Electrical Safety: Tools & Equipment

Use and maintain tools properly

Your tools are at the heart of your craft. Tools help you do your job with a high degree of quality. Tools can do something else, too. They can cause injury or even death! You must use the right tools for the job. Proper maintenance of tools and other equipment is very important. Inadequate maintenance can cause equipment to deteriorate, creating dangerous conditions. You must take care of your tools so they can help you and not hurt you.

- **Inspect tools before using them**—Check for cracked casings, dents, missing or broken parts, and contamination (oil, moisture, dirt, corrosion). Damaged tools must be removed from service and properly tagged. These tools should not be used until they are repaired and tested.
- **Use the right tool correctly**—Use tools correctly and for their intended purposes. Follow the safety instructions and operating procedures recommended by the manufacturer. When working on a circuit, use approved tools with insulated handles. However, **DO NOT USE THESE TOOLS TO WORK ON ENERGIZED CIRCUITS. ALWAYS SHUT OFF AND DE-ENERGIZE CIRCUITS BEFORE BEGINNING WORK ON THE**M.
- **Protect your tools**—Keep tools and cords away from heat, oil, and sharp objects. These hazards can damage insulation. If a tool or cord heats up, stop using it! Report the condition to a supervisor or instructor immediately. If equipment has been repaired, make sure that it has been tested and certified as safe before using it. Never carry a tool by the cord. Disconnect cords by pulling the plug—not the cord!

- **Use double-insulated tools**—Portable electrical tools are classified by the number of insulation barriers between the electrical conductors in the tool and the worker. The NEC permits the use of portable tools only if they have been approved by Underwriter's Laboratories (UL Listed). Equipment that has two insulation barriers and no exposed metal parts is called double-insulated. When used properly, double-insulated tools provide reliable shock protection without the need for a third ground wire. Power tools with metal housings or only one layer of effective insulation must have a third ground wire and three-prong plug.
- **Use multiple safe practices**—Remember: A circuit may not be wired correctly. Wires may contact other "hot" circuits. Someone else may do something to place you in danger. Take all possible precautions.

Wear correct PPE

OSHA requires that you be provided with personal protective equipment. This equipment must meet OSHA requirements and be appropriate for the parts of the body that need protection and the work performed. There are many types of PPE: rubber gloves, insulating shoes and boots, face shields, safety glasses, hard hats, etc. Even if laws did not exist requiring the use of PPE, there would still be every reason to use this equipment. PPE helps keep you safe. It is the last line of defense between you and the hazard.

- **Wear safety glasses**—Wear safety glasses to avoid eye injury.
- **Wear proper clothing**—Wear clothing that is neither floppy nor too tight. Loose clothing will catch on corners and rough surfaces. Clothing that binds is uncomfortable and distracting.

- **Contain and secure loose hair—**Wear your hair in such a way that it does not interfere with your work or safety.
- **Wear proper foot protection—**Wear shoes or boots that have been approved for electrical work. (Tennis shoes will not protect you from electrical hazards.) If there are non-electrical hazards present (nails on the floor, heavy objects, etc.), use footwear that is approved to protect against these hazards as well.
- **Wear a hard hat**—Wear a hard hat to protect your head from bumps and falling objects. Hard hats must be worn with the bill forward to protect you properly.
- **Wear hearing protectors**—Wear hearing protectors in noisy areas to prevent hearing loss.
- **Follow directions**—Follow the manufacturer's directions for cleaning and maintaining PPE.
- **Make an effort**—Search out and use any and all equipment that will protect you from shocks and other injuries.

PPE is the last line of defense against workplace hazards. OSHA defines PPE as "equipment for the eyes, face, head, and extremities, protective clothing, respiratory devices, protective shields and barriers." Many OSHA regulations state that PPE must meet criteria set by the American National Standards Institute (ANSI).

Head Protection

OSHA requires that head protection (hard hats) be worn if there is a risk of head injury from electrical burns or falling/flying objects.

Aren't all hard hats the same?

No. You must wear the right hat for the job. All hard hats approved for electrical work made since 1997 are marked "Class E." Hard hats made before 1997 are marked "Class B." These markings will be on a label inside the helmet or stamped into the helmet itself. Newer hats may also be marked ***"Type 1"*** or ***"Type 2***." Type 1 hard hats protect you from impacts on the top of your head. Type 2 hard hats protect you from impacts on the top and sides of your head.

How do I wear and care for my hard hat?

Always wear your hat with the bill forward. (Hats are tested in this position.) If you wear a hat differently, you may not be fully protected. The hat should fit snugly without being too tight. You should clean and inspect your hard hat regularly according to the manufacturer's instructions. Check the hat for cracks, dents, frayed straps, and dulling of the finish. These conditions can reduce protection. Use only mild soap and water for cleaning. Heavy-duty cleaners and other chemicals can damage the hat.

PPE Fact Sheet—The Right Equipment—Head to Toe

Do not "store" anything (gloves, wallet, etc.) in the top of your hard hat while you are wearing it. The space between the inside harness and the top of the hard hat must remain open to protect you. Do not put stickers on your hat (the glue can weaken the helmet) and keep it out of direct sunlight. If you want to express your personality, hard hats come in many colors and can be imprinted with custom designs by the manufacturer. Some hats are available in a cowboy hat design or with sports logos.

Foot Protection

Workers must wear protective footwear when there is a risk of foot injury from sharp items or falling/rolling objects—or when electrical hazards are present. As with hard hats, always follow the manufacturer's instructions for cleaning and maintenance of footwear. Remember that cuts, holes, worn soles, and other damage can reduce protection.

How do I choose the right footwear?

The footwear must be ANSI approved. ANSI approval codes are usually printed inside the tongue of the boot or shoe. Footwear will be marked ***"EH"*** if it is approved for electrical work. (The ANSI approval stamp alone does not necessarily mean the footwear offers protection from electrical hazards.) Note that footwear made of leather must be kept dry to protect you from electrical hazards, even if it is marked ***"EH."***

What about non-electrical hazards?

All ANSI approved footwear has a protective toe and offers impact and compression protection. But the type and amount of protection is not always the same. Different footwear protects you in different ways. Check the product's labeling or consult the manufacturer to make sure the footwear will protect you from the hazards you face.

1926 Subpart K - Electrical

This module is designed to assist workers in obtaining knowledge in working with electricity in and around the construction industry as well as any worksite that has electricity. This module emphasizes hazard identification, avoidance, and control. No attempt has been made to treat the topic exhaustively.

Electricity - The Dangers

Electrocution deaths and electric shock accidents at work sites, including construction projects (indoor and outdoor), restaurants, agricultural sites, industrial plants, and offices, are a serious and ongoing problem for workers in the U.S. It is estimated that 7% percent of all work-related fatalities are due to electrocution in some form, with around 700 employees being electrocuted per year. Electric shock is the 4th leading cause of death in occupational fatalities.

Striking power lines both above and below ground, problems or mishaps in electric building circuitry, and the combination of water and electric outlets are all deadly contributors which can lead to death by electric shock. OSHA cites numerous fatal accidents in which poor safety maintenance led to the electrocution fatality of employees. Often times, mere education and training can prevent the devastating results of electrocution.

When you work with power tools or electrical circuits there is a risk of electrical hazards, especially electrical shock. Risks are increased at construction sites because many jobs involve electric power tools.

Electrical trade workers must pay special attention to electrical hazards because they work on electrical circuits. Coming in contact with an electrical voltage can cause current to flow through the body, resulting in electrical shock and burns. Serious injury *or even death* may occur.


Courtesy of OSHA

Electricity has long been recognized as a serious workplace hazard, exposing employees to electric shock, electrocution, burns, fires, and explosions.

Electricity – How it Works

- **Electricity is the flow of energy from one place to another**
- **Requires a source of power: usually a generating station**
- **A flow of electrons (current) travels through a conductor**
- **Travels in a closed circuit**

Operating an electric switch is like turning on a water faucet.

Behind the faucet (or switch) there is a source of water (or electricity) with a way to transport it, and pressure to make it flow. The faucet's water source is a reservoir or pumping station. A pump provides enough pressure for the water to travel through the pipes. For electricity the source is the power generating station. A generator provides the pressure (voltage) for the electrical current to travel through electric conductors (wires).

Volts – the electrical pressure (measure of electrical force)

Amps – the volume or intensity of the electrical flow

Watts – the power consumed

Electrical Terms:

Current -- electrical movement (measured in amps)

Circuit -- **complete path of the current. Includes electricity source, a conductor, and the output device or load (such as a lamp, tool, or heater)**

Resistance -- restriction to electrical flow – Measured in ohms.

- **Four factors determine the resistance of a material to the flow of electricity.**
  - **What it is made of (silver is best, copper is most common)**
  - **Its diameter (smaller diameter = more resistance)**
  - **Its temperature (higher temperature = higher resistance)**
  - **Its length (longer = higher resistance)**

Conductors **– substances, like metals, with little resistance to electricity that allow electricity to flow**

Grounding **– a conductive connection to the earth which acts as a protective measure**

Insulators -- **substances with high resistance to electricity like glass, porcelain, plastic, and dry wood that prevent electricity from getting to unwanted areas**

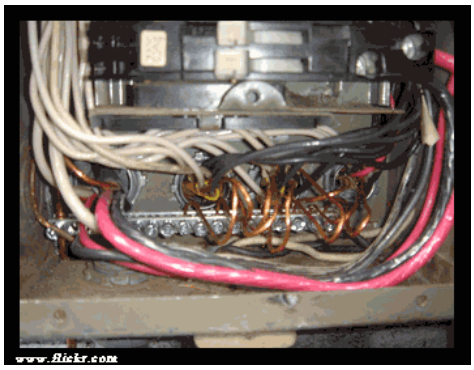
Electrical Injuries

There are four main types of electrical injuries:

- **Direct:**
  - **Electrocution or death due to electrical shock**

- **Electrical shock**
- **Burns**

- **Indirect – Falls**



When an electrical shock enters the body it may produce different types of injuries. Electrocution results in internal and external injury to body parts or to the entire body – often resulting in death. After receiving a "jolt" of electricity all or part of the body may be temporarily paralyzed and this may cause loss of grip or stability. A person may also involuntarily move as a result of receiving an electrical shock, resulting in a fall. Internal or external burns may result from contact with electricity.

Electrical Shock

An electrical shock is received when electrical current passes through the body. You will get an electrical shock if a part of your body completes an electrical circuit by…

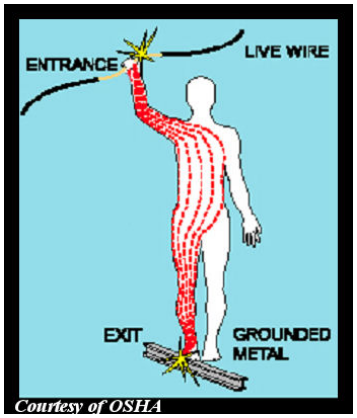
- **Touching a live wire and an electrical ground, or**
- **Touching a live wire and another wire at a different voltage**

Electricity travels in closed circuits, and its normal route is through a conductor. Electric shock occurs when the body becomes a part of the circuit.

Grounding is a physical connection to the earth, which is at zero volts.

The metal parts of electric tools and machines may become energized if there is a break in the insulation of the tool or machine wiring. A worker using these tools and machines is made less vulnerable to electric shock when there is a low-resistance path from the metallic case of the tool or machine to the ground. This is done through the use of an equipment grounding conductor—a low-resistance wire that causes the unwanted current to pass directly to the ground, thereby greatly reducing the amount of current passing through the body of the person in contact with the tool or machine.

Shock Severity



- **Severity of the shock depends on:**
  - **<u>Path</u> of current through the body**
  - **<u>Amount of current</u> flowing through the body (amps)**
  - **<u>Duration</u> of the shocking current through the body,**
- **LOW VOLTAGE DOES NOT MEAN LOW HAZARD**

Other factors that may affect the severity of the shock are:

- The voltage of the current.
- The presence of moisture

- The general health of the person prior to the shock.

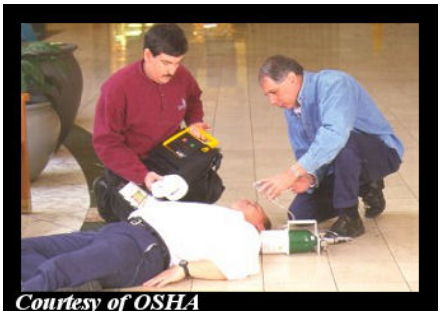
Low voltages can be extremely dangerous because, all other factors being equal, the degree of injury increases the longer the body is in contact with the circuit.

The resistance of the body varies based on:

- The amount of moisture on the skin (less moisture = more resistance)
- The size of the area of contact (smaller area = more resistance)
- The pressure applied to the contact point (less pressure = more resistance)
- Muscular structure (less muscle = less resistance)

Dangers of Electrical Shock

- **Currents above 10 mA* can paralyze or "freeze" muscles.**
- **Currents more than 75 mA can cause a rapid, ineffective heartbeat -- death will occur in a few minutes unless a defibrillator is used**



- **75 mA is not much current – a small power drill uses 30 times as much**

For example, 1/10 of an ampere (amp) of electricity going through the body for just 2 seconds is enough to cause death.

Currents above 10 mA can paralyze or "freeze" muscles. When this "freezing" happens, a person is no longer able to release a tool, wire, or other object. In fact, the electrified object may be held even more tightly, resulting in longer exposure to the shocking current. For this reason, hand-held tools that give a shock can be very dangerous. If you can't let go of the tool, current continues through your body for a longer time, which can lead to respiratory paralysis (the muscles that control breathing cannot move). You stop breathing for a period of time. People have stopped breathing when shocked with currents from voltages as low as 49 volts. Usually, it takes about 30 mA of current to cause respiratory paralysis.

Burns

- **Most common shock-related injury**
- **Occurs when you touch electrical wiring or equipment that is improperly used or maintained**
- **Typically occurs on hands**
- **Very serious injury that needs immediate attention**

Shock-related injuries include burns, internal injuries, and injuries due to involuntary muscle contractions.

The most common shock-related injury is a burn. Burns suffered in electrical incidents may be one or more of the following three types.

1. Electrical burns cause tissue damage, and are the result of heat generated by the flow of electrical current through the body. These are one of the most serious injuries you can receive and require immediate attention.

2. Arc or Flash burns are caused by high temperatures near the body produced by an electrical arc or explosion. Attend to them immediately.

3. Thermal contact burns occur when skin comes in contact with overheated electric equipment, or when clothing is ignited by an electrical incident.

Falls


Courtesy of OSHA

- **Electric shock can also cause indirect injuries**
- **Workers in elevated locations who experience a shock may fall, resulting in serious injury or death**

Electrical Hazards and How to Control Them

Electrical accidents are caused by a combination of three factors:

- **Unsafe equipment and/or installation,**
- **Workplaces made unsafe by the environment, and**
- **Unsafe work practices.**

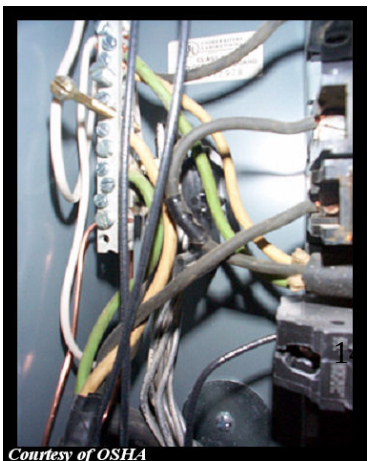
Electrical shocks, fires, or falls result from these hazards:

- Exposed electrical parts
- Overhead power lines
- Inadequate wiring
- Defective insulation
- Improper grounding
- Overloaded circuits
- Wet conditions
- Damaged tools and equipment
- Improper PPE

Hazard – Exposed Electrical Parts

Cover removed from wiring or breaker box

Control – Isolate Electrical Parts



- **Use guards or barriers**

- **Replace covers**

Reference 1926.403(i)(2)

Except as required or permitted elsewhere in the subpart, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by cabinets or other forms of enclosures, or by any of the following means:

- By location in a room, vault, or similar enclosure that is accessible only to qualified persons.

- By partitions or screens so arranged that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.

- By location on a balcony, gallery, or platform so elevated and arranged as to exclude unqualified persons.

- By elevation of 8 feet or more above the floor or other working surface and so installed as to exclude unqualified persons.