Cal/OSHA Guide to
Electrical Safety

California Department of Industrial Relations

State of California CAL OSHA Department of Industrial Relations

Cal/OSHA Consultation Service
Research and Education
Division of Occupational Safety and Health

This guide is not meant to be either a substitute for or a legal interpretation of the occupational safety and health regulations. Readers shall refer directly to Title 8 of the California Code of Regulations and the Labor Code for detailed information regarding the regulation's scope, specifications, and exceptions and for other requirements that may be applicable to their operations.

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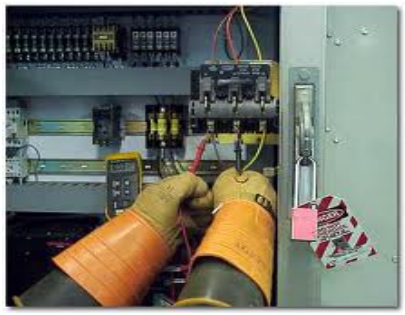


Why is electrical safety important?

Industry runs on electricity. Employees such as electrical engineers, electricians, electronic technicians, power line workers, and other employees work with electricity directly. Electricity is safe to use when adequate precautions are taken. However, when precautions are not taken electricity can be a killer. Hundreds of workers are either killed or disabled every year in California due to occupational accidents involving electric shock. This results in losses, including financial losses to both employees and employers.

As per the Bureau of Labor Statistics, 163 workers died from injuries from contact with electric current in 2010. 76 workers died from overhead power lines in the same year.

Source: US Department of Labor, Bureau of Labor Statistics
Fatal occupational injuries by event or exposure, 2009-2010

Electrocution From Overhead Power Line
A worker was electrocuted by overhead power line. The victim was carrying a metal ladder upright to his work van. The foreman and several co-workers verbally warned him about the overhead power line. However, several seconds later, the victim's ladder made contact with the overhead power line and the victim fell to the ground.

This booklet explains some of the most common electrical hazards and steps the law requires employers and employees to take in order to provide a safe and healthful workplace.

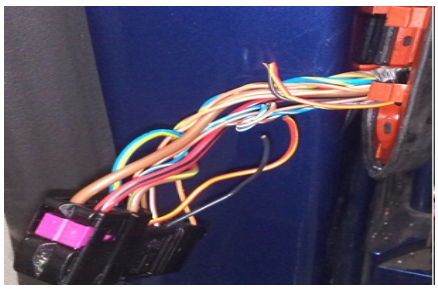
Common electrical hazards

With all electrical equipment operations, there is the threat of shock and/or electrocution. Electrical workers are potentially exposed to a variety of hazards such as electric shock (the most common hazard), arc flashes, falls, and thermal burns.

When you get an electric shock, current runs through your body because you have become a conductor. Electrocution occurs when enough current flows through your body to cause death from internal and/or external injuries.

The following are the most common electrical safety related hazards that pose a risk of being shocked and/or electrocuted.

- Exposed wires and energized parts



- Faulty/broken wiring or equipment
- Damaged outlets and missing covers
- Worn/damaged electrical cords

- Improperly used extension cords
- Overloaded outlets

- No warning signs
- Working under wet conditions

- Lack of or insufficient protective devices
- Unrestricted access to live exposed parts
- Lack of or insufficient personal protective equipment (PPE)
- Insufficient clearances around panels
- Lack of/improper lockout/tagout procedures
- Failure to maintain proper clearance from overhead lines
- Failure to follow manufacturer's instruction when using electrically powered equipment.

What do Cal/OSHA regulations require employers to do?

Cal/OSHA regulations on electrical safety require California employers to provide workers with a safe and healthful workplace. These regulations are contained in Title 8 of the California Code of Regulations (T8CCR). Most of the electrical health and safety regulations can be found in T8CCR, Chapter 4, Subchapter 5 in the Electrical Safety Orders, Sections 2299 through 2274 (http://www.dir.ca.gov/Title8/sub5.html).

Cal/OSHA regulations on electrical safety are grouped by electrical voltage. Regulations for low voltage are given in Sections 2299-2599 and the regulations for high voltage are given in Sections 2700-2989.

Section 1518 addresses safety requirements for the protection of yourself and others from electric shock in construction. Section 1541 addresses electrical safety requirements for excavation works including subsurface installations.

What can you do to protect yourself and others from electrical hazards?

Employees can prevent shocks and injuries/electrocution from electrical hazards by:

- Understanding electric shock and electrocution
- Recognizing potential hazards around electrical works
- Following Cal/OSHA requirements
- Maintaining clearances around panels
- Using proper protective devices
- Eliminating access to exposed energized parts

- Using proper PPE
- Using proper lockout/tagout procedures
- Maintaining proper clearance from overhead lines
- Following proper procedures for enclosed/underground electrical work
- Following manufacturer's instructions
- Following safe work practices

Understanding electric shock and electrocution

It is important to understand that shock can occur even without touching live electrical parts if there is enough voltage. For example, with electrical parts at 72,500 volts, you could get shocked even though you are a foot away from the live parts.

It is the rate of current flow through the body, more than anything else, which determines how serious the shock will be. As the current increases, effects on the body could range from a minor shock to paralysis of the lungs and heart.

How you are affected by electric shock depends on:

1. **The rate of flow of the current through your body**

   The rate of current flow (measured in amperes) depends on how good a conductor of electricity your body is. If you have dry hands and are standing on a nonconductive surface such as a rubber mat, your body will not be a good conductor and you may not even feel the shock. However, if you have wet hands, are perspiring or standing in water, your body will become a good conductor and you may get a severe shock or be killed.

2. **The length of time the current flows through your body**

   If the shock causes you to get attached to the electrical equipment, you could receive severe internal injury. The longer the contact, the greater the current flow, and hence the greater the shock.

3. **The path the current takes through your body**

   The most dangerous paths through the body are those where the current goes through vital organs. For example, current which runs from hand to hand, hand to head, or foot to hand (or head) and passes through vital organs can cause severe internal damage especially to the heart and lungs.

Recognizing potential hazards around electrical works

Electrical workers need to recognize/identify all of the potential hazards involving their work. They need to know that the chances of being electrocuted go up when working with high voltage and working around water, when sweating, or when not wearing/using proper protective clothing.

Before the work begins, it is important to identify and recognize if any of the hazardous conditions exist (including those listed above under "Common electrical hazards").

You can take precautionary measures against the hazard only when you know about it.

Following Cal/OSHA requirements

Following all of the requirements of Cal/OSHA including those from the Electrical

Safety Orders and Construction Safety Orders helps you in keeping the workplace safe and accident/injuries free. Because of the danger of electric shock, Cal/OSHA regulations specify that only qualified employees work on electrical equipment or systems.

A few of the most common Cal/OSHA requirements are briefly summarized below:

- No work is to be done on exposed, energized parts of equipment or systems until:
  - A responsible supervisor has determined that the work is to be done while the part or system is energized
  - Workers have been trained in the hazards involved and the specific techniques in their job
  - Personal protective equipment (including insulating gloves and eye protection) has been issued
  - Necessary barriers, barricades, tags or warning signs are in place
- You also need to always assume that circuits are energized unless you have locked them out and tested them to ensure they are de-energized. 2320.3

- When the work has been completed, the supervisor is responsible to ensure that all permanent barriers and covers are reinstalled.

- Before beginning construction work, the employer needs to know whether any part of an energized electric power circuit could make contact with employees or equipment. Employers must put legible markings and post warning signs as required to identify these circuits. 1518

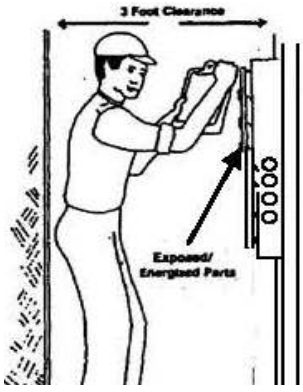
- Before beginning excavation work the approximate location of subsurface installations shall be determined. Excavation shall not commence until all of the requirements of 1541(b) are met.

Maintaining clearances around electric panels

Make sure there is sufficient clearance to operate and service electrical equipment safely. The chance that a worker may be shocked increases when he or she works on equipment with energized and exposed parts in a cramped space. Because of the danger posed to workers who work in cramped spaces, Cal/OSHA has established regulations setting minimum clear distances around electrical equipment rated at 600 volts or less. The minimum clear distances depend on:

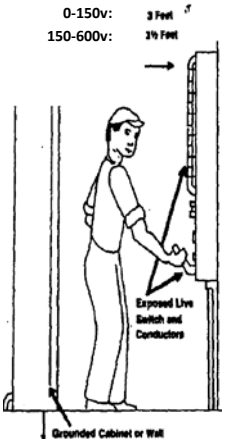
1. The voltage rating of the equipment
2. The nature of the work area

In this illustration, the worker is working on a switchboard, parts of which are exposed and energized. The minimum clearance under these conditions is 3 feet from the face of the switchboard to the opposing wall.



Wall not grounded. e.g. Plasterboard on Wood Studs

In this Illustration the worker can touch both an energized part of the switch board and the grounded wall. Current will flow through the worker to ground possibly causing a disabling Injury or death. To prevent this from happening, minimum clearances between the face of the switchboard and the opposite wall are to be 3 feet for voltages up to 150 and 3 1/2 feet for voltages between 151 and 600.



0-150v: 3 ft; 150-600v: 4 ft

In this illustration, there are exposed, energized parts on both sides of the work area. If the worker makes contact with both sets of switches, the worker can become part of a short circuit with potentially fatal amounts of current flowing through him. To avoid this, minimum clearances between the switches are to be 3 feet for voltages up to 150 and 4 feet for voltages between 151 and 600.

Motor control centers with live parts at relays and conductors exposed

Using proper protective devices

Using proper protective devices such as fuses and circuit breakers, grounding, and GFCI's is extremely important in all electrical works in order to eliminate the danger of shock and electrocution.

➢ Fuses and Circuit Breakers

Both fuses and circuit breakers are "over-current" devices used to prevent fires and damage to wiring and equipment caused by an excessive flow of current.

The current ratings of fuses and circuit breakers are so high (15 to 30 amperes for most residences) that they cannot protect against shock. When the current flow exceeds the rated levels, the fuse melts or the circuit breaker is tripped. In either case, the circuit is broken and current can no longer flow.

➢ Grounding

Electrical systems, equipment and tools that are not grounded or double-insulated are dangerous. Equipment is grounded to protect the operator against shock.

The ground conductor connects the metal case of a tool or equipment to ground. Under normal conditions, there is no current running through the ground conductor. However, if there is a fault in the tool or equipment the ground conductor takes the fault current safely to the ground.

If the ground conductor connectivity has been lost (such as a missing or broken ground prong on an electric cord), the worker's body might become the best path to the ground and the fault current would pass through the worker causing shock or electrocution.

If the ungrounded frame of a hand tool becomes energized, the quickest and easiest path for the current to take to ground is through the worker. Depending on the conditions, the effects of the shock will range from slight to fatal.

However, if the frame of the tool is grounded, the connection to ground provides an easy pathway for the current to follow. This does not mean that the worker will not receive a shock. A certain amount of current will flow through the worker. But the chances of serious injury or death are reduced because most of the current will follow the grounding wire.

➢ **Ground Fault Circuit Interrupters (GFCI)**

The GFCI is an inexpensive device which measures the difference in current levels going to and returning from a piece of electrical equipment. How does this device protect against shock?

If there is a ground fault in the equipment a certain amount of current may flow through the operator to ground. The GFCI senses this leakage, trips, and breaks the circuit within 1/40th of a second. Instead of possible electrocution, the worst effect on the operator will be a shock before the circuit is broken.

Workers who operate electrical equipment should be protected by GFCI's against the disabling and often fatal effects of ground faults.

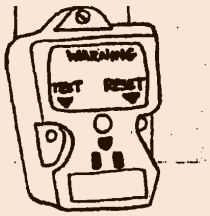
CAL/OSHA regulations require the use of GFCI's on all120 volt, AC, single phase, 15-20 ampere receptacles on construction sites when:

- the receptacles are used by workers
- the receptacles are not part of the permanent wiring of the structure

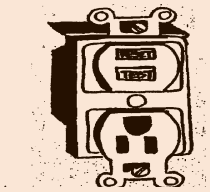
While GFCI's provide workers with the best protection from electric shock, employers may institute an Assured Equipment Grounding Conductor Program as an alternative to installing GFCI's.

There are three basic types of GFCI's, all of which have a test and reset button:

1. Portable adapter for existing wall outlets (convenient because it requires no installation and can be used on 2 as well as 3 outlets.

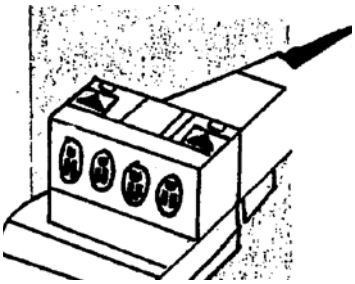


2. Replacement for wall outlets



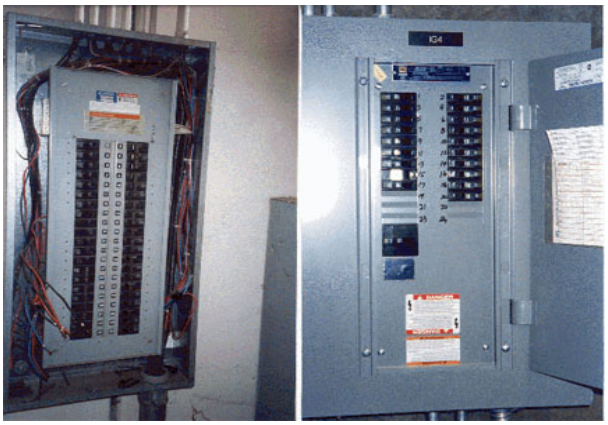
3. Circuit breaker type of GFCI

In addition, portable multiple outlet GFCI's are available for use on construction sites and industrial sites where heavy duty, multiple outlet GFCI's are required.



Heavy Duty GFCI

Eliminating access to exposed energized parts

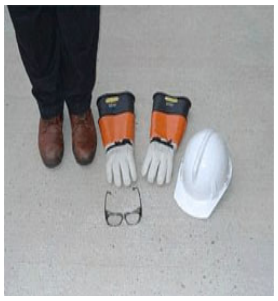


Covers on openings and electrical boxes restrict access to the exposed energized parts inside the openings and boxes.

All openings in boxes, enclosures or fittings shall be effectively guarded or closed. 2340.23

Missing covers and free access to exposed energized electrical parts are very common safety hazards in works involving electricity. However, these are easy to eliminate. Replacing missing covers in electrical panels and boxes, and covering the openings that have unrestricted access to exposed energized electrical parts save workers from the danger of shock and electrocution.

Using proper personal protective equipment (PPE)



Personal Protective Equipment (PPE) provides protection to workers from hazards. Depending on the job task to be performed, PPE for electrical workers generally includes safety glasses, flame-resistant (FR) face shields, hard hats, safety shoes, insulating (rubber) gloves with leather protectors, insulating sleeves, and FR clothing.

Additional PPE, such as fall protection equipment, respirators, chemical-resistant or cut-resistant gloves, and chaps, may be needed, depending on the potential hazard in the job.

Using proper lockout/tagout procedures

Many occupational Injuries and deaths occur during the cleaning, adjusting, and servicing of machinery. Here's why:

A machine needs servicing. The worker disconnects the machine from the power source and begins to service the machine. Has the worker taken the necessary precautions to prevent an accident? No. In a few minutes another worker comes by and reconnects the machine to the power source. The servicing worker may be injured by electric shock or may be caught in the moving parts of the machine.

When you have to do maintenance work on a machine, take these four steps to protect yourself and your coworkers from Injury:

1. De-energize the machine. Positively disconnect it from the power source. If there is more than one source of power, disconnect them all.
2. **Lock out** the disconnect switches. You must be given a lock and key for each disconnect before you begin working on the machine.

3. Tag the disconnect switches. Get tags or accident prevention signs from your supervisor.
4. Test the machine to make sure it won't start.
5. Keep the key with you.

Each worker who works on the machine must lock out and tag the power disconnect. **Never assume that the machine you are working on has been disconnected and locked out unless you have done it yourself.**

Maintain clearance from overhead lines

High voltage transmission and distribution lines carry a lot of energy or power and if accidently touched can be fatal.

Since they use equipment that can reach high farm workers and construction workers must be concerned with the hazards posed by high voltage overhead lines. Each year, workers who accidentally make contact with these lines are killed and disabled.

What precautions can you take to avoid this kind of accident?

Cal/OSHA Safety order 2946(b)(4) prohibits the storage of irrigation pipe or any other materials or equipment near high voltage overhead lines it they are long enough to reach the lines. With some exceptions, work done over “live” overhead lines is against the law. Workers should never get themselves or any tools or equipment within 10 feet of lines carrying between 600 - 50,000 volts.

Do not store tools, machinery, or equipment near "live" high voltage overhead lines if it is possible for them to come within the minimum clearance distance when they are being moved or used.

When you are using boom-type lifting or hoisting equipment, the minimum clearance is 10 feet from overhead lines carrying between 600 - 50,000 volts except when the equipment is in transit with the boom lowered and no load attached when the minimum clearance must be 6 feet. Post a warning sign on the equipment in clear view of the operator which says:

UNLAWFUL TO OPERATE THIS EQUIPMENT WITHIN 10 FEET OF HIGH VOLTAGE LINES OF 50,000 VOLTS OR LESS

If you don't know if a line is "live", assume that it is until whoever owns or operates the line verifies that the power is not on. If you are working near a "dead" line, make sure that it is clearly grounded at the work site.

Note:
A grounded line has a grounding wire clamped to it with the other end clamped to the structure or to a grounding rod.

Following proper procedures for enclosed/underground electrical work

Performing electrical work in enclosed areas including underground electrical vaults can be dangerous and fatal if work is not done properly.

When work is being done in an enclosed space, including underground electrical installations, an attendant trained in first aid, CPR, and rescue procedures is required to be above the hole and maintain communication with the worker(s) in the hole.

Workers may not enter any enclosed space including underground electrical vaults while the space contains a hazardous atmosphere. Before removing a cover, the enclosed space must be checked for indications of potential problems (for example, heat or pressure from a faulted cable), and a guardrail or barrier must be set up around the opening to

prevent objects from falling or being dropped into the space. After the cover is removed for entry, the atmosphere in the enclosed space must be tested for oxygen and flammable gases or vapors.

If a worker is working alone, the worker can enter a manhole briefly to inspect, perform housekeeping, and take readings as long as the worker is protected from any electrical and or physical hazards. However, attendants covered by the enclosed space requirements or permit-required confined space provisions are not permitted to enter a manhole.

All cables to be worked on need to be identified by electrical means unless their identity is obvious. Any energized cable that needs to be moved should be inspected for defects.

Following the manufacturer's instructions

Electrically powered equipment is used daily by most workers. Power tools, metal and woodworking machines, restaurant equipment, computers and many other types of electrical equipment are found in the workplace. Failure to use the equipment correctly can create hazards to employees. Generally, there are instructions from the manufacturers on the use and maintenance of each piece of equipment. Workers need to follow the instructions while using and maintaining the equipment in order to work safely.

Manufacturers typically refer to industrial standards such as ANSI, etc. Electrical workers need to have an understanding of their job related standards and follow the standards closely.

Following safe work practices

Workers also need to follow industry safe practices on how to work safely in jobs involving electrical works. The following list includes some of the common safe practices:

- Use a checklist to make sure that everything is OK and safe before starting work.
- Inspect tools, equipment and electrical fittings for damage or wear prior to each use. Repair or replace damaged equipment immediately.
- Use cords or equipment that are rated for the level of amperage or wattage that you are using.
- Do not use outlets or cords that have exposed wiring.
- Do not use power tools with the guards removed.
- Remember that the risk of electric shock is greater in areas that are wet or damp. Take proper caution.
- Check power cords and plugs daily. Discard if worn or damaged.

- Replace broken 3-prong plugs and make sure the third prong is properly grounded.
- Never use extension cords as permanent wiring.
- Do not plug several power cords into one outlet.
- Do not disconnect power supply by pulling or jerking the cord from the outlet.
- Always use the correct size fuse or breaker.
- Be aware that unusually warm or hot outlets may be a sign that unsafe wiring conditions exists.
- Use proper PPE for the electrical job.
- Always use ladders made of wood or other non-conductive materials when working with or near electricity or power lines.
- Keep equipment such as ladders, cranes, man-lifts, and scaffolds away from power lines and live electrical wires.

- Know where the breakers and boxes are located in case of an emergency.
- Label all circuit breakers and fuse boxes clearly.
- Do not block access to circuit breakers or fuse boxes.
- Assume that all overhead wires are energized and have high voltage.
- Never touch a fallen overhead power line.
- Before working at heights or carrying long objects, check the area for overhead power lines.
- Don't operate electrical equipment while you are standing in water.
- Don't repair electrical cords or equipment unless qualified and authorized.
- Have a qualified electrician inspect electrical equipment that has gotten wet before energizing it.
- Lockout and tagout when electrical equipment or lines are to be serviced, maintained or adjusted.
- Post enough warning signs to make people aware of the danger present.

- Use only grounded or double insulated power tools.
- Determine location of electrical power lines and cables before digging, drilling or similar works.

- Label all disconnecting switches and circuit breakers to indicate their use or equipment served.
- Always open disconnecting means before fuses are replaced.
- Use approved cabinets or enclosures to guard energized parts.
- Maintain access and working space around all electrical equipment as required.
- Close unused openings (including conduit knockouts) in electrical enclosures and fittings with appropriate covers, plugs or plates.

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Resources for Electrical Safety

Cal/OSHA's Electric Power Interruptions and Employee Safety
http://www.dir.ca.gov/dosh/dosh_publications/epies.pdf

Center of Excellence for Elecrtical Safety - Electrical Safety Resource Center
http://www.lanl.gov/safety/electrical/resources.shtml

NIOSH, Arc Flash Awareness
http://www.cdc.gov/niosh/mining/products/pdfs/afa.pdf

NIOSH, "Preventing Worker Deaths from Uncontrolled Release of Electrical, Mechanical, and Other Types of Hazardous Energy"

OSHA Quick Cards - Elecrtical Safety
http://www.osha.gov/Publications/electrical_safety.html

OSHA Construction eTool – Electrical Incidents
http://www.osha.gov/SLTC/etools/construction/electrical_incidents/mainpage.html

OSHA Health and Safety Topics – Electrical
http://www.osha.gov/SLTC/electrical/index.html

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