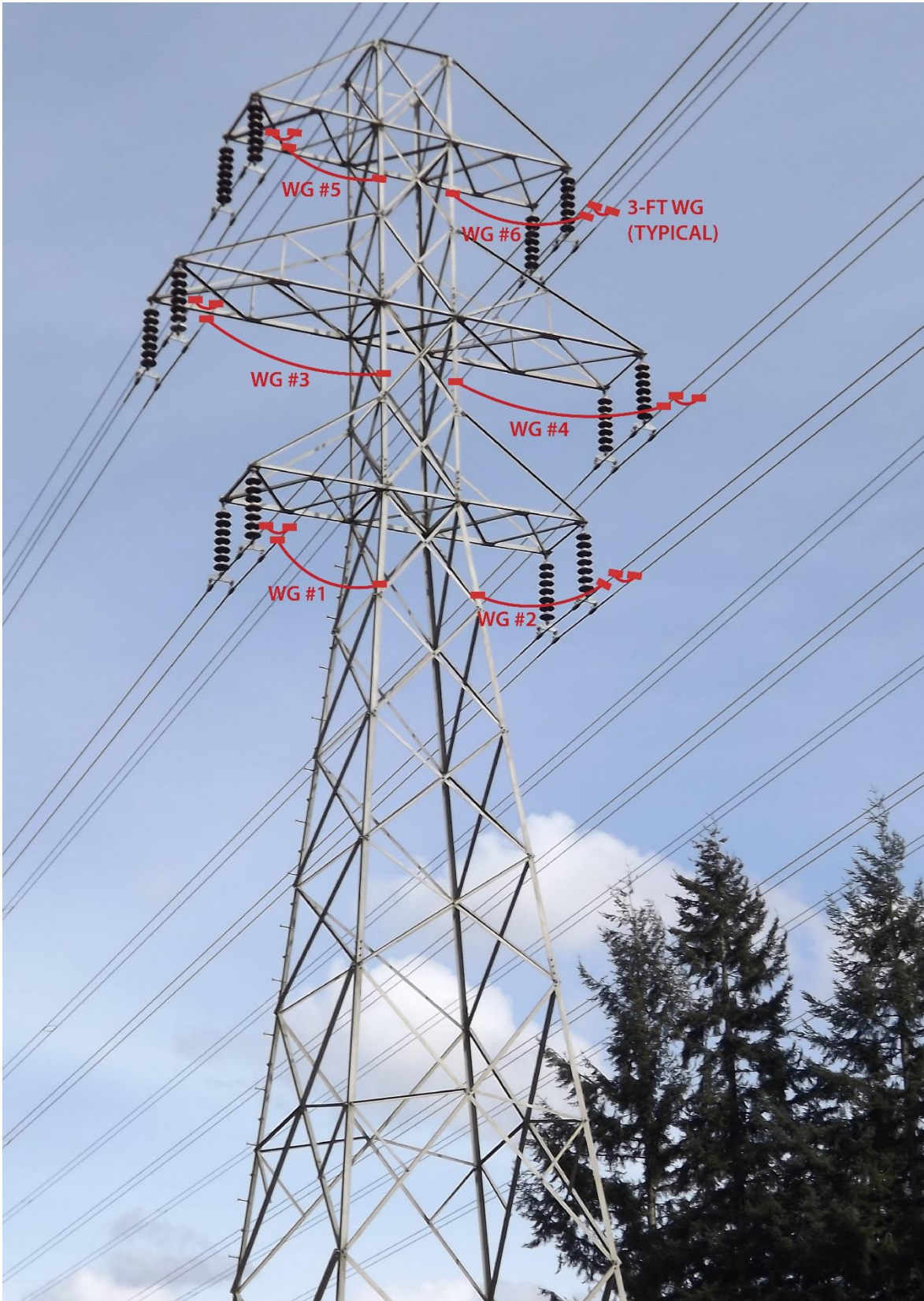
Follow these steps to apply personal protective grounds to 115 kV double circuit steel lattice towers with bundled conductors (Figure 8.8).

Step	Action
1	Identify the line.
2	Obtain a clearance.
3	Isolate the line. Obtain visible openings on the source side (and the load side if possible) of the line or equipment.
4	Test the line or equipment to be sure it is de-energized.
5	Make grounding connections in the following order: <ol style="list-style-type: none">Verify tower grounds (if any) are in good condition. Repair if necessary. <p>CAUTION! Because bundle spacers are unreliable conductors it is important to jumper the sub-conductors together before grounding the phase conductor</p> <ol style="list-style-type: none">Jumper the two sub-conductors of the bottom phase of circuit #1 together using a 3-ft working ground.Clamp one end of working ground (WG) #1 to the tower attachment point at the same elevation of the conductor to be grounded.Clamp the other end of WG #1 to the bottom phase of circuit #1.Jumper the two sub-conductors of the bottom phase of circuit #2 together using a 3-ft WG.Clamp one end of WG #2 to the tower attachment point at the same elevation of the conductor to be grounded.Clamp the other end of WG #2 to the bottom phase of circuit #2.Jumper the two sub-conductors of the middle phase of circuit #1 together using a 3-ft working ground.Clamp one end of WG #3 to the tower attachment point at the same elevation of the conductor to be grounded.Clamp the other end of WG #3 to the middle phase of circuit #1.Jumper the two sub-conductors of the middle phase of circuit #2 together using a 3-foot, working ground.Clamp one end of WG #4 to the tower attachment point at the same elevation of the conductor to be grounded.Clamp the other end of WG #4 to the middle phase of circuit #2.Jumper the two sub-conductors of the top phase of circuit #1 together using a 3-ft WG.Clamp one end of WG #5 to the tower attachment point at the same elevation of the conductor to be grounded.Clamp the other end of WG #5 to the top phase of circuit #1.Jumper the two sub-conductors of the top phase of circuit #2 together using a 3-ft WG.

Step	Action
	r) Clamp one end of WG #6 to the tower attachment point at the same elevation of the conductor to be grounded.
	s) Clamp the other end of WG #6 to the top phase of circuit #2.
	If a static wire or OPGW is present, continue with steps t through u:
	t) Clamp one end of WG #7 to the tower attachment point.
	u) Clamp the other end of WG #7 to the static wire or OPGW.
6	Remove the grounds in the reverse order.

Note: Tower shown in Figure 8.8 does not have an OPGW.

Figure 8.8. 115 kV Double Circuit Steel Lattice Towers with Bundled Conductor



9. Sources

Washington Administrative Code; Chapter 296-45 WAC Safety Standards for Electrical Workers

Encyclopedia of Grounding for De-Energized Construction & Maintenance; Hubbell Power Systems (Chance), Bulletin 07-0801, Rev 12/10

Seattle City Light, Power System Engineering Information; 2015

IEEE Std 1048-2003 - Guide for Protective Grounding of Power Lines

ASTM F855-14 - Standard Specifications for Temporary Protective Grounds to Be Used on De-energized Electric Power Lines and Equipment

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