GENERAL:

OSHA and state safety laws have helped to provide safe working areas for electricians. Individuals can work safely on electrical equipment with today's safeguards and recommended work practices. In addition, an understanding of the principles of electricity is gained. Ask supervisors when in doubt about a procedure. Report any unsafe conditions, equipment, or work practices as soon as possible.

FUSES:

Before removing any fuse from a circuit, be sure the switch for the circuit is open or disconnected. When removing fuses, use an approved fuse puller and break contact on the hot side of the circuit first. When replacing fuses, install the fuse first into the load side of the fuse clip, then into the line side.

GFCIs:

A groundfault circuit interrupter (GFCI) is an electrical device which protects personnel by detecting potentially hazardous ground faults and quickly disconnecting power from the circuit. A potentially dangerous ground fault is any amount of current above the level that may deliver a dangerous shock. Any current over 8 mA is considered potentially dangerous depending on the path the current takes, the amount of time exposed to the shock, and the physical condition of the person receiving the shock.

Therefore, GFCIs are required in such places as dwellings, hotels, motels, construction sites, marinas, receptacles near swimming pools and hot tubs, underwater lighting, fountains, and other areas in which a person may experience a ground fault.

A GFCI compares the amount of current in the ungrounded (hot) conductor with the amount of current in the neutral conductor. If the current in the neutral conductor becomes less than the current in the hot conductor, a ground fault condition exists. The amount of current that is missing is returned to the source by some path other than the intended path (fault current). A fault current as low as 4 mA to 6 mA activates the GFCI and interrupts the circuit. Once activated, the fault condition is cleared and the GFCI manually resets before power may be restored to the circuit. See Figure 1-22.
GFCI protection may be installed at different locations within a circuit. Direct-wired GFCI receptacles provide a ground fault protection at the point of installation. GFCI receptacles may also be connected to provide GFCI protection at all other receptacles installed downstream on the same circuit. GFCI CBs, when installed in a load center or panelboard, provide GFCI protection and conventional circuit overcurrent protection for all branch-circuit components connected to the CB.

Plug-in GFCIs provide ground fault protection for devices plugged into them. These plug-in devices are often used by personnel working with power tools in an area that does not include GFCI receptacles.

**Electrical Shock:**

Strange as it may seem, most fatal electrical shocks happen to people who should know better. Here are some electromedical facts that should make you think twice before taking chances.

It's not the voltage but the current that kills. People have been killed by 100 volts AC in the home and with as little as 42 volts DC. The real measure of a shock's intensity lies in the amount of current (in milliamperes) forced through the body. Any electrical device used on a house wiring circuit can, under certain conditions, transmit a fatal amount of current.

Currents between 100 and 200 milliamperes (0.1 ampere and 0.2 ampere) are fatal. Anything in the neighborhood of 10 milliamperes (0.01) is capable of producing painful to severe shock. Take a look at Table AI-1.

<table>
<thead>
<tr>
<th>Readings</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe Current Values</td>
<td>Causes no sensation - not felt.</td>
</tr>
<tr>
<td>1 mA or less</td>
<td>Sensation of shock, not painful; Individual can let go at will since</td>
</tr>
<tr>
<td>1 mA to 8 mA</td>
<td></td>
</tr>
</tbody>
</table>
As the current rises, the shock becomes more severe. Below 20 milliamperes, breathing becomes labored; it ceases completely even at values below 75 milliamperes. As the current approaches 100 milliamperes ventricular fibrillation occurs. This is an uncoordinated twitching of the walls of the heart's ventricles. Since you don't know how much current went through the body, it is necessary to perform artificial respiration to try to get the person breathing again; or if the heart is not beating, cardio pulmonary resuscitation (CPR) is necessary.

Electrical shock occurs when a person comes in contact with two conductors of a circuit or when the body becomes part of the electrical circuit. In either case, a severe shock can cause the heart and lungs to stop functioning. Also, severe burns may occur where current enters and exits the body.

Prevention is the best medicine for electrical shock. Respect all voltages, have a knowledge of the principles of electricity, and follow safe work procedures. Do not take chances. All electricians should be encouraged to take a basic course in CPR (cardiopulmonary resuscitation) so they can aid a coworker in emergency situations.

Always make sure portable electric tools are in safe operating condition. Make sure there is a third wire on the plug for grounding in case of shorts. The fault current should flow through the third wire to ground instead of through the operator's body to ground if electric power tools are grounded and if an insulation breakdown occurs.
FIRST AID FOR ELECTRIC SHOCK:

Shock is a common occupational hazard associated with working with electricity. A person who has stopped breathing is not necessarily dead but is in immediate danger. Life is dependent on oxygen, which is breathed into the lungs and then carried by the blood to every body cell. Since body cells cannot store oxygen and since the blood can hold only a limited amount (and only for a short time), death will surely result from continued lack of breathing.

However, the heart may continue to beat for some time after breathing has stopped, and the blood may still be circulated to the body cells. Since the blood will, for a short time, contain a small supply of oxygen, the body cells will not die immediately. For a very few minutes, there is some chance that the person's life may be saved.

The process by which a person who has stopped breathing can be saved is called artificial ventilation (respiration). The purpose of artificial respiration is to force air out of the lungs and into the lungs, in rhythmic alternation, until natural breathing is reestablished. Records show that seven out of ten victims of electric shock were revived when artificial respiration was started in less than three minutes. After three minutes, the chances of revival decrease rapidly.

Artificial ventilation should be given only when the breathing has stopped. Do not give artificial ventilation to any person who is breathing naturally. You should not assume that an individual who is unconscious due to electrical shock has stopped breathing. To tell if someone suffering from an electrical shock is breathing, place your hands on the person's sides at the level of the lowest ribs. If the victim is breathing, you will usually be able to feel movement.

Once it has been determined that breathing has stopped, the person nearest the victim should start the artificial ventilation without delay and send others for assistance and medical aid. The only logical, permissible delay is that required to free the victim from contact with the electricity in the quickest, safest way. This step, while it must be taken quickly, must be done with great care; otherwise, there may be two victims instead of one.

In the case of portable electric tools, lights, appliances, equipment, or portable outlet extensions, the victim should be freed from contact with the electricity by turning off the supply switch or by removing the plug from its receptacle. If the switch or receptacle cannot be quickly located, the suspected electrical device may be pulled free of the victim. Other persons arriving on the scene must be clearly warned not to touch the suspected equipment until it is deenergized.

The injured person should be pulled free of contact with stationary equipment (such as a bus bar) if the equipment cannot be quickly deenergized or if the survival of others relies on the electricity and prevents immediate shutdown of the circuits. This can be done quickly and easily by carefully applying the following procedures:

1. Protect yourself with dry insulating material.
2. Use a dry board, belt, clothing, or other available nonconductive material to free the victim from electrical contact. Do NOT touch the victim until the source of electricity has been removed.
Once the victim has been removed from the electrical source, it should be determined whether the person is breathing. If the person is not breathing, a method of artificial respiration is used.

**CARDIOPULMONARY RESUSCITATION (CPR):**

Sometimes victims of electrical shock suffer cardiac arrest or heart stoppage as well as loss of breathing. Artificial ventilation alone is not enough in cases where the heart has stopped. A technique known as CPR has been developed to provide aid to a person who has stopped breathing and suffered a cardiac arrest. Because you are working with electricity, the risk of electrical shock is higher than in other occupations. You should, at the earliest opportunity, take a course to learn the latest techniques used in CPR. The techniques are relatively easy to learn and are taught in courses available through the American Red Cross.

*Note:* A heart that is in fibrillation cannot be restricted by closedchest cardiac massage. A special device called a defibrillator is available in some medical facilities and ambulance services.

Muscular contractions are so severe with 200 milliamperes and over that the heart is forcibly clamped during the shock. This clamping prevents the heart from going into ventricular fibrillation, making the victim's chances for survival better.

**Lockout/Tagout**

Electrical power must be removed when electrical equipment is inspected, serviced, or repaired. To ensure the safety of personnel working with the equipment, power is removed and the equipment must be locked out and tagged out.

Per OSHA standards, equipment is locked out and tagged out before any preventive maintenance or servicing is performed. Lockout is the process of removing the source of electrical power and installing a lock which prevents the power from being turned ON. Tagout is the process of placing a danger tag on the source of electrical power which indicates that the equipment may not be operated until the danger tag is removed. See Figure 1-23.

A danger tag has the same importance and purpose as a lock and is used alone only when a lock does not fit the disconnect device. The danger tag shall be attached at the disconnect device with a tag tie or equivalent and shall have space for the worker's name, craft, and other required information. A danger tag must withstand the elements and expected atmosphere for as long as the tag remains in place. A lockout/tagout is used when:

- Servicing electrical equipment that does not require power to be ON to perform the service
- Removing or bypassing a machine guard or other safety device
The possibility exists of being injured or caught in moving machinery
Clearing jammed equipment
The danger exists of being injured if equipment power is turned ON

![Figure 1-23.](image)

Equipment must be locked out and tagged out before preventive maintenance or servicing is performed.

Lockouts and tagouts do not by themselves remove power from a circuit. An approved procedure is followed when applying a lockout/tagout. Lockouts and tagouts are attached only after the equipment is turned OFF and tested to ensure that power is OFF. The lockout/tagout procedure is required for the safety of workers due to modern equipment hazards. OSHA provides a standard procedure for equipment lockout/tagout. OSHA's procedure is:

1. Prepare for machinery shutdown.
2. Machinery or equipment shutdown.
3. Machinery or equipment isolation.
4. Lockout or tagout application.
5. Release of stored energy.
6. Verification of isolation.

**Warning:** Personnel should consult OSHA Standard 29CFR1910.147 for industry standards on lockout/tagout.

A lockout/tagout shall not be removed by any person other than the person that installed it, except in an emergency. In an emergency, the lockout/tagout may be removed only by authorized personnel. The authorized personnel shall follow approved procedures. A list of company rules and procedures are given to any person that may use a lockout/tagout. Always remember:

- Use a lockout and tagout when possible
- Use a tagout when a lockout is impractical. A tagout is used alone only when a lock does not fit the disconnect device
- Use a multiple lockout when individual employee lockout of equipment is impractical
- Notify all employees affected before using a lockout/tagout
- Remove all power sources including primary and secondary
- Measure for voltage using a voltmeter to ensure that power is OFF

**Lockout Devices.** Lockout devices are lightweight enclosures that allow the lockout of standard control devices. Lockout devices are available in various shapes and sizes that allow for the lockout of ball valves, gate valves, and electrical equipment such as plugs, disconnects, etc.

Lockout devices resist chemicals, cracking, abrasion, and temperature changes. They are available in colors to match ANSI pipe colors. Lockout devices are sized to fit standard industry control device sizes. See Figure 1-24.

![Image](image.png)

**Figure 1-24.** Lockout devices are available in various shapes and sizes that allow for the lockout of standard control devices.

Locks used to lock out a device may be color coded and individually keyed. The locks are rust-resistant and are available with various size shackles.

Danger tags provide additional lockout and warning information. Various danger tags are available. Danger tags may include warnings such as "Do Not Start," "Do Not Operate," or may provide space to enter worker, date, and lockout reason information. Tag ties must be strong enough to prevent accidental removal and must be self-locking and nonreusable.

Lockout/tagout kits are also available. A lockout/tagout kit contains items required to comply with the OSHA lockout/tagout standards. Lockout/tagout kits contain reusable danger tags, tag ties, multiple lockouts, locks, magnetic signs, and information on lockout/tagout procedures. See Figure 1-25. Be sure the source of electricity remains open or disconnected when returning to work whenever leaving a job for any reason or whenever the job cannot be completed the same day.
Figure 1-25.

Lockout/tagout kits comply with OSHA lockout/tagout standards.

Clothing and Personal Protective Equipment:

Clothing should fit snugly to avoid danger of becoming entangled in moving machinery or creating a tripping or stumbling hazard. See Figure 1-26.

Figure 1-26.

Clothing should fit snugly to avoid danger of becoming entangled in moving machinery or creating a tripping or stumbling hazard.

Recommended safe work clothes include:

- Thick-soled work shoes for protection against sharp objects such as nails. Wear work shoes with safety toes if the job requires. Make sure the soles are oil resistant if the shoes are subject to oils and grease
- Rubber boots for damp locations
- A hat or cap. Wear an approved safety helmet (hard hat) if the job requires
Confine long hair or keep hair trimmed and avoid placing the head in close proximity to rotating machinery. Do not wear jewelry. Gold and silver are excellent conductors of electricity.

**FIRE SAFETY:**

The chance of fire is greatly decreased by good housekeeping. Keep rags containing oil, gasoline, alcohol, shellac, paint, varnish, or lacquer in a covered metal container. Keep debris in a designated area away from the building. Sound an alarm if a fire occurs. Alert all workers on the job and then call the fire department. After calling the fire department, make a reasonable effort to contain the fire.

**Fire Extinguishers:**

Always read instructions before using a fire extinguisher. Always use the correct fire extinguisher for the class of fire. See Figure 1-27. Fire extinguishers are normally red. Fire extinguishers may be located on a red background so they can be easily located.
Be ready to direct firefighters to the fire. Inform them of any special problems or conditions that exist, such as downed electrical wires or leaks in gas lines. Report any accumulations of rubbish or unsafe conditions that could be fire hazards. Also, if a portable tool bin is used on the job, a good practice is to store a CO2 extinguisher in it.

**In-Plant Training:**

A select group of personnel (if not all personnel) should be acquainted with all extinguisher types and sizes available in a plant or work area. Training should include a tour of the facility indicating special fire hazard operations.

In addition, it is helpful to periodically practice a dry run, discharging each type of extinguisher. Such practice is essential in learning how to activate each type, knowing the discharge ranges, realizing which types are affected by winds and drafts, familiarizing
oneself with discharge duration, and learning of any precautions to take as noted on the nameplate.

**Extinguisher Maintenance Tips:**

Inspect extinguishers at least once a month. It is common to find units that are missing, damaged, or used. Consider contracting for such a service. Contract for annual maintenance with a qualified service agency. Never attempt to make repairs to extinguishers. This is the chief cause of dangerous shell ruptures.

**Hazardous Locations:**

The use of electrical equipment in areas where explosion hazards are present can lead to an explosion and fire. This danger exists in the form of escaped flammable gases such as naphtha, benzene, propane, and others. Coal, grain, and other dust suspended in air can also cause an explosion. Article 500 of The Electrical Code National covers hazardous locations. Any hazardous location requires the maximum in safety and adherence to local, state, and federal guidelines and laws, as well as in-plant safety rules. Hazardous locations are indicated by Class, Division, and Group.

**To sum it all up...**

**Working with electricity can be dangerous. However, electricity can be safe if properly respected.**

**So be careful out there!**