OSHA CONSTRUCTION eTOOL

Preventing Fatalities

Despite its high fatality rate, construction can be a safe occupation when workers are aware of the hazards, and use an effective Safety and Health Program. This eTool* will help you identify and control the hazards that commonly cause the most serious construction injuries. They are grouped under the following headings:

- Electrical Incidents
- Falls
- Struck-by
- Trenching and Excavation

*eTools are "stand-alone," interactive, Web-based training tools that provide guidance information for the development of a comprehensive safety and health program. Therefore, they include elements that go beyond specific OSHA mandates, such as recommendations for good industry practice. As indicated in the disclaimer, eTools do not create new OSHA requirements.
*(Best Viewed at 800 × 600. See User Guide).

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Electrical Incidents

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:

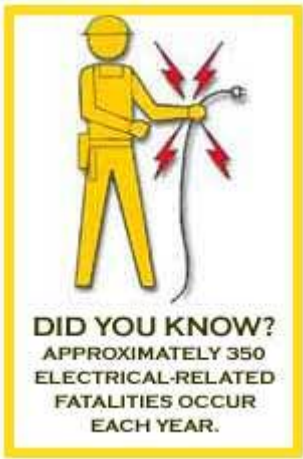
Contact with Power Lines

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.

SAFETY BULLETIN

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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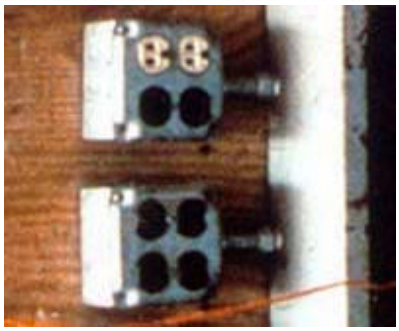
Lack of Ground-Fault Protection

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)

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-

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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Grounding

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.

View animation of these images

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.

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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.

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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.
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OSHA CONSTRUCTION eTOOL

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:

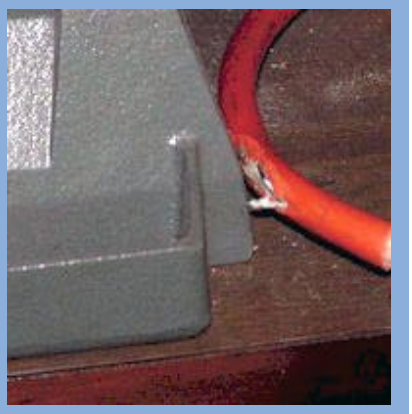
Double-Insulated Tools

- 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.

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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.

OSHA CONSTRUCTION eTOOL

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.

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.

SAFETY BULLETIN

Construction Worker Dies

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.

OSHA CONSTRUCTION eTOOL

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.

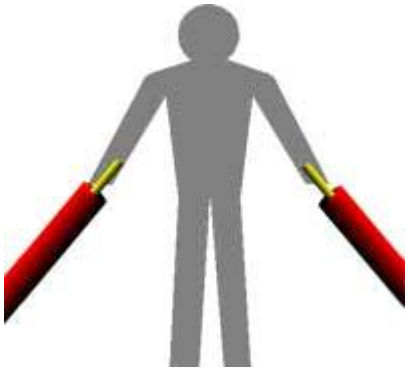
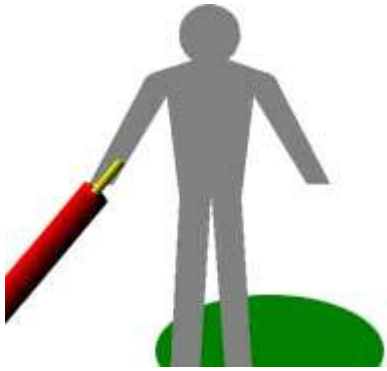
- What it is made of.
- Its size.
- Its temperature.

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.

OSHA CONSTRUCTION eTOOL

Falls

Falls are the leading cause of fatalities in the construction industry. An average of 362 fatal falls occurred each year from 1995 to 1999, with the trend on the increase.

It is important that safety and health programs contain provisions to protect workers from falls on the job. The following hazards cause the most fall-related injuries:

Unprotected Sides, Wall Openings, and Floor Holes

Improper Scaffold Construction

Unguarded Protruding Steel Rebars

Misuse of Portable Ladders

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OSHA CONSTRUCTION eTOOL

Falls: Unprotected Sides, Wall Openings, and Floor Holes

Am I In Danger?

Almost all sites have unprotected sides and edges, wall openings, or floor holes at some point during construction. If these sides and openings are not protected at your site, injuries from falls or falling objects may result, ranging from sprains and concussions to death.

This worker is not protected by any of the protective systems that are required by OSHA.

How Do I Avoid Hazards?

- Use at least one of the following whenever employees are exposed to a fall of 6 feet or more above a lower level:
  - Guardrail Systems
  - Safety Net Systems
  - Fall Arrest Systems
- Cover or guard floor holes as soon as they are created during new construction.
- For existing structures, survey the site before working and continually audit as work continues. Guard or cover any openings or holes immediately.
- Construct all floor hole covers so they will effectively support two times the weight of employees, equipment, and materials that may be imposed on the cover at any one time.
- In general, it is better to use fall *prevention* systems, such as guardrails, than fall *protection* systems, such as safety nets or fall arrest devices, because they provide more positive safety means.

SAFETY BULLETIN

Construction Worker Dies

Additional Information:

- OSHA Standard: 1926.501(b)(1)
- Worker Deaths by Falls: A Summary of Surveillance Findings and Investigative Case Reports. NIOSH Publication 2000-116 (2000, November). See listing on NIOSH website.

OSHA CONSTRUCTION eTOOL

Guardrail Systems

Where workers on a construction site are exposed to vertical drops of 6 feet or more, OSHA requires that employers provide fall protection in one of three ways *before* work begins:

- Placing guardrails around the hazard area.
- Deploying safety nets.
- Providing personal fall arrest systems for each employee.

This guardrail appears to be properly constructed except for the missing toeboard that is required to prevent object from falling to the floor below and possibly striking another worker.

Many times the nature and location of the work will dictate the form that fall protection takes. If the employer chooses to use a guardrail system, he must comply with the following provisions:

- Top edge height of top rails, or equivalent guardrail system members, must be between 39 and 45 inches above the walking/working level, except when conditions warrant otherwise and all other criteria are met (e.g., when employees are using stilts, the top edge height of the top rail must be increased by an amount equal the height of the stilts).
- Midrails, screens, mesh, intermediate vertical members, or equivalent intermediate structures, must be installed between the top edge and the walking/working surface when there is no wall or other structure at least 21 inches high.
  - Midrails must be midway between the top edge of the guardrail system and the walking/working level.
  - Screens and mesh must extend from the top rail to the walking/working level, and along the entire opening between rail supports.
  - Intermediate members (such as balasters) between posts must be no more than 19 inches apart.
  - Other structural members (such as additional midrails or architectural panels) must be installed so as to leave no openings wider than 19 inches.
- Guardrail systems must be capable of withstanding at least 200 pounds of force applied within 2 inches of the top edge, in any direction and at any point along the edge, and without causing the top edge of the guardrail to deflect downward to a height less than 39 inches above the walking/working level.
- Midrails, screens, mesh, and other intermediate members must be capable of withstanding at least 150 pounds of force applied in any direction at any point along the midrail or other member.
- Guardrail systems must not have rough or jagged surfaces that would cause punctures, lacerations, or snagged clothing.
- Top rails and midrails must not cause a projection hazard by overhanging the terminal posts.

Additional Information:

- OSHA Standard: 1926.501(b)(1)
- Worker Deaths by Falls: A Summary of Surveillance Findings and Investigative Case Reports. NIOSH Publication 2000-116 (2000, November). See listing on NIOSH website.

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OSHA CONSTRUCTION eTOOL

Safety Net Systems

Where workers on a construction site are exposed to vertical drops of 6 feet or more, OSHA requires that employers provide fall protection in one of three ways *before* work begins:

A safety net is being used under the roof of this building as an acceptable fall protection system.

- Placing guardrails around the hazard area,
- Install safety nets, or
- Providing personal fall arrest systems for each employee.

Many times the nature and location of the work will dictate the form that fall protection takes. If the employer chooses to use a safety net system, he must comply with the following provisions:

- Safety nets must be installed as close as practicable under the surface on which employees are working, but in no case more than 30 feet below.
- When nets are used on bridges, the potential fall area must be unobstructed.
- Safety nets must extend outward from the outermost projection of the work surface as follows:

Vertical distance from working level to horizontal plane of net	Minimum required horizontal distance of outer edge of net from the edge of the working surface
Up to 5 feet	8 feet
5 to 10 feet	10 feet
More than 10 feet	13 feet

- Safety nets must be installed with sufficient clearance to prevent contact with the surface or structures under them when subjected to an impact force equal to the drop test described below.
- Safety nets and their installations must be capable of absorbing an impact force equal to the drop test described below.
- Safety nets and safety net installations must be drop-tested at the jobsite:
  - After initial installation and before being used.
  - Whenever relocated.
  - After major repair.
  - At 6-month intervals if left in one place.
- The drop test consists of a 400 pound bag of sand 28-32 inches in diameter dropped into the net from the highest surface at which employees are exposed to fall hazards, but not

from less than than 42 inches above that level.

- When the employer can demonstrate that it is unreasonable to perform the drop-test described above, the employer or a designated competent person shall certify that the net and net installation have sufficient clearance and impact absorption by preparing a certification record prior to the net being used as a fall protection system. The certification must include:
  - Identification of the net and net installation.
  - Date that it was determined that the net and net installation were in compliance.
  - Signature of the person making the determination and certification.

- The most recent certification record for each net and net installation must be available at the jobsite for inspection.
- Safety nets must be inspected for wear, damage, and other deterioration at least once a week, and after any occurrence which could affect the integrity of the system.
- Defective nets shall not be used, and defective components must be removed from service.
- Objects which have fallen into the safety net, such as scrap pieces, equipment, and tools, must be removed as soon as possible from the net and at least before the next work shift.
- Maximum mesh size must not exceed 6 inches by 6 inches. All mesh crossings must be secured to prevent enlargement of the mesh opening, which must be no longer than 6 inches, measured center-to-center.
- Each safety net, or section thereof, must have a border rope for webbing with a minimum breaking strength of 5,000 pounds.
- Connections between safety net panels must be as strong as integral net components, and must not be spaced more than 6 inches apart.

Additional Information:

- OSHA Standard: 1926.502(c)
- Worker Deaths by Falls: A Summary of Surveillance Findings and Investigative Case Reports. NIOSH Publication 2000-116 (2000, November). See listing on NIOSH website.

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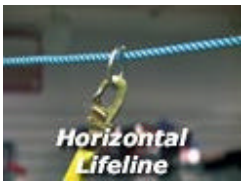
OSHA CONSTRUCTION eTOOL

Personal Fall Arrest Systems

A personal fall arrest system is one option of protection that OSHA requires for workers on construction sites who are exposed to vertical drops of 6 feet or more.

Click on any of the components of the personal fall arrest system illustrated below for descriptions and provisions required by OSHA.



Using Fall Arrest Systems Safely

This worker is protected by a properly constructed fall arrest system.

- Ensure that personal fall arrest systems will, when stopping a fall:
  - Limit maximum arresting force to 1,800 pounds.
  - Be rigged such that an employee can neither free fall more than 6 feet nor contact any lower level.
  - Bring an employee to a complete stop and limit maximum deceleration distance to 3½ feet.
  - Have sufficient strength to withstand twice the potential impact energy of a worker free falling a distance of 6 feet, or the free fall distance permitted by the system, whichever is less
- Remove systems and components from service immediately if they have been subjected to fall impact, until inspected by a competent person and deemed undamaged and suitable for use.
- Promptly rescue employees in the event of a fall, or assure that they are able to rescue themselves.
- Inspect systems before each use for wear, damage, and other deterioration, and remove defective components from service.
- Do not attach fall arrest systems to guardrail systems or hoists.

- Rig fall arrest systems to allow movement of the worker only as far as the edge of the walking/working surface, when used at hoist areas.

Additional Information:

- OSHA Standard: 1926.502(d)
- What is the Fall Distance. OSHA Region VII (1998, July). This 22-minute video introduces the viewer to fall distance calculations for personal fall arrest systems.
- Worker Deaths by Falls: A Summary of Surveillance Findings and Investigative Case Reports. NIOSH Publication 2000-116 (2000, November). See listing on NIOSH website.
- Interpretations and Clarifications - Subpart M -- Fall Protection (29 CFR 1926.500-503).

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Attachment Location

The attachment of the body harness must be located in the center of the wearer's back, near the shoulder level, or above the head.

- OSHA Standard: 1926.502(d)(17)

Body Harnesses

Body harnesses are designed to minimize stress forces on an employee's body in the event of a fall, while providing sufficient freedom of movement to allow work to be performed.

Do not use body harnesses to hoist materials.

As of January 1, 1998, body belts are not acceptable as part of a personal fall arrest system, because they impose a danger of internal injuries when stopping a fall.

- OSHA Standard: 1926.502(d)(18)

Vertical Lifelines/Lanyards

Vertical lifelines or lanyards must have a minimum breaking strength of 5,000 pounds, and be protected against being cut or abraded. Each employee must be attached to a separate vertical lifeline, except during the construction of elevator shafts, where two employees may be attached to the same lifeline in the hoistway, provided:

- Both employees are working atop a false car that is equipped with guardrails.
- The strength of the lifeline is 10,000 pounds (5,000 pounds per employee).
- All other lifeline criteria have been met.

Self-retracting vertical lifelines and lanyards that automatically limit free fall distance to 2 feet or less must be capable of sustaining a minimum tensile load of 3,000 pounds when in the fully extended position. If they do not automatically limit the free fall to 2 feet or less, ripstitch lanyards, and tearing and deforming lanyards, must be capable of sustaining a minimum tensile load of 5,000 pounds when in the fully extended position.

OSHA Standard: 1926.502(d)(9)

Webbing

Webbing are the ropes and straps used in lifelines, lanyards, and strength components of body harnesses. The webbing must be made from synthetic fibers.

- OSHA Standard: 1926.502(d)(14)

Anchorages

Anchorages used for attachment of personal fall arrest equipment must be independent of any anchorage being used to support or suspend platforms, and capable of supporting at least 5,000 pounds per employee attached, or must be designed and used as follows:

- As part of a complete personal fall arrest system which maintains a safety factor of at least two.
- Under the supervision of a qualified person.
- OSHA Standard:1926.502(d)(15)

Horizontal Lifelines

Horizontal lifelines are to be designed, installed, and used under the supervision of a qualified person, and as part of a complete personal fall arrest system which maintains a safety factor of at least two.

On suspended scaffolds or similar working platforms with horizontal lifelines that may become vertical lifelines, the devices used to connect to a horizontal lifeline must be capable of locking in both directions on the lifeline.

- OSHA Standard: 1926.451(g)(3)(ii)
- OSHA Standard: 1926.451(g)(3)(iii)
- OSHA Standard: 1926.502(d)(7)
- OSHA Standard: 1926.502(d)(8)

Connectors

Connectors, including D-rings and snaphooks, must be made from drop-forged, pressed or formed steel, or equivalent materials. They must have a corrosion-resistant finish, with smooth surfaces and edges to prevent damage to connecting parts of the system.

D-Rings must have a minimum tensile strength of 5,000 pounds, and be proof-tested to a minimum tensile load of 3,600 pounds without cracking, breaking, or becoming permanently deformed.

Snaphooks must have a minimum tensile strength of 5,000 pounds, and be proof-tested to a minimum tensile load of 3,600 pounds without cracking, breaking, or becoming permanently deformed. They must also be locking-type, double-locking, designed and used to prevent the disengagement of the snaphook by the contact of the snaphook keeper with the connected member.

Unless it is designed for the following connections, snaphooks must not be engaged:

- Directly to webbing, rope, or wire.
- To each other.
- To a D-ring to which another snaphook or other connector is attached.
- To a horizontal lifeline.
- To any object which is incompatibly shaped in relation to the snaphook such that the connected object could depress the snaphook keeper and release itself.
- OSHA Standard: 1926.502(d)(1)

Excerpt from Memo to Region VIII

Where an employer is using a fall arrest system that permits a fall of more than six feet, a citation should be issued under 1926.104(d) unless the employer shows that (1) limiting an arrested fall to six feet is infeasible; (2) the arresting fall distance, though more than 6 feet, is as short as feasible; (3) it has taken reasonable steps to determine that (a) the arresting forces will be limited to 1800 pounds and (b) the system will not fail in an arrested fall.

Example of an employer that takes "reasonable steps": An employer calculates the total arresting fall distance and the loads imposed on the system based on measurements, product data and appropriate calculations. Using product data, the employers determines that the components, as used, will have the necessary strength to sustain the loads and that the arresting forces on the worker would be limited to 1800 pounds.

Example of an employer that fails to take "reasonable steps": An employer sets up a system that allows an arrested fall of more than six feet. It asserts that, in its judgment, the system will work. However, it has made no assessment of how far the arrested fall would be, what the loads of an arrested fall would be, and failed to assess the load capacity of the system.

For more information, see Interpretations and Clarifications - Subpart M -- Fall Protection (29 CFR 1926.500-503).

Deaths Due to Unprotected Sides, Wall Openings and Floor Holes

Case Reports

The following Case Reports of falls investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

- An employee taking measurements was killed when he fell backward from an unguarded balcony to the concrete 9½ feet below.
- A roofer, handling a piece of fiberboard, backed up and tripped over a 7½ inch parapet. He fell more than 50 feet to ground level and died of severe head injuries.
- Two connectors were erecting light weight steel I-beams on the third floor of a 12-story building, 54 feet above the ground. One employee removed a choker sling from a beam and then attempted to place the sling onto a lower hook on a series of stringers. While the crawler tower crane was booming away from the steel, the wind moved the stringer into the beam the employee was standing on. The beam moved while the employee was trying to disengage the hook, causing him to lose his balance and fall to his death.

OSHA CONSTRUCTION eTOOL

Falls: Improper Scaffold Construction

Am I In Danger?

Working with heavy equipment and building materials on the limited space of a scaffold is difficult. Without fall protection or safe access, it becomes hazardous. Falls from such improperly constructed scaffolds can result in injuries ranging from sprains to death.

This scaffold is not in compliance with the regulations because it mixes several different scaffold components in the same scaffold. The guardrails are also improper because they are not complete.

How Do I Avoid Hazards?

- Construct all scaffolds according to the manufacturer's instructions.
- Install guardrail systems along all open sides and ends of platforms.
- Use at least one of the following for scaffolds more than 10 feet above a lower level:
  - Guardrail Systems
  - Fall Arrest Systems
- Provide safe access to scaffold platforms [*For more, see Scaffold Access*].
- Do not use climb cross-bracing as a means of access.

SAFETY BULLETIN

Construction Worker Dies

Additional Information:

- OSHA Standard: 1926.451(g)(1)
- OSHA Construction Scaffolding eTool
- Worker Deaths by Falls: A Summary of Surveillance Findings and Investigative Case Reports. NIOSH Publication 2000-116 (2000, November). See listing on NIOSH website.

OSHA CONSTRUCTION eTOOL

Scaffold Access

Climbing the structural cross-braces of a scaffold is *unsafe*, and *specifically forbidden* by federal standards. However, OSHA permits direct access from another scaffold, structure, or personnel hoist.

If such access is not possible, portable ladders, hook-on ladders, attachable ladders, stair towers, stairway-type ladders, ramps, walkways, or built-in ladders must be used, under the following regulations:

Portable, Hook-on, and Attachable Ladders

- Must be positioned so as not to tip the scaffold.

Hook-on and Attachable Ladders

- Must be specifically designed for the type of scaffold with which they are used.
- Must have their lowest rung no more than 24 inches above the level on which the scaffold is supported.
- When used on a supported scaffold more than 35 feet high, must have rest platforms at 35-foot maximum intervals.
- Must have a maximum rung length of 11½ inches, and a maximum space between rungs of 16¾ inches.

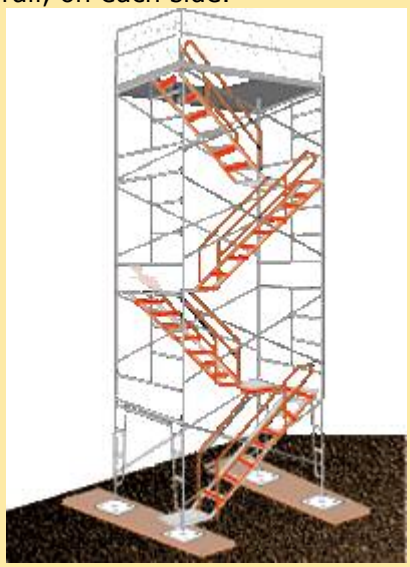
Stairway-type Ladders

- Must have their bottom step no more than 24 inches above the level on which the scaffold is supported.
- Must have rest platforms at 12-foot maximum intervals.
- Must have a minimum step width of 16 inches, except that mobile stairway-type ladders shall have a minimum step width of 11½ inches.
- Must have slip-resistant treads on all steps and landings.

Stair Towers

- Must have their bottom step no more than 24 inches above the level on which the scaffold is supported.

- Must have a stair-rail, consisting of a top-rail and a mid-rail, on each side.
  - The top-rail of each stair-rail must also be capable of serving as a handrail, unless a separate handrail is provided.
  - Stair-rails and handrails must be designed and constructed to prevent punctures, lacerations, snagged clothing, and projection.
  - Handrails, and top-rails used as handrails, must be at least 3 inches from other objects.
  - Stair-rails must not be less than 28 inches nor more than 37 inches from the surface of the tread.



- Must be at least 18 inches wide between stair-rails, and have a landing platform at least 18 inches wide by at least 18 inches long at each level.
- Must have slip-resistant surfaces on all treads and landings.
- Must be installed between 40 degrees and 60 degrees from the horizontal.
- Must have uniform riser height, within ¼ inch, for each flight of stairs, except for the top and bottom steps of the *entire system.*
- Must have uniform tread depth, within ¼ inch, for each flight of stairs.

Built-in Scaffold Ladders

- Must be specifically designed and constructed for use as ladder rungs.
- Must have a rung length of at least 8 inches.
- Must not be used as work platforms when rungs are less than 11½ inches, unless each employee uses fall protection or a positioning device [1926.502(e)].
- Must be uniformly spaced within each frame section.
- Must have rest platforms at 35-foot maximum intervals on all supported scaffolds more than 35 feet high.
- Must have a maximum space between rungs of 16¾ inches.

Steps and rungs of ladders and stairways must line up vertically with each other between rest platforms.

Ramps and Walkways

- Must have guardrails which comply with [1926.502(b)] 1926 Subpart M if more than 6 feet above lower levels.
- Must have a slope of no more than 1 vertical to 3 horizontal degrees (20 degrees above the horizontal).
- Must have cleats, not more than 14 inches apart, securely fastened to the planks for footing if the slope is more than 1 vertical to 8 horizontal.

Direct Access

- Direct access to or from another surface shall only be used when the scaffold is not more than 14 inches horizontally and 24 inches vertically from the other surface.

Additional Information:

- OSHA Standard: 1926.451(e)
- Worker Deaths by Falls: A Summary of Surveillance Findings and Investigative Case Reports. NIOSH Publication 2000-116 (2000, November). See listing on NIOSH website.

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Deaths Due to Improper Guardrails on Tubular Welded-frame Scaffolds

Case Reports

The following Case Reports of falls investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

- An employee preparing masonry fascia for removal from a building fell from the third level of a tubular welded-frame scaffold. No guarding system was provided for the scaffold. Further, the platform was coated with ice, creating a slippery condition.
- A contract employee was taking measurements from an unguarded scaffold inside a reactor vessel when he either lost his balance or stepped backwards and fell 14½ feet, sustaining fatal injuries.
- An employee was installing overhead boards from a scaffold platform consisting of two 2" x 10" boards with no guardrails. He lost his balance, fell 7½ feet to the floor, and was fatally injured.
- A laborer was working on the third level of a tubular welded-frame scaffold which was covered with ice and snow. Planking on the scaffold was inadequate, there was no guardrail, and no access ladder for the various scaffold levels. The worker slipped and fell head first approximately 20 feet to the pavement below.

OSHA CONSTRUCTION eTOOL

Falls: Unguarded Protruding Steel Rebars

Am I In Danger?

Unguarded protruding steel reinforcing bars are hazardous. Even if you just stumble onto an unguarded rebar you can impale yourself, resulting in serious internal injuries or death. *View Rebar Accident*

These rebar should be bent over or protected with caps so that a worker would not be injured by falling on them.

How Do I Avoid Hazards?

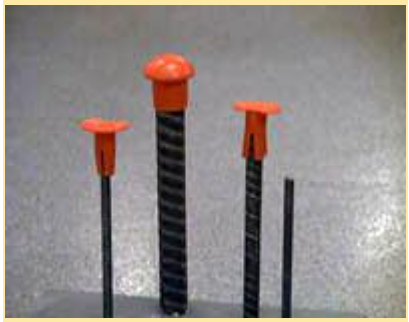
- Guard all protruding ends of steel rebar with rebar caps or wooden troughs, *or*
- Bend rebar so exposed ends are no longer upright.
- When employees are working at any height above exposed rebar, fall protection/ prevention is the first line of defense against impalement.

SAFETY BULLETIN

Construction Worker Dies

Rebar Caps

The OSHA Standard requires that rebar "be guarded to eliminate the hazard of impalement." Not all guards provide that level of protection. In some circumstances, the force of a fall can cause rebar to push clear through a plastic cap and still impale a worker, or the worker can be impaled by the rebar and the cap together.



Only rebar caps designed to provide impalement protection, such as those containing steel reinforcement, should be used.

This type of cap positions a 2 x 4 over the exposed rebar,

and has been approved by California OSHA.

Additional Information:

- OSHA Standard: 1926.701(b)
- Mushroom Style Plastic Rebar Covers Used For Impalement Protection. OSHA Standards Interpretation and Compliance Letter (1997, May 29).
- Worker Deaths by Falls: A Summary of Surveillance Findings and Investigative Case Reports. NIOSH Publication 2000-116 (2000, November). See listing on NIOSH website.

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Rebar Accident!

The following images are from video shot during an investigation of an actual rebar accident*.

- While standing on a rebar column he is in the process of plumbing, a worker in full body harness attempts to hook his positioning lanyards onto a location over his head.

- The positioning device hooks slip, and the worker falls approximately 8 feet to the footings below, where he is impaled through the groin on a protruding rebar.

- Though the rebar is capped, the force of the worker's fall pushes the cap clear to the ground, and bends the rebar nearly 45 degrees.

- This is an example of the rebar caps used at this site. Because it was not steel reinforced, it was insufficient to provide protection in a fall from elevation.

- An employee passing by the accident site gives perspective to the height involved. The victim was only standing approximately at the top of this image, yet the force of his fall bent the rebar like a coat hanger. Luckily, he was taken by helicopter to a nearby hospital and survived his injuries.

* *Courtesy of Utah Occupational Safety and Health Division*

Excerpt from Mushroom Style Plastic Rebar Covers Used For Impalement Protection - OSHA Standards Interpretation and Compliance Letter 05/29/1997

"Tests designed by California OSHA were conducted that entailed dropping sand-filled canvas bags onto rebar protected by standard mushroom caps. Weights of the bags ranged from 140 to 160 pounds, and the bags were dropped from three, five and seven feet. The mushroom caps provided absolutely NO protection.

"Manufacturers of the mushroom caps agree that those caps were designed to provide SCRATCH PROTECTION ONLY and were never intended to prevent impalement, even at grade.

"Considering the serious nature of the hazard, the standard mushroom-style plastic rebar caps should not be used for protection against impalement. Protective devices capable of withstanding at least 250 pounds dropped from a height of ten feet should be used. Although there are no 'approved' mushroom caps on the market, steel reinforced covers and wooden troughs are available, and have been approved by California OSHA and recognized by the California AGC to meet the design criteria."

Bear in mind that, where possible, fall protection is still the best solution. A fall from 10 feet or more on to a wooden trough or steel reinforced cap, even if it doesn't result in impalement, is still likely to produce serious injury.

Deaths Due to Not Guarding Protruding Steel Rebars

Case Reports

The following Case Reports of falls investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

- An employee pulling a concrete hose along a form fell two stories and hit his head on steel rebars which punctured his brain.
- A laborer fell through a roof opening about 8 feet to a patio foundation that had about 20 half-inch rebars protruding straight up. The laborer was impaled by one of the bars and died.

OSHA CONSTRUCTION eTOOL

Falls: Misuse of Portable Ladders

Am I In Danger?

You risk falling if portable ladders are not safely positioned each time they are used. While you are on a ladder, it may move and slip from its supports. You can also lose your balance while getting on or off an unsteady ladder. Falls from ladders can cause injuries ranging from sprains to death.

This ladder is being used at the proper angle, and appears to be stable and secure.

How Do I Avoid Hazards?

- Position portable ladders so the side rails extend at least 3 feet above the landing.
- Secure side rails at the top to a rigid support and use a grab device when 3 foot extension is not possible.
- Make sure that the weight on the ladder will not cause it to slip off its support.
- Before each use inspect ladders for cracked or broken parts such as rungs, steps, side rails, feet and locking components.
- Do not apply more weight on the ladder than it is designed to support [*For more, see Ladder Safety*].
- Use only ladders that comply with OSHA design standards [1926.1053(a)(1)].

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Construction Worker Dies

Additional Information:

- OSHA Standard: 1926.1053(b)(1)
- Worker Deaths by Falls: A Summary of Surveillance Findings and Investigative Case Reports. NIOSH Publication 2000-116 (2000, November). See listing on NIOSH website.

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Ladder Safety

The OSHA Standard for portable ladders contains specific requirements designed to ensure worker safety:

- Loads
- Angle
- Rungs
- Slipping
- Other Requirements

Loads

- Self-supporting (foldout) and non-self-supporting (leaning) portable ladders must be able to support at least four times the maximum intended load, except extra-heavy-duty metal or plastic ladders, which must be able to sustain 3.3 times the maximum intended load. *(See Figure 1.)*

Figure 1

Angle

- Non-self-supporting ladders, which must lean against a wall or other support, are to be positioned at such an angle that the horizontal distance from the top support to the foot of the ladder is about 1/4 the working length of the ladder. *(See Figure 2.)*

- In the case of job-made wooden ladders, that angle should equal about 1/8 the working length. This minimizes the strain of the load on ladder joints that may not be as strong as on commercially manufactured ladders.

Figure 2

Rungs

- Ladder rungs, cleats, or steps must be parallel, level, and uniformly spaced when the ladder is in position for use. Rungs must be spaced between 10 and 14 inches apart.

- For extension trestle ladders, the spacing must be 8-18 inches for the base, and 6-12 inches on the extension section.

- Rungs must be so shaped that an employee's foot cannot slide off, and must be skid-resistant. *(See Figure 3.)*

Slipping

- Ladders are to be kept free of oil, grease, wet paint, and other

slipping hazards.

- Wood ladders must not be coated with any opaque covering, except identification or warning labels on one face only of a side rail.

Figure 3

Other Requirements

- Foldout or stepladders must have a metal spreader or locking device to hold the front and back sections in an open position when in use. *(See Figure 4.)*

Figure 4

- When two or more ladders are used to reach a work area, they must be offset with a landing or platform between the ladders.
- The area around the top and bottom of ladder must be kept clear.
- Ladders must not be tied or fastened together to provide longer sections, unless they are specifically designed for such use. *(See Figure 5.)*
- Never use a ladder for any purpose other than the one for which it was designed.

Figure 5

Additional Information:

- OSHA Standard: 1926.1053(a)
- Additional Examples

Additional Examples

This is improperly using the top rung of this step ladder to work from.

Case Reports

The following Case Reports of falls investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

- An employee was climbing a 10 foot ladder to access a landing which was 9 feet above the adjacent floor. The ladder slid down, and the employee fell to the floor, sustaining fatal injuries. Although the ladder had slip-resistant feet, it was not secured, and the railings did not extend 3 feet above the landing.

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Struck-By

The second highest cause of construction-related deaths is being struck by an object. Approximately 75% of struck-by fatalities involve heavy equipment such as trucks or cranes. The number of workers fatally struck by a vehicle was at a seven-year high in 1998.

Safety and health programs must take into account the many ways struck-by accidents can occur. The following related hazards cause the most struck-by injuries:

Vehicles

Falling/Flying Objects

Constructing Masonry Walls

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Struck-By: Vehicles

Am I In Danger?

If vehicle safety practices are not observed at your site, you risk being pinned between construction vehicles and walls, struck by swinging backhoes, crushed beneath overturned vehicles, or other similar accidents. If you work near public roadways you risk being struck by trucks or cars.

This accident happened because the excavation was not properly guarded or barricaded.

How Do I Avoid Hazards?

- Wear seat belts that meet OSHA standards [1926.601(b)(9)], except on equipment that is designed only for standup operation, or that has no rollover protective structure.
- Check vehicles before each shift to assure that all parts and accessories are in safe operating condition [*For more, see* Vehicle Inspection].
- Do not drive a vehicle in reverse gear with an obstructed rear view, unless it has an audible reverse alarm, or another worker signals that it is safe.

- Drive vehicles or equipment only on roadways or grades that are safely constructed and maintained.
- Make sure that you and all other personnel are in the clear before using dumping or lifting devices.
- Lower or block bulldozer and scraper blades, end-loader buckets, dump bodies, etc., when not in use, and leave all controls in neutral position.
- Set parking brakes when vehicles and equipment are parked, and chock the wheels if they are on an incline.
- All vehicles must have adequate braking systems and other safety devices [*For more, see* Brake Systems].
- Haulage vehicles that are loaded by cranes, power shovels, loaders etc., must have a cab shield or canopy that protects the driver from falling materials.

Construction Worker Dies

- Do not exceed a vehicle's rated load or lift capacity.
- Do not carry personnel unless there is a safe place to ride.
- Use traffic signs, barricades or flaggers when construction takes place near public roadways.

- Workers must be highly visible in all levels of light. Warning clothing, such as red or orange vests, are required; and if worn for night work, must be of reflective material.

Additional Information:

- OSHA Motor Vehicles Standard: 1926.601
- OSHA Signaling Standard: 1926.201
- FHWA Programs, Best Practices-Work Zones. Federal Highway Administration.

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Vehicle Inspection

At the beginning of each shift, all vehicles that will be used must be inspected to assure that they are in safe operating condition and free of apparent damage that could lead to an accident. All defects must be corrected before the vehicle is placed in service.

Vehicle Inspection Checklist

Inspect the following parts, equipment, and accessories:

- Service brakes, including trailer brake connections
- Parking system (hand brake)
- Emergency stopping system (emergency brake)

- Tires
- Coupling devices
- Seat belts
- Horn

- Steering mechanism
- Operating controls
- Safety devices (e.g. reverse signal alarm, ROPS, etc.)

Additional items if necessary:

- Lights
- Reflectors
- Defrosters

- Windshield wipers
- Fire extinguishers

Additional Information:

- OSHA Standard: 1926.601(b)(14)

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Brake Systems

All motor vehicles and mechanized equipment used in construction are required to have:

- A service brake system, for slowing or stopping the vehicle during normal operations.
- An emergency brake system, as a back-up in the event that the service brake fails.
- A parking brake system, sometimes referred to as a *hand brake*.

It is permissible for these systems to share components, but in all cases they are *each* required to be maintained in good working condition, e.g. if the service brake and parking brake are working, they do not make up for a defective emergency brake.

Sometimes, additional assistance may be necessary. For example, when parking on an incline, parking brakes alone may need to be augmented by chocks under the wheels

Additional Information:

- OSHA Standard: 1926.601(b)(1)

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Deaths Due to Being Struck-By a Vehicle

Case Reports

The following Case Reports of vehicle accidents investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

- An employee was operating a bulldozer at the top edge of a sloped drainage ditch. The bulldozer began to slide down the side of the snow and ice covered excavation, tipped over on its side, and pinned the operator under the roll bars. The driver was not wearing a seatbelt.

- A contractor was operating a backhoe when an employee attempted to walk between the swinging superstructure of the backhoe and a concrete wall. As the employee approached from the operator's blind side, the superstructure hit the victim, crushing him against the wall. Employees had not been trained in safe work practices, and no barricades had been erected to prevent employee access to a hazardous area.

- A safety "over travel" cable attached between the frame and the dump box of a dump truck caught on a protruding nut of an airbrake cylinder. This prevented the dump box from being fully raised. The driver, apparently assuming that releasing the cable would allow the dump box to continue upward, reached over the frame and disengaged the cable with his right hand. The dump box then dropped suddenly, crushing his head.

- A worker was driving a front-end loader up a dirt ramp onto a lowboy trailer. The tractor was not centered and the tread slipped off the trailer. When the tractor began to tip, the operator jumped from the cab. As he hit the ground, the tractor's rollover protective structure fell on top of him, crushing him. The tractor was not equipped with seatbelts.

- A worker was cutting concrete along the white center line on a four-lane highway. Orange reflective barrels closed the left lane to traffic, which was routed to a single lane from approximately 8 miles. To accommodate the worker, three to four barrels had been moved into the active traffic lane, and a flagperson was slowing down traffic and directing it slightly onto the berm area. An approaching semi-tractor and trailer rig were exceeding the speed limit when the driver hit the guardrail and lost control of his vehicle. The tractor and trailer bounced back through the barrels and struck the worker from behind, killing him.

- While acting as a flagger on a highway construction project, an employee was struck and killed by an oncoming vehicle that failed to stop after being directed to do so.

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Struck-By: Falling/Flying Objects

Am I In Danger?

You are at risk from *falling* objects when you are beneath cranes, scaffolds, etc., or where overhead work is being performed. There is a danger from *flying* objects when power tools, or activities like pushing, pulling, or prying, may cause objects to become airborne. Injuries can range from minor abrasions to concussions, blindness, or death.

These workers are not protected from being struck by falling objects because they are working around/under other workers and not wearing hardhats.

How Do I Avoid Hazards?

General

- Wear hard hats.
- Stack materials to prevent sliding, falling, or collapse.
- Use protective measures such as toeboards and debris nets.

Power Tools, Machines, etc.

- Use safety glasses, goggles, face shields, etc., where machines or tools may cause flying particles.
- Inspect tools, such as saws and lathes, to insure that protective guards are in good condition.
- Make sure you are trained in the proper operation of powder actuated tools.

Cranes and Hoists

- Avoid working underneath loads being moved.
- Barricade hazard areas and post warning signs.
- Inspect cranes and hoists to see

SAFETY BULLETIN

Construction Worker Dies

that all components, such as wire rope, lifting hooks, chains, etc., are in good condition.

- Do not exceed lifting capacity of cranes and hoists.

Overhead Work

- Secure tools and materials to prevent them from falling on people below.
- Barricade hazard areas and post warning signs.
- Use toeboards, screens, or guardrails on scaffolds to prevent falling objects, *or,*
- Use debris nets, catch platforms, or canopies to catch or deflect falling objects.

Compressed Air

- Reduce compressed air used for cleaning to 30 psi, and only use with appropriate guarding and protective equipment.
- Never clean clothing with compressed air.

Additional Information:

- OSHA PPE Standard (Head protection): 1926.100(a)
- OSHA PPE Standard (Eye and face protection): 1926.102(a)
- OSHA Materials Handling & Storage Standard: 1926.250(a)
- OSHA Scaffolds Standard: 1926.451(h)
- OSHA Cranes & Derricks Standard: 1926.550(g)(4)(ii)(F)

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Case Reports

The following Case Reports of accidents investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

- An employee was standing under a suspended scaffold that was hoisting a workman and three sections of ladder. Sections of the ladder became unlashed and fell 50 feet, striking the employee in the skull. The employee was not wearing any head protection and died from injuries received.

- Two employees were using a wire rope to winch a wooden tool shed onto a flat bed trailer. The wire rope broke, snapped back, and struck one of the employees in the top of the head, killing him. The employee was not wearing a hard hat.

- Workers were using a winch to pull a 10-foot section of a 600 lb. grain spout through a vent hole, when the spout became wedged. Using pry bars, they attempted to free the spout, which was still under tension from the winch. When it popped free, the release of tension caused it to strike one of the workers in the head, who had no head protection.

- A carpenter was attempting to anchor a plywood form in preparation for pouring a concrete wall, using a powder actuated tool. The nail passed through the hollow wall, traveled some 27 feet, and struck an apprentice in the head, killing him. The tool operator had never been trained in the proper use of the tool, and none of the employees in the area, including the victim, were wearing personal protective equipment.

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Struck-By: Constructing Masonry Walls

Am I In Danger?

Constructing concrete and masonry walls is especially dangerous because of the tremendous loads that need to be supported. There are risks of major accidents, and even death, when jacks or lifting equipment are used to position slabs and walls, or when shoring is required until structures can support themselves.

These workers are constructing a block masonry wall.

How Do I Avoid Hazards?

- Do not place construction loads on a concrete structure until a qualified person indicates that it can support the load.
- Adequately shore or brace structures until permanent supporting elements are in place, or concrete has been tested to assure sufficient strength.
- Only allow those who are essential to and actively engaged in construction or lifting operations to enter the work area.
- Take measures to prevent unrolled wire mesh from recoiling, such as securing each end or turning the roll over.
- Do not load lifting devices beyond their capacity.
- Use automatic holding devices to support forms in case a lifting mechanism fails.

SAFETY BULLETIN

Construction Worker Dies

Additional Information:

- OSHA Standard: 1926 SUBPART Q

Deaths Due to Constructing Masonry Walls

Case Reports

The following Case Reports of accidents investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

- In inclement weather, a 34-year old worker was positioning vertical and horizontal rebar for a cap tie beam to be poured the next day. Potent, gusting winds caused a free standing masonry block wall to collapse, fatally injuring the employee. Bracing and shoring could have prevented the collapse, or lessened the impact.

- Three concrete finishers were working in the basement of a home under construction, placing cement for the basement floor. A cement truck was parked two feet away from the west wall, unloading 6 yards of cement into the basement. The 2-foot area around the foundation had been backfilled about an hour and a half before the cement finishers began their work. One of the employees directed the cement chute, starting at the northwest corner of the building. By the time he got to the southwest corner, the truck was empty. Suddenly, the west wall collapsed, crushing him to death. The other two employees were able to escape with only minor injuries.

- An employee and two co-workers were erecting 8'x35' pre-stressed concrete wall panels. They would set the panel, then anchor the bottom, and then unhook the panels from the crane. Three panels had already been set, and the victim was atop the panels waiting for the welder to finish anchoring the bottom of the third panel. The panels began to tip outward and slowly fall, and the victim fell or jumped, landing in the path of the falling panels. He died from the head injuries he sustained.

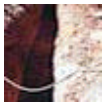
- The victim was a member of a crew that was erecting tilt-up wall panels around the perimeter of the slab floor of a one-story warehouse. The last three wall slabs were being hoisted into place with two 12-foot nylon web slings in a basket hitch. While the second panel was suspended in preparation for being set, it tilted in the sling and slid slightly, cutting through one sling and partially through the other. The erection crew scattered as it dropped, but the victim stopped momentarily to look back as he fled the building. Just then, the upper edge of a previously set panel, which had been dislodged by the falling panel, fell on him. He was crushed and killed.

OSHA CONSTRUCTION eTOOL

Trenching and Excavation

Cave-ins are perhaps the most feared trenching hazard. But other potentially fatal hazards exist, including asphyxiation due to lack of oxygen in a confined space, inhalation of toxic fumes, drowning, etc. Electrocution or explosions can occur when workers contact underground utilities.

OSHA requires that workers in trenches and excavations be protected, and that safety and health programs address the variety of hazards they face. The following hazards cause the most trenching and excavation injuries:


No Protective System

Failure to Inspect Trench and Protective Systems

Unsafe Spoil-Pile Placement

Unsafe Access/Egress

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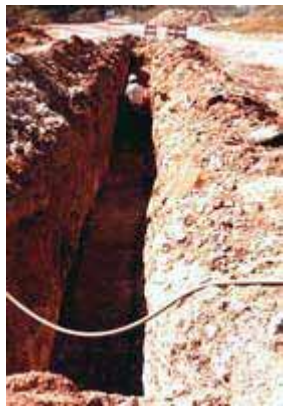
Trenching and Excavation: No Protective System

Am I In Danger?

All excavations are hazardous because they are inherently unstable. If they are restricted spaces they present the additional risks of oxygen depletion, toxic fumes, and water accumulation. If you are not using protective systems or equipment while working in trenches or excavations at your site, you are in danger of suffocating, inhaling toxic materials, fire, drowning, or being crushed by a cave-in.



This worker is in a trench with no protective system, that is not sloped or benched and has no means of egress.

How Do I Avoid Hazards?

Pre-job planning is vital to accident-free trenching; safety cannot be improvised as work progresses. The following concerns must be addressed by a competent person:

- Evaluate soil conditions [1926 Subpart P Appendix A] and select appropriate protective systems [1926 Subpart P Appendix F].
- Construct protective systems in accordance with the standard requirements [1926.652].
- Preplan; contact utilities (gas, electric) to locate underground lines, plan for traffic control if necessary, determine proximity to structures that could affect choice of protective system.

- Test for low oxygen, hazardous fumes and toxic gases, especially when gasoline engine-driven equipment is running, or the dirt has been contaminated by leaking lines or storage tanks. Insure adequate ventilation or respiratory protection if necessary.
- Provide safe access into and out of the excavation.
- Provide appropriate protections if water accumulation is a problem.
- Inspect the site daily at the start of each shift, following a rainstorm, or after any other hazard-increasing event.
- Keep excavations open the minimum amount of time needed to complete operations.

Construction Worker Dies

Additional Information:

- OSHA Standard: 1926.652
- Trench Safety. Auburn University Engineering Extension.
- Additional Examples

Additional Examples

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200 Constitution Avenue, NW
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Deaths Due to No Protective System

Case Reports

The following Case Reports of trenching accidents investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

- Two employees were installing 6" PVC pipe in a trench 40' long x 9' deep x 2' wide. No means of protection was provided in the vertical wall trench. A cave-in occurred, fatally injuring one employee and causing serious facial injuries to the other.

- An inadequately protected trench wall collapsed, killing one employee who had just gotten into the trench to check grade for installation of an 8" sewer line. The trench was 20-25 feet deep and had been benched about one bucket-width (4 feet) on each side. At the time of the collapse a backhoe was still extracting soil from the trench.

- Four employees were in an excavation 32' long x 7' deep x 9' wide boring a hole under a road. Eight-foot steel plates used as shoring were placed against the side walls of the excavation at about 30-degree angles. No horizontal bracing was used. One of the plates tipped over, crushing an employee.

OSHA CONSTRUCTION eTOOL

Trenching and Excavation: Failure to Inspect Trench and Protective System

Am I In Danger?

If trenches and excavations at your site are not inspected daily for evidence of possible cave-ins, hazardous atmospheres, failure of protective systems, or other unsafe conditions, you are in danger.

This excavation was properly inspected before the workers were allowed to work.

SAFETY BULLETIN

Construction Worker Dies

How Do I Avoid Hazards?

Inspect excavations:

- Before construction begins.
- Daily before each shift.
- As needed throughout the shift.
- Following rainstorms or other hazard-increasing events (such as a vehicle or other equipment approaching the edge of an excavation).

Inspections must be conducted by a competent person who:

- Has training in soil analysis.
- Has training in the use of protective systems.
- Is knowledgeable about the OSHA requirements.
- Has authority to immediately eliminate hazards.

To help evaluate different protection systems and identify the warning signs of excavation failure, see the Guide for Daily Inspection of Trenches and Excavations.

Additional Information:

- OSHA Standard: 1926.651(k)
- Trench Safety. Auburn University Engineering Extension.

OSHA CONSTRUCTION eTOOL

Guide for Daily Inspection of Trenches and Excavations

Project:		Date:	Weather:	Soil Type:
Trench Depth:	Length:	Width:	Type of Protective System:	

Yes	No	N / A	Excavation
			Excavations and Protective Systems inspected byCompetent Person daily, before start of work.
			Competent Person has authority to remove workers from excavation immediately.
			Surface encumbrances supported or removed.
			Employees protected from loose rock or soil.
			Hard hats worn by all employees.
			Spoils, materials, and equipment set back a minimum of 2' from edge of excavation.
			Barriers provided at all remote excavations, wells, pits, shafts, etc.
			Walkways and bridges over excavations 6' or more in depth equipped with guardrails.
			Warning vests, or other highly visible PPE provided and worn by all employees exposed to vehicular traffic.
			Employees prohibited from working or walking under suspended loads.
			Employees prohibited from working on faces of sloped or benched excavations above other employees.
			Warning system established and used when mobile equipment is operating near edge of excavation.

Yes	No	N / A	Utilities
			Utility companies contacted and/or utilities located.
			Exact location of utilities marked when near excavation.
			Underground installations protected, supported, or removed when excavation is open.

Yes	No	N / A	Wet Conditions
			Precautions taken to protect employees from accumulation of water.
			Water removal equipment monitored by Competent Person.
			Surface water controlled or diverted.
			Inspection made after each rainstorm.

Yes	No	N / A	Hazardous Atmosphere
			Atmosphere tested when there is a possibility of oxygen deficiency or build-up of hazardous gases.
			Oxygen content is between 19.5% and 21%.
			Ventilation provided to prevent flammable gas build-up to 20% of lower explosive limit of the gas.
			Testing conducted to ensure that atmosphere remains safe.
			Emergency Response Equipment readily available where a hazardous atmosphere could or does exist.
			Employees trained in the use of Personal Protective and Emergency Response Equipment.
			Safety harness and life line individually attended when employees enter deep confined excavation.

Signature of Competent Person, Date	

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Competent Person

Certain activities or safety procedures at a construction site require design, inspection or supervision by a competent person. The OSHA Construction Standard defines a competent person as someone who is:

- capable of identifying existing and predictable hazards in the surroundings, or
- working conditions which are unsanitary, hazardous, or dangerous to employees, and
- who has authorization to take prompt corrective measures to eliminate them.

Trenching and excavation work is dependent on these specialized employees because its highly technical nature, as well as its inherent hazards, require a greater level of training and experience than a normal worker would possess. The items below specify the trenching and excavation activities where a competent person is necessary.

Protective Systems or Equipment

- Monitoring water removal equipment and operations [1926.651(h)(2)].
- Inspecting excavations subject to runoff from heavy rains to determine need for diversion ditches, dikes, or other suitable protection [1926.651(h)(3)].
- Determining cave-in potential to assess need for shoring or other protective system [1926.652(a)(1)].
- Examining damaged material or equipment used for protective systems to determine its suitability for continued use [1926.652(d)(3)].
- Classifying soil and rock deposits, by both visual analysis and by testing, to determine appropriate protection; re-classifying, if necessary, based on changing conditions [1926 Subpart P App A].
- Determining the appropriate slope of an excavation to prevent collapse due to surcharge loads from stored material or equipment, operating equipment, adjacent structures, or traffic, and assuring that such slope is achieved [1926 Subpart P App B (c)(3)(iii)].

Inspecting Trench and Protective Systems

- Authorizing immediate removal of employees from the hazardous area where evidence of possible cave-in, failure of protective systems, hazardous atmospheres, or other hazardous conditions exists [1926.651(k)(2)].

Unsafe Access/Egress

- Designing structural ramps that are used solely by employees as a means of access or egress. Structural ramps used for access or egress of equipment must be designed by a competent person qualified in structural design [1926.651(c)(1)(i)].

Deaths Due to No Trench and Protective System Inspection

Case Reports

The following Case Reports of trenching accidents investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

- An employee was in a trench installing forms for concrete footers when it caved-in, causing fatal injuries. The trench, which was 7 1/2 feet deep, was in loose, sandy (Type C) soil, and no inspection was conducted prior to the start of the shift.

- In a trench 6 feet deep x 32 inches wide, an employee was applying a waterproofing primer containing methyl chloroform and 1,4-dioxane to the foundation of a house. The employee was overcome by the fumes, and later died of trichloroethane intoxication. No one had tested the atmosphere in the trench, the employees were not provided with respiratory protection, and mechanical ventilation was not used.

OSHA CONSTRUCTION eTOOL

Trenching and Excavation: Unsafe Spoil-Pile Placement

Am I In Danger?

Excavated material (spoils) at your site are hazardous if they are set too close to the edge of a trench/excavation. The weight of the spoils can cause a cave-in, or spoils and equipment can roll back on top of workers, causing serious injuries or death.

The spoil pile is required to be at least 2 feet from the edge of the trench and/or retained to prevent it from falling into the trench.

How Do I Avoid Hazards?

Provide protection by one or more of the following:

- Set spoils and equipment at least 2 feet back from the excavation.
- Use retaining devices, such as a trench box, that will extend above the top of the trench to prevent equipment and spoils from falling back into the excavation.
- Where the site does not permit a 2-foot set back, spoils may need to be temporarily hauled to another location.

SAFETY BULLETIN

Construction Worker Dies

Additional Information:

- OSHA Standard: 1926.651(j)(2)
- Trench Safety. Auburn University Engineering Extension.

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Deaths Due to Unsafe Spoil-Pile Placements

Case Reports

The following Case Reports of trenching accidents investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

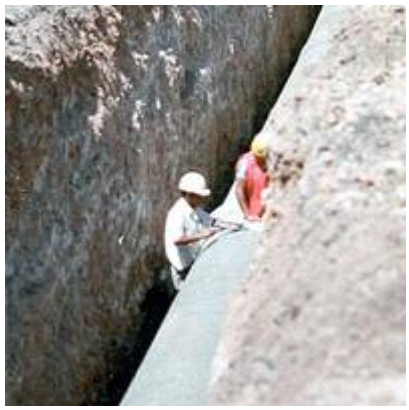
- A spoil-pile had been placed on top of a curb which formed the west face of a trench. A backhoe was spotted on top of the spoil-pile. The west face of the trench collapsed on two employees who were installing sewer pipe. One employee was killed; the other received back injuries. The trench was 8 feet deep with vertical walls. No other protection was provided. The superimposed loads of the spoil-pile and backhoe may have caused the collapse.

OSHA CONSTRUCTION eTOOL

Trenching and Excavation: Unsafe Access/Egress

Am I In Danger?

To avoid fall injuries during normal entry and exit of a trench or excavation at your job site, ladders, stairways, or ramps are required. In some circumstances, when conditions in a trench or excavation become hazardous, survival may even depend on how quickly you can climb out.



These workers are not protected from a cave-in, nor do they have any apparent safe access or egress from the trench.

How Do I Avoid Hazards?

- Provide stairways, ladders, ramps, or other safe means of egress in all trenches that are 4 feet deep or more.
- Position means of egress within 25 lateral feet of workers.
- Structural ramps that are used solely for access or egress from excavations must be designed by a competent person.
- When two or more components form a ramp or runway, they must be connected to prevent displacement, and be of uniform thickness.
- Cleats or other means of connecting runway components must be attached in a way that would not cause tripping (e.g., to the bottom of the structure).
- Structural ramps used in place of steps must have a non-slip surface.
- Use earthen ramps as a means of egress only if a worker can walk them in an upright position, and only if they have been evaluated by a competent person.

SAFETY BULLETIN

Construction Worker Dies

Additional Information:

- OSHA Standard: 1926.651(c)
- Trench Safety. Auburn University Engineering Extension.
- Additional Examples

Additional Examples

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Case Reports

The following Case Reports of trenching accidents investigated by OSHA illustrate how seemingly innocent workplace activities can have deadly consequences.

- Two employees were laying pipe in a trench 12-feet deep, when one of the employees saw the bottom face of the trench move. He jumped out of the way along the length of the trench; the other employee was fatally injured as the wall caved-in. The walls of the trench were not sloped, and no means of emergency egress were provided.

- In a 15-foot deep trench, which was not shored or sloped properly, two workers were laying sewer pipe. The only means of egress was by climbing the backfill. While exiting the trench, one of the workers was trapped by a small cave-in. The second employee tried to extricate him, but a second cave-in occurred, trapping the second employee at the waist. The second cave-in actually caused the death of the first employee; the second employee sustained a hip injury.

OSHA CONSTRUCTION eTOOL

User Guide

This eTool is best viewed at a screen resolution of 800 x 600. At a lower resolution you will not be able to view the full width of the page without using the scroll bar. This resolution can be set in Windows95 (or higher) using the following procedure:

- Click on the Start Button and select the Settings option, then click on Control Panel.
- Open Display by double clicking on the icon.
- Click on the Settings tab near the top of the window.
- Move the slider in the Desktop Area to 800 x 600. If your monitor or display adapter does not support this resolution, this option should not be available.
- Read and follow any additional instructions you receive.

To print full screen pages of this eTool, set left and right margins at a maximum of 0.25 inches.

- Select Page Setup from the File Menu of your browser.
- Change the settings for left and right margins to 0" (your browser may reset these values to a higher number which is the minimum setting it will allow, this is acceptable).
- Select OK.
- Exit page setup and print from the browser print icon or from the File menu.

Site Map

- Main Index Page
- Electrical Incidents
  - Contact with Power Lines
    - Cranes and Derricks
    - Crane Fire!
    - Deaths Due to Contact with Power Lines
  - Lack of Ground-Fault Protection
    - Ground-Fault Circuit Interrupters (GFCI)
    - Assured Equipment Grounding Conductor Program (AEGCP)
    - Deaths Due to Lack of Ground-Fault Protection
  - Path to Ground Missing or Discontinuous
    - Grounding
    - Deaths Due to Path to Ground Missing or Discontinuous
  - Equipment Not Used in Manner Prescribed
    - Power Tools
    - Deaths Due to Equipment Not Used in Manner Prescribed
  - Improper Use of Extension and Flexible Cords
    - Flexible Cords

- Deaths Due to 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
    - Photo Examples of Burns and other Injuries

- Falls
  - Unprotected Sides, Wall Openings and Floor Holes
    - Guardrail Systems
    - Safety Net Systems
    - Personal Fall Arrest Systems
      - Attachment Location
      - Body Harness
      - Vertical Lifeline
      - Webbing
      - Anchorages
      - Horizontal Lifeline or Lanyard
      - Connectors
    - Deaths Due to Unprotected Sides, Wall Openings and Floor Holes
  - Improper Scaffold Construction
    - Scaffold Access
    - Deaths Due to Improper Guardrails on Tubular Welded-frame Scaffolds
  - Not Guarding Protruding Steel Rebars
    - Rebar Accident!
    - Deaths Due Not Guarding Protruding Steel Rebars
  - Misuse of Portable Ladders
    - Ladder Safety
    - Death Due to Misuse of Portable Ladders
- Struck-By
  - Vehicles
    - Vehicle Inspection
    - Brake Systems
    - Deaths Due to Being Struck-By a Vehicle
  - Falling/Flying Objects
    - Deaths Due to Falling/Flying Objects
  - Constructing Masonry Walls
    - Deaths Due to Constructing Masonry Walls
- Trenching and Excavation
  - No Protective System
    - Deaths Due to No Protective System
  - Failure to Inspect Trench and Protective System
    - Guide for Daily Inspection of Trenches and Excavations
    - Deaths Due to No Trench and Protective System Inspection
  - Unsafe Spoil-Pile Placement
    - Deaths Due to Unsafe Spoil-Pile Placements
  - Unsafe Access/Egress
    - Deaths Due to Unsafe Access/Egress
- Safety and Health Program
- Scope

- User Guide
- Bibliography
- Glossary
- Credits
- Disclaimer

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OSHA CONSTRUCTION eTOOL

Scope

There are numerous hazards that can lead to serious injury in the construction industry. The hazards addressed in this eTool have been selected because statistics show they cause most construction-related fatalities. An effective Safety and Health Program should focus on these areas to help ensure that potentially fatal accidents are prevented.

Do the OSHA Construction Standards apply to me?

1. The standards apply to:
   - All contractors who enter into contracts which are for construction, alteration, and/or repair, including painting and decorating [1926.10(a)].
   - All subcontractors who agree to perform any part of the labor or material requirements of a contract [1926.13(c)].
   - All suppliers who furnish any supplies or materials, if the work involved is performed on or near a construction site, or if the supplier fabricates the goods or materials specifically for the construction project, and the work can be said to be a construction activity [1926.13(c)].
2. The controlling contractor assumes all obligations under the standards, whether or not he subcontracts any of the work [1926.16(b)].
3. To the extent that a subcontractor agrees to perform any part of the contract, he assumes responsibility for complying with the standards with respect to that part [1926.16(c)].
4. With respect to subcontracted work, the controlling contractor and any subcontractors are deemed to have joint responsibility [1926.16(d)].

Highlights of Standards

No employer who performs any part of a construction contract shall require any employee to work in surroundings or under conditions which are [1926.20(a)(1)]:

- Unsanitary, and/or
- Hazardous, and/or
- Dangerous to health or safety.

Additional Information:

- OSHA Construction Standards: 1926.10(a)

OSHA CONSTRUCTION eTOOL

Safety & Health Program

Several OSHA Construction Standards address safety and health program elements. Following is a list of topics relevant to developing and maintaining a safety program, along with some regulatory citations applicable to each topic.

A. Initiate and Maintain Such Programs as May be Necessary to Comply with this Part-1926.20(b)

B. Management Commitment to Safety and Health

(1) Provide employees with sanitary and safe working conditions [1926.20(a)].

(2) Assign safety and health responsibilities [1926.20(b)].

(3) Give safety and health designees authority to correct hazards [1926.32(f)].

(4) Ensure employees may voice safety and health concerns without fear of reprisal [1903.11(d)].

(5) Inform employees of hazards [1926.21(b), 1926.33, 1926.59(h), Subpart Z, 1926.454].

(6) Coordinate hazard communication with other employers on site [1926.59(h), 1926.65, 1926.652].

(7) Post the OSHA State or Federal Poster [1903.2(a)].

C. Hazard Identification and Determination

(1) Evaluate operations, procedures, facilities, and equipment to identify hazards [1926.20(a), 1926.21(b)].

(2) Monitor exposure levels [1926.55, Subpart Z, 1926.62, 1926.1101].

(3) Ensure regular safety and health inspections [1926.20(b)(2), 1926.703(b), 1926.1081(g)].

(4) Conduct accident investigations [1904.4].

(5) Determine if engineering or administrative controls or personnel protective equipment are to be used [1926.103(a), 1926.951].

D. Hazard Elimination and Control

(1) Ensure machines and tools are in safe working order and in compliance with

relevant standards [1926.20(b)(3), 1926.550(a), 1926.951].

(2) Institute engineering and work practice controls to eliminate health hazards [1926.55, Subpart Z, 1926.103].

(3) Perform housekeeping to remove hazards posed by scrap and debris in work areas [1926.25, 1926.852, 1926.152(c)(5), 1926.900(k)(5)].

(4) Provide appropriate PPE when other controls are infeasible [1926.28(a), Subpart E].

(5) Guarantee safe means of egress [1926.34].

E. Emergency Response Planning

(1) Develop emergency response plans [1926.35, 1926.65(q)].

(2) Develop fire prevention and protection programs [1926.24, Subpart F, 1926.352].

F. First Aid and Medical

(1) Provide medical services, first aid treatment, and supplies [1926.50(a), 1926.103(e), Subpart Z, 1926.50(c), 1926.50(d)].

(2) Ensure availability of emergency rescue for injured employees [1926.50(e), 1926.106(a), 1926.21(b)(6), 1926.802(b)].

(3) Post emergency numbers for physicians, hospitals, or ambulances [1926.50 (f)].

G. Training

(1) Train employees to recognize hazards [1926.21(b)(2), 1926.65, 1926.302(e), 1926.1060].

(2) Train workers to recognize and avoid unsafe conditions [1926.21(b)(2), 1926.65, 1926.454, 1926.901(c)].

(3) Provide training on safe work practices and applicable standards [1926.21(b), 1926.103(k), 1926.750(b)(2)(iii)].

(4) Provide training on safe operation of equipment and machinery [1926.20(b)(4), 1926.302(e)].

(5) Provide training on hazards of access ladders and stairways [1926.1060(a), 1926.454, 1926.800(b) and (c)].

(6) Provide training on confined and enclosed space entry hazards and precautions [1926.21(b)(6), 1926.353(b), 1926.801].

H. Recordkeeping and Abatement Verification

(1) Record injuries and fatalities [1904.5, 1904.8].

(2) Maintain medical records [1926.33].

(3) Maintain exposure records [1926.33].

(4) Maintain appropriate documents and tags for abatement verification [1903.19].

OSHA CONSTRUCTION eTOOL

Glossary

GENERAL CONSTRUCTION

ANSI: American National Standards Institute.

Approved: Sanctioned, endorsed, accredited, certified, or accepted as satisfactory by a duly constituted and nationally recognized authority or agency.

Authorized person: A person approved or assigned by the employer to perform a specific type of duty or duties or to be at a specific location or locations at the jobsite. See *Designated person.*

Certified: Equipment is "certified" if it (a) has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner, or (b) is of a kind whose production is periodically inspected by a nationally recognized testing laboratory, and (c) it bears a label, tag, or other record of certification.

Competent person: One who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Construction work: Work for construction, alteration, and/or repair, including painting and decorating.

Defect: Any characteristic or condition which tends to weaken or reduce the strength of the tool, object, or structure of which it is a part.

Designated person: See *Authorized person*.

Employee: Every laborer or mechanic, regardless of the contractual relationship which may be alleged to exist between the laborer and mechanic and the contractor or subcontractor who engaged him. "Laborer" generally means one who performs manual labor or who labors at an occupation requiring physical strength; "mechanic" generally means a worker skilled with tools.

Employer: Contractor or subcontractor.

Equivalent: Alternative designs, materials, or methods to protect against a hazard which the employer can demonstrate will provide an equal or greater degree of safety for employees than the methods, materials or designs specified in the standard.

Hazardous substance: A substance which, by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, or otherwise harmful, is likely

to cause death or injury.

Qualified Person: One who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work, or the project.

Safety factor: The ratio of the ultimate breaking strength of a member or piece of material or equipment to the actual working stress or safe load when in use.

SAE: Society of Automotive Engineers.

Shall: Mandatory.

Should: Recommended.

Suitable: That which fits, and has the qualities or qualifications to meet a given purpose, occasion, condition, function, or circumstance.

ELECTRICAL INCIDENTS

Ampere: The unit by which the flow of current through a conductor is measured.

Arc: A discharge of electricity through a gas, such as air.

Attachment Cap: See *Plug*.

Circuit: The path along which electric current flows from start to finish is called a *circuit.* The circuit includes the generator or battery which starts the current, the wires, and any electrical device that the current operates. If any part of the circuit is removed, the current cannot flow. The circuit is then *broken* or *open.* Because electric current seeks to complete its circuit, it will travel along any path that is presented (path of least resistance), which is why humans are at risk of electrocution when they handle damaged tools or cords, or contact un-insulated wires. In effect, they become part of the circuit.

Circuit breaker: A protective device which automatically opens, or *trips,* a circuit, without damage to itself, when the current exceeds a predetermined level.

Conductor: A substance or body that allows a current of electricity to pass continuously along it. Metals, such as copper or aluminum, are good conductors. In a circuit, current-carrying wires are termed "conductors", as in a flexible cord.

Current: The flow of electrons through a conductor, measured in amperes (amps). If the current flows back and forth through a conductor, it is called *alternating current* (AC). If the current flows in one direction only, as in a car battery, it is called *direct current* (DC). AC is most widely used because it is possible to increase ("step up") or decrease ("step down") the current through a transformer. For example, when current from an overhead power line is run through a pole-mounted transformer, it can be stepped down to normal household current. Also, alternating current can travel enormous distances with little loss of *voltage*, or power.

Cycle: When alternating current flows back and forth through a conductor, it is said to *cycle*. In each cycle, the electrons flow first in one direction, then the other. In the United States, the normal rate for power transmission is 60 cycles per second, or 60 Hertz (Hz).

De-energize: To free from any electric connection and/or electric charge.

Electricity: The flow of an atom's electrons through a conductor.

Electrode: A conductor used to establish electrical contact with a nonmetallic part of a circuit.

Energize: To direct electric current through a conductor. Power lines and wires can be intentionally energized (or de-energized) to carry current to an electrical device. But conductive surfaces which are unintentionally energized, like the metal case of a tool, the metal housing of a circuit box, or a metal object such as an aluminum ladder, present a danger of electrocution.

Fault: An insulation failure that exposes electrified conductors, causing current to leak and possibly resulting in electric shock.

Fuse: A protective device which allows a piece of metal to become part of a circuit. The metal melts under heat created by excessive current, thereby interrupting the circuit and preventing the flow of electricity from exceeding the circuit's current-carrying capacity.

GFCI (Ground-fault circuit interrupter): A device that detects an insulation failure by comparing the amount of current flowing to electrical equipment with the amount of current returning from the equipment. Whenever the difference is greater than 5 milliamps, the GFCI trips and thereby interrupts the flow of electricity.

Ground: A conducting connection, intentional or unintentional, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Ground-fault: A fault, or insulation failure, in the wire used to create a path to ground.

Grounding: To prevent the buildup of hazardous voltages in a circuit by creating a low-resistance path to earth or some other ground plane.

Guarding: Placement of live parts of electrical equipment where they cannot accidentally be contacted, such as in a vault, behind a shield, or on a raised platform, to which only qualified persons have access.

Impedance: Opposition to the flow of alternating (AC) electric current. See *Resistance*.

Insulation: Non-conductive materials used to cover or surround a conductor, permitting it to be handled without danger of electric shock.

Insulator: Any material, such as glass or rubber, that prevents the flow of electric current.

Kilowatt: One thousand watts.

Lockout: To lock a switch in the "off" position by means of a padlock, or to lock electrified equipment behind a locked door, to which only qualified persons have the key.

Low-Impedance: Low resistance to A/C current.

Milliampere: A unit of measurement equaling one thousandth (1/1000) of an ampere.

Ohm: The unit by which resistance to electrical current is measured. From *Ohm's Law* (Current=Voltage/Resistance, or in other words, Current=Voltage/Ohms), a mathematical expression of the relationship between these three elements.

Overcurrent: Any current in excess of the rated capacity of equipment or of a conductor.

Phase: In AC power systems, load current is drawn from a voltage source which typically takes the form of a sine wave. Ideally, the current drawn by the loads in

the system is also a sine wave. With a simple, resistive load such as a light bulb, the *current* sine wave is always aligned with the *voltage* sine wave. This is called *single-phase.* A single-phase power system normally uses three wires, called hot, neutral, and ground, and the voltage is typically 120/240. Most home and office outlets operate in this manner. With some loads, such as motors, and in high voltage systems, the current sine wave is purposely delayed and lags behind the voltage sine wave. The amount of this lag is expressed in degrees and is called a *phase difference*. A common example is three-phase power, where the system has three "hot" wires, each 120 degrees out of phase with each other.

Plug: A device to which the conductors of a cord are attached, which is used to connect to the conductors permanently attached to a receptacle.

Polarity: The relationship between poles of *positive* and *negative* charge, particularly with regard to wiring of conductors where the ungrounded (hot) conductor and grounded (neutral) conductor form a circuit.

Qualified Person: One familiar with the construction and operation of the equipment and the hazards involved.

Raceway: A channel designed expressly for holding wires, cables, or busbars, including conduit, tubing, wireways, busways, gutters, or moldings.

Rating: The stated operating limit of a piece of equipment, expressed in a unit of measure such as volts or watts.

Receptacle: A device, such as a jack or an outlet, to which conductors are attached, and where a plug makes contact with a source of electric current.

Resistance: Anything that impedes the flow of electricity, particularly in direct (DC) current. Resistance is measured in *ohms*.

Tag: To identify electric equipment by class, group and the temperature range for which it is approved.

Volt: The unit by which electrical force or pressure is measured.

Voltage: The fundamental force or pressure that causes electricity to flow through a conductor. Measured in *volts*.

Watt: The unit by which *electric energy,* or the ability of electricity to do work, is measured. A thousand watts, or one *kilowatt,* equals 1.34 horsepower.

FALLS

Adjustable suspension scaffold: A suspension scaffold equipped with a hoist that can be operated by an employee on the scaffold.

Anchorage: A secure point of attachment for lifelines, lanyards or deceleration devices.

Body belt: A strap with means both for securing it about the waist and for attaching it to a lanyard, lifeline, or deceleration device. (As of January 1, 1998 body belts are not acceptable as part of a personal fall arrest system.)

Body harness: Straps which may be secured about the employee in a manner that will distribute the fall arrest forces over at least the thighs, pelvis, waist, chest, and shoulders, with means for attaching it to other components of a personal fall arrest system.

Brace: A rigid connection that holds one scaffold member in a fixed position with respect to another member, or to a building or structure. See *Cross braces*.

Cleat: A structural block used at the end of a platform to prevent the platform

from slipping off its supports. Cleats are also used to provide footing on sloped surfaces such as crawling boards.

Connector: A device that is used to couple (connect) parts of the personal fall arrest system and positioning device systems together. It may be an independent component of the system, such as a carabiner, or it may be an integral component of part of the system, such as a buckle or D-ring sewn into a body belt or body harness, or a snaphook spliced or sewn to a lanyard or self-retracting lanyard.

Controlled access zone (CAZ): An area in which certain work (e.g., overhand bricklaying) may take place without guardrail systems, personal fall arrest systems, or safety net systems, and access to the zone is controlled.

Cross braces: Two braces which cross each other in the form of an X.

Deceleration device: Any mechanism, such as a rope grab, rip-stitch lanyard, specially-woven lanyard, tearing or deforming lanyard, automatic self-retracting lifeline/lanyard, etc., which serves to dissipate a substantial amount of energy during a fall arrest, or otherwise limit the energy imposed on an employee during fall arrest.

Deceleration distance: The additional vertical distance a falling employee travels, excluding lifeline elongation and free fall distance, before stopping, from the point at which the deceleration device begins to operate. It is measured as the distance between the location of an employee's body belt or body harness attachment point at the moment of activation (at the onset of fall arrest forces) of the deceleration device during a fall, and the location of that attachment point after the employee comes to a full stop.

Fabricated frame scaffold: A scaffold consisting of platforms supported on fabricated end frames with integral posts, horizontal bearers, and intermediate members.

Failure: Load refusal, breakage, or separation of component parts. Load refusal is the point where the ultimate strength is exceeded.

Free fall: The act of falling before a personal fall arrest system begins to apply force to arrest the fall.

Free fall distance: The vertical displacement between onset of the fall and just before the fall arrest system begins to apply force to arrest the fall. This distance excludes deceleration distance, and lifeline/lanyard elongation, but includes any deceleration device slide distance or self-retracting lifeline/lanyard extension before they operate and fall arrest forces occur.

Guardrail system: A barrier erected to prevent employees from falling to lower levels.

Hole: A gap or void 2 inches (5.1 cm) or more in its least dimension, in a floor, roof, or other walking/working surface.

Hoist: A manual or power-operated mechanical device to raise or lower a suspended scaffold.

Infeasible: Impossible to perform the construction work using a conventional fall protection system (i.e., guardrail system, safety net system, or personal fall arrest system) or technologically impossible to use any one of these systems to provide fall protection.

Ladder stand: A mobile, fixed-size, self-supporting ladder consisting of a wide flat tread ladder in the form of stairs.

Landing: A platform at the end of a flight of stairs.

Lanyard: A flexible line of rope, wire rope, or strap which generally has a connector at each end for connecting the body belt or body harness to a deceleration device, lifeline, or anchorage.

Leading edge: The edge of a floor, roof, or formwork for a floor or other walking/working surface (such as the deck) which changes location as additional floor, roof, decking, or formwork sections are placed, formed, or constructed. A leading edge is considered to be an "unprotected side and edge" during periods when it is not actively and continuously under construction.

Lifeline: A component consisting of a flexible line connected vertically to an anchorage at one end (vertical lifeline), or connected horizontally to anchorages at both ends (horizontal lifeline), and which serves as a means for connecting other components of a personal fall arrest system to the anchorage.

Low-slope roof: A roof having a slope less than or equal to 4 to 12 (vertical to horizontal).

Lower levels: Those areas or surfaces to which an employee can fall. Such areas or surfaces include, but are not limited to, ground levels, floors, platforms, ramps, runways, excavations, pits, tanks, material, water, equipment, structures, or portions thereof.

Maximum intended load: The total load of all persons, equipment, tools, materials, transmitted loads, and other loads reasonably anticipated to be applied to a scaffold or scaffold component at any one time.

Opening: A gap or void 30 inches (76 cm) or more high and 18 inches (48 cm) or more wide, in a wall or partition, through which employees can fall to a lower level.

Open sides and ends: The edges of a platform that are more than 14 inches (36 cm) away horizontally from a sturdy, continuous, vertical surface (such as a building wall) or a sturdy, continuous horizontal surface (such as a floor), or a point of access. Exception: For plastering and lathing operations the horizontal threshold distance is 18 inches (46 cm).

Overhand bricklaying: The process of laying bricks and masonry units such that the surface of the wall to be jointed is on the opposite side of the wall from the mason, requiring the mason to lean over the wall to complete the work. Related work includes mason tending and electrical installation incorporated into the brick wall during the overhand bricklaying process.

Personal fall arrest system: A system used to stop an employee in a fall from a working level. It consists of an anchorage, connectors, a body harness and may include a lanyard, deceleration device, lifeline, or suitable combinations of these. As of January 1, 1998, using a body belt for fall arrest is prohibited.

Platform: A work surface elevated above lower levels. Platforms can be constructed using individual wood planks, fabricated planks, fabricated decks, and fabricated platforms.

Positioning device system: A body belt or body harness system rigged to allow an employee to be supported on an elevated vertical surface, such as a wall, and work with both hands free while leaning.

Rated load: The manufacturer's specified maximum load to be lifted by a hoist or to be applied to a scaffold or scaffold component.

Rope grab: A deceleration device which travels on a lifeline and automatically, by friction, engages the lifeline and locks so as to arrest the fall of an employee. A rope grab usually employs the principle of inertial locking, cam/level locking, or both.

Roof: The exterior surface on the top of a building. This does not include floors or formwork which, because a building has not been completed, temporarily become the top surface of a building.

Roofing work: The hoisting, storage, application, and removal of roofing materials and equipment, including related insulation, sheet metal, and vapor barrier work, but not including the construction of the roof deck.

Safety-monitoring system: A safety system in which a competent person is responsible for recognizing and warning employees of fall hazards.

Scaffold: Any temporary elevated platform (supported or suspended) and its supporting structure (including points of anchorage), used for supporting employees or materials or both.

Self-retracting lifeline/lanyard: A deceleration device containing a drum-wound line which can be slowly extracted from, or retracted onto, the drum under slight tension during normal employee movement, and which, after onset of a fall, automatically locks the drum and arrests the fall.

Snaphook: A connector comprised of a hook-shaped member with a normally closed keeper, or similar arrangement, which may be opened to permit the hook to receive an object and, when released, automatically closes to retain the object. Snaphooks are generally one of two types: The locking type with a self-closing, self-locking keeper which remains closed and locked until unlocked and pressed open for connection or disconnection; or the non-locking type with a self-closing keeper which remains closed until pressed open for connection or disconnection. As of January 1, 1998, the use of a non-locking snaphook as part of personal fall arrest systems and positioning device systems is prohibited.

Stair tower (Scaffold stairway/tower): A tower comprised of scaffold components and which contains internal stairway units and rest platforms. These towers are used to provide access to scaffold platforms and other elevated points such as floors and roofs.

Steep roof: A roof having a slope greater than 4 in 12 (vertical to horizontal).

Stilts: A pair of poles or similar supports with raised footrests, used to permit walking above the ground or working surface.

Toeboard: A low protective barrier that will prevent the fall of materials and equipment to lower levels and provide protection from falls for personnel.

Tubular welded-frame scaffold: See *Fabricated frame scaffold*.

Unprotected sides and edges: Any side or edge (except at entrances to points of access) of a walking/working surface, e.g., floor, roof, ramp, or runway where there is no wall or guardrail system at least 39 inches (1.0 m) high.

Unstable objects: Items whose strength, configuration, or lack of stability may allow them to become dislocated and shift and therefore may not properly support the loads imposed on them. Unstable objects do not constitute a safe base support for scaffolds, platforms, or employees. Examples include, but are not limited to, barrels, boxes, loose bricks, and concrete blocks.

Walking/working surface: Any surface, whether horizontal or vertical, on which an employee walks or works, including, but not limited to, floors, roofs, ramps, bridges, runways, formwork, and concrete reinforcing steel, but not including ladders, vehicles, or trailers, on which employees must be located in order to perform their job duties.

Walkway: A portion of a scaffold platform used only for access and not as a work level.

Warning line system: A barrier erected on a roof to warn employees that they are approaching an unprotected roof side or edge, and which designates an area in which roofing work may take place without the use of guardrail, body belt, or safety net systems to protect employees in the area.

STRUCK-BY

Chock: A wedge, block, or large stone placed against the tires of a vehicle to prevent its moving, especially on an incline.

Formwork: The total system of support for freshly placed or partially cured concrete, including the mold or sheeting (form) that is in contact with the concrete as well as all supporting members including shores, reshores, hardware, braces, and related hardware.

Jacking operation: The task of lifting a slab (or group of slabs vertically from one location to another (e.g., from the casting location to a temporary (parked) location, or to its final location in the structure), during the construction of a building/structure where the lift-slab process is being used.

Lift slab: A method of concrete construction in which floor and roof slabs are cast on or at ground level and lifted into position using jacks.

Limited access zone: An area alongside a masonry wall that is under construction and clearly demarcated to limit access by employees.

Pre-cast concrete: Concrete members (such as walls, panels, slabs, columns, and beams) which have been formed, cast, and cured before final placement in a structure.

Reshoring: The construction operation in which shoring equipment (also called reshores or reshoring equipment) is placed, as the original forms and shores are removed, to support partially cured concrete and construction loads.

Rollover protective structure (ROPS): Vehicle structures such as roll-bars, frames, roll-protective cabs etc., designed to prevent the vehicle operator from being crushed as a result of a rollover.

Seatbelt: A device, usually worn around the waist, consisting of a strap or straps anchored to a vehicle so as to hold a person in his seat.

Shore: A supporting member that resists a compressive force imposed by a load; or the operation by which a supporting member is placed.

Vertical slip forms: Forms that are jacked vertically during the placement of concrete.

TRENCHING AND EXCAVATION

Bell-bottom pier hole: A type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

Benching (Benching system): A method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in: The separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

Cross braces: The horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or

wales.

Excavation: Any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Faces: The vertical or inclined earth surfaces formed as a result of excavation work.

Failure: The breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere: An atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Protective system: A method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Ramp: An inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer: A person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Sheeting: The members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield system): A structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either pre-manufactured or job-built in accordance with 1926.652(c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (Shoring system): A structure such as a metal hydraulic, mechanical, or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.

Sides: See *Faces*.

Sloping (Sloping system): A method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Spoil: The dirt, rocks, and other materials removed from an excavation and either temporarily or permanently put aside.

Stable rock: Natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Structural ramp: A ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

Support system: A structure such as underpinning, bracing, or shoring, that provides support to an adjacent structure, underground installation, or the sides of an excavation.

Tabulated data: Tables and charts approved by a registered professional engineer and used to design and construct a protective system

Trench (Trench excavation): A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m).

Trench box: See *Shield*.

Trench shield: See *Shield*.

Uprights: The vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other.

Wales: Horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

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