DO's AND DON'Ts OF PERSONAL PROTECTIVE GROUNDING

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Abstract – Temporary protective grounding serves a critical safety function when working on electrical power systems. Although many field service personnel are well-familiar with the requirements of using temporary protective grounds, many others have only a partial understanding of important aspects of it. This paper reviews the more important aspects of the application of temporary protective grounds, including sizing, order of placement and removal, results of misapplication and common rules for working with temporary protective grounds.

Index Terms — Temporary protective grounds, electrical safety, safety grounds, sizing grounds sets, inspecting ground sets, testing ground sets, grounding procedures, application of grounds.

I. INTRODUCTION

The use of temporary protective grounds when placing electrical power systems into an electrically-safe work condition requires years of experience to fully understand and implement. For many less senior field service workers, what they learn about temporary personal protective grounds is often passed on by the more senior personnel. Although on-the-job training is an important part of this type of training, it can also lead to workers having gaps in their knowledge, leading to unsafe acts and practices. Because the worker may not understand what these unsafe acts are or their consequences, he or she may continue to perform this task in an unsafe manner and suffer injury or death as a result.

II. APPLICABLE STANDARDS

A. OSHA 29CFR1910.269(n)

The OSHA regulations in 1910.269(n) [1] are very basic and can be vague. Anyone who has done any work on medium- and high-voltage electrical power systems should certainly know what these basic requirements are:

1) 1910.269(n)(2) – temporary protective grounds shall have an impedance low enough to allow immediate operation of the overcurrent protective device (OCPD).
2) 1910.269(n)(3) – temporary protective grounds shall be placed to create an equipotential zone.
3) 1910.269(n)(4) – temporary protective grounds shall be sized to carry the maximum short circuit available current for the time necessary to clear the fault. Grounds shall be no smaller than No. 2 AWG copper.
4) 1910.269(n)(5) – lines and equipment shall be tested and found absent of nominal voltage prior to placing grounds.
5) 1910.269(n)(6) – when attaching grounds, the ground end shall be attached first using live-line tools.
6) 1910.269(n)(7) – when removing grounds the connection to the line or equipment shall be removed first using live-line tools.
7) 1910.269(n)(8) – the cable may not be grounded if there is a possibility of a hazardous transfer of energy during a fault.
8) 1910.269(n)(9) – grounds may be removed when required for testing purposes.

B. OSHA 29CFR1910.333(b)(ii)

There is very little description about grounding in 1910.333 Subpart S [2], as it applies to utilization equipment, although it can apply to some types of medium-voltage equipment, such as motor starters.

1) Capacitors and high-capacitive lines and equipment shall be shorted and grounded.

C. NFPA 70E Article 120

NFPA 70E [3] requirements closely mirror those of the OSHA regulations. Changes have been made to reflect the 2021 edition of the NFPA 70E. This section is now titled, "*Process for Establishing and Verifying an Electrically Safe Work Condition".*

Establishing and verifying an electrically safe work condition shall include all of the following steps, which shall be performed in the order presented, if feasible:

(1) Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.

(2) After properly interrupting the load current, open the disconnecting device(s) for each source.

(3) Wherever possible, visually verify that all blades of the disconnecting devices are fully open or that drawout-type circuit breakers are withdrawn to the test or fully disconnected position.

(4) Release stored electrical energy.

(5) Block or relieve stored nonelectrical energy in devices to the extent the circuit parts cannot be unintentionally energized by such devices.

(6) Apply lockout/tagout devices in accordance with a documented and established procedure.

(7) Use an adequately rated portable test instrument to test each phase conductor or circuit part to test for the absence of voltage. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on any known voltage source.

Exception No. 1 to 7: An adequately rated permanently mounted absence of voltage tester shall be permitted to be used to test for the absence of voltage of the conductors or circuit parts at the work location, provided it meets all of the following requirements:

(1) It is permanently mounted and installed in accordance with the manufacturer's instructions and tests the conductors and circuit parts at the point of work;

(2) It is listed and labeled for the purpose of testing for the absence of voltage;

(3) It tests each phase conductor or circuit part both phase-to-phase and phase-to-ground;

(4) The test device is verified as operating satisfactorily on any known voltage source before and after testing for the absence of voltage.

Exception No. 2 to 7: On electrical systems over 1000 volts, noncontact capacitive test instruments shall be permitted to be used to test each phase conductor.

Informational Note No. 1: See UL 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements, for rating, overvoltage category, and design requirements for voltage measurement and test instruments intended for use on electrical systems 1000 volts and below.

Informational No. 2: For additional information on rating and design requirements for permanently mounted absence of voltage testers, refer to UL 1436, Outlet Circuit Testers and Other Similar Indicating Devices.

Informational Note No. 3: For additional information on rating and design requirements for voltage detectors, refer to IEC 61243-1, Live Working — Voltage Detectors — Part 1: Capacitive type to be used for voltages exceeding 1kV a.c., or IEC 61243-2, Live Working — Voltage Detectors — Part 2: Resistive type to be used for voltages of 1kV to 36 kV a.c., or IEC 61243-3, Live Working — Voltage Detectors — Part 3: Two-pole low voltage type.

(8) Where the possibility of induced voltages or stored electrical energy exists, ground all circuit conductors and circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, apply temporary protective grounding equipment in accordance with the following:

a. Placement. Temporary protective grounding equipment shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to a shock hazard (i.e., hazardous differences in electrical potential). The location, sizing, and application of temporary protective grounding equipment shall be identified as part of the employer's job planning.

b. Capacity. Temporary 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.

Informational Note: ASTM F855, Standard Specification for Temporary Protective Grounds to be Used on De-energized Electric Power Lines and Equipment, is an example of a standard that contains information on capacity of temporary protective grounding equipment.

c. Impedance. Temporary protective grounding equipment and connections shall have an impedance low enough to cause immediate operation of protective devices in case of unintentional energizing of the electric conductors or circuit parts.

D. IEEE 3007.3

The color book series of IEEE standards is being replaced by what is known as the "dot" series of standards. IEEE 3007.3, Section 7.4.3 [4] covers the use of personal protective grounds and basically covers the same information as NFPA 70E.

E. IEEE C2

The National Electric Safety Code (NESC) [5] primarily covers operations and work practices for overhead and underground line work. It again covers mostly the same information as the OSHA regulations, but adds more detail in the performance of those requirements. As an example, Section 445 covers personal protective grounds. 445A covers the installation of grounds and states:

"*A. Installing grounds*
When installing protective grounds on a previously energized part, the following sequence and precautionary measures shall be observed.
EXCEPTION: In certain situations, such as when grounding conductors are supported on some high-voltage towers, it may be appropriate to perform the voltage test before bringing the grounding device into the work area.
B. Current-carrying capacity of grounds
The grounding device shall be of such size as to carry the induced current and anticipated fault current that could flow at the point of grounding for the time necessary to clear the line.
NOTE: Refer to ASTM F-855-04 [B24] for specifications for protective grounding equipment.
2. Initial connections
Before grounding any previously energized part, the employee shall first securely connect one end of the grounding device to an effective ground. Grounding switches may be employed to

connect the equipment or lines being grounded to the actual ground connections.

3. Test for voltage

The previously energized parts that are to be grounded shall be tested for voltage except where previously installed grounds are clearly in evidence. The employee shall keep every part of the body at the required distance by using insulating handles of proper length or other suitable devices.

4. Completing grounds

a. If the part shows no voltage, the grounding may be completed.

b. If voltage is present, the source shall be determined to ensure that presence of this voltage does not prohibit completion of the grounding.

c. After the initial connections are made to ground, the grounding device shall next be brought into contact with the previously energized part using insulating handles or other suitable devices and securely clamped or otherwise secured thereto. Where bundled conductor lines are being grounded, grounding of each subconductor should be made.

Only then may the employee come within the distances from the previously energized parts specified in Rule 441A or proceed to work upon the parts as upon a grounded part."

All of the aforementioned standards contain very much the same information. The devil's in the details though, and that is what this paper is about.

III. GROUND SET FIELD USE REQUIREMENTS

There are different types of grounds for different purposes. Temporary protective grounds guard against the accidental reenergizing of circuits or equipment. "Static" grounds are only used to prevent isolated electrical devices from accruing a static charge from induced voltages. An example of static grounding would be the shorting and grounding used when testing a transformer that is electrically isolated from all other lines and equipment and is free-standing. The grounding used for this purpose is much smaller and does not have the same requirements as temporary protective grounds. The lines or equipment connected to such a transformer would use temporary protective grounds in order to protect against lightning strikes or reenergization.

Temporary protective grounds must meet the requirements of ASTM F855[6]. Each component (clamp, ferrule and cable) of the ground set must be designed and constructed to carry the maximum short circuit available current and for the type of fixture it will be attached to. A clamp designed for flat bus will not work well on tubular bus, or vice versa. One of the authors has heard field technicians explain their choice of ground sets by saying "We use 4/0 AWG; it should be enough." It is advisable to understand how to size temporary protective grounds and not rely on intuition or old practices. Don't take shortcuts and improvise as shown in Figure 1.

Fig. 1 – Example of Unsafe Improvisation

Grade	Grounding Clamp Torque Strength, min: Yield[B] lbf·in.	Yield[B] n·m	Ultimate lbf·in.	Ultimate n·m	Short Circuit Properties[A]: Withstand Rating, Symmetrical kA RMS, 60 Hz: 15 cycles (250 ms)	30 cycles (500 ms)	Copper Cable Size	Ultimate Rating Capacity[CD], Symmetrical kA RMS, 60 Hz: 15 cycles (250 ms)	30 cycles (500 ms)	60 cycles (1 s)	Maximum Copper Test Cable Size	Continuous Current Rating, A RMS, 60 Hz
1	280	32	330	37	14	10	#2	18	13	9	2/0	200
2	280	32	330	37	21	15	1/0	29	21	14	4/0	250
3	280	32	330	37	27	20	2/0	37	26	18	4/0	300
4	330	37	400	45	34	25	3/0	47	33	23	250 kcmil	350
5	330	37	400	45	43	30	4/0	59	42	29	250 kcmil	400
6	330	37	400	45	54	39	250 kcmil or 2 2/0	70	49	35	350 kcmil	450
7	330	37	400	45	74	54	350 kcmil or 2 4/0	98	69	48	550 kcmil	550

[A] Withstand and ultimate short circuit properties are based on performance with surges not exceeding 20 % asymmetry factor (see 9.1 and 12.3.4.2).
[B] Yield shall mean no permanent deformation such that the clamp cannot be reused throughout its entire range of application.
[C] Ultimate rating represents a symmetrical current which the assembly or individual components shall carry for the specified time.
[D] Ultimate values are based upon application of Onderdonk's equation to 98 % of nominal circular mil area allowed by Specifications B172 and B173.

Table 1 Protective Ground Cable, Ferrule, Clamp and Assembly Ratings for Symmetrical Current
From ASTM F855

A. Sizing Temporary Protective Grounds

Table 1 (shown as Table 1 above) from ASTM F855 is used to determine the sizing of temporary protective grounds based on the available short circuit current and clearing time of the OCPD. Table 2 is used when applications have a high X/R ratio. There are two ratings given in Table 1; "withstand" and "ultimate". Quoting from ASTM F855:

1) "*3.1.5 ultimate capacity—this represents a current which it is calculated the component is capable of conducting for the specified time. It is expected that component damage may result. The component shall not be reused, except in test situations.*

2) *3.1.6 withstand rating—this represents a near symmetrical current which shall be conducted without any component being damaged sufficiently to prevent being operable and reusable. The protective ground shall be capable of passing a second test at this current after being cooled to ambient temperature*."

As a matter of leaving some safety factor into the choice, using ground sets sized to the withstand rating would be advisable. The amount of time for OCPD operation should be based on the power systems characteristics.

One other factor to consider is the length of the grounding set cable. The longer the cable length, the higher the impedance of the cable will be. The goal is to have the lowest impedance practical so the short circuit current will flow to ground through the ground set causing as little damage as possible. A ground set not rated for available fault current would act like a fuse and create a potential for injury and property damage. In discussions at the ASTM F18 committee meetings it was generally agreed that 20' is the longest length a grounding cable should have. Cable longer than 20' begins to affect the ampacity of the ground set. Longer ground set cable also increases the risk of someone being struck by the cable if it is reenergized. When a ground set is energized it may whip about due to the magnetic forces being imposed upon it. Ground cables energized under such circumstances may cause significant personal injuries.

B. Installation and Removal

An appropriate sequence for installation and removal of temporary protective grounds could be as follows:

1) Test for the absence of nominal voltage. OSHA and NFPA 70E state that all circuits are to be considered energized until proven deenergized by testing. There may be induced voltage showing, but it will be much lower than the system operating voltage.
2) Always use live-dead-live testing (also known as "Three Step Voltage Test") when performing absence of voltage tests. Test the voltage detector on a known live circuit, test all circuits that should be deenergized, then retest the voltage detector on a known live circuit. Voltage detectors can and do stop working and the author has had several voltage detectors go bad after the initial test. Following proper procedures, even when you are certain the circuit is dead, could save your life.
3) Never, *ever* tap a circuit or device with a "static ground" to see if it is dead. Back in the day, electrical workers would take a 12 AWG wire and staple it to a broomstick handle. One end was connected to ground while the other end was stripped bare. The bare end was used to tap the "deenergized" conductor to ensure it was dead. This is another form of improper improvisation. If the circuit is still energized the short circuit current could vaporize the wire, creating an arc flash with the potential for serious injury or death.

4) Connect the ground-side connection securely. Ensure the location where the grounds are to be placed is clean and free from anything that could cause high impedance. Common practice is to wire-brush the surface or to use the serrated jaws of the ground clamp to clean the surface area. The ground-side clamp must always be securely attached first. If there is an induced potential on the lines or equipment or the line is inadvertently left energized and the line-side is attached first, the entire ground set would be energized. By attaching the ground-side first, that potential would be dissipated.
5) Use only ground clamps that are intended for use with the type of bus or equipment being attached to. Using a clamp intended for tubular bus or vice versa will not allow the proper clamping force needed and the clamp may come loose during a short circuit. This would result in considerable damage to equipment and possible injury to anyone nearby. Figure 2 shows a poorly-mated clamp connection.

Fig. 2
Incorrect Clamp Used for Application

6) Using a live-line tool only, connect the other clamps to the conductors or equipment. OSHA 1910.269 specifically states that a live-line tool is to be used when attaching or removing ground sets. The use of a live-line tool removes the worker from the immediate vicinity if the line were to become reenergized for some reason and also places the worker beyond the Restricted Approach Boundary (what OSHA refers to as the Minimum Safe Approach Distance for a qualified person).
7) Use a ground set as short as possible. This reduces the chances of the cable striking someone if it is accidentally reenergized and also reduces the overall impedance of the ground set.
8) If a ground set has "T" handles, it is to be used for static grounds only. They are suitable for use when a transformer or other piece of isolated electrical equipment must be grounded during an electrical test and can't be subject to reenergization or fault-level currents. Always wear rubber insulating gloves when placing or removing static grounds.
9) Wear proper personal protective equipment (PPE) when exposed to electric shock and arc flash hazards. Yes, it is hot, it is bulky, it does make you sweat but it will also protect you if there's an arc flash or shock potential. OSHA 1910.269 does not give details of what PPE is to be used when applying and removing protective grounds. NFPA 70E Table 130.7(C)(15)(a) lists use of HRC 2, 3 and 4 based on type and voltage of the equipment, but only when the grounds are applied. Electric hazards also exist when the grounds are being removed and workers need to use appropriate PPE for their protection. Workers need to ask themselves what would happen if there's a lightning strike or inadvertent equipment reenergization when grounds are being removed.

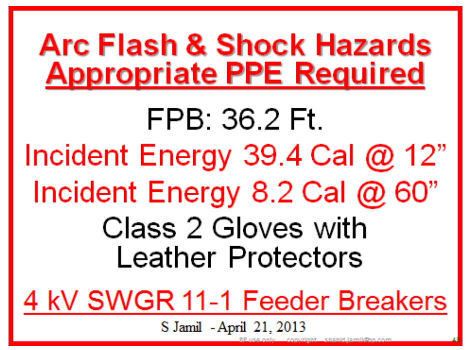


Fig. 3
Example Arc Flash Warning Label

10) Place grounds close enough to protect workers, but not so close that they could injure people nearby. Refer to paragraph C for more information.
11) Never come into contact with grounds while they are being placed or afterwards. The jacket on grounds is used to protect the fine conductors from being damaged, not as insulation. Don't step on them or reposition them using bare hands. The jacket would be of little use on higher voltage electrical systems.
12) Inspect grounds before using them. ASTM F2499 [7] provides guidance on the proper inspection and testing of ground clusters. Figure 4 is a common problem found on ground sets. In Figure 4, the cable is oxidized, the strands are exposed to damage, etc. Some of the other reasons why ground sets may get damaged or become ineffective are: human errors, lightning strikes, static build-up, induced voltage feedback from adjacent circuits, mechanical or equipment failure, switching errors, stored charges from capacitors, faulty automatic re-closing devices, corrosion, contact with chemicals, accidental pinching, mishandling, etc.

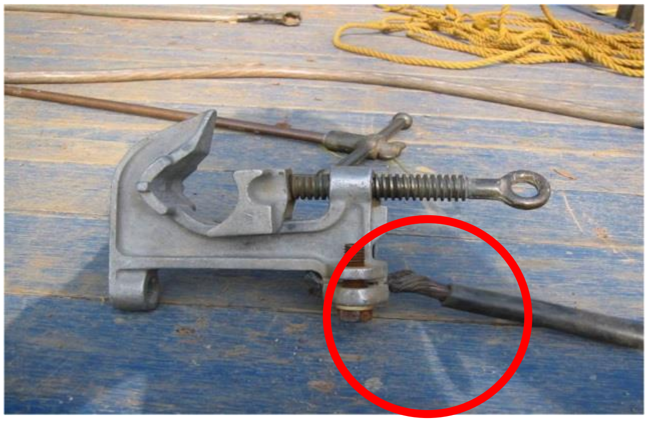


Fig. 4
Defective Ground Clamp Assembly

13) Always track ground sets when placing them on equipment or circuits. Every year accidents are caused by grounds being left on when a system is reenergized. If sized and installed properly, the OCPD should clear the circuit before substantial damage is done. One company uses the alerting and tagging system shown in Figure 5A and 5B. Each ground set has a unique identification (ID) number that is stamped into a metal tag. That ID tag is attached to the ground set and to a removable clip. When the ground set is placed into service, the tag is unclipped from the ground set and locked onto the LOTO device, which also has a tag showing which circuit it is placed on. When the LOTO is released, the technician knows which ground has to be retrieved and where it is.

Fig. 5A and 5B
One Company's Tracking System

14) Another practice successfully used by one global energy company to ensure grounds are removed is to include both application and removal of grounds in the electrical equipment switching procedures where qualified persons strictly follow each and every step of the switching procedure and sign or initial the steps after their execution. This practice is further enhanced by hanging yellow "Grounds Applied" tags on the door of the equipment where grounds are applied, shown as Figures 6A and 6B.

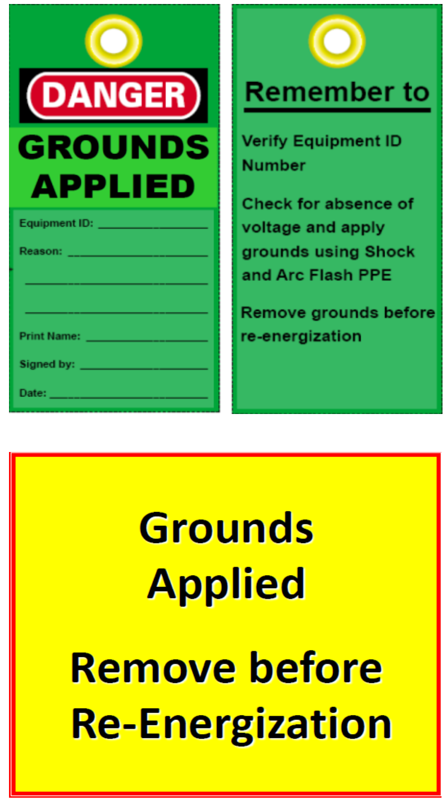


Fig. 6A and 6B
One Company's Alerting & Tagging Signs

15) Another, possibly less effective practice, is to count the number of grounds applied before and after the switching is carried out.
16) If grounds are defective, tag them and remove them from service. The same tagging system used to identify each ground set, can also be used to track and inspect ground sets for condition and testing. If the ground set is defective, that ID number is entered into the system, the grounds removed from service and the grounds are repaired and tested or disposed of. The grounds must not be put back in service until these are repaired and tested by an accredited testing laboratory.
17) Never stand near grounds that may be lying on the ground. If they are reenergized they will try to straighten out with great force and may hit workers in the vicinity. Using safety barrier tape or barriers could make other workers aware of the hazard and avoid the area.
18) Never coil grounds. If they are on carriers, remove the entire conductor from the carrier and stretch it out on the ground (earth). When short circuit current tries to pass through a coil of wire, the coil acts as an inductor or choke. Often the result is vaporized conductor.

19) Inspect the grounds after using them. Take a few minutes to ensure they are still serviceable. Use ASTM F2499 as a guide for your inspection.
20) Test personal protective grounds on a regular basis. ASTM F2499 states that grounds are to be tested at a "*time interval established by the user to ensure that defective grounding jumper assemblies are detected and removed from service in a timely manner*". It is the author's opinion that personal protective grounds are safety-related devices and, as such, should be tested annually.

C. Placement Of Grounds

Location of personal protective grounds either ensures or jeopardizes the safety of workers. Therefore, it is essential that grounds be placed between all possible energy sources and the workers. The following illustrates proper ground placement for various electrical systems:

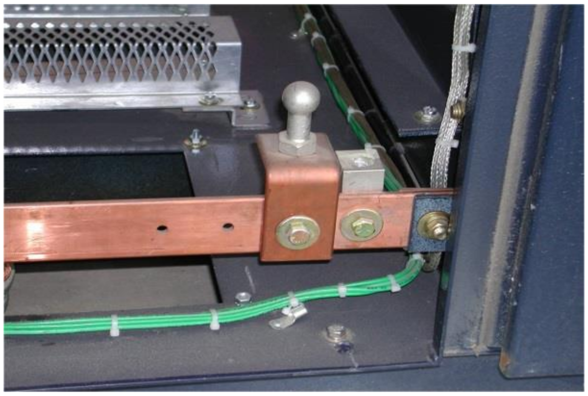
1) In radial power systems, where there is only one energy source, grounds are applied at the transformer secondary or switchgear when any work is to be done at the switchgear.
2) In secondary selective systems when any work is to be done at the switchgear bus, grounds are applied near the tie-breaker and incoming breaker connections. This approach allows the worker to remain between the grounds and grounds protect the worker from any accidental reenergization.
3) When any work is to be done on overhead lines, grounds are applied at both ends of the power line section or pole being worked on to protect workers from lightning and accidental reenergization.
4) It is necessary that all temporary energy sources (including portable, short term or construction power generators, or potential backfeeds) are investigated, isolated, locked, tagged and grounded.

D. The Best Ground Set?

Tests performed by one major utility company indicate that the ball and socket style of ground set may be superior to other styles in terms of lowest resistance and ease of use. This type of ground set can only be used when the correct ball stud is installed into the bus during a shutdown. Once installed, the ball stud is easily accessed by removing the rubber cover using a live-line tool, Figures 8a and 8b.

Fig. 7
Ball-and-Socket Ground Cluster

The ball and socket ground sets can have more surface contact than clamps, and are easier to apply using live-line tools. The ball and socket ground set is especially useful when used on medium-voltage metal clad switchgear or other equipment using flat bus and comes in several mounting configurations.



Figs. 8a and 8b
Ball-and-Socket Ground Cluster as Used on Switchgear

IV. CONCLUSIONS

Personal protective grounds provide a safe, reliable method to protect workers from hazards that may occur while the electrical power system is deenergized. This includes unanticipated events, such as lightning strikes, induced potentials and accidental reenergizing of the system.

This paper reviewed a number of important standards and field-use requirements to observe while choosing and using personal protective grounds and is not intended as advice with respect to specific installations. As an overview, the authors cannot foresee all possible needs in actual field use. Field service technicians and linemen who use personal protective grounds must assess the conditions and needs at the site and time of use in consultation with their electrical experts.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

[1] OSHA 29CFR1910.269, *Electric Power generation, Transmission and Distribution*, 1994.

[2] OSHA 29CFR1910.333, *Selection and Use of Work Practice.*

[3] NFPA 70E, *Standard for Electrical Safety in the Workplace*, 2012 edition, National Fire Protection Association.

[4] IEEE Standard 3007.3, *IEEE Recommended Practice for Electrical Safety in Industrial and Commercial Power Systems*, 2012, International Association of Electrical and Electronic Engineers

[5] IEEE Standard C2, *National Electrical Safety Code*, 2012, International Association of Electrical and Electronic Engineers

[6] ASTM Standard F855, *Standard Specification for Temporary Protective Grounds to be Used on De-energized Electric Power Lines and Equipment,* 2009, American Society for Testing and Materials

[7] ASTM Standard F2249, *Standard Specification for In-Service Test Methods for Temporary Grounding Jumper Assemblies Used on De-Energized Electric Power Lines and Equipment*, 2009, American Society for Testing and Materials

VII. VITA

James R. (Jim) White has been the Training Director of Shermco Industries, Inc., in Irving, Texas since 2001. Jim is certified by the National Fire Protection Association (NFPA) as a Certified Electrical Safety Compliance Professional (CESCP). He is the principal member for Shermco Industries on the NFPA Technical Committee "*Recommended Practice for Electrical Equipment Maintenance*" (NFPA 70B). Jim represents the interNational Electrical Testing Association (NETA) as an alternate member of the NFPA Technical Committee "*Standard for Electrical Safety in the Workplace*" (NFPA 70E), is NETA's principle representative on the NEC Code Making Panel CMP-13 and represents NETA on the ASTM F18 Committee "*Electrical Protective Equipment For Workers*". Jim is an IEEE Senior Member and in 2011 received the IEEE/PCIC "*Electrical Safety Excellence*" award. In 2013 Jim received NETA's "*Outstanding Achievement Award*". Jim is a past Chairman (2008) of the IEEE Electrical Safety Workshop and is the author of three books available through American Technical Publishers, "*Significant Changes to NFPA 70E – 2015 Edition*", "*Electrical Safety, A Practical Guide to OSHA and NFPA 70E*" and "*Circuit Breakers – A Technician's Guide to Low and Medium-Voltage Circuit Breakers*".

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Shahid has been very active in the area of electrical safety and has authored/co-authored 8 electrical safety papers and received three "First Paper" and one "Honorable Mention" awards from PCIC/IEEE and "Third Best Presentation" award from PCIC/IEEE Electrical Safety Workshop. Shahid has chaired/co-chaired/coordinated three PCIC/IEEE Electrical Safety Workshops in Indianapolis (1997), Madras, India (1998) and New-Delhi (2000). He has co-presented papers and tutorial at international conferences and workshops, developed training programs and carried out electrical safety training for over 1500 qualified and unqualified workers in Canada, India, Indonesia, Singapore, Thailand, the USA and South American Countries. US Immigration and Naturalization Services recognized exceptional experience and expertise in Electrical Safety and granted the Permanent Residence (Green Card).

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SUMMARY (PARTIAL) - DO'S AND DON'TS OF PERSONAL PROTECTIVE GROUNDING

No.	Subject	Short Description	Potential Consequences of Failure to Apply	Comments
1	Size of grounding cables	Grounding cables must withstand available short circuit currents, at the location of grounds to be applied, and for the duration of nearest upstream protection device operating time setting.	Selection of less than necessary size ground cable may result in melting of the ground cable and failure to achieve the necessary protection for the workers and the equipment involved.	In most cases, note not all cases, ground cable of 4/0 AWG size is suitable.
2	Check for absence of voltage	Always check for absence of voltage before applying grounds and check the integrity of voltage tester before and after checking for absence of voltage.	Failure to check for absence of voltage puts the worker exposed to potential hazardous voltages.	The absence of voltage test is also known as "Three-Step-Voltage Test".
3	Sequence of application of Grounds	Always attach the ground part of the ground cables to an effective ground first, then attach ground to nearest phase, and next to the second nearest phase and the last to the farthest phase.	If the sequence described is not followed the worker may be exposed to hazardous potential and related hazards.	
4	Sequence of removal of grounds	Always remove the ground from the farthest phase first, then remove from the next to the farthest phase and then from the nearest phase. Then remove the ground cable from the system ground.	Again if the sequence described is not followed the worker may be exposed to hazardous voltages.	
5	Personal protective equipment	In addition to standard PPE, always use PPE for protection from electric shock and arc flash hazards	If necessary PPE is not used, the worker may be exposed to hazards they are expected to protect themselves from.	
6	Length of ground cables	Ground cable length should be as short as possible but not more than 20'.	Longer ground cables also increase the risk of workers being struck by the cable if it is reenergized. When a ground cables are energized they may whip about due to the magnetic forces being imposed upon them. Energized ground cables have the potential to cause personal injury and property damage.	Longer cables will also affect the ground cable ampacity and may cause the ground cable to melt and not provide the expected protection to the workers and equipment.
7	Tightness of ground connections	Always ensure the ground connections are properly tightened so that the ground cables do not come-off if the cables are accidentally reenergized.	Loose ground cable connections can come-off the equipment being protected and may cause personal injury and property damage.	
8	Removal of grounds for equipment testing	When ground cables are removed to allow testing of the equipment being protected, equipment must be considered energized by all workers.	When ground cables are removed there is a potential for their accidental re-energization and therefore all applicable safety precautions and PPE must be used.	

SUMMARY (PARTIAL) - DO'S AND DON'TS OF PERSONAL PROTECTIVE GROUNDING (CONTINUED)

No.	Subject	Short Description	Potential Consequences of Failure to Apply	Comments
9	Maximize working distance when applying and removing grounds	Always use live-line tools both when applying and removing grounds. Use of the live-line tools will result in lower arc flash incident energy exposure.		A 60" working distance may be used in arc flash study for application and removal of grounds.
10	Track ground cables	Develop a program to ensure ground cables are removed before power to the equipment is restored.	Incidents have occurred where ground cables were left on the equipment and the equipment were reenergized. These incidents have resulted in equipment damage and injuries to workers.	Different methods have been detailed in the paper to ensure ground cables are removed before equipment is reenergized.
11	Never coil ground cables	If ground cables are on reels or carriers, remove and stretch them out on the ground (earth).	In the events of short circuit fault, current will pass through a coil of wire, the coil will act as an inductor or choke. This will result in damaged or vaporized conductor.	
12	Inspect and Test	Inspect grounding devices prior to every use and test every two years and whenever their capability is suspected.	Use of damaged grounding devices is almost same as if these are not used.	Grounding devices may get damaged or become ineffective due to wear and tear, mishandling or rough treatment, contact with moisture or chemicals, accidental pinching, etc., and require inspection and testing at regular intervals.