OSHA CONSTRUCTION eTOOL

HOME
ELECTRICAL
FALLS
STRUCK-BY
TRENCHING

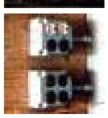
Electrical Incidents

USER GUIDE SCOPE S&H PROGRAM GLOSSARY BIBLIOGRAPHY CREDITS

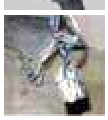
Electricity has become essential to modern life. Perhaps because it is such a familiar part of our surroundings, it often is not treated with the respect it deserves.

Safety and health programs must address electrical incidents and the variety of ways electricity becomes a hazard. In general, OSHA requires [1926.416(a)(1)] that employees not work near any part of an electrical power circuit unless protected. The following hazards are the most frequent cause of electrical injuries:


Contact with Power Lines


Lack of Ground-Fault Protection


Path to Ground Missing or Discontinuous


Equipment Not Used in Manner Prescribed


Improper Use of Extension and Flexible Cords

Background Information

- How Electricity Works
- How Shocks Occur
- How Electric Current Affects the Human Body
- Burns and Other Injuries

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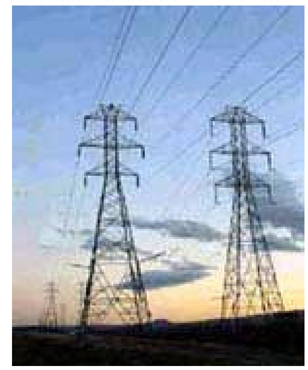
Contact with Power Lines

Am I In Danger?

Overhead and buried power lines at your site are especially hazardous because they carry extremely high voltage. Fatal electrocution is the main risk, but burns and falls from elevation are also hazards. Using tools and equipment that can contact power lines increases the risk.



Overhead power lines are un-insulated and can carry tens of thousands of volts, making them extremely dangerous to employees who work in their vicinity.

Examples of Equipment That Can Contact Power Lines

- Aluminum paint rollers
- Backhoes
- Concrete pumpers
- Cranes [*For more, see* Cranes and Derricks]
- Long-handled cement finishing floats
- Metal building materials
- Metal ladders
- Raised dump truck beds
- Scaffolds [*For more, see* 1926.451(f)(6)]

How Do I Avoid Hazards?

- Look for overhead power lines and buried power line indicators. Post warning signs.
- Contact utilities for buried power line locations.
- Stay at least 10 feet away from overhead power lines.
- Unless you know otherwise, assume that overhead lines are energized.
- De-energize and ground lines when working near them. Other protective measures include guarding or insulating the lines.
- Use non-conductive wood or fiberglass ladders when working near power lines.

Contact with Power Lines Kills Worker

Additional Information:

- OSHA Standard: 1926.416(a)
- Crane Fire! OSHA Construction eTool, (2000, August). A pictorial example of an actual crane fire incident.
- Overhead Power Lines - Don't Get Zapped!: Employer Kit. OSHA Region VII, (2000,

March 17). The Falls and Overhead Power Lines (OHPL) Task Force has developed this program to help in reducing electrocutions involving contact with overhead power lines in the construction industry.

- Electrical Safety: Safety and Health for Electrical Trades. NIOSH Publication No. 2002-123 (2002, January), 88 pages. 1,730 KB PDF version available.
- OSHA Assistance for the Electrical Contractors Industry. This page provides information about the hazards that electrical workers may experience as a part of their jobs

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Cranes and Derricks

Crane Fire! click here

Nearly 30% of the approximately 350 electrical-related fatalities that occur each year involve cranes and overhead power lines. Because of the voltages involved, overhead power lines present an extremely high risk of fatal electric shock. If contact occurs, proper safety procedures should be followed.

The danger posed by overhead power lines at the construction site is often compounded by other factors, such as uneven ground that could cause the crane to weave or bob into power lines, and windy conditions that can make the power lines sway, reducing clearance. To address these risks:

- Identify overhead power lines and mark safe routes where cranes must repeatedly travel.
- Operate the crane at a slower-than-normal speed in the vicinity of power lines.
- When working around overhead power lines, de-energize and ground them, or take other protective measures such as guarding or insulating the lines.
- If the power lines are not de-energized, operate cranes in the area ONLY if a safe minimum clearance is maintained.
- If maintaining safe clearance by visual means is difficult, designate a person to observe the clearance and to give immediate warning when the crane approaches the limits of safe clearance.
- All persons should keep well away from the crane whenever it is close to power lines.
- Do not contact the crane or its load until a signal person indicates that it is safe to do so.
- Use cage-type boom guards, insulating links, or proximity warning devices, but do not substitute for de-energizing and grounding lines, or maintaining safe clearance.
- While handling equipment or materials by boom near transmitter towers, de-energize the transmitter, or (for equipment) use equipment with an electrical ground connected directly to the upper structure of the boom, or (for materials) attach materials to ground jumper cables. Use nonconductive poles having large alligator clips or other similar protection to attach the ground to the cable load.

Minimum Clearances

While Working	
Line Voltage	**Distance**
50kV or below	10 feet
50kV and higher	10 feet + .4 inches for each 1kV above 50kV

In Transit	
Line Voltage	**Distance**
50kV and below	4 feet minimum
50kV to 345kV	10 feet
Over 345kV to 750kV	16 feet

Procedures To Follow If Contact Occurs

Contact between a crane and an energized line does not automatically lead to an electrical incident. To protect against electrical shock, the following procedures are recommended:

- The crane operator should remain inside the cab until the lines have been de-energized.
- All other personnel should keep away from the crane, ropes, and load, since the ground around the machine might be energized.
- The crane operator should try to remove the crane from contact by reversing direction.

Additional Information:

- OSHA Standard: 1926.550(a)(15)

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Crane Fire!

Below is an actual crane fire incident*.

Click on the image for an enlarged view.

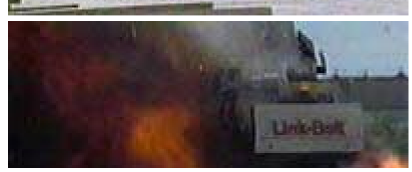
- **Crane contacts overhead power line during freeway construction.**

- **46,000 volts travel through the crane and beneath the concrete road.**

- **Eyewitness: "In a split second the whole crane, cab, everything exploded in flames."**

- **Fire Chief: "Electricity will find its path, and if you're in that path, it will injure you."**

- **Hydraulic fluid and**



underground insulation become fuel for the flames.

- **Slabs of concrete are lifted in the air.**

- **Debris rains down through the smoke and fire.**

- **The roadbed becomes fully engulfed.**

- **Fortunately, the crane operator escapes with only minor injuries.**

**Courtesy of KTVX News4Utah, Salt Lake City, UT*

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Scaffold Too Close To Power Line

Seven employees of a masonry company were erecting a brick wall from a tubular, welded-frame scaffold approximately 24 feet high. The scaffold had been constructed only 21 horizontal inches across from a 7,620-volt power line. A laborer carried a piece of wire reinforcement (10 feet long by 8 inches wide) along the top section of the scaffold and contacted the power line with it. The laborer, who was wearing leather gloves, received an electric shock and dropped the wire reinforcement, which fell across the power line and simultaneously contacted the metal rail of the scaffold, energizing the entire scaffold. A 20-year-old bricklayer standing on the work platform in contact with the main scaffold was electrocuted

Crane Boom Too Close To Power Line

A 56-year-old construction laborer was removing forms from a concrete wall poured several days earlier. As he removed the forms, he wrapped them with a length of cable called a choker, which was to be attached to a crane. The victim signaled the operator of the crane to extend the boom and lower the hoist cable. Both the operator and the victim failed to notice that the boom had contacted a 2,400-volt overhead power line. When the victim reached down to connect the choker to the hoist cable, he suddenly collapsed. Co-workers provided CPR, but were unable to revive the victim. Only after a rescue squad arrived about 4 minutes later did anyone realize that the crane was in contact with a power line -- a those present had assumed that the victim had suffered a heart attack.

Crane Boom Swung Into Power Line

A 29-year-old worker was electrocuted when he pushed a crane cable into a 7,200-volt power line. The victim was part of a crew that was constructing a concrete wall. Before work began, the company safety director made sure that insulated line hoses were placed over sections of the the power line near the jobsite and that a safety clearance zone was marked off for arriving cement trucks. After the wall was poured, one driver cleaned the loading chute of his cement truck with a water hose mounted on the truck. As he began to pull away, the crew supervisor yelled to him, asking if the crew could use his water hose to wash out their cement bucket suspended from the crane. The driver stopped the truck under the power line, and the victim, not realizing that the truck had moved, swung the boom to position the bucket behind the truck. When he grasped the handle of the bucket to pull it down, the crane cable came into contact with the overhead line. The victim provided a path to ground and was electrocuted.

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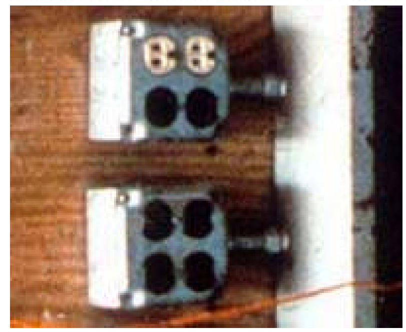
Lack of Ground-Fault Protection

Am I In Danger?

Due to the dynamic, rugged nature of construction work, normal use of electrical equipment at your site causes wear and tear that results in insulation breaks, short-circuits, and exposed wires [*for more, see* Flexible Cords *and* Power Tools]. If there is no ground-fault protection, these can cause a ground-fault that sends current through the worker's body, resulting in electrical burns, explosions, fire, or death.



These receptacles are not protected by a GFCI. If there is no AEGCP on this jobsite this would be a violation.

How Do I Avoid Hazards?

- Use ground-fault circuit interrupters (GFCIs) on all 120-volt, single-phase, 15- and 20-ampere receptacles, *or* have an assured equipment grounding conductor program (AEGCP).
- Follow manufacturers' recommended testing procedure to insure GFCI is working correctly.
- Use double-insulated tools and equipment, distinctively marked.
- Use tools and equipment according to the instructions included in their listing, labeling or certification.
- Visually inspect all electrical equipment before use. Remove from service any equipment with frayed cords, missing ground prongs, cracked tool casings, etc. Apply a warning tag to any defective tool and do not use it until the problem has been corrected.

SAFETY BULLETIN

Lack of GFCI Spells Death for Construction Worker

Additional Information:

- OSHA Standard: 1926.404(b)(1)(i)
- Electrical Safety: Safety and Health for Electrical Trades. NIOSH Publication No. 2002-123 (2002, January), 88 pages. 1,730 KB PDF version available.
- OSHA Assistance for the Electrical Contractors Industry. This page provides information about the hazards that electrical workers may experience as a part of their jobs.

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Ground-Fault Circuit Interrupters (GFCI)

A ground-fault occurs when there is a break in the low-resistance grounding path from a tool or electrical system. The electrical current may then take an alternative path to the ground through the user, resulting in serious injuries or death. The ground-fault circuit interrupter, or GFCI, is a fast-acting circuit breaker designed to shut off electric power in the event of a ground-fault within as little as 1/40 of a second. It works by comparing the amount of current *going to* and *returning from* equipment along the circuit conductors. When the amount *going* differs from the amount *returning* by approximately 5 milliamperes, the GFCI interrupts the current.

Figure 1: GFCI
View animation of this image

The GFCI is rated to trip quickly enough to prevent an electrical incident. If it is properly installed and maintained, this will happen as soon as the faulty tool is plugged in. If the grounding conductor is not intact or of low-impedance, the GFCI may not trip until a person provides a path. In this case, the person will receive a shock, but the GFCI should trip so quickly that the shock will not be harmful.

The GFCI will *not* protect you from line contact hazards (i.e. a person holding two "hot" wires, a hot and a neutral wire in each hand, or contacting an overhead power line). However, it protects against the most common form of electrical shock hazard, the ground-fault. It also protects against fires, overheating, and destruction of wire insulation.

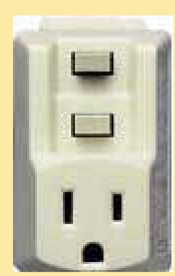
For construction applications, there are several types of GFCIs available, with some variations:

Receptacle Type

- The Receptacle Type incorporates a GFCI device within one or more receptacle outlets. Such devices are becoming popular because of their low cost.

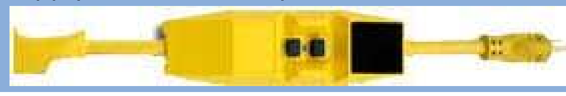
Portable Type

- Portable Type GFCIs come in several styles, all designed for easy transport. Some are designed to plug into existing non-GFCI outlets, or connect with a cord and plug arrangement. The portable type also incorporates a no-voltage release device that will disconnect power to the outlets if any supply conductor is open. Units approved for outdoor use will be in enclosures suitable for the environment. If exposed to rain, they must be listed as waterproof.



Cord-Connected Type

- The Cord-Connected Type of GFCI is an attachment plug incorporating the GFCI module. It protects the cord and any equipment attached to the cord. The attachment plug has a non-standard appearance with test and reset buttons. Like the portable type, it incorporates a no-voltage release device that will disconnect power to the load if any supply conductor is open.



Because GFCIs are so complex, they require testing on a regular basis. Test permanently wired devices monthly, and portable-type GFCIs before each use. All GFCIs have a built-in test circuit, with test and reset buttons, that triggers an artificial ground-fault to verify protection. Ground-fault protection, such as GFCIs provide, is required by OSHA in *addition* to (not as a substitute for) general grounding requirements.

Additional Information:

- OSHA Standard: 1926.404(b)(1)(ii)
- Electrical Safety: Safety and Health for Electrical Trades. NIOSH Publication No. 2002-123 (2002, January), 88 pages. 1,730 KB PDF version available.

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Assured Equipment Grounding Conductor Program (AEGCP)

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If an Assured Equipment Grounding Conductor Program (AEGCP) is used in place of GFCIs for ground-fault protection, the following minimum requirements apply, though additional tests or procedures are encouraged:

- Keep a written description of the program at the jobsite. Outline specific procedures for the required equipment inspections, tests, and test schedule, and make them available to OSHA and to affected persons *upon demand*.
- Designate one or more competent persons to implement the program. OSHA defines a *competent person* as someone who is a) qualified to identify hazards, and b) authorized to take prompt corrective measures.
- Visually inspect all cord sets, attachment caps, plugs and receptacles, and any equipment connected by cord and plug, *before use each day*. If you see any external damage, such as deformed or missing pins, damaged insulation, etc., or discover internal damage, take the equipment out of use until it is repaired.
- Perform two OSHA-required tests on all electrical equipment: a continuity test, and a terminal connection test. Tests are required:
  - Before first use.
  - After any repairs, and before placing back in service.
  - After suspected damage, and before returning to use.
  - Every 3 months *[see 1926.404(b)(1)(iii)(E)(4) for exceptions].*
- Maintain a written record of the required tests, identifying all equipment that passed the test and the last date it was tested (or the testing interval). Like the program description, make it available to OSHA inspectors and affected persons *upon demand.*

Additional Information:

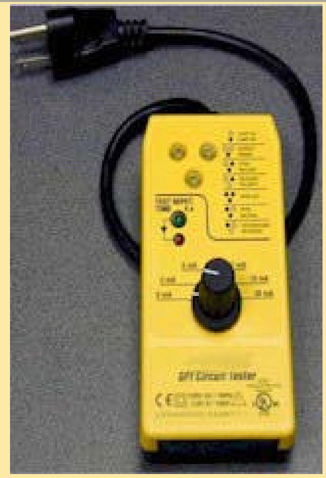
- OSHA Standard: 1926.404(b)(1)(iii)
- Electrical Safety: Safety and Health for Electrical Trades. NIOSH Publication No. 2002-123 (2002, January), 88 pages. 1,730 KB PDF version available.

Continuity Test

The continuity test ensures that the equipment grounding conductor is electrically continuous. Perform this test on all cord sets, receptacles that are not part of a building or structure's permanent wiring, and cord- and plug-connected equipment required to be grounded. Use a simple continuity tester, such as a lamp and battery, bell and battery, an ohmmeter, or a receptacle tester.

Terminal Connection Test

The terminal connection test ensures that the equipment grounding conductor is connected to its proper terminal. Perform this test with the same equipment used in the first test.



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No GFCI

A journeyman HVAC worker was installing metal duct work using a double-insulated drill connected to a drop light cord. Power was supplied through two extension cords from a nearby residence. The individual's perspiration-soaked clothing/body contacted bare exposed conductors on one of the cords, causing an electrocution. No GFCI's were used. Additionally, the ground prongs were missing from the two cords.

OSHA CONSTRUCTION eTOOL

Electrical Incidents: Path to Ground Missing or Discontinuous

Am I In Danger?

If the power supply to the electrical equipment at your site is not grounded or the path has been broken, fault current may travel through a worker's body, causing electrical burns or death [*for more see,* Flexible Cords *and* Power Tools]. Even when the power system is properly grounded, electrical equipment can instantly change from safe to hazardous because of extreme conditions and rough treatment.

Removing the ground pin from a plug to fit an ungrounded outlet not only means your work area is unsafe, but makes the cord unfit for future work where there is grounding.

How Do I Avoid Hazards?

- Ground all power supply systems, electrical circuits, and electrical equipment.
- Frequently inspect electrical systems to insure that the path to ground is continuous.
- Visually inspect all electrical equipment before use. Take any defective equipment out of service.
- Do not remove ground prongs from cord- and plug-connected equipment or extension cords.
- Use double-insulated tools.
- Ground all exposed metal parts of equipment.
- Ground metal parts of the following non-electrical equipment, as specified by the OSHA standard [1926.404(f)(7)(v)]:
  - Frames and tracks of electrically operated cranes.
  - Frames of non-electrically driven elevator cars to which electric conductors are attached.
  - Hand-operated metal shifting ropes or cables of electric elevators.
  - Metal partitions, grill work, and similar metal enclosures around equipment of over 1kV between conductors.

Construction Worker Dies Using Ungrounded Power Saw

Additional Information:

- OSHA Standard: 1926.404(b)(1)(i)
- Electrical Safety: Safety and Health for Electrical Trades. NIOSH Publication No. 2002-

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Grounding

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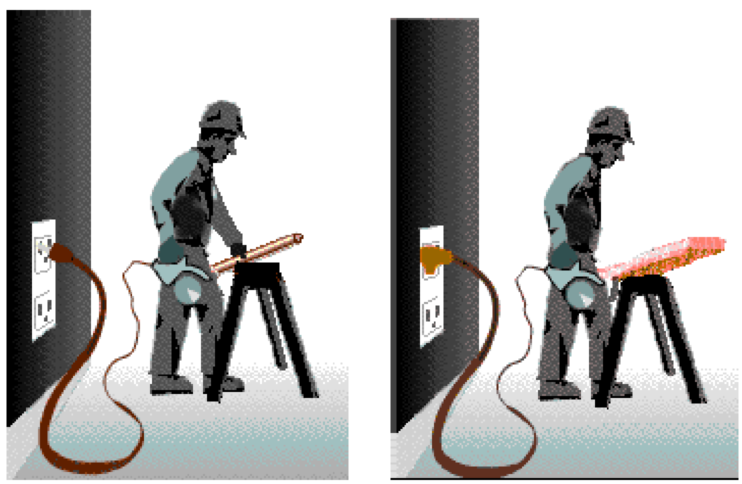
The term "ground" refers to a conductive body, usually the earth. "Grounding" a tool or electrical system means intentionally creating a low-resistance path to the earth. When properly done, current from a short or from lightning follows this path, thus preventing the buildup of voltages that would otherwise result in electrical shock, injury and even death.



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There are two kinds of grounds; both are required by the OSHA construction standard:

- System or Service Ground: In this type of ground, a wire called "the neutral conductor" is grounded at the transformer, and again at the service entrance to the building. This is primarily designed to protect machines, tools, and insulation against damage.
- Equipment Ground: This is intended to offer enhanced protection to the workers themselves. If a malfunction causes the metal frame of a tool to become energized, the equipment ground provides another path for the current to flow through the tool to the ground.

There is one disadvantage to grounding: a break in the grounding system may occur without the user's knowledge. Using a ground-fault circuit interrupter (GFCI) is one way of overcoming grounding deficiencies.

Summary of Grounding Requirements

- Ground all electrical systems [see 1926.404(f)(1)(v) for exceptions].
- The path to ground from circuits, equipment, and enclosures must be permanent and continuous.

- Ground all supports and enclosures for conductors [see 1926.404(f)(7)(i) for exceptions].
- Ground all metal enclosures for service equipment.
- Ground all exposed, non-current-carrying metal parts of fixed equipment [see 1926.404(f)(7)(iii) for exceptions].
- Ground exposed, non-current-carrying metal parts of tools and equipment connected by cord and plug [see 1926.404(f)(7)(iv) for exceptions].
- Ground the metal parts of the following non-electrical equipment:
    - Frames and tracks of electrically operated cranes.
    - Frames of non-electrically driven elevator cars to which electric conductors are attached.
    - Hand-operated metal shifting ropes or cables of electric elevators.
    - Metal partitions, grill work, and similar metal enclosures around equipment of over 1kV between conductors.

Methods of Grounding Equipment

- Ground all fixed equipment with an equipment grounding conductor that is in the same raceway, cable, or cord, or that runs with or encloses the circuit conductors (except for DC circuits only).
- Conductors used for grounding fixed or moveable equipment, including bonding conductors for assuring electrical continuity, must be able to safely carry any fault current that may be imposed on them.
- Electrodes must be free from nonconductive coatings, such as paint or enamel, and if practicable, must be embedded below permanent moisture level.
- Single electrodes which have a resistance to ground greater than 25 ohms must be augmented by one additional electrode installed no closer than 6 feet to the first electrode.
- For grounding of high voltage systems and circuits (1000 volts and over), refer to 1926.404(f)(11).

Additional Information:

- OSHA Standard: 1926.404(f)
- Electrical Safety: Safety and Health for Electrical Trades. NIOSH Publication No. 2002-123 (2002, January), 88 pages. 1,730 KB PDF version available.

Ground Wire Not Attached

A fan connected to a 120-volt electrical system via an extension cord provided ventilation for a worker performing a chipping operation from an aluminum stepladder. The insulation on the extension cord was cut through and exposed bare, energized conductors which made contact with the ladder. The ground wire was not attached on the male end of the cord's plug. When the energized conductor made contact with the ladder, the path to ground included the worker's body, resulting in death.

Adapter For 3-Prong Cord Not Grounded To Outlet

On May 27, 1986, two workers were using a 110-volt auger to install tie-down rods for a manufactured home. The auger has a one-quarter horsepower motor encased in a metal housing with two handles. One handle has a deadman's switch. Electricity to the auger was supplied by a series of 50-foot extension cords running to an adjacent property. Since the outlet at the adjacent property had no socket for a ground prong, the extension cords were plugged into the outlet using an adapter, but the ground wire of the adapter was not grounded. Two of the extension cords had no ground prongs, and some of them were repaired with electrical tape. The workers had removed their shirts and were sweating. One worker, holding the deadman's switch, received a shock from a ground fault in the auger and was knocked back from the machine. The auger then fell across the other worker, the 24-year-old victim. The first worker knocked the auger off the victim, but saw that the electric cord was wrapped around the victim's thigh. He yelled for his co-workers to disconnect the power, which they did. The workers administered CPR to the victim, but to no avail.

Short In Power Saw/Ungrounded Temporary Power Supply

On July 10, 1986, a 22-year-old carpenter was working at the construction site of large apartment complex, using a portable electric saw to construct the wooden framework of a laundry building. Electricity to operate portable power tools was supplied by a temporary service pole 50 feet away. The pole had not been inspected by the city and was not in compliance with code requirements (it was not grounded). The victim used two extension cords to supply power: a home made cord plugged into an ungrounded receptacle on the pole, and a UL-approved cord extending from the homemade cord to the saw. The accident site was wet; also, humidity was high and the victim was sweating. Reportedly, he was shocked throughout the morning, and he had replaced one of the extension cords in an effort to eliminate the shocks. The source of the shocks -- the saw -- was not replaced. As the victim climbed down a makeshift ladder, he shifted the saw from his right hand to his left, and was shocked. This caused him to fall from the ladder and land in a puddle of water, still holding the saw. Apparently, his hand contracted and he was "locked" to the saw. A co-worker disconnected the power cord to the saw, too late to save the victim.

Electrical Incidents: Equipment Not Used in Manner Prescribed

Am I In Danger?

If electrical equipment is used in ways for which it is not designed, you can no longer depend on safety features built in by the manufacturer. This may damage your equipment and cause employee injuries [*for more, see* Power Tools].

This "handy box" is being improperly used as an extension cord receptacle. It is made to be permanently mounted.

SAFETY BULLETIN

Construction Worker Dies

Common Examples of Misused Equipment

- Using multi-receptacle boxes designed to be *mounted* by fitting them with a power cord and placing them on the floor.
- Fabricating extension cords with ROMEX® wire.
- Using equipment outdoors that is labeled for use only in dry, indoor locations.
- Attaching ungrounded, two-prong adapter plugs to three-prong cords and tools.
- Using circuit breakers or fuses with the wrong rating for over-current protection, e.g. using a 30-amp breaker in a system with 15- or 20-amp receptacles. Protection is lost because it will not trip when the system's load has been exceeded.
- Using modified cords or tools, e.g., removing ground prongs, face plates, insulation, etc.
- Using cords or tools with worn insulation or exposed wires.

How Do I Avoid Hazards?

- Use only equipment that is approved to meet OSHA standards [1926.403(a)].
- Use all equipment according to the manufacturer's instructions [1926.403(b)(2)].
- Do not modify cords or use them incorrectly [*for more, see* Flexible Cords].
- Be sure equipment that has been shop fabricated or altered is in compliance.

Additional Information:

- OSHA Standard: 1926.403(b)(2)
- Electrical Safety: Safety and Health for Electrical Trades. NIOSH Publication No. 2002-123 (2002, January), 88 pages. 1,730 KB PDF version available.
- OSHA Assistance for the Electrical Contractors Industry. This page provides information about the hazards that electrical workers may experience as a part of their jobs.

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Power Tools

Because power tools are so common in construction, workers are constantly exposed to a variety of hazards. The very tool that makes their job easy and efficient may one day be the cause of a tragic accident. It is good to be reminded of common-sense safety practices.

Tool Safety Tips

- Never carry a tool by the cord.
- Never yank the cord to disconnect it from the receptacle.
- Keep cords away from heat, oil, and sharp edges (including the cutting surface of a power saw or drill).
- Disconnect tools when not in use, before servicing, and when changing accessories such as blades, bits, etc.
- Avoid accidental starting. Do not hold fingers on the switch button while carrying a plugged-in tool.
- Use gloves and appropriate safety footwear when using electric tools.
- Store electric tools in a dry place when not in use.
- Do not use electric tools in damp or wet locations unless they are approved for that purpose.
- Keep work areas well lighted when operating electric tools.
- Ensure that cords from electric tools do not present a tripping hazard.
- Remove all damaged portable electric tools from use and tag them: "Do Not Use."
- Use Double-Insulated Tools.

Specific Examples:

Double-Insulated Tools

- Hand-held tools manufactured with non-metallic cases are called *double-insulated*. If approved, they do not require grounding under the National Electrical Code. Although this design method reduces the risk of grounding deficiencies, a shock hazard can still exist.

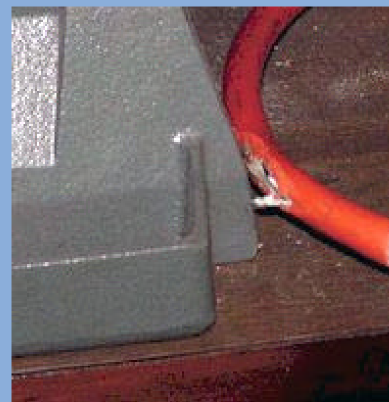
- Such tools are often used in areas where there is considerable moisture or wetness. Although the user is *insulated* from the electrical wiring components, water can still enter the tool's housing. Ordinary water is a conductor of electricity. If water contacts the energized parts inside the housing, it provides a path to the outside, bypassing the double insulation. When a person holding a hand tool under these conditions contacts another conductive surface, an electric shock occurs.

- If a power tool, even when double-insulated, is dropped into water, the employee should resist the initial human response to grab for the equipment without first disconnecting the power source.

Portable Tool Use with Extension Cords

- Another potential hazard is using extension cords with portable tools. In construction, these cords suffer a lot of wear and tear. Often, the damage is only to the insulation, exposing energized conductors. When a person handling the damaged cord contacts the exposed wires while holding a metal tool case or contacting a conductive surface, serious electrical shock can result, causing a fall, physical injury, or death.

- Since neither *insulation* nor *grounding* protects you from these conditions, use other protective measures. One acceptable method is a *ground-fault circuit interrupter* (GFCI).



Additional Information:

- OSHA Standard: 1926.302(a)

- Electrical Safety: Safety and Health for Electrical Trades. NIOSH Publication No. 2002-123 (2002, January), 88 pages. 1,730 KB PDF version available.

Occupational Safety & Health Administration
200 Constitution Avenue, NW
Washington, DC 20210

Damaged Extension Cord Leaves Arc Welder Ungrounded

A 29-year-old welder attempted to connect a portable arc welder to an electrical outlet using an extension cord. The power switch on the welder was already in the "on" position, and the female end of the extension cord, which was spring loaded, had apparently been dropped and broken. As a result, the ground prong of the welder plug did not insert into the ground terminal of the cord, so that as soon as a connection was made, the outside metal case of the welder became energized, electrocuting the victim. An examination revealed that the spring, cover plate, and part of the melamine casing were missing from the face of the female connector (the spring and some melamine fragments were found at the accident site). The victim was totally deaf in one ear and suffered diminished hearing in the other. He may have dropped the extension cord at the site and not heard the connector break.

Handling Damaged Extension Cord When Energized

A 19-year-old construction laborer was working with his foreman and another laborer to construct a waterfront bulkhead for a lakeside residence. Electricity for power tools was supplied from an exterior 120-volt, grounded AC receptacle located at the back of the residence. On the day of the incident, the victim plugged in a damaged extension cord and laid it out towards the bulkhead. There were no eyewitnesses to the accident, but evidence suggests that while the victim was handling the damaged and energized extension cord, he provided a "path to ground" and was electrocuted. The victim collapsed into the lake and sank 4-1/2 feet to the bottom.

Electrical Equipment In Poor Condition

An 18-year-old worker at a construction site was electrocuted when he touched a light fixture while descending from a scaffold for his afternoon break. The source of the electricity was apparently a short in a receptacle, but examination revealed that the electrical equipment used by the contractor was in such poor condition that it was impossible to make a certain determination of the source of the short. Extension cords had poor splices, no grounds, and reversed polarity. One hand drill was not grounded, and the other had no safety plate. Out of several possible scenarios, the most likely was contact between the exposed wires of an extension cord and a screw that protruded from the receptacle, which had its face plate removed. The light fixture, which served as a ground, was known to be faulty for at least 5 months before the incident.

Improper Modification of Plugs

An employee was texturing a wall using an air compressor. The plug of the compressor and an extension cord had been modified to fit a wall outlet for a common household clothes dryer (220 V). While attempting to unplug the compressor from the extension cord, the employee was fatally shocked. The modification of the plug was not an intended use or prescribed by the manufacturer.

Electrical Incidents: Improper Use of Extension and Flexible Cords

Am I In Danger?

The normal wear and tear on extension and flexible cords at your site can loosen or expose wires, creating hazardous conditions [*for more, see* Flexible Cords]. Cords that are not 3-wire type, not designed for hard-usage, or that have been modified, increase your risk of contacting electrical current.

These cords are improperly wired directly to the electrical circuit, are not protected by a GFCI, and are two-wire cords that are not grounded and not rated for hard- or extra-hard service.

SAFETY BULLETIN

Construction Worker Dies

How Do I Avoid Hazards?

- Use factory-assembled cord sets.
- Use only extension cords that are 3-wire type.
- Use only extension cords that are marked with a designation code for hard or extra-hard usage.
- Use only cords, connection devices, and fittings that are equipped with strain relief.
- Remove cords from receptacles by pulling on the plugs, not the cords.
- Continually audit cords on-site. Any cords found not to be marked for hard or extra-hard use, or which have been modified, must be taken out of service immediately.

Additional Information:

- OSHA Standard: 1926.405(g)(1)(iii)
- Electrical Safety: Safety and Health for Electrical Trades. NIOSH Publication No. 2002-123 (2002, January), 88 pages. 1,730 KB PDF version available.
- OSHA Assistance for the Electrical Contractors Industry. This page provides information about the hazards that electrical workers may experience as a part of their jobs.

Flexible Cords

With the wide use of power tools on construction sites, flexible extension cords often are necessary. Because they are exposed, flexible, and unsecured, they are more susceptible to damage than is fixed wiring. Hazards are created when cords, cord connectors, receptacles, and cord- and plug-connected equipment are improperly used and maintained.

Strain Relief [1926.405(g)(2)(iv)]

- To reduce hazards, flexible cords must connect to devices and to fittings in ways that prevent tension at joints and terminal screws. Flexible cords are finely stranded for flexibility, so straining a cord can cause the strands of one conductor to loosen from under terminal screws and touch another conductor.

Cord Damage [1926.405(a)(2)(ii)(I)]

- A flexible cord may be damaged by door or window edges, by staples and fastenings, by abrasion from adjacent materials, or simply by aging. If the electrical conductors become exposed, there is a danger of shocks, burns, or fire.

Durability [1926.405(a)(2)(ii)(J)]

- The OSHA construction standard requires flexible cords to be rated for hard or extra-hard usage. These ratings are derived from the National Electrical Code, and are required to be indelibly marked approximately every foot along the length of the cord. Examples of these codes are: S, ST, SO, and STO for hard service, and SJ, SJO, SJT, and SJTO for junior hard service.

Grounding [1926.405(a)(2)(ii)(C)]

- Extension cords must be 3-wire type so they may be grounded, and to permit grounding of any tools or equipment connected to them.

Wet Conditions [1926.405(j)(1)(v)]

- When a cord connector is wet, electric current can leak to the equipment grounding conductor, and to humans who pick up that connector if they provide a path to ground. Such leakage can occur not just on the face of the connector, but at any wetted portion. Limit exposure of connectors and tools to excessive moisture by using watertight or sealable connectors.

Additional Information:

- OSHA Standard: 1926.405(g)
- Electrical Safety: Safety and Health for Electrical Trades. NIOSH Publication No. 2002-123 (2002, January), 88 pages. 1,730 KB PDF version available.

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Flexible Cord Not 3-Wire, Hard Service Variety

A worker received a fatal shock when he was cutting drywall with a metal casing router. The router's 3-wire power cord was spliced to a 2-wire cord and plug set which was not rated for hard service. A fault occurred, and with no grounding and no GFCI protection, the worker was electrocuted.

No Strain Relief

A worker was operating a ¾" electric chisel when an electrical fault occurred in the casing of the tool, causing him to be fatally electrocuted. An OSHA inspection revealed that the tool's original power cord had been replaced with a flat cord, which was not designated for hard service, and that strain relief was not provided at the point where the cord entered the tool. Additionally, the ground prong was missing and there was no GFCI protection.

How Electricity Works

Operating an electrical switch is like turning on a water faucet. Behind the faucet (or switch) there is a source of water (or electricity), 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. The switch's electrical source is a power generating station. A generator provides the pressure for the electrical current to travel through electrical conductors, or wires.

Three factors determine the resistance of a substance to the flow of electricity.

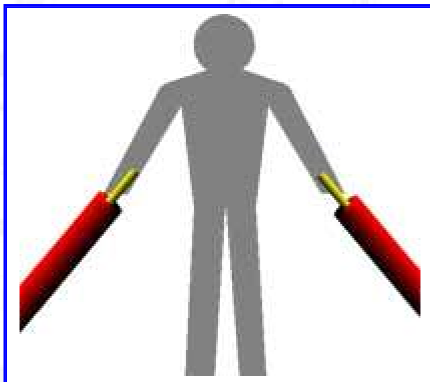
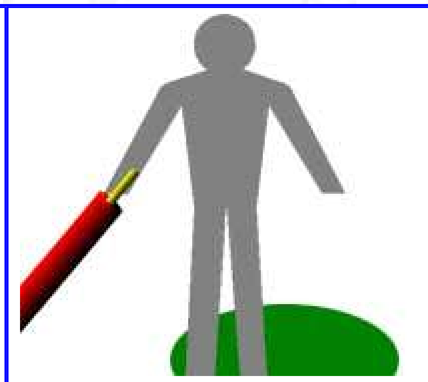
- What it is made of.
- Its size.
- Its temperature.

Substances with very little resistance to the flow of electrical current are called *conductors*. Examples are metals. Substances with such a high resistance that they can be used to prevent the flow of electrical current are called *insulators*. Examples are glass, porcelain, plastic, and dry wood.

Pure water is a poor conductor of electricity, but small amounts of impurities, such as salt and acid (perspiration contains both), make it a ready conductor. Therefore, although dry wood is a poor conductor, when saturated with water it becomes a ready conductor. The same is true of human skin. When skin is dry, it is a poor conductor of electrical current. When it is moist, it readily conducts electricity. Use *extreme caution* when working with electricity where there is water in the environment or on the skin.

How Shocks Occur

Electricity travels in closed circuits, normally through a conductor. Shock results when the body becomes part of the electrical circuit; current enters the body at one point and leaves at another. Typically, shock occurs when a person contacts:

		
Both wires of an energized circuit.	One wire of an energized circuit and the ground.	A metallic part in contact with an energized wire while the person is also in contact with the ground.

Metallic parts of electric tools and machines can become energized if there is a break in the insulation of their wiring. A low-resistance wire between the metallic case of the tool/machine and the ground – an equipment grounding conductor – provides a path for the unwanted current to pass directly to the ground. This greatly reduces the amount of current passing through the body of the person in contact with the tool or machine. Properly installed, the grounding conductor provides protection from electric shock.

Close this window

How Electrical Current Affects the Human Body

Three primary factors affect the severity of the shock a person receives when he or she is a part of an electrical circuit:

- Amount of current flowing through the body (measured in *amperes*).
- Path of the current through the body.
- Length of time the body is in the circuit.

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

- The voltage of the current.
- The presence of moisture in the environment.
- The phase of the heart cycle when the shock occurs.
- The general health of the person prior to the shock.

Effects can range from a barely perceptible tingle to severe burns and immediate cardiac arrest. Although it is not known the exact injuries that result from any given amperage, the following table demonstrates this general relationship for a 60-cycle, hand-to-foot shock of one second's duration:

Current level (in milliamperes)	Probable effect on human body
1 mA	Perception level. Slight tingling sensation. Still dangerous under certain conditions.
5 mA	Slight shock felt; not painful but disturbing. Average individual can let go. However, strong involuntary reactions to shocks in this range may lead to injuries.
6-30 mA	Painful shock, muscular control is lost. This is called the freezing current or "let-go" range.
50-150 mA	Extreme pain, respiratory arrest, severe muscular contractions. Individual cannot let go. Death is possible.
1000-4300 mA	Ventricular fibrillation (the rhythmic pumping action of the heart ceases.) Muscular contraction and nerve damage occur. Death is most likely.
10,000 mA	Cardiac arrest, severe burns and probable death.

Wet conditions are common during low-voltage electrocutions. Under dry conditions, human skin is very resistant. Wet skin dramatically drops the body's resistance.

Dry Conditions: Current = Volts/Ohms = 120/100,000 = 1mA
a barely perceptible level of current

Wet conditions: Current = Volts/Ohms = 120/1,000 = 120mA
sufficient current to cause ventricular fibrillation

Back >

If the extensor muscles are excited by the shock, the person may be thrown away from the circuit. Often, this can result in a fall from elevation that kills a victim even when electrocution does not.

Back >

When muscular contraction caused by stimulation does not allow the victim to free himself from the circuit, even relatively low voltages can be extremely dangerous, because the degree of injury increases with the length of time the body is in the circuit.

LOW VOLTAGE DOES NOT IMPLY LOW HAZARD!

100mA for 3 seconds = 900mA for .03 seconds
in causing fibrillation

Back >

Note that a difference of less than 100 milliamperes exists between a current that is barely perceptible and one that can kill.

Back >

High voltage electrical energy greatly reduces the body's resistance by quickly breaking down human skin. Once the skin is punctured, the lowered resistance results in massive current flow.

Ohm's law is used to demonstrate the action.
At 1,000 volts, Current = Volts/Ohms = 1,000/500 = 2 Amps
which can cause cardiac standstill and serious damage to internal organs.

Back >

Burns and Other Injuries

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

Burns

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

- Electrical Burns cause tissue damage, and are the result of heat generated by the flow of electric current through the body. Electrical burns are one of the most serious injuries you can receive and should be given immediate attention.

  Photo Example

  Warning: Please be advised these images are of a graphic nature.

- High temperatures near the body produced by an electric arc or explosion cause Arc or Flash Burns. They should also be attended to promptly.

  Photo Example

  Warning: Please be advised these images are of a graphic nature.

- Thermal Contact Burns occur when skin comes in contact with overheated electric equipment, or when clothing is ignited in an electrical incident.

  Photo Example

  Warning: Please be advised these images are of a graphic nature.

Internal Injuries

Excessive electricity flowing through the human body can cause serious damage to internal organs. Resulting medical problems include hemorrhage (or internal bleeding), tissue destruction, and nerve or muscle damage. These internal injuries may not be immediately apparent to the victim or observers; however, left untreated, they can result in death.

Photo Example

Warning: Please be advised these images are of a graphic nature.

Involuntary Muscle Contraction

Normal muscle contraction is caused by very small amounts of electricity that are created within our bodies. Muscles violently contract when stimulated by excessive amounts of electricity. These involuntary contractions can damage muscles, tendons, and ligaments, and may even cause broken bones. If the victim is holding an electrocuting object, hand muscles may contract, making it impossible to drop the object and prolonging contact with the current. Also, injury or death may result when violent muscle contractions cause workers to fall from ladders and scaffolds or inadvertently strike other objects.

Photo Example

Warning: Please be advised these images are of a graphic nature.

Photo Examples of
Burns and Other Injuries

Electrical Burns

- **Entrance Wound:** High resistance of skin transforms electrical energy into heat, which produces burns around the entrance point (dark spot in center of wound). This man was lucky; the current narrowly missed his spinal cord.

- **Exit Wound:** Current flows through the body from the entrance point, until finally exiting where the body is closest to the ground. This foot suffered massive internal injuries which weren't readily visible, and had to be amputated a few days later.

Arc or Flash Burns

- This man was near a power box when an electrical explosion occurred. Though he did not touch the box, electricity *arced* through the air and entered his body. The current was drawn to his armpits because perspiration is very conductive.

Thermal Contact Burns

- Current exited this man at his knees, catching his clothing on fire and burning his upper leg.

Internal Injuries

- This worker was shocked by a tool he was holding. The entrance wound and thermal burns from the overheated tool are apparent

- Same hand a few days later, when massive subcutaneous tissue damage had caused severe swelling (swelling usually peaks 24-72 hours after electrical shock). To relieve pressure , which would have damaged nerves and blood vessels, the skin on the arm was cut open.

Involuntary Muscle Contraction

- This worker fell and grabbed a powerline to catch himself. The resulting electric shock mummified his first two fingers, which had to be removed. The acute angle of the wrist was caused by burning of the tendons, which contracted, drawing the hand with them.