FMEA ENERGY CONNECTIONS CONFERENCE & TRADE SHOW

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Grounding Procedures: An In-Depth Review from APPA's New Safety Manual

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Lafayette Utilities System

- **Our Utility**
  - 424 LUS Employees
  - 2 Customer Service Centers
  - 70,000 Customers
- **Electric**
  - 3 Power Plants
  - 18 Electric Substations
  - Peak + Reserves = 487.4 MW
- **Water**
  - 4 Water Treatment Plants
  - 19 Water Wells
- **Wastewater**
  - 4 Wastewater Treatment Plants
  - 19 Packaged Plants
  - 185 Lift Stations

City of Tallahassee Electric and Gas

- **Our Utility**
  - 288 COT Electric and Gas Employees
  - 7 Divisions
  - 123,000± Customers

- **Electric**
  - 2 Power Plants
  - 23 Electric Substations
  - Available generation
    - 725 MW (natural gas)
    - 62 MW (solar)

- **Gas**
  - 1,000± miles of gas line
  - 36,000± customers

Electric and Gas Mission Statement

We enrich the quality of life in Tallahassee by providing quality energy services and being leaders in our organization, community and industry.

Covered in this Session

- Changes made to grounding procedures
- Reasons behind these changes
- Why the Safety Manual Revision Team (SMRT) made certain recommendations
- Highlight the recommended Underground and Overhead Grounding Procedures
- Suggestive implementation at your Utility

Highlight Of Changes Made

The SMRT committee wanted to:
Consolidate the grounding procedures so that it would be easier to referenced. This new section is 514 in the 17th Addition.

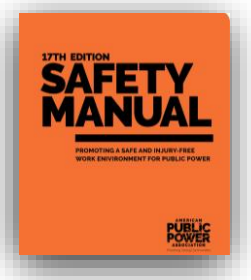
Emphasized equipotential grounding on overhead.

Emphasized isolation grounding on underground.

Emphasized a visible air gap in all grounding procedures, referenced in Table 202-1 and NESC 444-1.

New Grounding Section 514

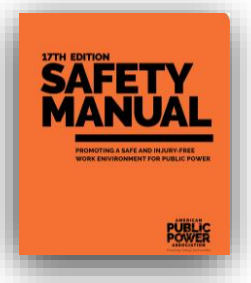
New Grounding Section 514



514 Grounding

- Brand new section
- Developed by a subcommittee
- New content, not simply incorporation of NESC text
- Five Sections: General, Overhead, Underground, Substation, and Secondary & Metering
- Committee wanted to create one section to make it easier to reference the grounding requirements

Grounding General



514 Grounding - General

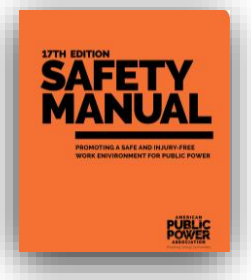
a) All previously energized conductors shall be considered energized until isolated with a visible air gap, if possible, tested with a device designed to detect voltage, and grounded. Before starting to work, preliminary inspection or test shall be made to determine what conditions exist. Care shall be exercised to handle neutral wires with the same caution that is used with energized wires.

Table 202-1 Air Gap Clearances

Table 202-1. Minimum Clearances for Open Air Gaps (Reference NESC 441-1)				
Voltage in Kilovolts phase-to-phase[1 2 3]	**Electric Supply Stations**		**Overhead Lines**	
	(mm)	(in)	(mm)	(in)
1.0 to 8.3	178	7	127	5
8.4 to 15.5	305	12	178	7
15.6 to 27	381	15	229	9
27.1 to 38	458	18	305	12
38.1 to 48.2	534	21	534	21
48.3 to 72.5	788	31	788	31

[1] For single-phase lines off of three phase systems, use the phase-to-phase voltage of the system.
[2] For single-phase systems, use the highest voltage available.
[3] Table values taken from IEEE Std C37.30.1™2011 [B56]

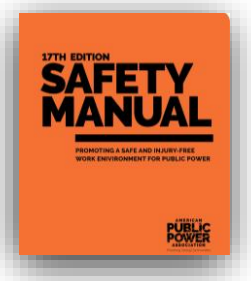
Grounding General



514 Grounding - General

b) When work is to be done on equipment, conductors, or cables, precautions to prevent backfeed shall be taken, including grounding of secondary conductors. This applies to work being performed on overhead and underground systems. Sources of backfeed, such as distributed energy resources, shall be considered when de-energizing lines and equipment. Refer to NESC 444.C.3

Grounding General

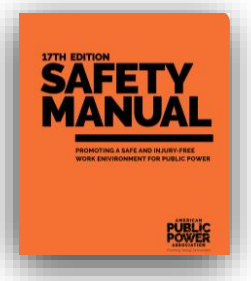


514 Grounding - General

c) For new construction, see Section 507.6, Working on De-energized Lines and Equipment.

d) Voltage testing: De-energized conductors and equipment, which are to be grounded, shall first be tested for the presence of nominal voltage using an approved testing device.

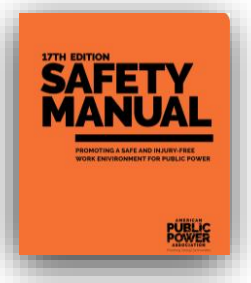
Grounding General



514 Grounding - General

e) All connections shall be made to a cleaned surface. A wire brush shall be used to clean conductors, or a serrated jaw clamp shall be used on distribution voltage-level conductors. Serrated jaws should not be used on high-voltage transmission applications.

Grounding General



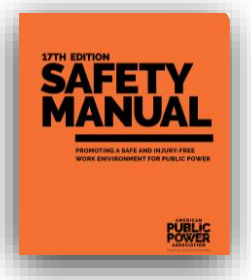
514 Grounding - General

f) Attaching and removing grounds:

(1) When attaching grounds, the ground end shall be attached first, and the other end shall be attached and removed by means of insulating tools. Where bundled conductor lines are being grounded, grounding of each sub conductor should be made.

(2) When removing grounds, the grounding device shall first be removed from the line or equipment using insulating tools.

Grounding General

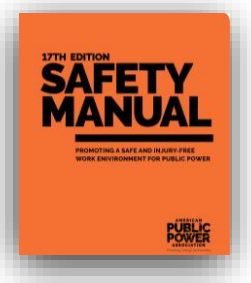


514 Grounding - General

g) Testing without grounds: Grounds may be temporarily removed during tests, only under the supervision of the employee in charge and subject to authorization by the designated person. During the test procedure, each employee will use insulating equipment and shall be isolated from any hazards involved.

h) Grounding electrode: When grounding electrodes are used, such electrodes shall have a resistance to ground low enough to remove the danger of harm to personnel or permit prompt operation of protective devices.

Grounding General



514 Grounding - General

i) Hazardous touch and step potentials may exist around grounded equipment or between separately grounded systems. Additional measures for worker protection may include barriers, insulation, work practices, isolation, or grounding mats. Refer to NESC 444D.

j) 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. See ASTM ratings of clamps, ferrules, and assemblies.

LUS's Maximum Fault Current

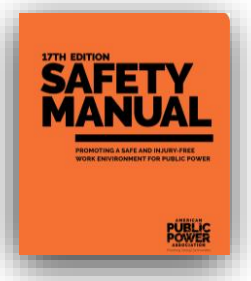
SYSTEM	AVAILABLE FAULT CURRENT (LUS)	GROUNDING CONDUCTOR SIZE
LUS 13.8Kv Feeder	12,797 Amps	2/0 Grounding conductor*
LUS 13.8Kv Tap	Under 12,797 Amps	2/0 Grounding conductor *
LUS 13.8Kv Substation Buss	12,797 Amps	2/0 Grounding conductor *
LUS 69Kv Transmission /Buss	Over 30,000 Amps	4/0 Grounding conductor **
LUS 230Kv Transmission /Buss	Under 30,000 Amps	2/0 Grounding conductor*

Note: * 2/0 conductors to be used where fault current is under 30,000 amps. Conductors can be paralleled to increase capacity.

** 4/0 conductors to used where fault current is above 30, 000 amps.

Maximum Fault current available on the LUS 13.8Kv system is 12,797 amps. This is on feeders 2051,2052,2053and 2054.

Grounding General



514 Grounding - General

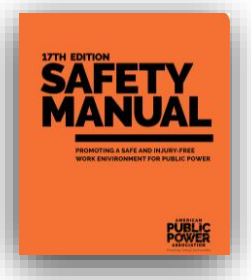
k) Protective grounding equipment shall have an ampacity greater than or equal to that of a No. 2 AWG copper.

l) It is recommended that protective grounds be tested annually or after being exposed to fault current.

m) See OSHA Standard 29 CFR 1910.269(n) for more information on grounding.

Grounding Overhead 514.1

Grounding Overhead

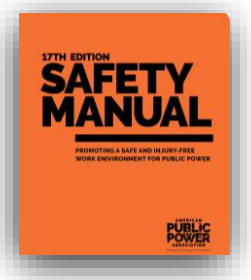


514.1 Overhead

a) 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. See Equipotential and Equipotential Zone in Definitions.

b) Equipotential grounding is required whenever possible. If an equipotential zone cannot be established at the worksite and bracket grounding is utilized, rubber gloves and other appropriate personal protective equipment shall be required.

Grounding Overhead

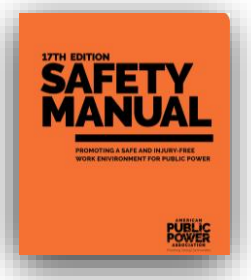


514.1 Overhead

c) When handling conductors at ground level that have previously been energized or have the potential to become energized, employees shall wear rubber gloves. The use of dielectric-rated protective footwear is also recommended.

Note: See Section 507.6, Working on De-energized Lines and Equipment, for new construction.

Grounding Overhead

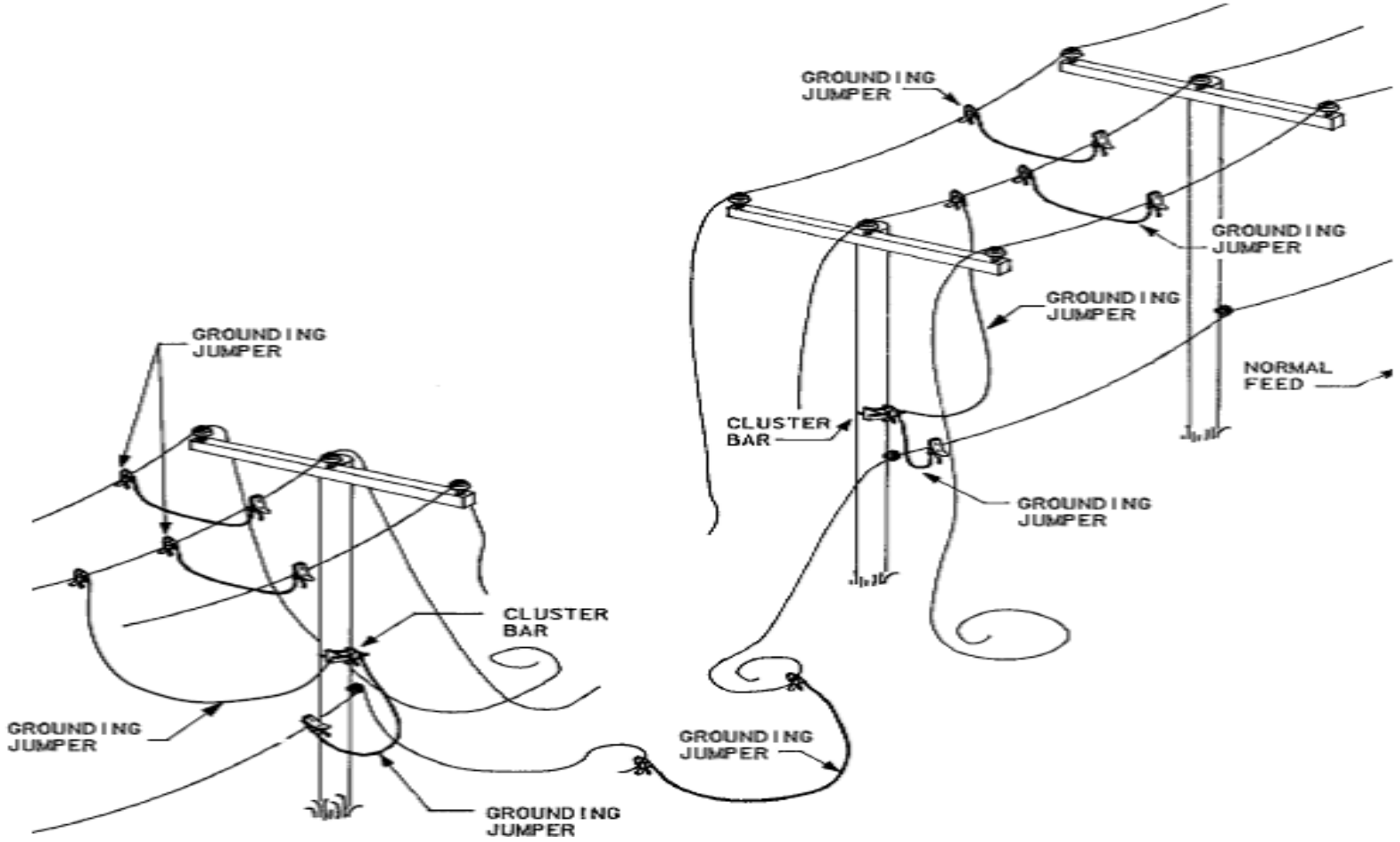


514.1 Overhead

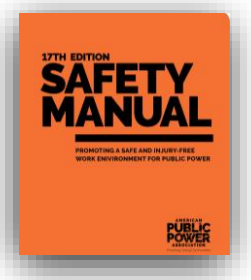
d) Equipotential grounding is required when workers are working on or in close proximity to a structure, whether working from the structure (climbing) or from an aerial device.

e) If conductor(s) is broken or work is being performed from an aerial device in mid-span where no structure is in the immediate work area, dual point grounding (bracket grounding) may be utilized. When using dual point grounding, grounds shall be installed as close as practical to the work location and no farther away than one span or 300 feet.

Bracket Grounding



Grounding Overhead

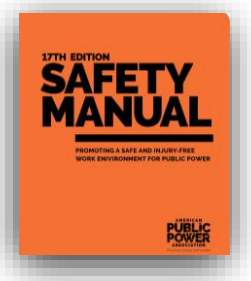


514.1 Overhead

f) Tower Ground: Grounding to a tower shall be made with a tower clamp capable of conducting the anticipated fault current.

g) Ground lead: A ground lead, to be attached to either a tower ground or driven ground, shall be capable of conducting the anticipated fault current and shall have minimum conductance of No. 2 AWG copper.

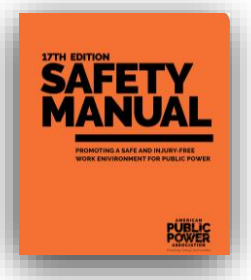
Grounding Overhead



514.1 Overhead

h) Lifting equipment, aerial lift device and material handling trucks, and digger/derricks line trucks shall be bonded to an effective ground or considered energized and barricaded when used near equipment or lines energized above 600 volts. Employers may elect to barricade lifting equipment, aerial lift device and material handling trucks, and digger/derricks line trucks, instead of bonding to the best available ground. In either case, the general public should be prevented from coming in contact with the equipment. When installing truck grounds, the employee installing the ground must use a handline to raise and lower to the ground.

Grounding Overhead



514.1 Overhead

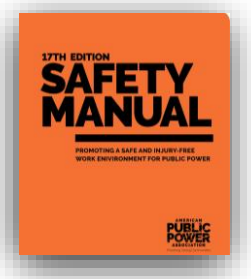
i) Single-point equipotential grounding procedures.

(1) A visible open air gap shall be established. Refer to Table 202-1 for Minimum Clearance for Open Air Gaps (NESC Table 444-1).

(2) A voltage test shall be made using an approved testing device designed to test voltage.

(3) Conductors, where grounding clamps are to be applied, shall be cleaned using a wire brush unless serrated clap jaws are used.

Grounding Overhead



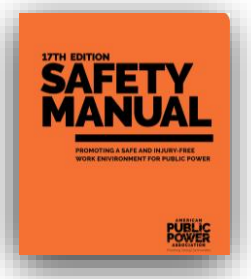
514.1 Overhead - Make grounding connections in the following order

(4) Make the grounding connections in the following order:

(a) A chain binder, with provisions for attaching a personal protective ground, shall be tightened around the pole at a position below where the lineworker will place their feet.

(b) A personal protective ground shall be attached to the chain binder and extended to the system neutral. If the neutral is not present or cannot be approached safely, effective grounding must be obtained.

Grounding Overhead



514.1 Overhead - Make grounding connections in the following order

(c) Personal protective grounds shall be extended from the chain binder to a single phase, and from that phase to the other phases in a short-circuit fashion.

(d) When work is completed, the personal protective grounds shall be removed in reverse order of installation.

Visible Air Gap & Voltage Tester

APPA Safety Manual Chart 202-1

NESC Table 444-1

Table 444-1 Minimum Clearances for Open Air Gap

Voltage in Kilo Volts Phase-to-Phase	Electric Supply Stations		Overhead Lines	
	(mm)	(in)	(mm)	(in)
1.0 to 8.3	178	7	127	5
8.4 to 15.5	305	12	178	7
15.5 to 27	381	15	229	9
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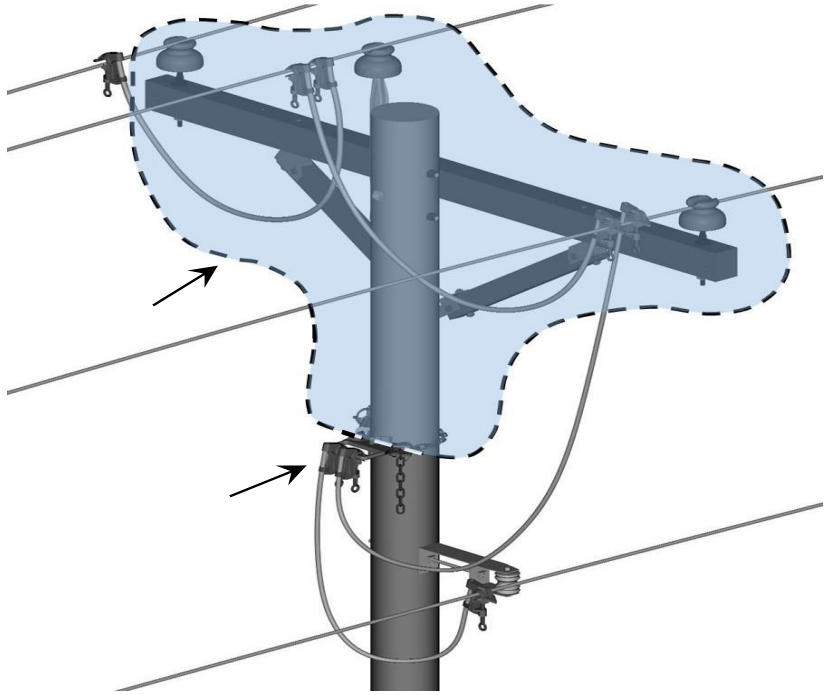
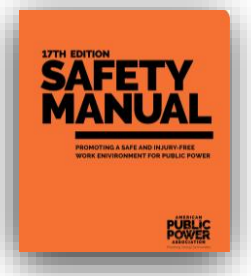
48.3 to 72.5	788	31	788	31

Equipotential Grounding



Grounding Overhead

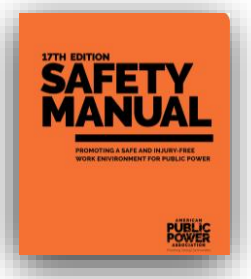


514.1 Overhead - Make grounding connections in the following order

(e) When a circuit is to be opened (e.g., opening jumpers at a junction pole or cutting slack), a temporary personal protective ground shall be installed across the open point.

(f) When it is not practical to use single-point grounding at the pole where work is to be performed, such as when wires are down, grounds shall be installed on both sides of the work location but not farther than adjacent structures.

Grounding Overhead

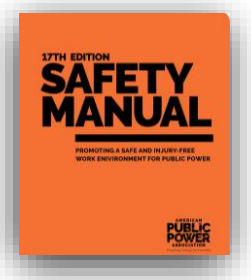


514.1 Overhead - Make grounding connections in the following order

(g) When work is completed, the personal protective grounds shall be removed in reverse order of installation.

Note: On those systems without a neutral or pole ground, a temporary ground rod should be driven into the earth or other suitable bond to earth used. Attach the grounds to the ground rod, pole ground, or other alternative bond to earth in place of the neutral.

Grounding Overhead



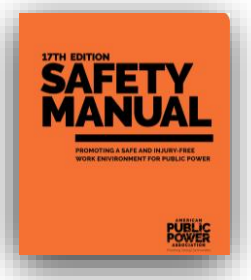
514.1 Overhead

(j) Dual point bracket grounding procedures: The following procedures shall be performed on each side of the work area. Grounds shall be placed as close as possible to the work area and not more than 300 feet away.

(1) A visible open air gap shall be established; refer to Table 202-1 for Minimum Clearance for Open Air Gaps. Refer also to NESC Table 444-1.

(2) A voltage test shall be made using a device designed to test voltage.

Grounding Overhead



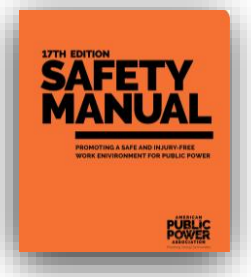
514.1 Overhead

(3) Conductors, where grounding clamps are to be applied, shall be cleaned using a wire brush unless serrated clap jaws are used.

(4) Make the grounding connections in the following order:

(a) Personal protective grounds shall be extended from the system neutral to the closest single phase, and from that phase to the other phases in a short-circuit fashion.

Grounding Overhead

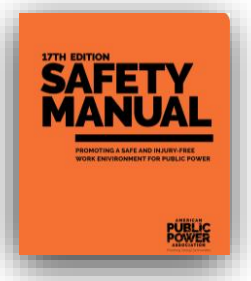


514.1 Overhead

(b) When work is completed, the personal protective grounds shall be removed in reverse order of installation.

Grounding Underground 514.2

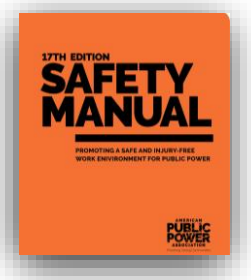
Grounding Underground



514.2 Underground

Note: A capacitance charge can remain in a URD cable after it has been disconnected from the circuit, and a static-type arc can occur when grounds are applied to such cables.

Grounding Underground

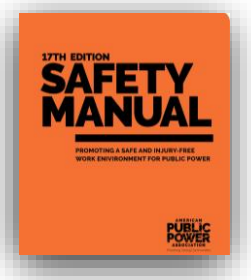


514.2 Underground

a) All URD cables and equipment, including services that have been energized or could become energized from any source, shall be considered as energized until the equipment is isolated with a visible air gap (per Table 202-1), or tested with a device designed to test voltage and has been grounded.

b) When work is performed on cable at a location remote from the cable terminal, the cable must be isolated at the terminal or equipotential grounded at the work location if there is a possibility of hazardous transfer of potential should a fault occur.

Grounding Underground

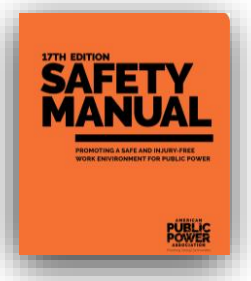


514.2 Underground

c) 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. See Equipotential and Equipotential Zone in Definitions.

d) Cables shall be equipotential grounded before splicing or working on de-energized cables. When establishing an equipotential zone is not possible, the cable shall be completely isolated from all known and potential sources, including the concentric neutral.

Grounding Underground

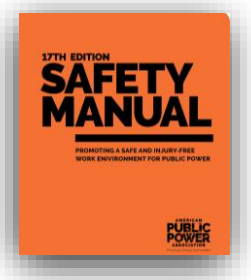


514.2 Underground

e) De-energized cables to be worked on shall be grounded at a point as close to the work as possible or completely isolated from all possible sources.

f) The isolation method is recommended on direct buried cable if an equipotential zone cannot be established.

Grounding Underground

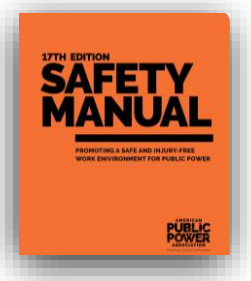


514.2 Underground

g) All underground cables and apparatus carrying current at voltages greater than 600 volts shall be de-energized and grounded or isolated before cables are cut into or spliced. Refer to Section 509.5, Work on De-energized Cables, for more information on cutting into or splicing de-energized cables.

h) All conductors of a three-phase circuit shall be isolated or equipotential grounded when work is to be performed on any of the cables.

Grounding Underground



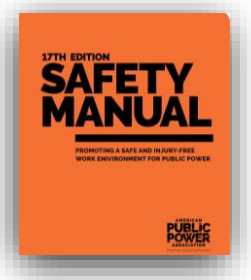
514.2 Underground

i) Ground lead shall be capable of conducting the anticipated fault current and shall have a minimum conductance of No. 2 AWG copper.

j) To establish an equipotential zone on cables, the following steps shall be followed.

(1) Cables to be grounded shall be identified at each location where grounds will be applied.

Grounding Underground



514.2 Underground

(2) A visible opening shall be established on each end of the cable by parking the cable's elbows on feed-thru bushings.

(3) A voltage test shall be made using a device designed to test voltage.

(4) The cable shall be grounded using a properly sized grounding elbow or approved grounding device. For a three-phase system, all phases shall be de-energized and grounded.

Example of an Underground Grounding Situation

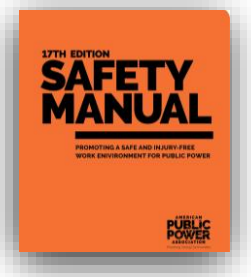
When an employee is replacing a splice in a vault, the damaged splice must be removed and replaced. The cable is positively identified, and both ends are grounded at their termination points. At the worksite, the neutral concentric connection to ground is removed from both ends of the cable. The phase conductor is separated, and this leaves these ends of the cable ungrounded. There is the possibility that these ends of the cable are at different potentials, due to ground potential differences at the remote ends.

Example of an Underground Grounding Situation

Cutting off a piece of jacket on both cable ends to ground the concentric is possible, but not always practical, since the three phase cables are typically bundled together and difficult to separate for the jacket removal. Should employees treat these cables as hot or find some way to ground the cables at the worksite?

This example is one of the reasons that the Isolation method is recommended.

Grounding Underground



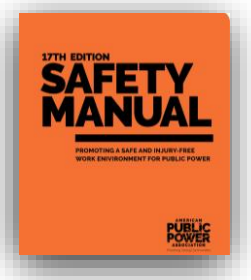
514.2 Underground

k) To completely isolate the cables, the following steps shall be followed:

(1) Cables to be grounded shall be identified at each location where grounds will be applied.

(2) A visible air gap, if possible, shall be established on each end of the cable by parking the cable's elbows on feed-thru bushings.

Grounding Underground

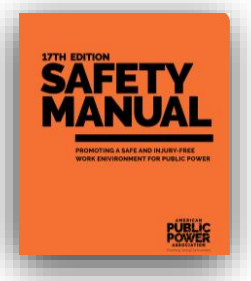


514.2 Underground

(3) A voltage test shall be made using a device designed to test voltage.

(4) Both ends of the cable shall be grounded using a properly sized grounding elbow or approved grounding device. For a three-phase system, all phases shall be de-energized and grounded.

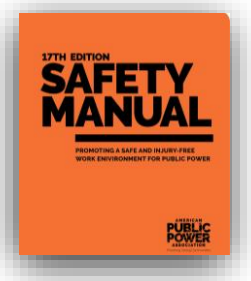
Grounding Underground



514.2 Underground

(5) While the cable is grounded, verify the cable at the location where splicing will take place by spiking the cable or utilizing an approved remote cable cutting device. Refer to Section 509.5, Work on De-energized Cables, for more information on spiking and cutting de-energized cables.

Grounding Underground



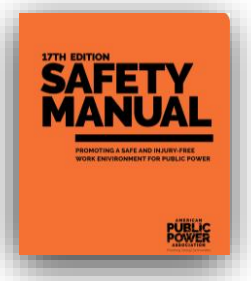
514.2 Underground

(6) After the cable is verified and cut, isolate the cable by removing grounds on both ends of the cable, and disconnect the concentric neutral on both ends.

- Appropriate personal protective equipment and clothing shall be worn while disconnecting the concentric neutral, and care shall be taken to avoid differences in electrical potential.

(7) Voltage tests shall be made with a device designed to test voltage on both ends of the cable where previously cut.

Grounding Underground

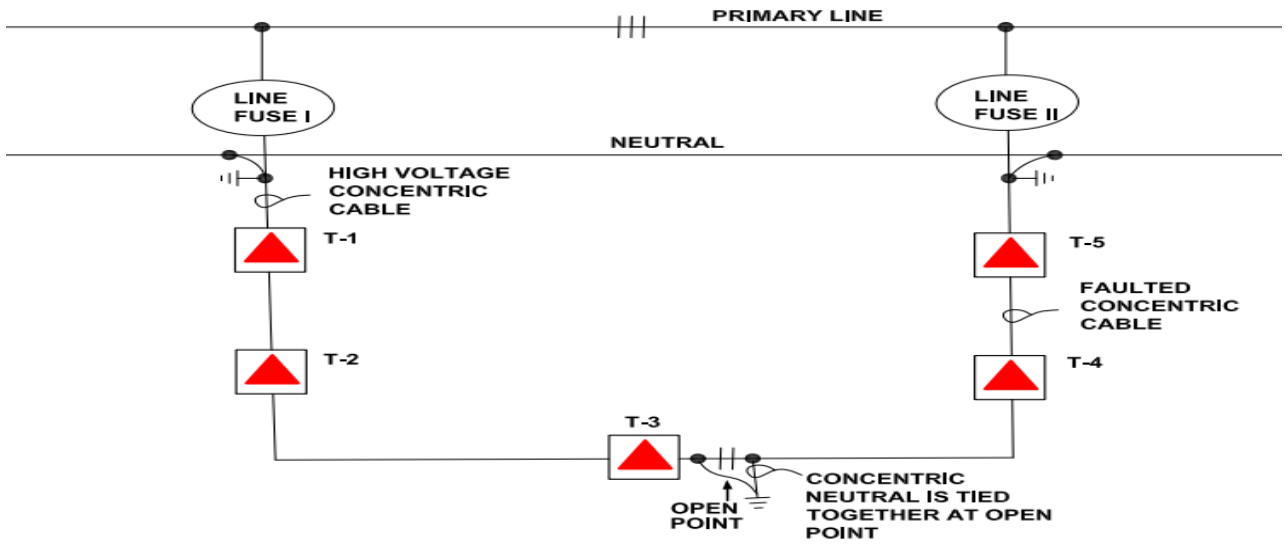


514.2 Underground

(8) When work is completed, reconnect the concentric neutral on both ends of the cable before being re-energized.

- Appropriate personal protective equipment and clothing shall be worn while reconnecting the concentric neutral, and care shall be taken to avoid differences in electrical potential.

Example of a Circuit utilizing the isolation method

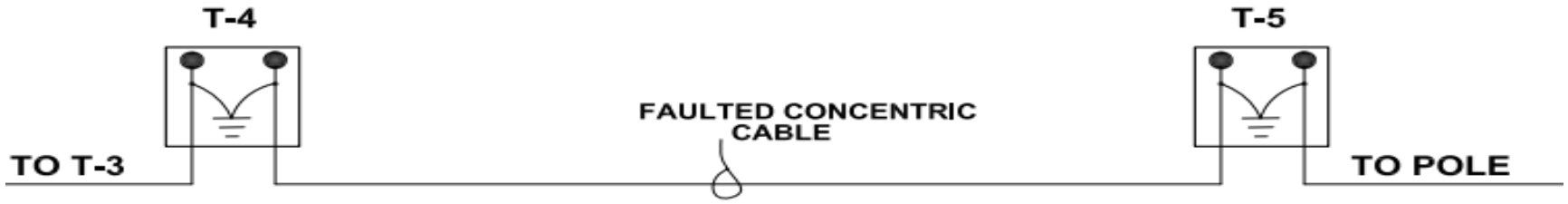


I) LINE FUSE I HAS 7 AMPS OF LOAD, LINE FUSE II HAS 5 AMPS OF LOAD. THE CONCENTRIC NEUTRAL HAS 2 AMPS IN IT.

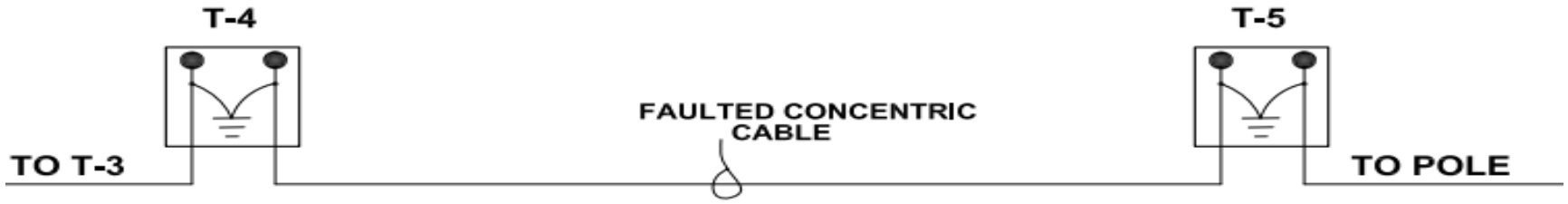
II) THE OPEN POINT IN THE CIRCUIT IS IN T-3 GOING TO T-4.

III) THE CONCENTRIC NEUTRAL IS TIED TOGETHER AT THE OPEN POINT.

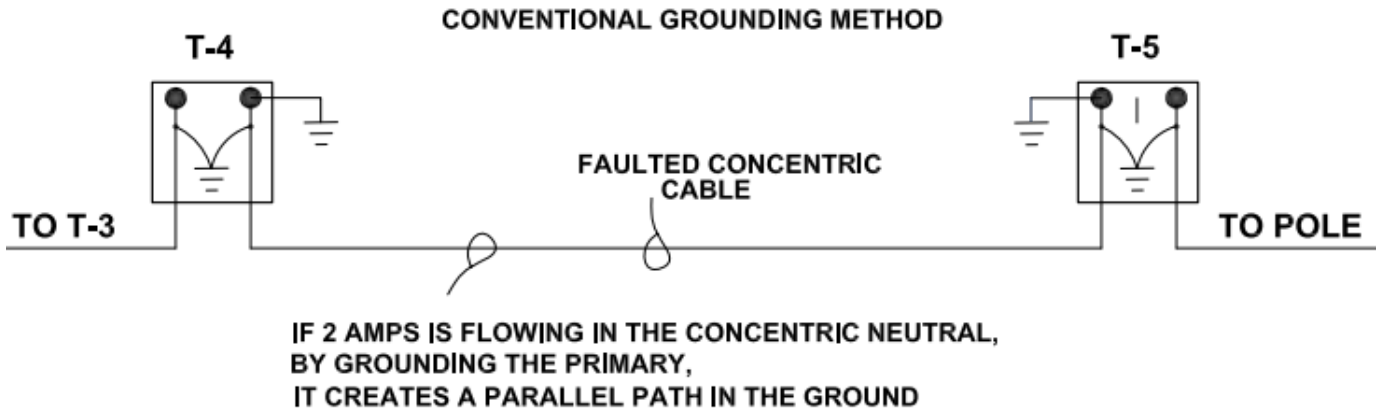
Step one: Create an air gap by placing both ends of the cable on parking stands.



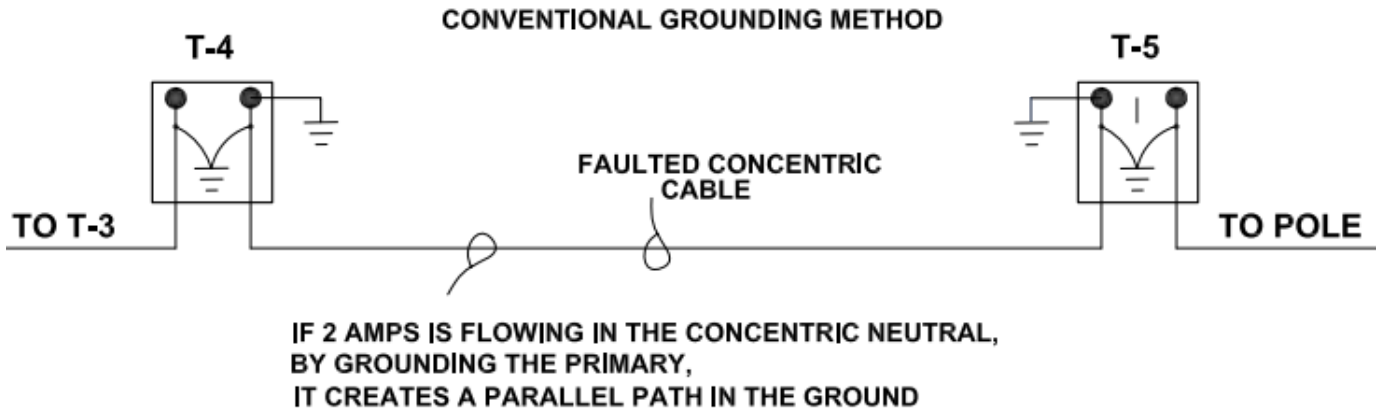
Step Two: Verify the cable is de-energized with an approved testing device.



Step Three: Ground each end of the de-energized cable.

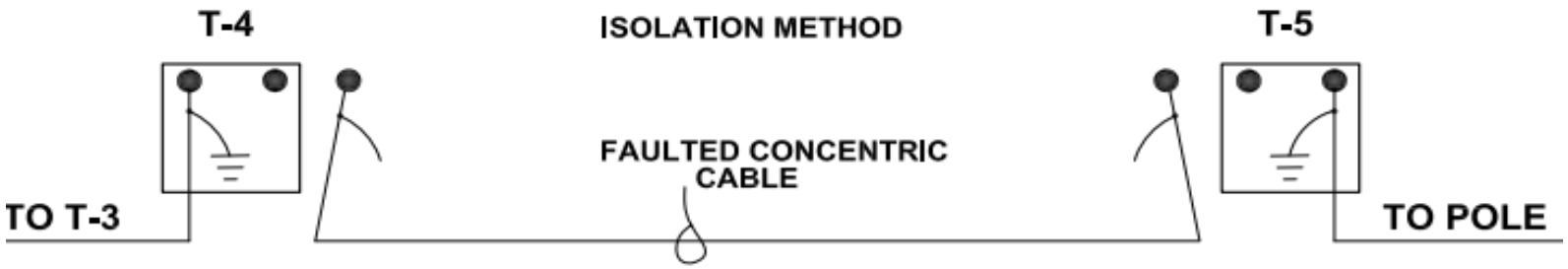


Step Four: Unground de-energized cable and place back on parking stands.

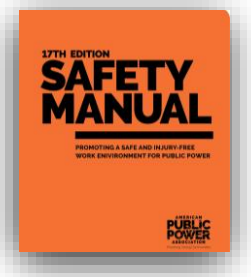


Step Five: Disconnect the concentric neutral using the proper PPE.

Cable is now completely isolated



Grounding Underground



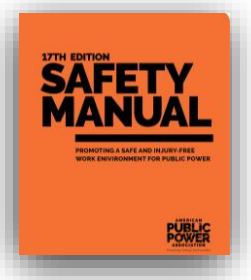
514.2 Underground

l) See OSHA Standard 29 CFR 1910.269(n) for more information on grounding.

m) See Section 514, Grounding — General, for switchgear de-energization grounding.

Grounding Substations 514.3

Grounding Substations



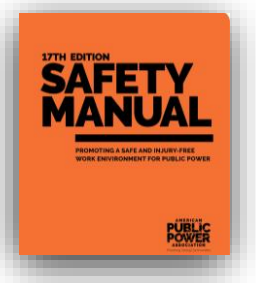
514.3 Substations

a) Before working on de-energized primary circuits or equipment:

(1) A visible air gap, if possible, shall be provided. Refer to Table 202-1 for Minimum Clearance for Open Air Gaps. Refer also to NESC Table 444-1.

(2) A voltage test shall be made using a device designed to test voltage.

Grounding Substations

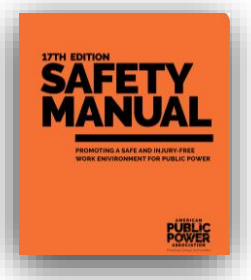


514.3 Substations

(3) The equipment shall be grounded, and an equipotential zone must be established whenever possible.

b) Switchgear shall be de-energized and grounded prior to performing work involving removal of protective barriers unless other suitable means are provided for employee protection. The personnel safety features in switchgear shall be replaced after work is completed. Refer to NESC 444D for Employee's Protective Grounds.

Grounding Substations



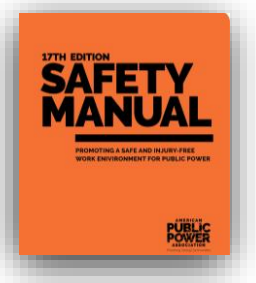
514.3 Substations

c) Testing without grounds: Grounds may be temporarily removed during tests, only under the supervision of the employee in charge and subject to authorization by the designated person. During the test procedure, each employee will use insulating equipment and shall be isolated from any hazards involved.

d) Ground de-energized bus and switches when repair work is being performed.

Grounding Secondary and Metering 514.4

Grounding Secondary & Metering

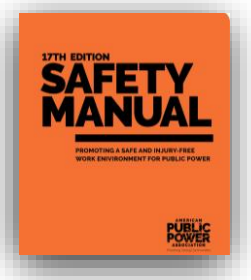


514.4 Secondary and Metering

a) All sources shall be isolated with a visible air gap, properly grounded, or worked as energized. This includes possible backfeed from generators, solar panels, and other potential backfeed sources. This could be done by opening a disconnect, if available, removing the meter, or disconnecting secondary conductors. Refer to Table 202-1 for Minimum Clearance for Open Air Gaps. Refer also to NESC Table 444-1.

b) A voltage test shall be made using a device designed to test voltage.

Grounding Secondary & Metering

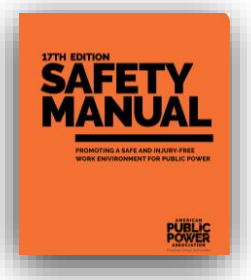


514.4 Secondary and Metering

c) Secondary cables shall be equipotential grounded before splicing or working de-energized. When establishing an equipotential zone is not possible, the cable shall be completely isolated from all known and potential sources, including the neutral.

d) De-energized secondary cables and equipment to be worked on shall be grounded at a point as close to the work as possible or completely isolated from all possible sources.

Grounding Secondary & Metering



514.4 Secondary and Metering

e) The isolation method is recommended on direct buried secondary cable if an equipotential zone cannot be established.

f) All secondary grounds and clamps shall be sized for the maximum available fault current.

Thank you!

Questions?

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