

Electrical Transmission & Distribution Partnership

Continuing Education Training: Grounding and Bonding

Presenter Guide
1st Quarter 2020

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Introduction

This Grounding and Bonding continuing education course is intended as a facilitator led process. The facilitator may choose to augment the material with videos, handouts or other media to enhance the learning experience. The facilitator may want to incorporate visual aids to enhance the presentation.

Using this material combined with practical experience, good presentation skills, and knowledge of adult learning techniques, the facilitator has a greater opportunity to deliver the information effectively.

Microsoft® PowerPoint® combined with good instructional skills and instructor/student dialogue help with information retention and understanding. PowerPoint® presents the information to the attendee and the facilitator summarizes the content of the slides. It is critical to engage and involve the attendee in the process. Ask open-ended questions that will elicit conversation and discussion, but be cautious to maintain control of the discussion.

Conversation and scenarios are good, but can cause the discussion to run long. If it seems like the group is losing focus during the course, the facilitator can direct the group back on track by using comments like “This is a great discussion, but let’s get back to the subject at hand”.

Another tool is the “Parking Lot” which is simply a newsprint chart or dry erase board or note pad where the facilitator records unanswered questions during the meeting and that may require more research. It is vital to capture any ongoing discussions or questions on the “Parking Lot” and follow up when the information is known.

Deliver this continuing education module in the second quarter of 2019. Delivery time is approximately 1 to 1.5 hours in one setting, or divided-up into three, twenty to thirty minute settings. There is text animation on most of the slides. Text and images appear by varying levels on mouse clicks. **It is critical that the facilitator makes him or herself familiar with the material prior to delivery.**

At the end of this document are two handouts regarding Slip, Trip, and Fall prevention. The presenter can use these handouts as well as relevant examples in conjunction with the PowerPoint® presentation to augment the materials. The handouts may serve as stand-alone documents.

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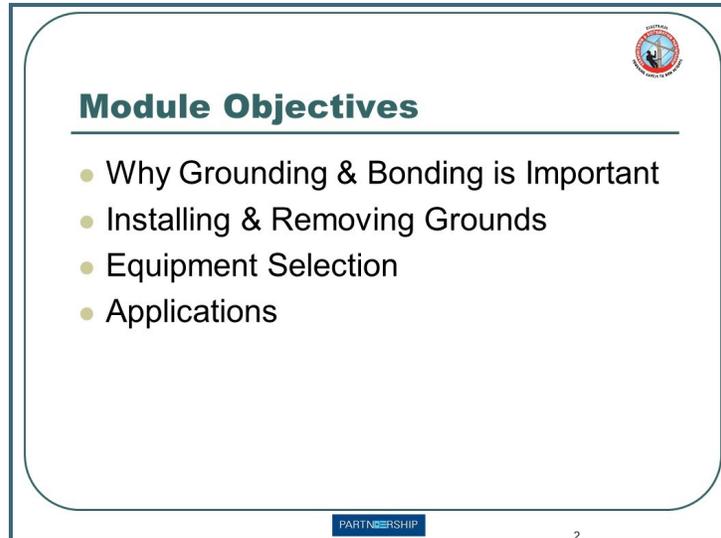
Slide 1

Grounding & Bonding
Continuing Education
Fourth Quarter 2020



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Slide 2



Slide 2 features a white background with a blue border. In the top right corner, there is a small circular logo. The main content is titled "Module Objectives" in a bold, dark blue font, underlined. Below the title is a bulleted list of four items. At the bottom center, there is a small blue box with the word "PARTNERSHIP" in white, and a small number "2" to its right.

Module Objectives

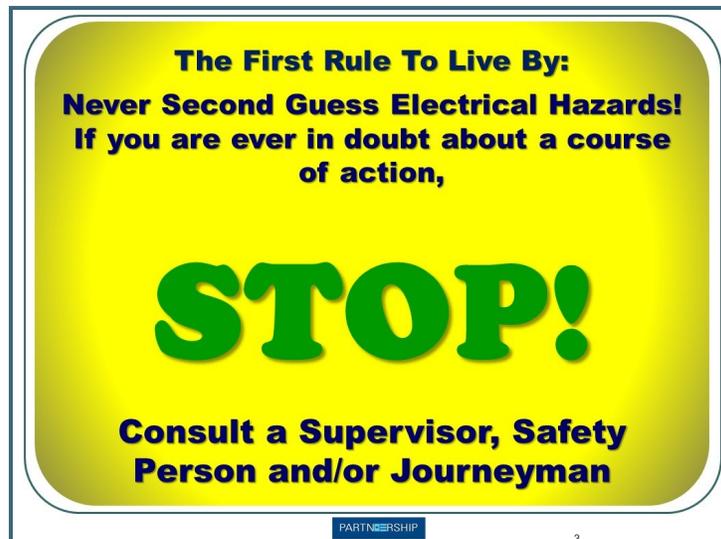
- Why Grounding & Bonding is Important
- Installing & Removing Grounds
- Equipment Selection
- Applications

PARTNERSHIP 2

Explain that the following are the topics of discussion:

The basics, accidental energization, safety fundamentals, installing and removing grounds, equipment selection, equipment grounding and bonding, parallel ground sets, ways to establish equipotential zones, and finally a recap.

Slide 3



Slide 3 has a yellow background with a blue border. The text is centered and reads: "The First Rule To Live By: Never Second Guess Electrical Hazards! If you are ever in doubt about a course of action, STOP! Consult a Supervisor, Safety Person and/or Journeyman". At the bottom center, there is a small blue box with the word "PARTNERSHIP" in white, and a small number "3" to its right.

**The First Rule To Live By:
Never Second Guess Electrical Hazards!
If you are ever in doubt about a course
of action,**

STOP!

**Consult a Supervisor, Safety
Person and/or Journeyman**

PARTNERSHIP 3



Strong emphasis: There is always time to do it the right way the first time.

Slide 4



Effects of Electrical Contact

- Shock Trauma
- Burns
- Loss of limbs
- Internal injuries
- Psychological Trauma
- Loss of livelihood



PARTNERSHIP
4



Discuss the path of the current determines the severity of the shock. If the path crosses the heart, results may be fatal. Explain all the negative consequences of electrical contact.

Slide 5



Electrical Contact Events by General Activity

Injury Classification	General Activity	2018	2017	Grand Total
Electric Contact	Aerial Work	1	1	1
	Conductors Installing/Removing (*1)	10	8	18
	Digging/Excavation Manual	1	1	1
	Equipment Assembly/Disassembly	1	1	1
	Grounds Installing/Removing (*1)	1	1	2
	Materials Handling Manual	2	2	2
	Operating Vehicle/Equipment	1	1	1
	Other/Unknown/Blank		1	1
	Pole/Tower/Structure -Assembly/Disassembly (*1)	3	2	5
	Standing	1	1	1
	Unknown	1	1	1
Grand Total		18	16	34
* Fatal events 2018				

PARTNERSHIP
5

Explain this table was pulled from the 2018 log analysis report. There has been an increase in the data provided from 2017, to 2018. In 2018, there were three events which were fatal involving installing/removing conductors, installing/removing grounds, and assembly/disassembly of pole/tower/structure.

Slide 6



Electrical Contact Statistics

Injury Classification	2018	2017	2016	2015
Electric Contact	3	5	1	1
Struck By (*1)	1			2
Fall	1	2		
Misc/Other (*2)	2			
Caught Between (*1)	2			
Motor Vehicle		1		1
Grand Total	9	8	1	4
*2018 - Helicopter Events				



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This slide shows that while the fatalities have declined in the year 2018 as compared to 2017, we still continue to have these types of events.

Slide 7



Electrical Contact and Arc Flash Events

Injury Classification	OSHA Recordable					SIF Events	
	2018	2017	2016	2015	Grand Total	2018	2017
Electric Contact	18	16	11	26	71	8	9
Arc Flash	17	10	27	17	71	6	1
Grand Total	35	26	38	43	142	14	10



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Events which electrical contact and arc flash occurred have increased since 2016.

Slide 8

How a circuit can become unintentionally energized?

- Switching
- Induction
- Back-feed
- Lightning strikes
- Vehicle Accidents
- Equipment Failure



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Explain that we definitely want to keep our work areas as safe as possible! On systems that have been de-energized, many items have to be considered for the continuous safety of employees. Accident energizing– The employee in charge of the work and the employees will undoubtedly make certain that the system is de-energized before starting work, but through carelessness or misunderstanding, switches may be closed and energize the system in the work area. Accidents on adjacent systems, at crossovers or on overbuild, could result in an energized line coming in contact with the de-energized system. Fault Currents- on adjacent systems can cause an increase in the amount of induced or feed-over voltage on de-energized lines. While these fault currents should be of a short duration and until circuit protection takes over the values are high enough to require the work area be properly grounded.

Lightning - Although the de-energized work area may be bathed in bright sunlight, a storm on some other portion of the system could result in lightning striking the system causing increases in voltage and current transients which would make the work area unsafe. Induced Voltage - from adjacent power lines is a constant consideration. Even though the system has been de-energized there is an electro-magnetic feed over from adjacent energized circuits. The value of the induced feed-over will depend on the voltage and how close it is to the de-energized circuit. Induced voltages must be grounded to avoid possible electrical injury, discomfort, and inadvertent jerk reactions that could cause the employee to fall into circuits or equipment or otherwise be injured. Vehicle accidents can cause unintentional contact.

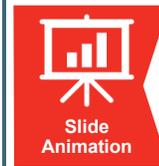
Slide 9

Key Safety Fundamental

To avoid hazardous differences in electrical potential:

- Insulate yourself from the hazard
- Isolate yourself from the hazard
- **Work in a Equal Potential zone**

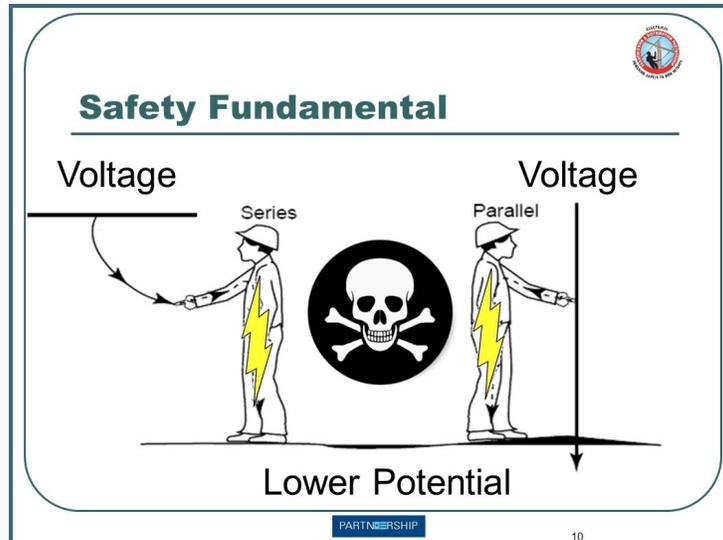
PARTNERSHIP 9



Explain that a key safety fundamental in regards to electrical safety is to identify the hazard and then to determine what method of protection to use to protect one's self from the hazard. Many times, we can insulate ourselves from the hazard. We may use rubber-insulating equipment to protect us. Other times we may choose to isolate ourselves from the hazard or isolate the hazard from us. When we assure that there is no possible hazardous difference in potential and that the system, circuit, and/or apparatus on which we are working will remain in that state then isolate is a protective measure. Lastly, we may choose to work in a zone of equalized potential. Live-line-bare-hand work is an example of equal potential work.

No matter the chosen method, if the protection is adequate for the hazard involved then the bottom line is that we have lowered our risk. **The primary purpose of this topic is to discuss equal potential grounding and bonding.**

Slide 10



Explain that a key safety fundamental is never to place your body in series or in parallel with two possible potential differences. Bridging these differences may place the worker at risk.

Slide 11



Explain the correct method and order of installing and removing grounds.

Slide 12



Installing Grounds

- When attaching grounds
 - Attach ground end of the cable to an earth ground potential **first**
 - **Always** use a live line tool



PARTNERSHIP 12

Explain that once potential testing is complete, and it has been confirmed that the line is de-energized, the grounds may be attached. In order for grounds to work properly, the conductor or part the ground clamp is to be attached to must be cleaned. One method to accomplish this is to use a wire brush mounted on the end of a live line tool to brush oxidation from the part. It is critical to maintain minimum approach distance from the part of circuit during this step. Also grounding clamps brushed and cleaned prior to use to ensure a good connection. The grounds must be applied with a live line tool and tightened down. Should a fault occur, the violent reaction may cause a loose or improperly installed clamp to fail.

Slide 13



Removing Grounds

- When removing grounds
 - The grounding device shall be removed from the normally energized conductor, line or equipment **first**
 - **Always** use a live line tool



PARTNERSHIP 13

Explain that when removing ground, the grounding device shall first be removed from the normally energized (but now de-energized) conductor, line or equipment first using insulating live line tools. Emphasize that the installation and removal of grounds is not a bare-hand or rubber glove procedure.

Slide 14

Equipment Selection



14

Explain that the following slides will discuss issues to consider when selecting grounding and bonding equipment.

Slide 15



OSHA Standard

- 1926.962(c) Equipotential zone
 - Temporary protective grounds shall be placed at such locations and arranged in such a manner that the employer can demonstrate will prevent each employee from being exposed to hazardous differences in electric potential





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Explain that certain OSHA standards regulated the construction of power transmission and distribution systems. This OSHA standard is a “Performance” standard. OSHA does not tell the employer how to do this only that the employer shall do this.

Slide 16

Maximum Fault Current Capability for Grounding Cables		
Cable Size	Clearing Time	RMS Amperes
#2	15 Cycles	17,000
	30 Cycles	13,000
1/0	15 Cycles	26,000
	30 Cycles	20,000
2/0	15 Cycles	33,000
	30 Cycles	26,000
4/0	15 Cycles	53,000
	30 Cycles	41,000

ASTM F-855  16

Review current carrying capabilities chart. Discuss company and host employer grounding cable size standard. Reference ASTM F 855.

Slide 17



Explain that the following information discusses ways of establishing an equal potential work zone.

Slide 18



Safe Work Practices

- Job Briefing
 - Shall be held with all workers involved before beginning any job to discuss the potential hazards and what protective measures will be used for employee protection and safeguarding of the public and the customer



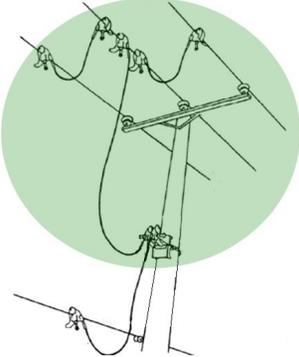
PARTNERSHIP 18

Discuss that prior to starting any grounding task, a job briefing must be held. Discuss the hazards involved. Discuss the preventative measures that will be used to protect the workers, the public, and the customer. Consider documenting the location of the grounds on the job briefing. This will help avoid the chance of unintentionally leaving grounds on a line.

Slide 19



Distribution-Neutral on Pole

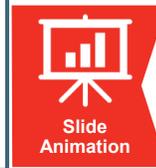
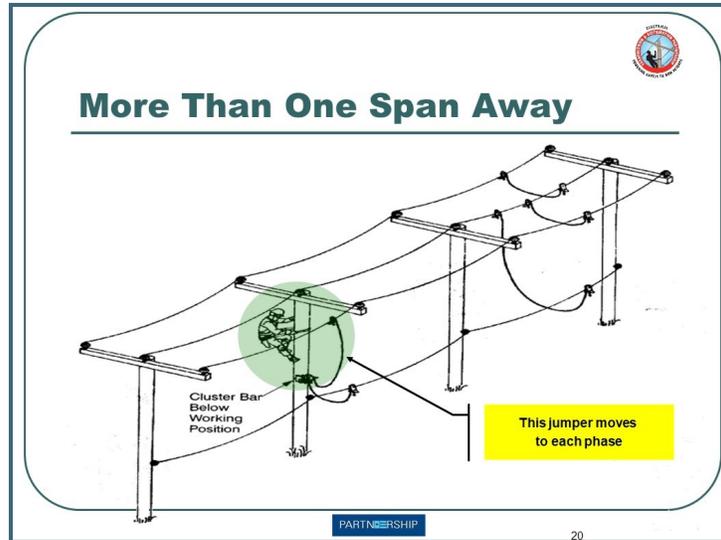


PARTNERSHIP 19



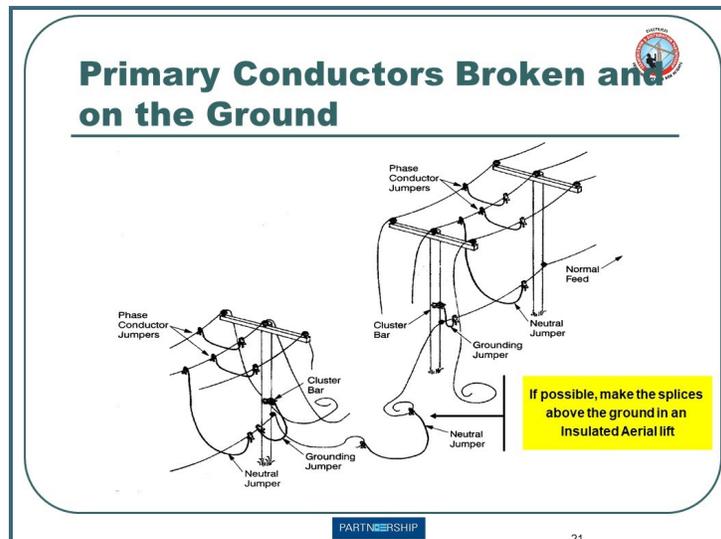
Explain that this is one method of creating an equal potential zone on a wooden pole, distribution circuit.

Slide 20



Explain that when working away from the master or trip grounds this is one method of creating an equal potential work zone.

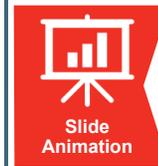
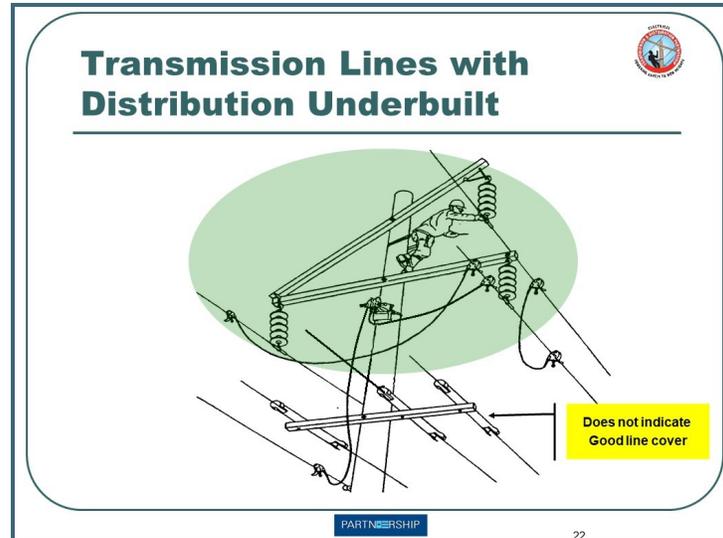
Slide 21



Explain that working with downed conductors creates particular hazards. In this case, the worker may consider using the “insulate” method of protection. The worker may choose to wear rubber insulating gloves (and sleeves) and rubber insulating over-shoes for protection.

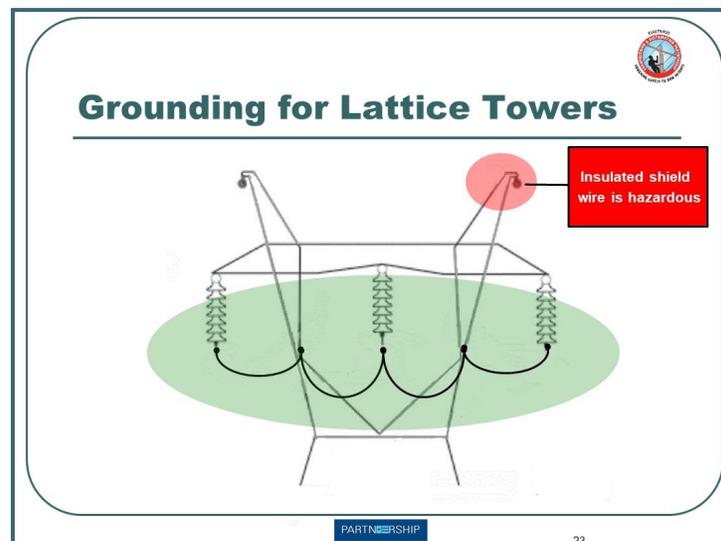
The downed conductor may also be handled using live line tools. If possible consider making the splice(s) working from an insulated aerial lift truck.

Slide 22



Explain that this is one method of creating an equal potential work zone on a transmission pole with a distribution under-built circuit. Mention that in case of a small neutral one may need to attach the ground attachment to a driven ground rod.

Slide 23



On steel lattice towers, one may attach the grounding jumpers from the phase conductors to the steel tower. The tower may be used as the ground source or the conductors may be tied to the shield wire(s). If the shield wires are used as a ground source it may still be necessary to bond the conductors to the tower in order to create an equal potential work zone on the tower.

Important note: Be sure to discuss the hazards of insulated shield wire. In certain cases the shield wire is energized at a distribution voltage to supply lighting at river crossings and/or airports. In other cases the shield wire may be a communication conductor. In either case the point is to explain that insulated shield wires may possess a dangerous potential. This must be considered during the pre-job planning stage of the operation.

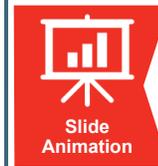
Slide 24

Dead End Structures

If the continuity is maintained with the permanent jumper, one grounding jumper may suffice

If the continuity is not maintained with the permanent jumper, two grounding jumpers are required

PARTNERSHIP 24

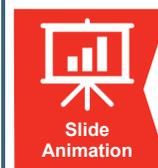


Explain the need to maintain continuity. Explain that it is critical that a lineman does not bridge the gap between the jumper and the conductor with their body.

Slide 25

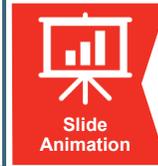
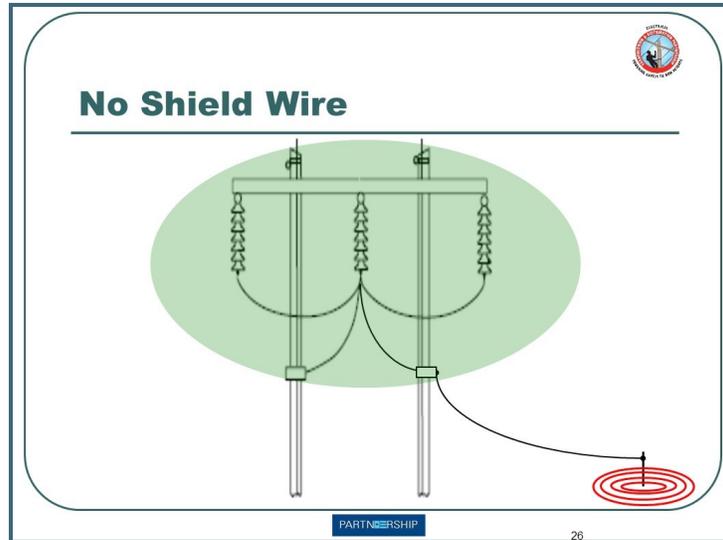
With Shield Wire

PARTNERSHIP 25



Discuss that this is the grounding set-up that will most commonly be used especially on wooden “H” frame structures. Explain that if the structure has a shield wire that a ground jumper must be installed between the shield wire and a phase conductor. Ask the group what would have to be done if a worker were on each pole? The desired answer is “A cluster bracket and personal ground would need to be installed on the opposing structure.” Explain that in certain cases it may be a good work practice to use both shield wires.

Slide 26



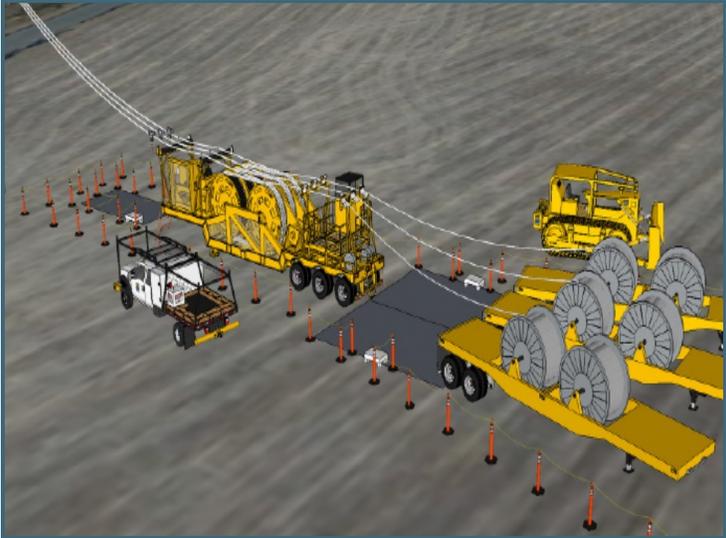
Explain that in the absence of a shield wire, or in situations where the customer does not permit the use a shield wire, it may be necessary to use a temporary ground rod (TGR) as the ground source. Explain that this remote ground rod may cause step potential hazards.

Slide 27



Various methods to establish an equal potential zone for conductor stringing.

Slide 28

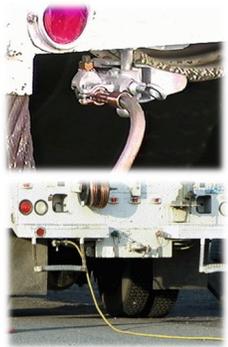


Various methods to establish an equal potential zone for conductor stringing.

Slide 29



Equipment Grounding



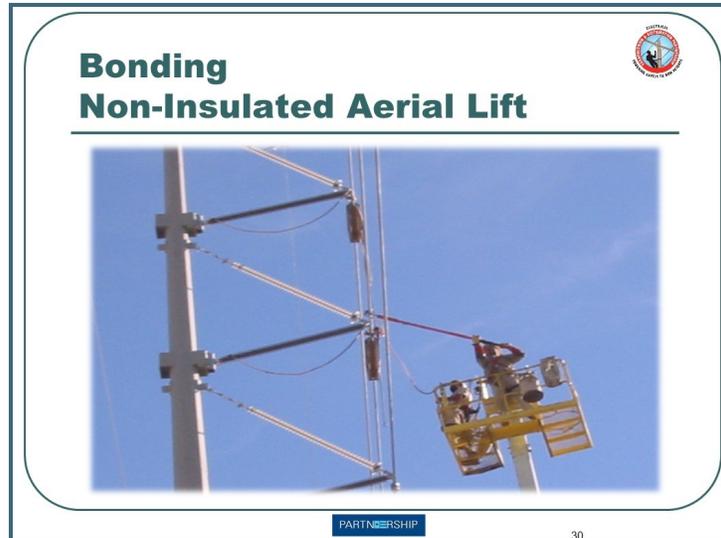
- Equipment
 - Approved connection point capable of handling the anticipated fault current
- Ground Source
 - To system neutral (or)
 - A pole ground (or)
 - To a grounded structure (or)
 - To a Temporary Ground Rod
 - *driven or screw type*

PARTNERSHIP 29

Explain that company safety policy may determine the type of connections used to connect a vehicle to the ground point. In most cases, the attachment point will be to either the system neutral or a driven or portable screw type ground.

The choice may be based on company policy/and/or the availability of the system neutral and if the customer will allow it to be used for protective grounding. The system neutral and/or pole ground may provide the lowest resistance path for fault current to return, thus offering the best protection available. When a driven or screw ground is used, its ability to conduct fault current will depend on its setting depth, soil conditions, amount of contact with the earth and the size and material composition of the ground rod. These elements, unless tested are unknown and could cause problems if fault current were to flow. These unknowns can also increase the risk of hazardous step and touch potentials. When grounding vehicles and equipment, always make the first connection to the vehicle (make sure the connection point is clean of oil, paint or debris that could increase the resistance). Next connect the ground to the designated connection point (neutral of ground rod). When connecting to the system neutral, use a hot line tool to make the connection. Workers must not climb on or off vehicles that are in proximity to energized conductors.

Slide 30



Discuss the need to bond a non-insulated basket to the conductor before contacting the conductor. Discuss that this must be done (both on and off) using an insulated tool. Also discuss that the chassis of the vehicle should be bonded to the structure so that in the event of an accidental re-energization the fault current will not flow solely to ground through the boom of the aerial lift truck.

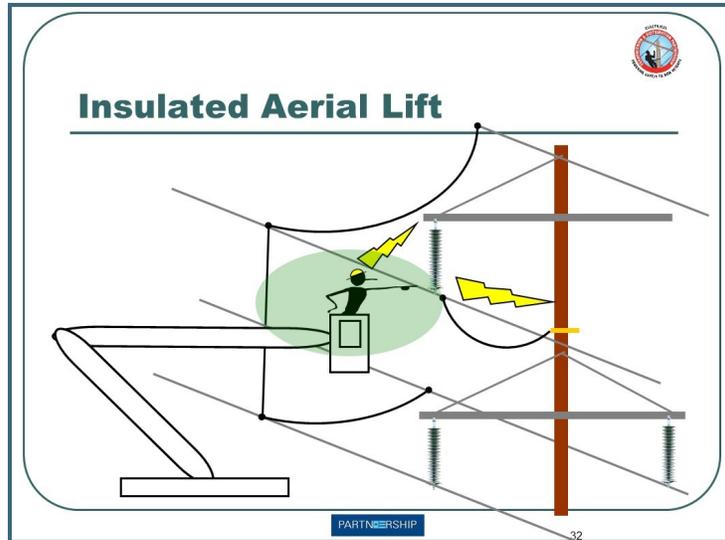
Slide 31



Explain that when using a basket bond in an elevated work location, it is important that if an emergency situation should occur, and the worker in the basket may not be able to remove the bond, that a plan is in place to bring the basket down. One method is to use a “Breakaway” bonding cable. The particular item shown in the picture is made by the Tallman equipment company.

Part number: BAC 625 on page 220 of the Tallman catalogue.

Slide 32



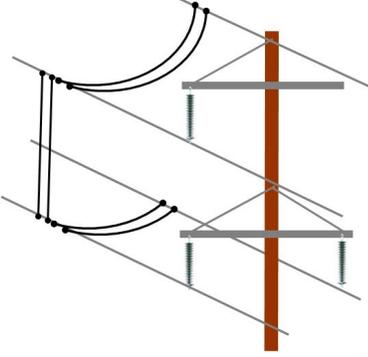
Explain that when working from an INSULATED aerial lift, a Temporary Protective Ground is not needed so long as you Maintain Minimum Approach Distance from all other objects at a different potential

Slide 33



Parallel Ground Sets

- Determine the current carrying capacity of a single ground
- Multiply by 2
 - Reduce by 10% if restrained
 - Reduce by 20% if unrestrained



PARTNERSHIP 33

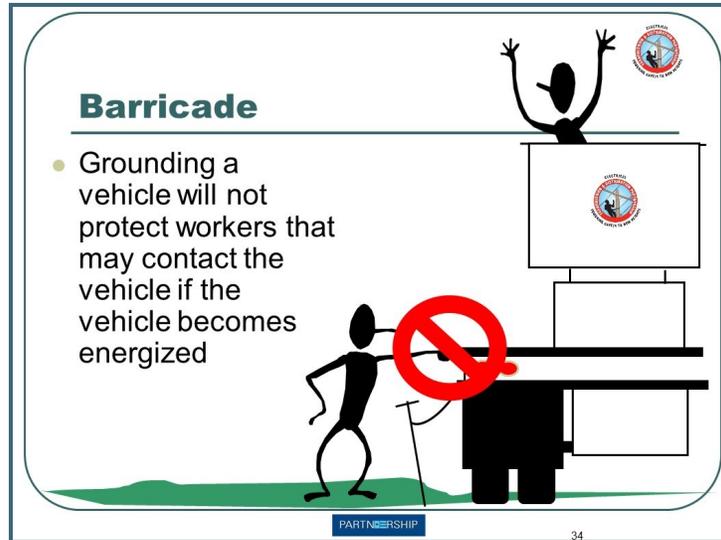


Explain that more than two parallel protective grounding sets should be avoided if possible. The increased available fault current that makes paralleling necessary also creates other risk issues at the worksite. Extreme electromechanical forces are present as the current approaches 60 000 A. These forces may cause the clamp to break. These forces may also reduce the rated use time of the grounding system by an unknown and inconsistent amount. The conductor, heated by the fault current flow, may break before reaching the fusing time associated with a particular current magnitude. The voltage drop caused by mutual inductance may also cause current imbalance in the multiple paths. It may be possible to reduce the protective ground system requirement from two cables to one cable by allowing an increased cable size, a reduction of the required protection time, or a combination of both. The appropriate source within the users company should be consulted for resolution of these variations. If more than two grounding cables are required, custom-designed grounding cables with special installation techniques should be developed for that site. An alternative technique is the installation of rigid bus grounds.

Slide 34

Barricade

- Grounding a vehicle will not protect workers that may contact the vehicle if the vehicle becomes energized



PARTNERSHIP 34



Discuss that vehicle grounding helps protect the vehicle and relay the circuit interrupting device. The simple act of grounding a vehicle or piece of equipment does not guarantee employee safety. When a worker touched a vehicle or piece of equipment, the worker is a resistor in a parallel circuit. All branches of a parallel receive the same voltage. If the vehicle or equipment can become energized, ground it, barricade it, and: **STAY AWAY!**

Slide 35

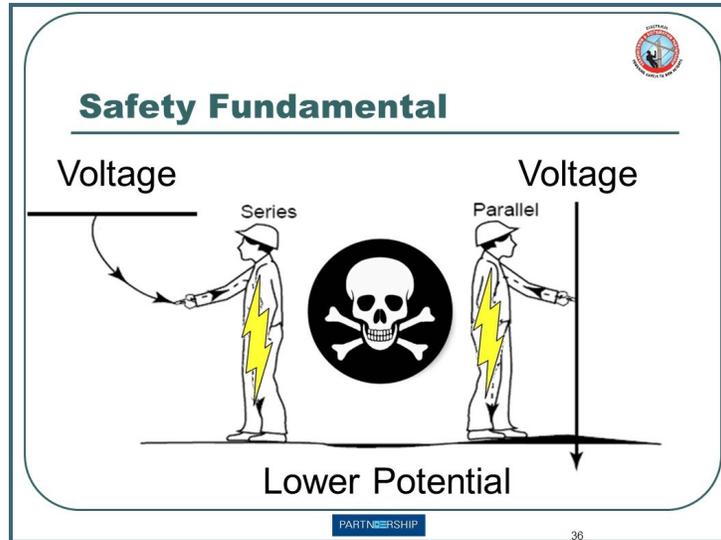
Recap



ELECTRICAL DISTRIBUTION PARTNERSHIP
PARTNERSHIP

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Slide 36



Explain that a key safety fundamental is to never place your body in series or in parallel with two possible potential differences. Bridging these differences may place the worker at risk.

Slide 37

Key Safety Fundamental

To avoid hazardous differences in electrical potential:

- Insulate yourself from the hazard
- Isolate yourself from the hazard
- **Work in a Equal Potential zone**

At the bottom center, there is a small blue box with the word "PARTNERSHIP" and the number "37" to its right.

Review this slide again. Ask for questions and thank the group for their time and attention.

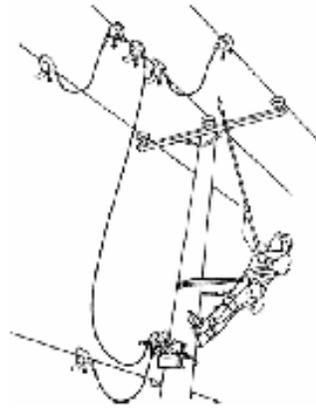
At the end of this document is a handout that may be used as a stand-alone document or used to augment this material.

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Grounding & Bonding Handout

IF IT'S NOT GROUNDED, IT'S NOT DEAD!

How many times have we heard that said? Well the fact is, just because a circuit or piece of equipment is grounded, even properly, that's no guarantee that there is no hazardous potential present. To begin to understand temporary protective grounding, we need to understand the purpose for grounding. All circuits are protected by current sensitive devices like fuses, reclosing devices, and breakers. Those devices are designed to de-energize a circuit, or remove the source of potential in the event of a system over-load or an unexpected fault.



For electrical workers, we install grounds for two reasons. By installing grounding jumpers in a grounded and short-circuited configuration we ensure that the circuit is de-energized (removed from the source) and if the circuit was to accidentally become re-energized, the current sensitive devices we mentioned earlier will be activated. The design intent of those devices is to remove the circuit or equipment from the source of potential by providing an open point.

Key Points to Consider

- ☛ **Plan the Job, Plan for Safety!** Prior to installing grounding equipment, conduct a tailboard or pre-job briefing. Take this time to explain the procedure or task, discuss the hazards associated with the task, and discuss how workers are going to protect themselves from those hazards.



Take the time to perform a good, in-depth tailboard or pre-job briefing. When you consider the economic and human costs of accidents, talk is cheap!
Accidents are not!

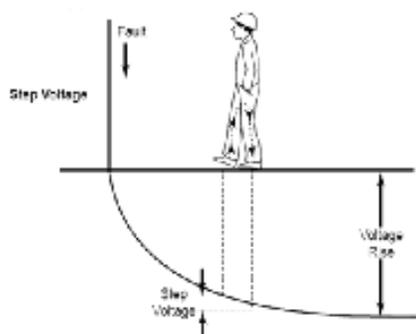
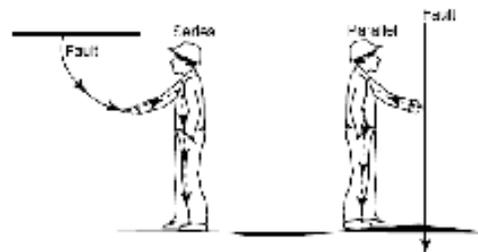


- ☛ Always inspect all temporary grounding devices prior to use. Remove from service and do not use any damaged or defective equipment.
- ☛ Always, Always, Always, test the circuit or equipment for the absence of potential (voltage) before installing grounds!
- ☛ Use only an approved device like a voltage indicator or noisy tester to test for potential. Fuzzing is not an approved method and can, in some cases, give you a false reading!

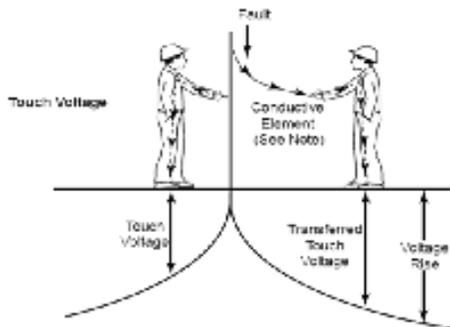
- ☛ **When installing grounding jumpers, the first clamp installed is to the ground source.**
- ☛ **When removing grounding jumpers, the last clamp removed is to the ground source.**
- ☛ The installation and removal of temporary grounding equipment is NOT a bare-hand or rubber glove procedure. What does this mean? Grounding devices, with the exception of running type grounds at wire set-ups must be installed and removed using a **live-line tool**.
- ☛ Temporary grounding devices are designed to cause circuit interrupting devices to operate. In the event of an unintentional re-energizing of a circuit, the interrupting device; the fuse, breaker or reclosing device requires time to operate. Until the interrupting device operates, the entire circuit is energized at system voltage!

☛ Avoid hazardous differences in potential! Current flow through the body can be harmful and even fatal.

☛ If your body completes the circuit by creating a series path or a parallel path between two different potentials, harmful levels of current could flow through your body.



☛ Be aware of the hazards of Step and Touch Potential. No matter what temporary grounding method is used, workers on the ground could be exposed to hazardous potential differences.



- Workers on the ground must be protected by the use of rubber insulating footwear, insulating mats or grounding mats
- Avoid touching any equipment such as bucket trucks, digger derricks, wire stringing equipment, etc, that could become unintentionally energized

- Temporary protective grounding devices must be able to conduct the maximum available fault current that could flow at the point of grounding.

Cable Size	Clearing Time	Amperes
2/0	15 Cycles	33,000
	30 Cycles	26,000
4/0	15 Cycles	53,000
	30 Cycles	41,000

This table from ASTM F-855 shows the current carrying capacity of 2/0 and 4/0 copper grounding cable.

These ratings could change if the cable is damaged, if clamps are damaged, or if the proper clamp is not used.

- Always ensure that the clamp matches the part.
- Do not attach round jaw clamps to a flat surface.
- Do not attach flat jaw clamps to a round surface.



Your only true protection is when you protect yourself from dangerous difference in electrical potential. This statement holds true no matter what type of work you are performing, whether it be live-line bare-hand work, using the rubber glove method on distribution circuits, or performing de-energized work.

The key to working safely is to recognize and understand where hazardous potential differences are, and knowing how to protect yourself and your co-workers from them.