STUDY GUIDE

ELECTRICAL SAFETY HAZARDS AWARENESS

THIS GUIDE SHOULD BE USED BY INSTRUCTORS TO SUPPLEMENT THE NON-ELECTRICAL WORKER TRAINING MODULE PRESENTATIONS

EFCOG ELECTRICAL SAFETY IMPROVEMENT PROJECT

TABLE OF CONTENTS

REFERENCES

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OBJECTIVES

TERMINAL OBJECTIVE

1.00 Given information regarding electrical safety, various examples, and realistic work scenarios, the student shall be able to identify and describe electrical hazards and precautions that should be taken to avoid injury in the workplace.

ENABLING OBJECTIVES

1.01 Explain how electrical current adversely affects the human body.

1.02 Describe the step and touch potential hazard.

1.03 Explain safe work practice requirements for Non-electrical Workers.

1.04 Explain the characteristics and hazards associated with power arcs and precautions that should be taken to avoid injury by an arc blast.

1.05 Explain the NFPA approach boundaries for qualified and unqualified workers

1.06 Explain the actions to be taken when an electrical emergency arises.

1.07 State the BASIC RULE(s) for all electrical work performed

1.08 Describe electrical hazards that may be encountered by Non-electrical Workers.

- Welders
- Heavy Equipment Operators
- Excavators
- Warehouse Workers
- Painters

1.09 Describe potential accidents and hazards associated with the following equipment or components:

- Portable generators
- Battery banks/Chargers

1.10 List some electrical safety tips that all workers must adhere to when working with any of the following:

- Power tools
- Extension Cords
- Molded Case Circuit Breakers
- Down power lines
- Ladders

ELECTRICAL CURRENT

Basically, electrical hazards can be categorized into three types. The first and most commonly recognized hazard is electrical shock. The second type of hazard is electrical burns and the third is the effects of blasts which include pressure impact, flying particles from vaporized conductors and first breath considerations.

EO 1.01 **Explain** how electrical current adversely affects the human body.

Electrical Shock

Electric shock occurs when the body becomes part of an electrical circuit. Shocks can happen in three ways.

- A person may come in contact with both conductors in a circuit.
- A person may provide a path between an ungrounded conductor and the ground.
- A person may provide a path between the ground and a conducting material that is in contact with an ungrounded conductor.

The terms high voltage and low voltage are relative terms. In transmission-line terminology, "low voltage" is much higher than the 600 volts. At home, you would not think of 600 volts as being low voltage.

Even when applied to 120-volt circuits, the term low voltage is deceiving. To some people low voltage means low hazard. Actually, low voltage does not necessarily mean low hazard, because potential difference is only one factor making up the dangerous effects of electricity. For purposes of this Lesson, you can think of "low voltage" as being a potential difference of 24-600 volts.

The extent of injury accompanying electric shock depends on three factors.

- The amount of current conducted through the body.
- The path of the current through the body.
- The length of time a person is subjected to the current.

The amount of the current depends on the potential difference and the resistance. The effects of low current on the human body range from a temporary mild tingling sensation to death. An electric shock can injure you in either or both of the following.

- A severe shock can stop the heart or the breathing muscles, or both.
- The heating effects of the current can cause severe burns, especially at points where the electricity enters and leaves the body.

Other effects include severe bleeding, breathing difficulty, and ventricular fibrillation. In addition, you may strike something, or have some other accident as a result of your response to the shock. The effects of electric current are listed in Figure 1.

Current in milliamperes	**Effects**
1 or less	No sensation; probably not noticed
1 to 3	Mild sensation not painful
3 to 10	Painful shock.
10 to 30	Muscular control could be lost or muscle clamping
30 to 75	Respiratory paralysis
75mA to 4 **amps**	Ventricular Fibrillation
Over 4 **amps**	Tissue begins to burns. Heart muscles clamp and heart stops beating

Figure 1 Effects of Electrical Current On the Human Body

Current is the killing factor in electrical shock. Voltage is important only in that it determines how much current will flow through a given body resistance. The current necessary to operate a 10 watt light bulb is eight to ten times more current than the amount that would kill a person. A pressure of 120 volts is enough to cause a current to flow which is many times greater than that necessary to kill.

The following values are given for human resistance to electrical current in Figure 2:

TYPE OF RESISTANCE	RESISTANCE VALUES
Dry skin	100,000 to 600,000 Ohms
Wet skin	1,000 Ohms
Hand to Foot	400 to 600 Ohms
Ear to Ear	100 Ohms

Figure 2 Resistance Values

With 120 volts and a skin resistance plus internal resistance totaling 1200 Ohms, we would have 1/10 ampere electric current, that is 100 milliamperes. If skin contact in the circuit is maintained while the current flows through the skin, the skin resistance gradually decreases. During this time, proper first aid can mean the difference between life and death. Sufficient circulation can sometimes be maintained by heart compression, which should always be supported with mouth-to-mouth resuscitation. This combination of treatments is commonly known as CPR.

STEP AND TOUCH POTENTIAL

EO1.02 **Describe** the step and touch potential hazard.

Step Potential

During a ground fault, current flows through the grounding system to a ground rod or some type of system ground (steel structure, guy wire) seeking a return to its source. This current flow could possibly exist in, or along the surface of the ground for quite some distance around the point where the earth becomes energized. The current will follow, as nearly as possible, the conductors supplying the fault current. Step potential is caused by the flow of fault current through the earth. The closer a person is to the ground rod or grounded device, the greater the concentration of current and the higher the voltage. The current flow creates a voltage drop as it flows through the earth's surface and a person standing with their feet apart bridges a portion of this drop thus creating a parallel path for current flow as seen in the these two illustrations in Figure 3.

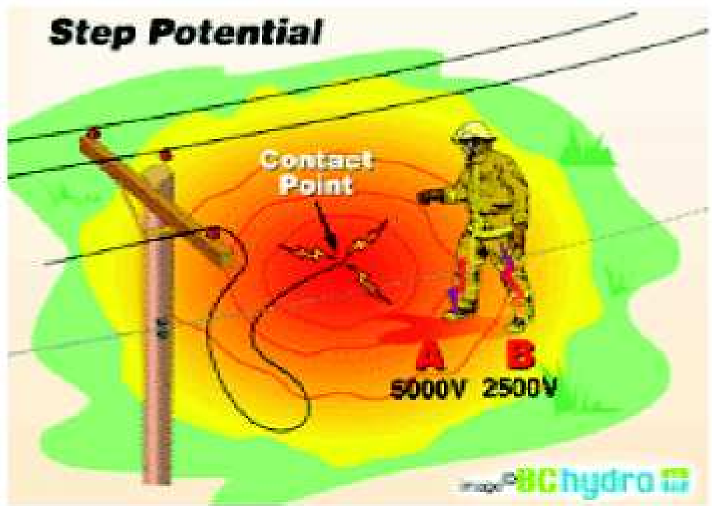


Figure 3 Step Potential

The wider apart a person's legs are, the larger the voltage difference across the body. Protection from the step potential hazard should be to stay in the zone of equipotential while working. Simply being alert to this hazard is the best defense. For this reason, unqualified personnel standing on the ground are cautioned to stay clear of structures.

This means that a person standing near the point where fault current enters the earth may have a large potential difference from foot-to-foot. The potential difference over the same span will be less and less as the span is moved away from either the fault current entry point or the fault current return point at the source.

Touch Potential

Touch potential is a problem similar to step potential – see Figure 4. It involves a fault current flow in the earth establishing a potential difference between the earth contact point and some nearby conductive structure or hardware.

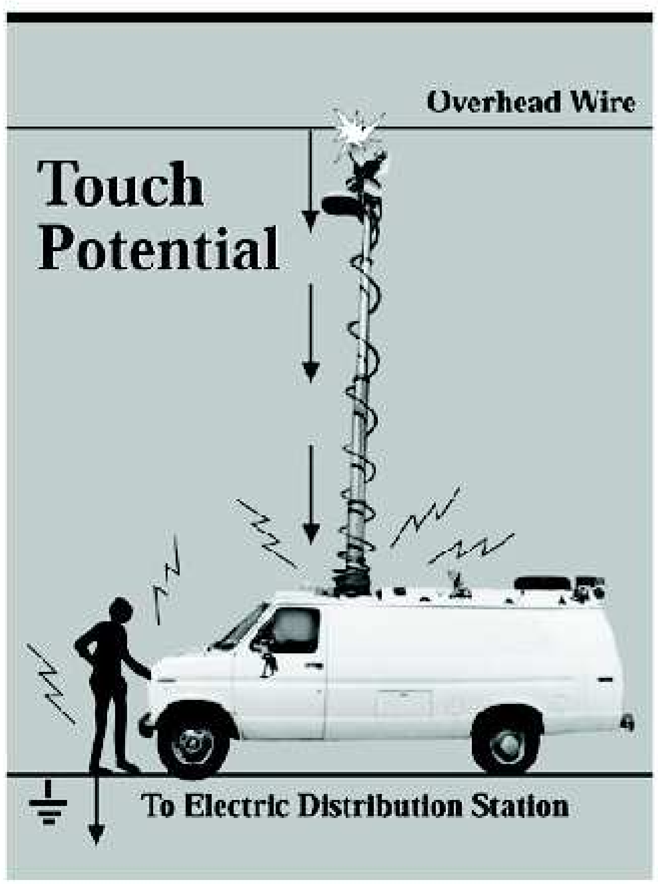


Figure 4 Touch Potential

Protection for step and touch potential is the use of switch operating platforms and ground grids. The worker must remain upon a local conductive mat as the highest voltage gradient has been moved to the mat's edges. Sub stations on Site have a ground grid located under the rocks, but if an individual is located outside this area and while standing on the earth, touches a ground or a grounded object, a difference in potential may exist during a ground fault.

SAFE WORK PRACTICES

EO1.03 **Explain** safe work practice requirements for Non-Electrical Workers.

Safe Work Practices

The first step in developing a safe work environment is to have procedures in place which provide guidelines for employees to perform various tasks safely. The procedure should help eliminate injuries by providing rules and guidelines for people working on or near energized electrical circuit conductors. It should address qualifications, tools, protective equipment, approval levels and attendance required for various tasks, as well as other additional cautionary information. Also this procedure should address safe approach distances for qualified and **unqualified** personnel.

When conductors are or may become energized, an alternative way of ensuring safety from the electrical hazards is to observe a safe approach distance (or clearance) from exposed conductors. It is important to know how close persons, or conductive objects which they might be carrying, can approach without endangering themselves. These clearances are greater for an **unqualified** person than for a qualified person.

The OSHA rules only give safe approach distances and clearances to overhead lines. See Table (Figure 5) . This Table also shows clearances for qualified and unqualified persons working at ground level and other locations where the conductors are more stationary.

A procedure should also address the requirements for "Electric Utility Safe Practices On or Near Transformation, Transmission, and Distribution Electrical Conductors" and be compliant with 29CFR 1910.269. The provisions of this procedure apply to installations under the exclusive control of electric utilities personnel when personnel work on or near the following types of energized electrical circuit conductors;

- Conductors used for communication or metering of electrical energy.
- Conductors used for the control, transformation, transmission, and distribution of electric energy.
- Conductors under the exclusive control of the utility, located in buildings or located outdoors, used exclusively for the purposes of generation, control, transformation, transmission, and distribution of electric energy.

Attachment 6, Table 2

<u>Minimum Safe Approach Distance to Unguarded, Energized Electrical Conductors</u>

<table>
<tr><th rowspan="2">COLUMN #1

Nominal Phase To Phase Voltage</th><th rowspan="2">COLUMN #2

Nominal Phase To Ground Voltage</th><th colspan="3">COLUMN #3

Distance For Qualified Personnel</th><th colspan="2">COLUMN #4
Distance For Unqualified Personnel (Limited Approach)</th></tr>
<tr><th>Prohibited Approach (notes 1&4)</th><th>Restricted Approach (notes1& 4)</th><th>Overhead Lines (notes1 & 3)</th><th>Stationary Conductors (notes 2 & 4)</th><th>Overhead Lines (notes 2 & 4)</th></tr>
<tr><td colspan="7">(LOW VOLTAGE)</td></tr>
<tr><td>120</td><td rowspan="3">120</td><td rowspan="5">Avoid Contact</td><td rowspan="5">Avoid Contact</td><td rowspan="5">N/A</td><td rowspan="7">3’-6”</td><td rowspan="7">10’-0”</td></tr>
<tr><td>120/240</td></tr>
<tr><td>208Y/120</td></tr>
<tr><td>240/120 (high-leg Δ)</td><td>208</td></tr>
<tr><td>240</td><td>240</td></tr>
<tr><td>480Y/277</td><td>277</td><td rowspan="2">0’-1”</td><td rowspan="2">1’-0”</td><td rowspan="2">1’-0”</td></tr>
<tr><td>480</td><td>480</td></tr>
<tr><td colspan="7">(MEDIUM VOLTAGE)</td></tr>
<tr><td>2400</td><td rowspan="2">2400</td><td rowspan="5">0’-7”</td><td rowspan="5">2’-2”</td><td rowspan="5">2’-2”</td><td rowspan="5">5’-0”</td><td rowspan="6">10’-0”</td></tr>
<tr><td>4160Y/2400</td></tr>
<tr><td>4160</td><td>4160</td></tr>
<tr><td>7620</td><td>7620</td></tr>
<tr><td>13800Y/7970</td><td>7970</td></tr>
<tr><td>13800</td><td>13800</td><td>0’-7”</td><td>2’-2”</td><td>2’-2”</td><td>5’-0”</td></tr>
<tr><td colspan="7">(HIGH VOLTAGE)</td></tr>
<tr><td>115000</td><td>66400</td><td>2’-8”</td><td>3’-2”</td><td>3’-2”</td><td>8’-0”</td><td>10’-8”</td></tr>
<tr><td>230000</td><td>132800</td><td>4’-9”</td><td>5’-3”</td><td>5’-3”</td><td>13’-0”</td><td>13’-0”</td></tr>
</table>

NOTES:
1. Applies to Qualified Personnel with PPE.
2. Applies to Qualified Personnel without PPE.
3. Distances for Overhead Lines meet or exceed OSHA Section 1910.269.
4. NFPA 70E

Figure 5 Minimum Safe Approach Distances

POWER ARC

EO 1.04 **Explain** the characteristics and hazards associated with power arcs and the precautions that should be taken to avoid injury by an arc blast.

Characteristics of an Arc

Electrical workers are frequently in close proximity to energized parts where power arcs can occur. It is not necessary to touch an energized conductor to receive an electrical shock. Anyone who has rubbed their feet across a carpeted room and reached for a metal doorknob can attest to that. High voltage may cause current flow through the air from one conductive surface to another if the voltage is great enough and conditions are right.

A lightning strike, which might have an electrical potential of millions of volts, is an electrical arc that could span miles. Similarly, in electrical work, when there is a difference of potential between two points, an arc can occur under the right set of conditions. Not only could an electrical arc jump from a conductor to a person and give them a shock but arcing can result in serious burns and explosive blasts.

Typically, arcing distances are rather small. Safe approach distances should include a safety factor to the arcing distances in order to account for such things as inadvertent movement and variable work conditions.

Workers should always be aware of the arcing hazard when handling tools and equipment near energized electrical conductors. Personal Protective Equipment (PPE) may be required in certain situations depending on the amount of energy available at the source.

The power arc is a discharge of electricity through a combination of ionized air and vaporized conductor material. The conductive material is vaporized by temperatures in an arc which can be as high as 35,000 degrees Fahrenheit.

Burns associated with high energy arcs can be fatal even if the victim is several feet from the arc, and severe burns at distances up to ten feet are common. Clothing may also be ignited at distances of several feet. This may also be fatal, because the clothing cannot be removed or extinguished quickly enough to prevent serious burns over much of the body's skin.

The following table, (Figure 6), gives several examples of the increased temperature of human skin above normal when exposed to power arcs of varying lengths.

Arc Sphere Diameter		Distance from Center					
		20"	24"	30"	36"	60"	120"
In.	cm.	50.8 cm.	61 cm.	76.2 cm.	91.4 cm.	152 cm.	305cm.
1	2.54	69F	47F	31F	21F	8F	2F
2	5.08	274F	191F	122F	85F	30F	8F
3	7.62	619F	429F	275F	191F	69F	17F
4	10.2	1100F	764F	489F	339F	122F	31F
6	15.2	2474F	1718F	1100F	764F	275F	69F
8	20.3	4398F	3054F	1955F	1358F	489F	122F
10	25.4	6872F	4772F	3054F	2121F	764F	191F
12	30.5	9896F	6872F	4398F	3054F	1100F	275F
16	40.6	17593F	12217F	7819F	5430F	1954F	489F

Figure 6 Arc Temperature vs Distance

Electrical Arc Blasts

In addition to an electrical shock and burns, another hazard to employees is the blast effect that can result from arcing. If the current involved is great enough, these arcs can cause injury and start fires. Extremely high-energy arcs can damage equipment causing fragmented metal to fly in all directions. Low-energy arcs can cause violent explosions or blasts in atmospheres containing explosive gases, vapors or combustible dusts.

The hot vaporized metal from the arc blast will combine with oxygen and become an oxide of the metal of the arc. These molten particles will stick to almost anything actually melting into many surfaces. Clothing may ignite as a result of contact with this molten material and a victim may receive serious burns. Also, your body has an instinctive reaction when you are suddenly startled to breath in heavy or gasp. Inhaling the hot vaporized particles will cause serious damage to your respiratory system by burning the lungs, throat and esophagus.

There is no equipment available to completely protect electrical workers from the effects of blast. However, safe practices, such as standing to the hinged side of a cubicle door when operating a breaker, and other precautions listed below can be taken to minimize the effect of a blast. The main protections against arc blasts are listed in the following chart.

Exposure Limitation	The amount of time you spend around high energy equipment; don't loiter.
Distance	Always stay as far away as possible from high energy equipment unless you have a need to be there.
Mass	Try to keep some type of sturdy material between you and a potential blast.
Protective Clothing	Flash suits may offer some protection to minimize burns resulting from blasts.

If an arcing fault occurs while a worker is in close proximity, the survivability of the worker is mostly dependent upon system design aspects, such as characteristics of the over-current protective device and precautions the worker has taken prior to the event, such as wearing personal protective equipment appropriate for the hazard.

The effects of an arcing fault, as seen in Figure 7 can be devastating to a person. The intense thermal energy released in a fraction of a second can cause severe burns. Molten metal is blown out and can burn skin or ignite flammable clothing. One of the major causes of serious burns and deaths to workers is ignition of flammable clothing due to an arcing fault. The tremendous pressure blast from the vaporization of conducting materials and superheating of air can fracture ribs, collapse lungs and knock workers off ladders or blow them across a room.

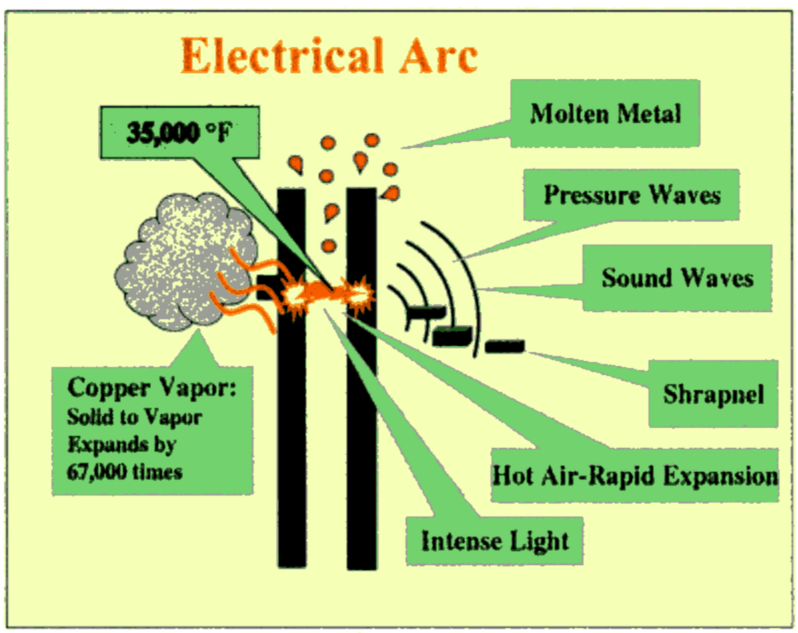


Figure 7 - Electric Arc Model

Figure 8 and Figure 9 are pictures of actual arc blasts. Hot molten metal can be seen radiating out from the blasts.

Figure 8 Arc Flash

Figure 9 Worker near an Arc Flash

NFPA 70E APPROACH BOUNDARIES

EO 1.05 **Explain** the NFPA approach boundaries for qualified and unqualified workers.

A Flash Hazard Analysis shall be done before a person approaches any exposed electrical conductor or circuit part that has not been placed in an electrical safe work condition. A Flash Hazard Analysis determines the incident energy exposure of the worker (in calories per square centimeter).

Flash Protection Boundary

The radiant energy released by an electric arc is capable of maiming or killing a human being at distances of up to ten or even twenty feet. In addition to radiant heat, the molten material and objects ejected by the electrical blast can also be lethal. The flash protection boundary is the closest approach allowed by qualified or unqualified persons without the use of arc protection PPE.

The flash protection boundary is the distance from an arc fault to limit skin temperature to a "just curable" 2nd degree skin burn [less than 80°C (176°F)] if not protected by Personal Protective Equipment – see Figure 10.

For work within the Flash Protection Boundary, the employer must document the incident energy exposure (in calories per square centimeter). This incident energy level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. The incident energy exposure determines fire retardant clothing and personal protective equipment requirements.

The hazard risk category in NFPA 70E establishes requirements for personal protective equipment (PPE) and clothing based on the incident energy exposure (in calories per square centimeter) associated with the specific task.

If a flash hazard analysis is performed, the hazard risk category shall be selected such that it always bounds the calculated incident energy exposure (i.e. the Arc Thermal Performance Value (ATPV) for the selected hazard risk category shall be greater than the calculated energy incident exposure).

Note: An optional flash hazard analysis may provide a more accurate determination of the incident energy exposure and possibly reduce the hazard risk category, resulting in a reduction of clothing/PPE requirements. This might be advantageous if the task will be performed at the lower end of the voltage ranges specified in the Tables, or if the task work location is remote from the power source resulting in reduced bolted fault currents.

Note: Qualified electrical workers shall be aware of the final established flash boundary distance as well as the shock protection distances and ensure that unprotected persons near the work area are not allowed to cross the greater distance of the two. A physical boundary is preferred. The established boundary shall be sufficient to ensure that the qualified worker(s) are not distracted from their work assignment(s) to maintain the integrity of this boundary.

Limited Approach Boundary

This is the shock protection distance from a live part within which (limited space) only a "Qualified Person" may work. It is the "approach" distance for unqualified personnel – unqualified persons must maintain this distance from the exposed energized conductors or circuit parts, including the longest conductive object being handled, so that they cannot contact or enter the specified air insulation distance to the exposed energized electrical conductors or circuit parts. There may be times when the limited approach boundary is inside of the flash protection boundary (The distance within which a person could suffer 2nd degree burns from an arc flash, if not protected by personal protective equipment). A person must not cross the flash protection boundary unless he or she are wearing appropriate personal protective clothing and are under the close supervision of a qualified person. In certain instances, the flash protection boundary might be a greater distance than the limited approach boundary and the greater distance shall be utilized to trigger the need for personal protective equipment.

For a person to cross the limited approach boundary and enter the limited space, he or she must be qualified to perform the job/task.

Restricted Approach Boundary

To cross the restricted approach boundary and enter the restricted space, the qualified person must have a documented plan approved by authorized management for tasks.

Use personal protective equipment appropriate for working near exposed energized conductors or circuit parts and rated for the voltage and energy level involved. Be certain no part of the body enters the prohibited space. Minimize the risk due to inadvertent movement by keeping as much of the body out of the restricted space, using only protective body parts in the space as necessary to accomplish the work.

Prohibited Approach Boundary

A prohibited approach boundary is a shock protection boundary to be crossed only by qualified persons (at a distance from a live part) which, when crossed by a body part or object shall require the same protection as if direct contact is made with a live part. To cross the prohibited boundary and enter the prohibited space is considering the same as making contact with the exposed energized conductors or circuit parts.

Figure 10 illustrates an electrical conductor along with the flash protection boundary and the three shock protection boundaries.

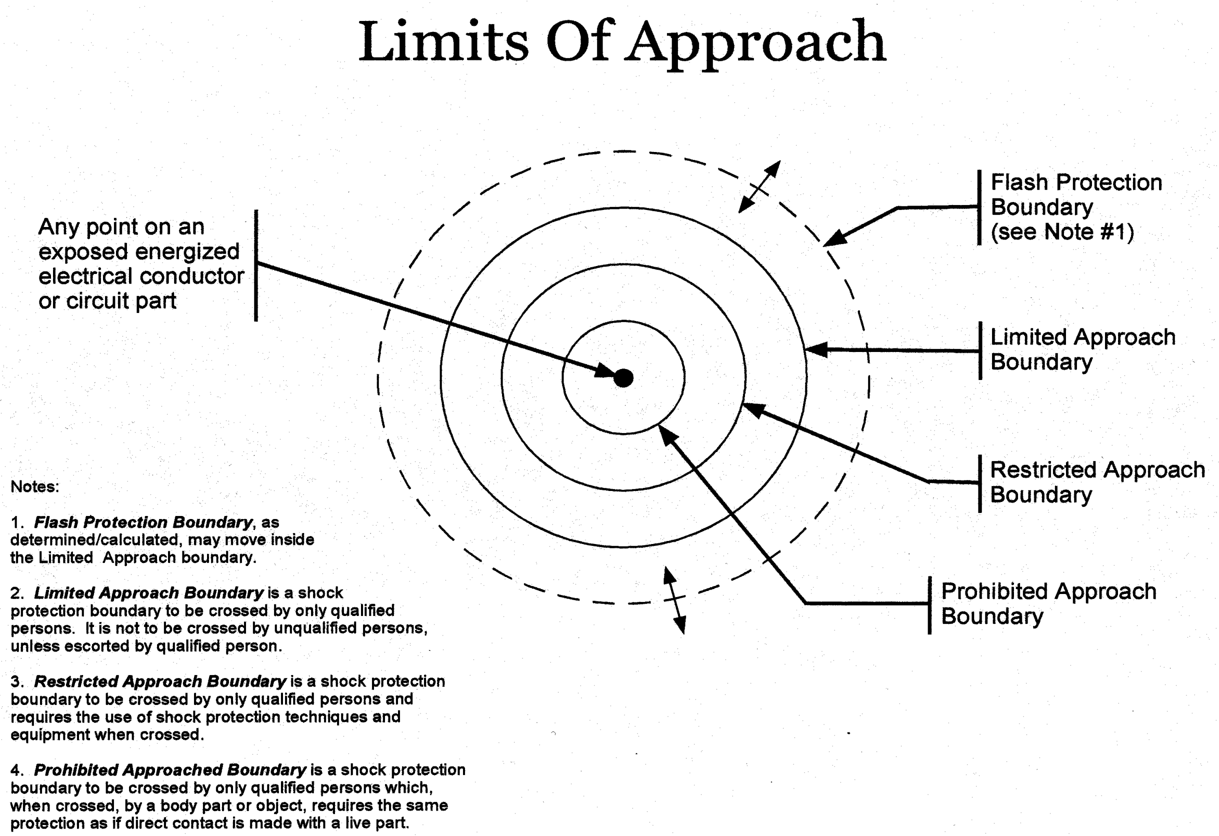


Figure 10 - Limits of Approach

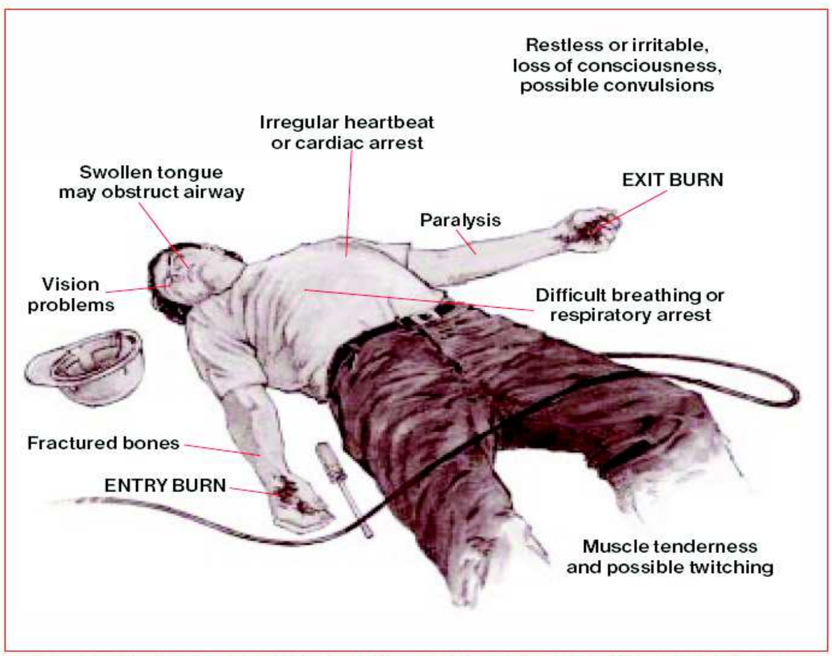
ELECTRICAL EMERGENCIES

EO 1.06 **Explain** the actions to be taken when an electrical emergency arises.

Electrical Emergencies

Electrical accidents as shown in Figure 11 cause countless injuries and cost the lives of hundreds of Americans each year. Injury could be minimized and many lives saved if proper rescue techniques and treatment are used. Electrical accidents may occur at almost any time or place. Timely response and treatment of victims is a major concern. You must use your best judgment in an electrical emergency. Do you know the proper actions to take? Do you know what dangers could be encountered?

When an electrical accident occurs, due to the effect of muscle clamping, a victim is often incapable of moving or releasing the electrical conductor. Attempts to rescue an accident victim may pose as great a hazard for the rescuer as it does for the victim. Caution should be a primary consideration during any electrical accident or emergency. There should always be an emergency response plan for scheduled electrical maintenance or work.



A worker with an electrical injury may have any of a number of signs and symptoms.

Figure 11 Worker With an Electrical Injury

Electrical Accidents

Ask the following questions before doing hazardous electrical work! If an accident occurs, what will you do?

Accidents happen when you least expect them, things to consider are:
They cost lives.
Can I limit impact?
Rescue and treatment of shock is essential.

Lives will be saved if proper rescue techniques are used.

Rescue may pose as great a hazard for the rescuer as for the victim:
Victims may be unable to move.
Victims may be held to circuits by muscles that have contracted.
Victims must be rescued as soon as possible to survive.

What action will you take when you find an electrical accident victim?
Who will you call first?
What tools or protective equipment will you need?
What are your primary safety considerations?
What will your first response be?

Electrical Rescue Techniques

Approaching the accident:
Never rush into an accident situation.
Call 911 as soon as possible.
Get the aid of trained electrical personnel if possible.
Approach the accident scene cautiously.

Examining the scene:
Visually examine victims to determine if they are in contact with energized conductors.
Metal surfaces, objects near the victim or the earth itself may be energized.
You may become a victim if you touch an energized victim or conductive surface.
Do not touch the victim or conductive surfaces while they are energized.
De-energize electrical circuits if at all possible.

Methods to de-energize:
An extension or power cord probably powers portable electrical equipment.
Unplug portable electrical equipment to remove power.
Open a disconnecting device or circuit breaker to de-energize fixed electrical equipment.

Hazards and solutions:
Be alert for hazards such as stored energy, heated surfaces and fire.
If you can’t de-energize the power source use extreme care:
Ensure that your hands and feet are dry.
Wear protective equipment such as low voltage gloves and overshoes if available.
Stand on a clean dry surface.
Use nonconductive material to remove a victim from the conductor.

High voltage rescue:
Special training is required for rescues if high voltage is present.
Protective equipment such as high voltage gloves and overshoes must be worn.
Special insulated tools should be used

Insulated tools:
Insulated tools, with high voltage ratings, are a lifesaver!
Use devices such as hot sticks or shotgun sticks to remove a victim from energized conductors.
In some cases, nonconductive rope or cord may be used to remove a victim from a conductor.

<u>Rescuing the victim:</u>
Stand on a dry rubber blanket or other insulating material if possible.
Do not touch the victim or conductive material near the victim until the power is off.
Once power is off, examine the victim to determine if they should be moved.
Give "First Aid."

<u>First Aid:</u>
A victim may require Cardio-Pulmonary Resuscitation (CPR).
If the victim is breathing and has a heartbeat, give first aid for injuries and treat for shock.
Ensure the victim gets medical care as soon as possible.
Provide medical personnel with information on voltage level, shock duration & entry/exit points. The treating/attending physician must have detailed specific information to properly diagnose and care for the victim. The physician must determine whether the victim should be sent to a "Trauma or Burn Center."

Stay with the victim until help arrives.

EO 1.07 **State** the BASIC RULE(s) for all electrical work.

Basic Electrical Safety Rule(s)

The OSHA regulation regarding electrical safe practices states two very important basic points. The first is that live parts shall be de-energized before working on or near them. The second point is that even after the exposed parts have been de-energized, they shall still be treated as energized until they are locked out and/or tagged out. That is why the **BASIC RULE** for electrical safe practices procedure is stated as follows;

ALL ELECTRICAL CIRCUIT CONDUCTORS, BARE OR INSULATED, ARE ASSUMED TO BE ENERGIZED UNTIL PROVEN OTHERWISE. THEY SHALL BE DE-ENERGIZED, LOCKED OUT AND TESTED FOR THE ABSENCE OF VOLTAGE BEFORE WORKING ON THEM OR WORKING NEAR THEM. WORK ON ELECTRICAL CIRCUIT CONDUCTORS MAY ONLY BE PERFORMED BY QUALIFIED PERSONNEL WHO HAVE BEEN AUTHORIZED TO DO THE WORK.

As with any procedure, revisions are commonplace. Workers should always check to ensure they are working from the latest revision when using a procedure.

The safest way to avoid electrical hazards is to de-energize the conductors to be worked on or near, and, assure that they cannot be re-energized. This is known as putting the conductors in an electrically safe work condition and should always be your first consideration.

An electrically safe work condition will be achieved and verified by the following process:

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) Where it is possible, visually verify that all blades of the disconnecting devices are fully open or that drawout type circuit breakers are withdrawn to the fully disconnected position.

4) Apply lockout/tagout devices in accordance with a documented and established policy.

5) Use adequately rated voltage detector to test each phase conductor or circuit part to verify they are de-energized. Before and after each test, determine the voltage detector is operating satisfactorily.

6) Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or 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 ground connecting devices rated for the available fault duty.

Working On Or Near Energized Conductors

OSHA also spells out the rules for working on or near energized parts. Energized parts that operate at less than 50 volts to ground do not have to be de-energized before working on or near them, if you are sure there are no other hazards which could occur.

If the electrical circuit conductors are 50 volts or more to ground you cannot work on them energized, except under very restrictive conditions. OSHA rules will allow you to work on or near energized circuit parts if you can prove that de-energizing introduces additional or increased hazards. OSHA also permits this type work if de-energization is infeasible due to equipment design or operational limitations.

Some examples of additional or increased hazards might be the de-activation of an emergency alarm system or shutting down a hazardous location ventilation system. Testing, some forms of troubleshooting, or the impracticality of shutting down some continuous industrial processes are examples of infeasibility.

Working on or near electrical conductors or circuit parts which are or may become energized shall only be done by qualified employees who have been trained to recognize electrical hazards and have been trained to avoid injury by using safe practices, precautionary techniques and protective equipment.

Working on or near exposed energized conductors requires extensive planning and higher level management approvals. With the exception of testing, working on or near energized circuit parts will usually not be approved.

The OSHA rules only give safe approach distances and clearances to overhead lines.

ELECTRICAL HAZARDS ENCOUNTERED BY SPECIFIC WORK GROUPS

Electrical hazards are often present in all work areas; therefore, 29 CFR 1910.332 requires Non-electrical workers to receive electrical safety training. Non-electrical workers who work in specified areas that may expose them to higher then normal exposure must receive electrical training that's specific to their job. This section will cover electrical safety requirements for these jobs.

1.08 Describe electrical hazards that may be encountered by Non-electrical Workers.

- Welders
- Heavy Equipment Operators
- Excavators
- Warehouse Workers
- Painters

Welders

All Welders who use electrical systems to "Weld, Cut, or Braze" must have a working knowledge of the electrical hazards that's an inherent part of their job and take positive steps to eliminate and/or mitigate those hazards – see Figure 12. The following are some of the safety rules and guidelines that apply to welders and may be used in other disciplines.

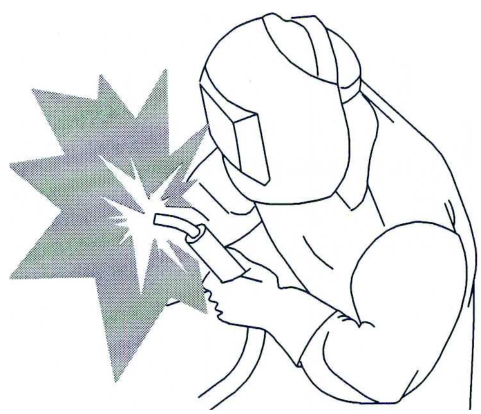


Figure 12 Welding

Electric shock is a peril associated with electric resistance and electric arc welding. A shock can happen because the equipment isn't properly grounded, direct contact (Figure 14) with energized leads or from contact with the welding leads via moist gloves or clothing, damp floors or humid air. The environmental conditions of the welder (such as wet or cramped spaces) may make the likelihood of a shock greater. Even if the shock itself isn't too serious, the jolt could throw a welder out of position causing major injuries. Falls and other accidents can result from even a small shock; brain damage and death can result from a large shock.

Always wear dry hole-free **insulating** gloves to protect against or reduce electric shock. The welder should also wear rubber-soled shoes, and use an insulating layer, such as a dry board or a rubber mat, for protection on surfaces that can conduct electricity.

Arc Welding and Cutting 29 Code of Federal Regulation (CFR) 1910.254(d)(7): Manufacturer's Instructions: Printed rules and instruction covering the operation of the equipment supplied by the manufacturer shall be strictly followed. Mr. Dave Werba, Miller Electric Co. - Technical Support, stated that "insulating gloves" referred to both protection from heat, sparks, etc. and electrical insulating properties. He suggested using "Electrical Line-man's Gloves."
Ground the piece being welded and the frame of all electrically powered machines. The insulation on electrode holders and electrical cables should be kept dry and in good condition. Do not change electrodes with bare hands, wet gloves, when standing on wet floors or grounded surfaces – see Figure 15.

Figure 14 Bare Hands - Requires Dry Insulating Gloves

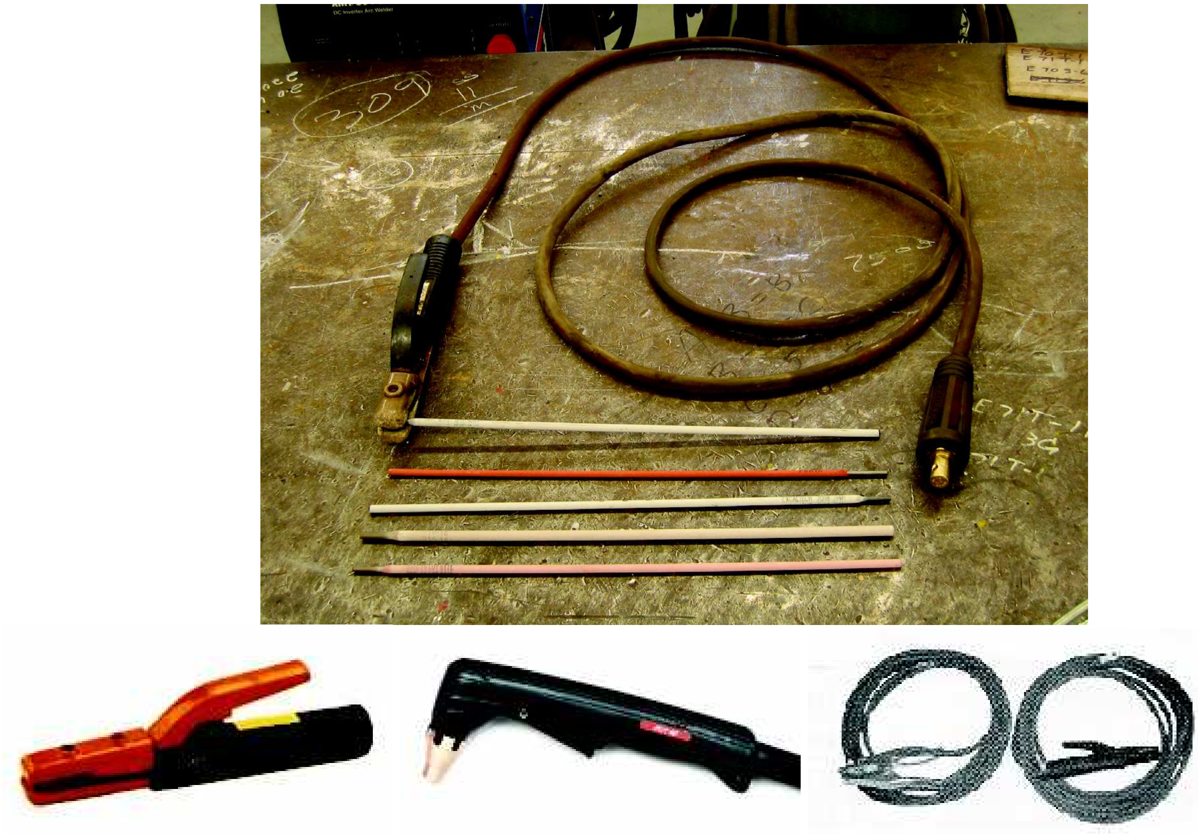


Figure 15 Welding Electrodes

A minor slag burn could startle a worker just long enough to lose balance and fall. Wear safety belts or lifelines when welding in high places or wherever a slip or fall could be dangerous.
In arc-or-stick welding, the open circuit voltage that exists between the electrode holder and the ground during the “off arc” or “no load” period presents a potential hazard to the worker and those around him. The worker becomes exposed to this voltage when setting up work, changing working position, or changing welding electrodes.

The insulation on welding electrode holders is sometimes damaged from rough use and from moving welding equipment through/around tight spaces – see Figure 16 Contact with skin or damp clothing by the bare metal exposed when this occurs can result in a shock. Similarly, welding leads and cables can become cut or nicked from rough handling and use, exposing the bare metal of the conductor. Leads, cables and electrode holders should be inspected prior to work and more frequently in rough use situations. When working in tight and confined spaces, care should be taken to prevent hot sparks and slag from falling onto and damaging welding leads.

Figure 16 Damaged Electrode (Energized)

Welders must protect themselves and OTHERS in the vicinity from electrical shock. OSHA requires the welding machines to be turned off when it is left for appreciable/extended periods of time. 29 CFR 1926.351(d)(3): When the arc welder or cutter has occasion to leave his work or to stop work for any appreciable length of time, or when the arc welding or cutting machine is to be moved, the power supply switch to the equipment shall be opened.
In order to protect those in the vicinity of welding/plasma arc operations, you must prevent the general population from coming in contact with the ENERGIZED ELECTRODES – see Figure 17. The electrode and work circuit is electrically live whenever the output is on (power switch is in the ON position. 29 CFR1910.254 para (d)(7) and 1926.254: Electrode holders. Electrode holders when not in use shall be so placed that they cannot make electrical contact with persons, conducting objects, fuel or compressed gas tanks.

Z49.1 3.2.3.3 Safe Conditions. Welders shall cut or weld only where all safety precautions have been met.

> E3.2.3.3 <u>Do not work alone where conditions are especially hazardous, such as where electric shock is a hazard, or where ventilation is poor, etc.</u> (Electric Shock is always a hazard and is an ever present danger!)
> 3.2.3 Welders
> 3.2.3.1 Safe Handling of Equipment. Welders shall understand the hazards of the operation to be performed and the procedures being used to control hazardous conditions. Welders shall handle the equipment safely and use it so as not to endanger lives and property.
> 4. Protection of Personnel and the General Area
> 4.1 Protection of the General Area
> 4.1.1 Equipment. Welding equipment, machines, cable, and other apparatus shall be located so that it does not present a hazard to personnel. Good housekeeping shall be maintained.
> 4.1.2 Signs. Signs shall be posted designating welding areas, and indicating that eye protection and other applicable protective devices shall be worn.

Personnel assigned to work in areas where there may be electrical hazards, <u>should be informed</u> of the nature of the hazard and personal protective measures necessary. They must be familiar with protective equipment, alerting techniques and emergency assistance methods. Para 5.: <u>Use safety signs, tags,</u>

barricades or standby attendants as needed to keep unauthorized persons out of a work area where electrical hazards might exist. A physical barrier is always the preferred method of keeping personnel away from the dangerous electrical potential/current encountered/available during welding evolutions.

Each welder shall be familiar with the area used for performing welding and ***shall take the proper precautions*** to prevent fires, electrical shock, eye injury, inhalation of hazardous fumes, burns, excessive noise, and heat exhaustion to themselves and others who may occupy the area.

Figure 17 DANGEROUS CONDITION - Unattended Energized Electrode Holder

Specific Electrical Measures

The avoidance of electrical shock is largely within the control of the welder. Therefore, it is especially important that the welder be thoroughly trained on safe welding procedures. Safe procedures must be observed at all times when working with equipment having voltages necessary for arc welding. These voltages can be dangerous to life. Even mild shocks can cause involuntary muscular contractions. Electric shock from welding can kill!! Any electric welder, AC or DC, has the power to cause electrocution if the electrode touches your bare skin while you are grounded.

To avoid electric shocks and possible electrocution, personnel should take the following precautions:

- Welders must always be concerned about the possibility of electrical shock. Wet working conditions must be avoided because water is an excellent conductor and electricity will always follow the path of least resistance. Even a person's perspiration can lower the body's resistance to electrical shock. Standing on a dry rubber mat, or when welding outdoors, standing on a dry board, is always advisable.
- Poor connections and bare spots on cables further increase the possibility of electrical shock, so equipment operators should routinely inspect for effective ground connections. A proper ground connection is always necessary because it provides a safety connection from a welding machine frame to the earth.
- Connections typically used for grounding an engine-driven welding machine include a cable connected from a ground stud on the welding machine to a metal stake driven/placed into/in the ground.
- The workpiece being welded and the frame or chassis of all electrically powered machines must be connected to a good electrical ground. This can be accomplished by connecting it to a properly grounded building frame or other appropriate ground. Chains, wire ropes, cranes hoists and elevators must never be used as grounding connectors.
- The work lead is not the grounding lead. The work lead connects the work terminal on

the power source to the workpiece. A separate lead is required to ground the workpiece or power source.

- When arc welding equipment is properly grounded, a voltage may exist between the electrode and any conducting object. Examples of conducting objects include buildings; power tools, work benches, welding power source cases, and work pieces.
- Never touch the electrode and any metal object unless the welding power source is OFF.
- When installing a welding system, connect the frames of each unit such as welding power source, control, worktable and water circulator to the building ground. Conductors must be adequate to carry ground currents safely. Equipment made electrically hot by stray current may deliver a powerful shock.
- Never ground to an electrical conduit or to a pipe carrying any gas or flammable liquid such as oil or fuel.
- Use proper precautionary measures and recommended safe practices at all times. Train personnel using welding and cutting equipment to reduce the risk of injuries, fatalities, and electrical accidents.
- Read all instructions, labels and installation manuals before installing, operating or servicing the equipment.
- Do not strike the arc without covering the face and eyes. Give warning to others before striking the arc.
- All of the following are electrically energized when the power is “on”: electrode and welding circuit, input power circuit and machine internal circuits, the wire, reel of wire, drive rolls, and all other metal parts touching the energized electrode.
- Have all installation, operation, maintenance, and repair work performed only by qualified people.
- Do not work alone.
- Wear dry, hole-free, insulating gloves in good condition and protective clothing.
- Isolate/Insulate yourself from the workpiece and ground by wearing high top rubber soled shoes or standing on a dry insulated mat or platform.
- Use fully insulated electrode holders. Never dip the holder into water to cool it or lay it on conductive surfaces or the work surface.
- Do not touch holders connected to two welding machines at the same time.
- **Do not allow the holder or electrode to come in contact with any other person.**
- Do not use worn, damaged, undersized, or poorly spliced cables, welding gun cables, or torch cables. Make sure all connections are tight, clean, and dry – see Figure 18

Figure 18 Damaged Cable

- Do not wrap cables carrying electric current around any part of your body.
- Ground the workpiece to a good electrical earth ground. The work lead is not a ground lead. Do not use the work lead as a ground lead. Use a separate connection to ground the workpiece to earth – see Figure 19.

Figure 19 Ground Clamp Not Connected

- Do not touch an energized electrode while you are in contact with the work circuit.
- When using auxiliary power from welding generators, it is recommended that you use a circuit protected by a ground fault circuit interrupter (GFCI) such as receptacles in boxes, extension cords, and the like. Use of an assured grounding system is also acceptable and is equivalent to use of a GFCI protected circuit.
- In confined spaces or in locations that are electrically hazardous due to water or perspiration, do not use welding equipment with AC output unless it is also equipped with a voltage reducer and remote output control. Use equipment with DC output and do not work alone.
- Additional safety precautions are required when welding is performed under any of the following electrically hazardous conditions: in damp locations or while wearing wet

clothing; on metal floors, gratings, scaffolds, or other metal structures; in cramped positions such as sitting, kneeling, or lying; or when there is a high risk of unavoidable or accidental contact with the workpiece or ground. Where these conditions are present, use one of the following types of equipment presented in order of preference:

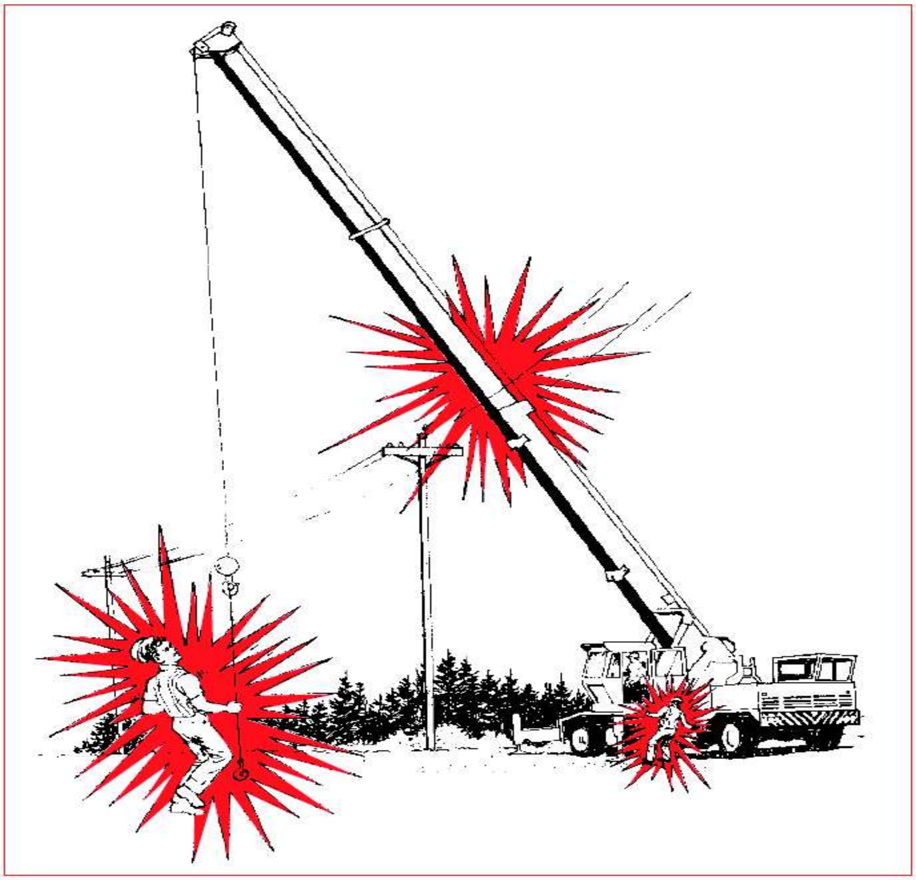
- Semiautomatic DC constant voltage metal electrode (wire) welder,
- DC manual covered electrode (stick) welder, or
- AC welder with reduced open-circuit voltage. In most situations, use of a DC, constant voltage wire welder is recommended. And, do not work alone!
- Electrodes or welding wire should never be touched with bare hands when in the holder or welding gun. Holders or welding guns should never be held under the armpits. Remember, hot work increases risk due to the reduced skin resistance when sweating occurs.

- Turn off all equipment when not in use.
- Use only well maintained equipment. Repair or replace damaged parts before further use.
- Wet working conditions should be avoided. Even a person's perspiration can lower the body's resistance to electrical shock.

Welding can cause other hazardous conditions, such as fires. Always take extra precaution to prevent all accidents while welding. Simple preventive actions such as placing your welding cables and other equipment where they will not obstruct passageways, ladders, and stairways will help prevent accidents.

Heavy Equipment Operators

Contact with overhead power lines is a major cause of fatalities in the construction industry. As many as 100 workers are killed each year by inadvertent power line contacts, most of which occur through the use of high reaching material-handling equipment. A study of accidents involving power line contacts has indicated that the use of **CRANES** is the most common cause of fatalities as seen in Figure 20.



If mobile equipment touches a power line, electricity can travel from the power line to a worker touching any part of the equipment, including a pendant control.

Figure 20 Crane Coming in Contact with Power Lines

It's easy to prevent serious accidents involving cranes and power lines. The following safety tips should be adhered to when operating a crane near overhead power lines.

- Keep a safe distance between yourself and power lines. Ten feet is generally considered the minimum safe distance. **Always** consider all power lines as energized and dangerous. **Any** contact with a crane boom will probably cause serious injury to operators and workers, and damage to equipment.
- Look up **before** you unload or load a crane from a truck or lowboy. Make sure there are no overhead lines before you start.
- Educate your crew, particularly new employees about the dangers of overhead power lines. Utility companies have a ten feet (10') minimum approach distance to overhead power lines as illustrated in Figure 21 This distance is law in some states.

Figure 21 Minimum Power Line Approach Distance

- Be safe! The crane's mast or boom must be kept at least 10 feet away from a normal distribution power line at all times. And that includes the load line and the load. Skilled crane operators know that distances in the air are hard to judge, and that a spotter is a good, safe idea. When you must work near any power line, use the shortest boom possible. Never move a crane under a power line unless there are adequate clearances.

If your crane boom or mast contacts a power line, the operator should immediately try to swing the boom into the clear. If it is necessary to leave the equipment, anyone on the machine should jump entirely clear of the unit. Jump so that both feet hit the ground at the same time, and keep them close together. Walk away in a small step shuffle because a lot of power flowing into the ground can create differences in electrical potential around the problem: enough difference to actually shock anyone whose feet are too far apart. Once clear of the equipment, do not return for any reason until the power line has been grounded or determined to be safe by your electric utility or the owner of the line. And keep any others around from touching or approaching the equipment.

Contact with overhead power lines continues as a major cause of electrical accidents, injuries and fatalities. The Figure 22 and Figure 23 represent typical accident scenarios:

Figure 22 Dump Truck Contacting Power Lines

Figure 23 Television Media Antenna Contacting Power Lines

Excavators

Buried power and communication lines are more prevalent today than ever before. These lines pose a special hazard to operators of equipment used during trenching and excavation activities. Therefore, operators need to be aware of the hazards penetration of energized power lines poses and take positive steps to eliminate the hazard before digging. Figure 24 illustrates some of these hazards.

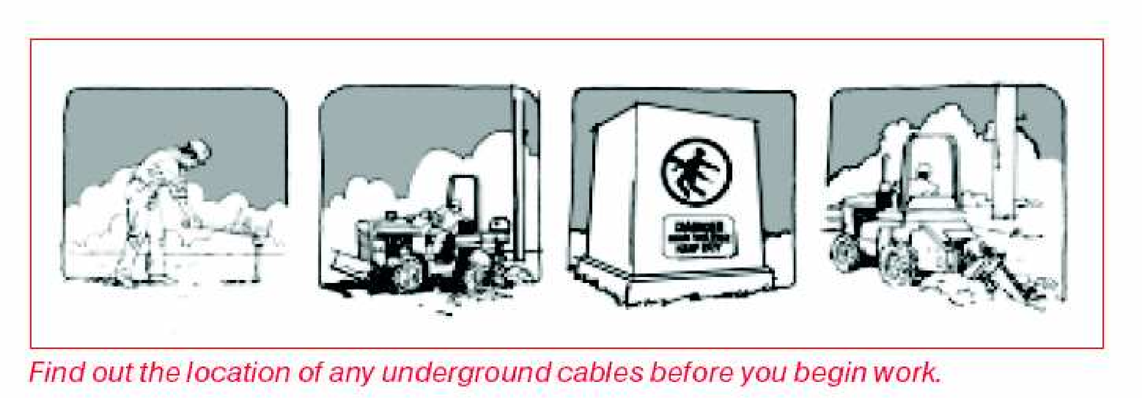


Figure 24 Underground Hazards

- Locate underground power lines and other utilities before digging. Utility companies will assist with location and marking and should be contacted prior to digging.
- Workers must ensure that power is removed from the lines and a zero energy state has been verified.
- Workers must ensure that the system is locked and tagged out.
- All workers must have a questioning attitude about safety and especially electrical safety.

Remember, penetration of energized underground conductors by workers can result in shock and even death.

Warehouse Workers

Warehouse workers are exposed to a wide variety of hazards. These may include chemicals, vehicular traffic, awkward working positions, height, and electrical shock potential. Of these the least addressed one is electricity. Therefore workers tend to ignore electrical safety conditions because they simply don’t recognize the hazard. This section will address some of these hazardous conditions and discuss ways to remove them.

Electricity in warehouses is often encountered during storage and retrieval of parts that are stored at height and involve the use of some type of lifting device such as a forklift. Warehouse workers must be aware of the following electrical hazards and implement positive controls so that they may be avoided.

Figure 25 Forklift Crossing Cable Guard

- Use cable guards when running temporary power cords as shown in Figure 25.
- Verify that power lifting platforms do not raise high enough to place worker within the minimum safe approach distance of high energy lighting and equipment conductors.
- Ensure that containers used to store explosive/flammable chemicals are properly grounded as illustrated in Figure 26.

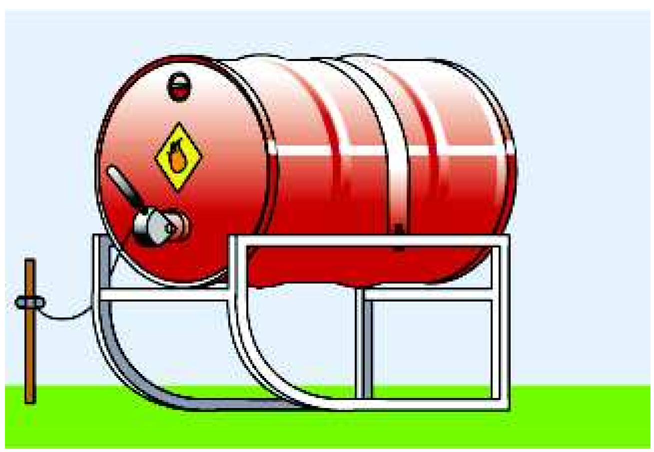


Figure 26 Grounded Container

- Verify that the travel paths used to move stock is free from electrical outlets, controls, and power panels that may be damaged by moving equipment.
- Power panels and high voltage switches and disconnects should be guarded if they are not physically separated from the work area.
- All workers should know where disconnects, circuit breakers and switches are located in their area of responsibility.

Painters

Painters are usually injured by electricity when they come in contact with energized systems through their paint roller or their ladder. These injuries can usually be avoided simply by being more aware of their surrounding and understanding that you must follow the basic rule when electrical energy is present.

Figure 27 Painting Hazard

Painters must recognize voltage carrying conductors and stay outside the 3 ft 6 inch boundary until a de-energized state is proven as illustrated in Figure 27. They must be able to recognize different types of conductors such as Cables (insulated and un-insulated), buss bars, and power carrying rails in the work place. Figure 28 shows some of these conductors.

Figure 28 Buss Bars and Power Rails

POTENTIAL ACCIDENTS AND HAZARDS

EO 1.09 **Describe** potential accidents and hazards associated with the following equipment or components.

- **Portable Generators**
- **Battery Banks**
- **Battery Chargers**

Portable Generators

Portable generators are used to provide an alternate source of AC power to equipment. These generators may be diesel or gasoline driven. The units range in size from being relatively small to furnish power for emergency lighting and/or control circuits or they may be very large and are capable of generating several megawatts of power. These generators are to be considered operable at all times, unless locked out because they may be remotely operated and could be in the standby state or running. Even small portable generators as seen in Figure 29 easily produce enough current and voltage to kill. Also, if the generator has just been turned off the equipment could still be hot and present the possibility of a burn if touched.

Figure 29 Portable Generator

Battery Banks

DC systems on Site include banks of batteries, motor-generator (MG) sets or battery chargers, and the necessary system wiring and controls to supply the DC power. The function of a DC electrical system is to provide power to essential control systems and equipment, which does not depend on normal AC power.

For safety, it is required that battery rooms have an eyewash station, in case acid from the batteries is sprayed in the face of the operator. Ventilation fans should always be operating to prevent hydrogen gas buildup. Due to the possibility of hydrogen gas being present there will be NO SMOKING in the battery rooms and always make sure the ventilation fans are operating before entering. Only qualified personnel should enter a battery room. Only necessary tools should be taken into the battery room. All tools should be insulated tools. Rubber blankets should be utilized any time when working overhead. This reduces the likelihood of shorting out the DC system. Batteries should be covered with suitable insulating materials (i.e., rubber blankets) when personnel are working overhead with tools or metallic objects. Shorting the DC system is extremely dangerous because the system may not be protected by an over current device.

Battery Chargers

There are numerous styles of battery operated trucks that range from small, motorized pallet trucks to much larger high lift trucks. No matter what kind of truck you have, there are similar hazards associated with their batteries and their chargers. There are two styles of batteries in industrial trucks today: Lead acid or nickel-iron. Both of these batteries pose a health threat in several ways:

- Gases emitted during changing can be highly volatile
- Corrosive chemicals within the battery

For these reasons, battery charging stations and the employees that work around them must be properly equipped and certain safety procedures implemented.

The following procedures must be followed:

1. Eye or face protection must be worn when connecting a charger to a battery.
2. Chargers must be turned off when leads are being connected or disconnected.
3. All leads and cables must be checked and in good condition.
4. When charging batteries and when moving batteries, vent caps must be kept firmly in place to avoid electrolyte splashing
5. If charging is to be conducted on a battery in a mobile piece of equipment, the battery compartment cover must be left open to vent heat and explosive gases.
6. There must be adequate ventilation in the charging area.
7. The battery charger must be protected from damage. This usually means a physically protected area.
8. Facilities for quick drenching or flushing of the eyes and body must be provided at or near the charging area (approved emergency eyewash and safety shower).
9. Smoking and other ignition sources must be prohibited in the charging area. “No Smoking” signs must be posted.

ELECTRICAL SAFETY TIPS

EO 1.10 **List** some electrical safety tips that all workers must adhere to when working with any of the following:

- Power Tools
- Extension Cords
- Molded Case Circuit Breakers
- Downed Power Lines
- Ladders

Background

Hospital Emergency Rooms provide life-saving measures to tens of thousands of individuals injured/maimed/impaired as a direct/indirect result of the effects of electric current passing through their bodies usually through a careless act. Over a thousand individuals are electrocuted annually. Fires in the home and on-the-job are initiated as a result of improper use and care of electrical equipment, extension cords, and plugs. Causes for these events include inattention through repetition, unexpected events and inexperience and overconfidence. We can eliminate a large percentage of these injuries and death through the application/use of safe tool/electrical practices.
Contact with current from machines, tools, appliances and light fixtures accounted for 10 percent of the electrocution deaths in construction in 1999. With the myriad of extension cords and portable power tools used on a jobsite, there is a real danger of shocks from damaged cords, lights and tools. Dampness increases the risk.

OSHA requires all tools be grounded on a jobsite and that ground fault circuit interrupters (GFCIs) be used. THE CPWR (Center to Protect Worker Rights) reports that OSHA requires all machinery and power cords to be grounded with three-prong plugs or have a double-insulated design. Use only factory-made extension cords that are designed and marked for hard or extra-hard use.
The most frequent OSHA citations are for electrical problems. The most frequently cited standards are:

- 1926.404(f)(6) Improper or inadequate grounding path from circuits, equipment and enclosures
- 1926.405(g)(2) Improper connections of flexible cords to devices and fittings
- 1926.416(e)(1) Use of worn or frayed electric cords or cables
- 1926.403(b)(2) Improper use or installation of listed, labeled or certified equipment
- 1926.404(b)(1) Improper attachment of grounded conductors to terminals and leads, causing designated polarity to reverse
- 1926.404(b)(1)(I) Failure to implement GFCIs or assure equipment grounding conductor programs

Electrical Power Tool Safety

- Use the tool ***only*** for its designed purpose.
- Read the Owner's Manual and follow manufacturer's safety instructions.
- Remember electric-powered tools must have a three-wire plug with ground or be double insulated.
- Use of electric-powered tools with a GFCI breakers will drastically reduce the possibility of electric shock or electrocution.
- Don appropriate PPE.
- If an extension cord is required, make sure it is for the correct wattage and has the proper plugs. Verify condition of the cord and plugs and check for rated use: indoor or outdoor.
- Ensure the power switch is "OFF" before plugging or unplugging tools.
- Never disconnect power by pulling on the cord – use the PLUG.
- Never carry a tool by the cord.
- Unplug the cord before making adjustments, changing/replacing parts/accessories.
- Inspect tool before each use. Replace tool if parts are worn or damaged as seen if Figure 30. Remove from service and tag "Danger, Do Not Operate."

Figure 30 Damaged Insulation and Plug

- Do not use electric-powered tools in damp or wet locations.
- Keep the cord away from heat, oil/chemicals, sharp edges and ensure it doesn't become a tripping hazard as seen in Figure 31.

- Remember there are specific practices also when drilling or penetrating areas which may contain energized conductors.
  1. Drilling or penetrating areas which contain or may contain energized electrical conductors is considered "working near". Such work requires extreme caution and good planning. Drills or penetrating equipment must be grounded so that accidental contact with an unexpected energized electrical conductor will be cleared quickly by the circuit protective device. Double insulated equipment cannot be counted on to provide protection when accidental contact is made with energized circuits. A drill bit stop should be used to limit the distance of any penetration.
  2. Enclosures, raceways, compartments, walls, ceilings, floors or underground areas where energized electrical conductors are or may be hidden from direct view must be thoroughly investigated before penetrating into them. The custodian should ensure that an engineering review of drawings or other documentation about the work site is conducted.

Figure 31 Defective Wiring

Extension Cords

- Inspect the cord before each use. Replace the cord if worn or damaged. Remove from service and tag "Danger, Do Not Operate."
- Keep extension cords away from heat, oil/chemicals, sharp edges and ensure they do not become a tripping hazard.
- Make sure extension cord is for the correct amperage and has the proper plug. Figure 32
- Verify condition of the cord and plugs and check rated use: indoor or outdoor.
- Don't overload electrical outlets. Figure 33
- Never disconnect power by pulling on the cord – use the PLUG.

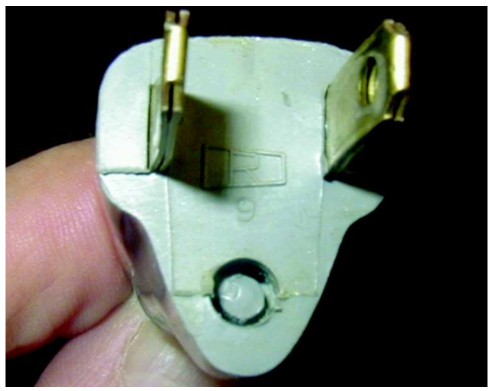


Figure 32 Three Prong Plug Missing Ground

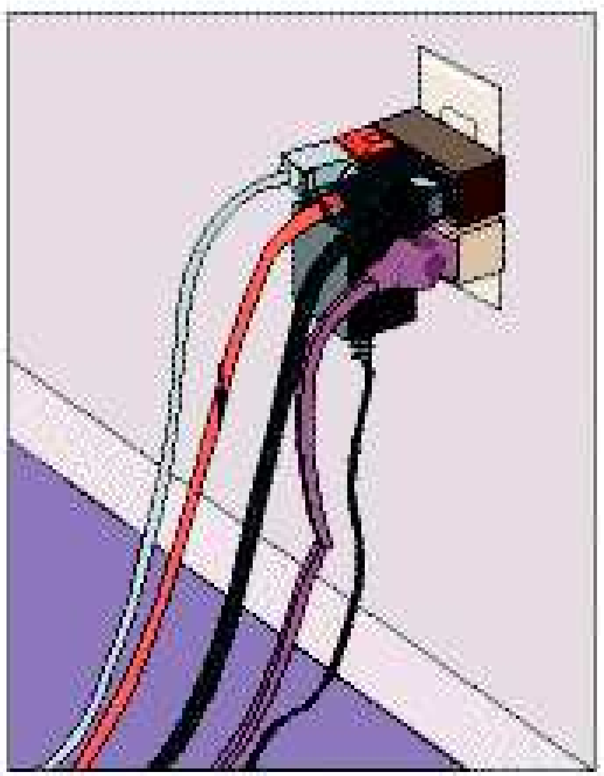


Figure 33 – Overloaded Outlet

Molded Case Circuit Breakers

Molded Case Circuit Breakers like in Figure 34, require little or no routine maintenance throughout their normal lifetime. Breakers bearing the designation "SWD" are designed to be used as a switch and for over current protection. General duty breakers are used for over current protection and are not designed to be used as a switch.

Figure 34 Circuit Breakers

Circuit breakers should only be operated by a designated area operations group or custodian who knows what equipment the circuit breaker operates. Our Conduct of Operations states that if electrically powered equipment operates a circuit protective device such as a breaker, the circuit may be reset one time with the concurrence of the shift manager. Repetitive closing without investigating the cause is prohibited. Electrical breakers in systems rated at 480 volts or higher must not be reset without a written plan or procedure.

Downed Power Lines

It is important to remember that wires installed on utility poles carry electricity. When wires are down, they are dangerous -- electricity can still flow through them. Never assume that a downed power line is not energized as they still could be "live". See Figure 35. Telephone and cable TV wires may be entangled with electric wires and must also be treated as live. Another danger from downed power lines can come in the form of a wire touching or laying on a metal building or metal fence. Again, this could energize the building or fence and kill or injure someone if they were to come in contact with it. Stay at least 50 feet away from all downed wires and keep others from going near them as well.
Be especially careful when driving or parking a vehicle near downed wires. If downed wires are in the street, near the curb, or on the sidewalk, use extreme caution. Never drive over downed power lines. Even if not energized, they can become entangled in your vehicle.

Figure 35 Downed Power Line

In the event that a wire comes down on a vehicle with passengers, the best advice is to stay in the vehicle until professional help arrives to safely remove you from the vehicle. See Figure 36. If you MUST get out of the vehicle because of fire or other life-threatening hazards, jump clear of the vehicle so that you do not touch any part of the car and the ground at the same time.

Figure 36 Power Line on Vehicle

Jump as far as possible away from the vehicle with both feet landing on the ground at the same time. Once you clear the vehicle, shuffle away, with both feet on the ground, or hop away, with both feet landing on the ground at the same time. Do not run away from the vehicle as the electricity forms rings of different voltages. Running may cause your legs to "bridge" current from a higher ring to a lower voltage ring. See Figure 37. This could result in a shock. Get a safe distance away.

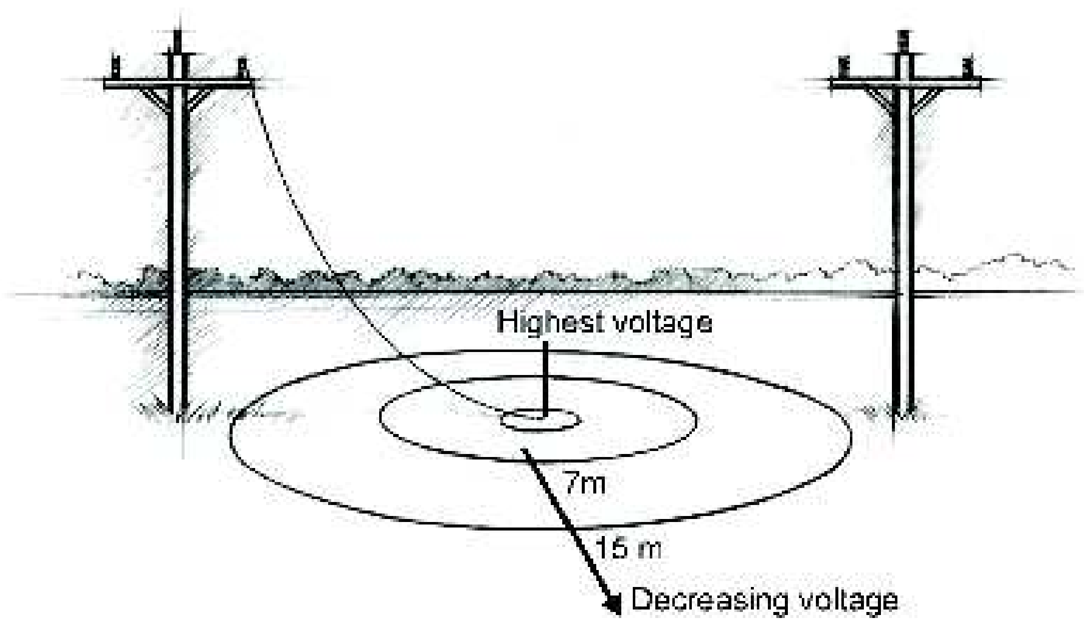
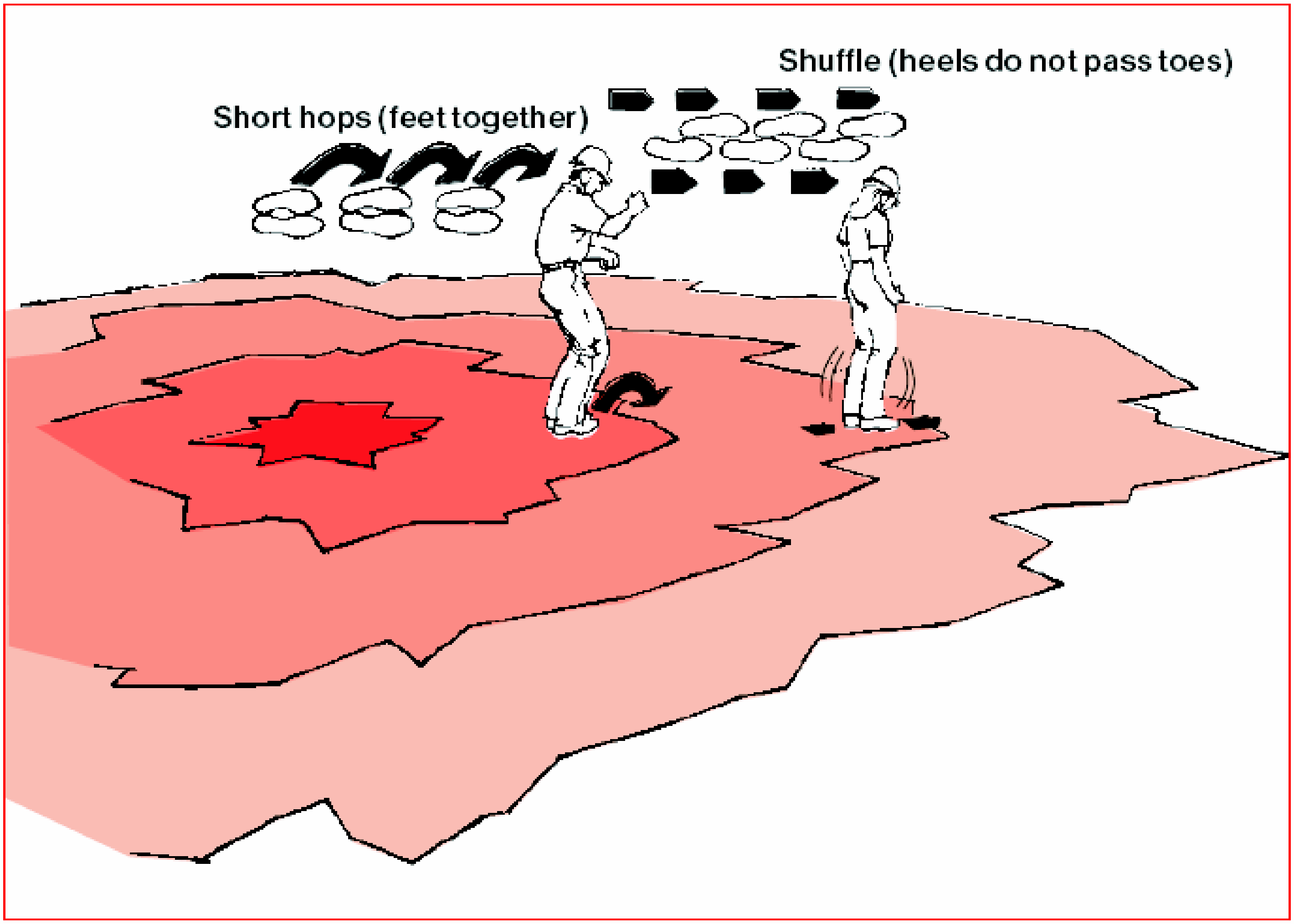


Figure 37 Step Potential "Voltage Ring"

The voltage drops as you move away from the point of contact. If one part of your body touches a high-voltage zone while another part of your body touches a low-voltage zone, you will become a conductor for electricity. This is why you should shuffle away from the line, keeping your feet close together as illustrated in Figure 38.



If you must move on energized ground, shuffle or hop while keeping your feet together and touching each other. Do not take steps.

Figure 38 - Proper Movement Over Energized Ground

Ladders

Safety regulations promulgated by the Occupational Safety and Health Administration (OSHA) establish specific requirements intended to prevent workers from positioning portable metal ladders where they might contact electrical conductors [29 CFR* 1926.450(a)(11) and 1926.951(c)(1)]. These regulations stipulate that "portable metal or conductive ladders shall not be used for electrical work or where they may contact electrical conductors." Other pertinent regulations require that "portable ladders in use shall be tied, blocked, or otherwise secured to prevent their being displaced" [29 CFR 1926.450(a) (10]. Additional OSHA regulations require employers to instruct each worker to recognize and avoid unsafe conditions [29 CFR 1926.21(b) (2)], and to provide prompt medical attention in case of serious injury [29 CFR 1926.50].

Figure 39 Non-Conductive ladder

To guard against electrocution from ladder/power line contact, OSHA regulations prohibit the use of conductive ladders near any energized power line. Conductive ladders should be clearly marked to inform workers they can not be used around electrical equipment. See Figure 39.

Use only nonconductive ladders when performing electrical work, welding or where there is danger of contact with electrical conductors. Fiberglass is the preferred material for nonconductive ladders used on site.