Electrical Hazards in Construction…

Hundreds of workers are killed or injured every year due to exposure to hazardous electrical energy. Electric shock, burns and falls are some of the hazards associated with working with electricity; electrocution is death by electric shock.

Working with and around electricity should be taken seriously as a dangerous business. This is no place to cut corners or cheat on safety. You should pay attention and know what it takes to stay safe…

Work Smart, Build Safe!

This publication includes:

1. The purpose of the Occupational Safety and Health Administration (OSHA) and its enforcement duty under law.
2. Introduction to electrical hazards and how shocks occur.
3. Recognition and avoidance of common electrical hazards.
4. Procedures for preventing contact with overhead and underground power lines.
5. Ground fault protection requirements for jobsites.
6. Information on extension cords and other electrical equipment.
7. Lockout/Tagout procedures.
8. Electrical safety-related work practices.
9. Personal protective equipment (PPE).
10. OSHA Fact Sheets.

OSHA DISCLAIMER

This material was produced under grant number SH-31209-SH7 from the Occupational Safety and Health Administration, U.S. Department of Labor. It does not necessarily reflect the views or policies of the U.S. Department of Labor, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.

www.buildsafe.org

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The content of this *Electrical Hazards in Construction* book is primarily derived from OSHA's electrical standards and NFPA requirements. Other contributions come from OSHA Letters of Interpretation, OSHA Fact Sheets and posters.

We hope you enjoy the course!

The Construction Safety Council would like to thank the following for their generous support and contributions to this training program:

- The Occupational Safety & Health Administration (OSHA)
- Department of Health and Human Services
- Centers for Disease Control and Prevention
- National Institute for Occupational Safety and Health
- LoMastro & Associates, Inc.

Reasons for Development

- Protect the safety and health of the worker.
- Train competent persons to perform frequent and regular inspections of the jobsites, materials and equipment.
- Help employers understand and react to electrical hazards in construction and comply with Federal rules and regulations.

Employers have the responsibility to:

(1) Develop safety programs to comply with OSHA standards.

(2) Provide for frequent and regular inspections of the jobsites, materials, and equipment to be made by competent persons designated by the employer.

(3) Not allow the use of any machinery, tool, material, or equipment which is not in compliance with any applicable requirement of OSHA. Such machine, tool, material, or equipment shall either be identified as unsafe by tagging or locking the controls to render them inoperable or shall be physically removed from its place of operation.

(4) Permit only those employees qualified by training or experience to operate equipment and machinery.

Employer's responsibility to train workers:

(1) The employer should avail himself of the safety and health training programs OSHA provides.

(2) The employer shall instruct each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to the work environment to control or eliminate any hazards or other exposure to illness or injury.

Course Goal

The goal of this course is to enhance communication of electrical hazards between employers and employees and to prevent accidents. At the conclusion, each course participant will possess the confidence to recognize and avoid unsafe conditions and behaviors as well as be able to identify regulations applicable to electrical hazards in construction. Participants will be able to:

- Train competent persons.
- Become more aware of electrical hazards in construction and function within a safety management system.

Course Participants Will Learn

- Occupational Safety & Health Administration (OSHA) electrical standards.
- The decision making process to perform a job safety plan, identify hazards, assess risks, and select appropriate risk control methods from the hierarchy of controls, including personal protective equipment.
- How and when to make managerial decisions, such as how to implement a job-site *Electrical Safety Management System*.

Intended Audience

The target audience is the construction employer, manager, employee or employee representative who, as part of a safety and health program, would either be acting to fulfill the requirements of a competent person (to conduct frequent and regular inspections of a jobsite) or performing safety and health evaluations for their member employees and performing training as described in OSHA's construction safety & health standard 29 CFR 1926. This audience may include:

- Jobsite Competent Persons
- Qualified Persons
- Site Supervisors
- Owners

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Introduction to Electrical Hazards

Discussion Points

- Types of electrical injuries
- OSHA's Focus Four
- How shocks occur
- Factors affecting severity of electric shock
- Arc blast hazards
- The basics of electricity

So much in life wouldn't be possible if it weren't for electricity. It powers our alarm clocks, coffee pots, TV's and power tools; in fact it's hard to imagine life without electricity. But, it can be as dangerous as it is useful.

Electrical Injuries

There are four main types of electrical injuries:

- Electrocution (death due to electrical shock);
- Electrical shock;
- Burns (Arc Blast); and,
- Falls

OSHA Focus Four

Construction safety is one of OSHA's top concerns, making up more than 60% of OSHA's inspections. Four main hazards have been identified by OSHA as responsible for the majority of injuries and fatalities.

1. Falls
2. Caught-in-Between
3. Struck-by
4. Electrocution

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 one wire of an energized circuit and the ground.
- A person contacts a metallic part in contact with an energized wire while the person is also in contact with the ground.
- A person contacts both wires of an energized circuit.

Factors Affecting Severity of Electrical Shock

1. Amount of current flow
2. Path of current flow
3. Duration of current flow

Electrocution Triangle

The amount of current flowing through the body, the **path** the **current** takes through the body and the length of **time** that the body is in the circuit all have an effect on the severity of an injury; remove any one of these factors from the electrocution triangle, and the potential for injury is reduced.

Effects of Electric Current on Human Body

Source: (NIOSH) Publication Number 2009–113

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.
1000-4,300 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.

Note: One (1) ampere equals 1,000 milliamperes.

Remember…

Common household circuit breakers or fuse boxes (picture) operate at 15 or 20 amperes. This means that a circuit breaker will "trip" when it senses an overload of 15,000 – 20,000 milliamperes.

Circuit breakers and fuses are not designed to protect from electric shock, but rather to prevent fires if a wire becomes overheated.

Arc Blast

According to the National Fire Protection Association (NFPA 70E – 2018), an ***Arc Flash Hazard*** is defined as a source of possible injury or damage to health associated with the release of energy caused by an electric arc. The results are often violent and when a human is in close proximity to the arc flash, serious injury and even death can occur.

Arc flash can be caused by:

- Dust
- Dropping tools
- Accidental touching
- Condensation
- Material failure
- Corrosion
- Faulty Installation

Three factors determine the severity of an arc flash injury:

- Proximity of the worker to the hazard
- Temperature
- Time for circuit to break

Typical results from an arc flash

- Burns (Non-FR clothing can burn onto skin)
- Fire (could spread rapidly through building)
- Flying objects (often molten metal)
- Blast pressure (upwards of 2,000 lbs. / ft^2)
- Sound Blast (noise can reach 140 dB – as loud as a handgun)
- Heat (upwards of 35,000 degrees F)

Arc Flash Suit (NFPA 70E – 2018) is a complete arc-rated clothing and equipment system that covers the entire body, except for the hands and feet. An arc flash suit may include pants or overalls, a jacket or a coverall, and a beekeeper-type hood fitted with a face shield.

Arc Rating (NFPA 70E – 2018). Arc rating is the value attributed to materials that describes their performance to exposure to an electrical arc discharge. The arc rating is expressed in cal/cm^2 and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakopen threshold (EBT) (should a material system exhibit a breakopen response below the ATPV value). Arc rating is reported as either ATPV or EBT, whichever is the lower value.

The Basics of Electricity

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 flow through the pipes. The switch's electrical source is a power generating station. A generator provides the pressure (voltage) for the electrical current to travel through electrical conductors, or wires.

Electricity is the flow of an atom's electrons through a conductor; caused by a force (voltage) placed on the conductor.

Electrons are the outer particles of an atom that contain a negative charge. When electrons flow through a conductor, the flow is called ***electric current***.

Where does Electricity come from?

Electricity is produced in a generating plant. When electricity leaves a power plant, its voltage is increased in order to transmit it over long distances. The high-voltage power travels along transmission lines to a substation, then distributed through more lines to service drops that step down the voltage to levels between 240 and 480 volts.

Electrical Terms and Definitions

Four primary terms are used in discussing electricity:

1. Voltage
2. Current
3. Resistance
4. Ground

Voltage

Voltage is the fundamental force or pressure that causes electricity to flow through a conductor and is measured in volts (V). Voltage is synonymous with electrical pressure. The more voltage present, the more force or pressure is pushing the electricity. An overhead power line uses high voltage (thousands of volts) to carry electricity over large distances, from generating stations to our communities and then to our homes and businesses.

Voltage, Nominal (as defined by the NFPA 70: National Electric Code)

A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240 volts, 480Y/277 volts, 600 volts).

Note: The actual voltage on which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Common Voltage (V) Thresholds

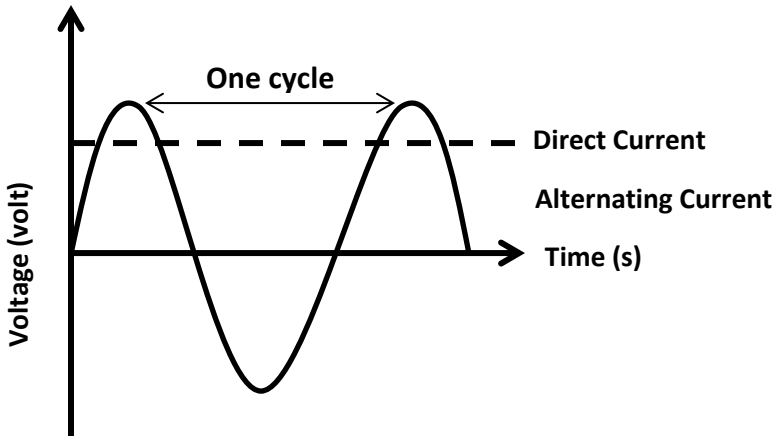
< 50 V	Below OSHA threshold for guarding requirements. Most common equipment includes phone, cable TV, fire alarm and other communication systems.
> 50 V	OSHA threshold for guarding of live parts, "live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact…".
110/120 V	Common household voltage present at the receptacle outlet.
240 V	What is delivered to a home then split into two opposing circuits operating at 110/120 volts each. Some large appliances require the full 240 volts to operate.
208 or 480 V	3-phase power systems, more typically found in commercial or industrial applications for large motors and other equipment.
277 V	Used for powering lighting equipment in commercial or industrial operations.
< 600 V	OSHA threshold for what is considered low voltage.
> 600 V	OSHA threshold for what is considered high voltage.

Note: Additional shock protection and approach boundaries to exposed energized electrical conductors or circuit parts are established in NFPA 70E: *Standard for Electrical Safety in the Workplace*.

Current

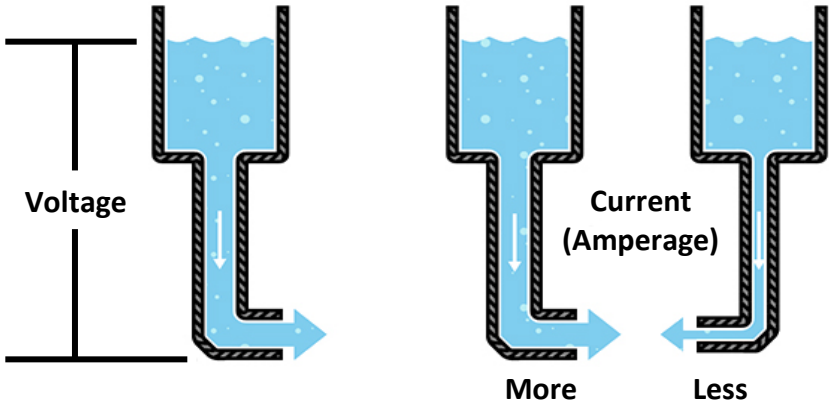
Current is the flow of electrons from a source of voltage through a conductor and is measured in amperes (Amps). If the current flows back and forth (a cycle) through a conductor, it is called ***alternating current (AC)***. In each cycle the electrons flow first in one direction, then the other. In the United States, the normal rate is 60 cycles per second [or 60 Hertz (Hz)]. If current flows in one direction only (battery operated/cordless tools), it is called ***direct current (DC)***.

AC is most widely used because it is possible to step up or step down (i.e., increase or decrease) the voltage through a transformer. For example, when voltage from an overhead power line is run through a pole-mounted transformer, it can be stepped down to normal household voltage.



Voltage – Current Illustration

Voltage and current can be illustrated by comparing them to water flow through a pipe. The tank of water is the pressure source or voltage. As the water flows through the pipe, the volume of water becomes the current (amperes). The smaller the diameter of the pipe will generate more water pressure (higher voltage), but the less water flow. A larger diameter pipe will result in lower pressure, but higher volume. The diameter of the pipe is compared to resistance.



Resistance

Resistance is anything that impedes (blocks) the flow of electricity through a conductor and is measured in Ohms.

Factors that determine a substance's resistance to the flow of electricity are:

- What it is made of;
- Its size & length; and,
- Its temperature.

- Substances with very little resistance to the flow of electrical current are called *conductors*. Examples of good conductors are metals. Gold, silver, aluminum and copper are the best metal conductors of electricity.
- Substances with such a high resistance that they can be used to prevent the flow of electrical current are called *insulators*. Examples of insulators are glass, porcelain, plastic, and dry wood.

Remember, if voltages are high enough, then most anything is a conductor of electricity, such as tree branches.

(Picture) This tree branch is arcing 10,000 volts of electricity. A person contacting this branch, without protective gloves, will most certainly be injured or killed.

Ohm's Law

Ohm's Law is a mathematical equation that shows the relationship between Voltage, Current and Resistance in an electrical circuit. Ohm's Law is stated as:

V = I x R

R = V / I

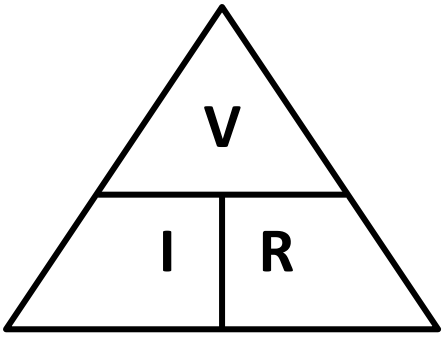
I = V / R

V – is for voltage (volts), R – is for resistance (ohms), I – is for current (ampere)

Ohm's Law states that one volt will cause a current of one ampere to flow through a conductor having the resistance of one ohm.

An easy way to remember this formula is to use the symbols and image to the right.

- To determine amps (I = V/R), cover the "I" in the figure to the right.
- To determine resistance (R = V/I), cover the "R".
- To determine volts (V = I x R), cover the "V".



Ohm's Law – An Example

A worker is using an electric saw and perspiring. He has a hand-to-hand resistance of 1,000 ohms. The worker contacts 120 volts with one hand and touches a ground surface with the other. This completes the loop to the voltage sources. Using Ohm's Law, calculate the flow of current.

Answer:

* Compare your answer to the *Effects of Electric Current on Human Body* table on page 3.

Ground

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.

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.

Introduction to OSHA

Discussion Points

- OSHA's purpose and employer duty to provide a safe place of employment
- Employer/employee rights & responsibilities under the OSHAct
- Refusing to work because conditions are dangerous
- OSHA's multi-employer worksite citation policy
- Rights as a whistleblower
- OSHA policy on providing and paying for personal protective equipment
- Reporting of fatalities and catastrophes
- OSHA and NFPA industry consensus standards for electrical work
- Qualified person

Occupational Safety & Health Administration (OSHA)

OSHA's Purpose…

To assure safe and healthful working conditions for working men and women; by authorizing enforcement of the standards developed under the Act; by assisting and encouraging the States in their efforts to assure safe and healthful working conditions; by providing for research, information, education, and training in the field of occupational safety and health; and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that this Act may be cited as the "Occupational Safety and Health Act of 1970" (OSHAct).

General Duty Clause…

(a) ***Each employer***

(1) *Shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees.*

(2) *Shall comply with occupational safety and health standards promulgated under this Act.*

(b) ***Each employee*** *shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct.*

What is OSHA's General Duty Clause?

Section 5(a)(1) of the OSHAct has become known as *"The General Duty Clause."* It is a catch-all phrase for citations if OSHA identifies unsafe conditions for which a regulation does not exist.

In practice, OSHA, legal precedent, and the review commission have established that if the following elements are present, then a "general duty clause" citation may be issued.

1. An employer failed to keep the workplace free of a hazard to which employees of that employer were exposed.
2. The hazard was recognized. (Examples might include: through jobsite safety personnel, employees, trade unions and other associations/organizations.)
3. The hazard was causing or was likely to cause death or serious physical harm.
4. There was a feasible and useful method to correct the hazard.

General Duty Clause Citation Example

One example of an OSHA *General Duty Clause* citation is to reference the NFPA 70E: *Standard for Electrical Safety in the Workplace*.

One particular OSHA standard states…

OSHA Standard Reference:

1910.335(a)(1)(i)

"Employees working in areas where there are potential electrical hazards shall be provided with, and shall use, electrical protective equipment that is appropriate for the specific parts of the body to be protected and for the work to be performed."

The above OSHA standard makes reference to *"electrical protective equipment that is appropriate for the specific parts of the body."* However, OSHA falls short of specifying what exactly is "appropriate."

In order to comply with the *General Duty* of this standard, the employer would need to know the magnitude of the electrical hazard and the level of protection that a specific piece of personal protection equipment will provide. Doing this without a reference to the NFPA 70E standard would be difficult. Furthermore, failing to provide the level of protection as stated in the NFPA 70E standard would be in violation of an employer's *General Duty*.

Job Safety and Health

IT'S THE LAW!

OSHA

Occupational Safety & Health Administration
U.S. Department of Labor

EMPLOYEES:

- You have the right to notify your employer or OSHA about workplace hazards. You may ask OSHA to keep your name confidential.
- You have the right to request an OSHA inspection if you believe that there are unsafe and unhealthful conditions in your workplace. You or your representative may participate in that inspection.
- You can file a complaint with OSHA within 30 days of retaliation or discrimination by your employer for making safety and health complaints or for exercising your rights under the OSH Act.
- You have a right to see OSHA citations issued to your employer. Your employer must post the citations at or near the place of the alleged violation.
- Your employer must correct workplace hazards by the date indicated on the citation and must certify that these hazards have been reduced or eliminated.
- You have the right to copies of your medical records or records of your exposure to toxic and harmful substances or conditions.
- Your employer must post this notice (OSHA 3165-12-06R) in your workplace.
- You must comply with all occupational safety and health standards issued under the *OSH Act* that apply to your own actions and conduct on the job.

EMPLOYERS:

- You must furnish your employees a place of employment free from recognized hazards.
- You must comply with the occupational safety and health standards issued under the *OSH Act*.

This free poster available from OSHA - *the Best Resource for Safety and Health*

Free assistance in identifying and correcting hazards or complying with standards is available to employers, without citation or penalty, through OSHA-supported consultation programs in each state.

1-800-321-OSHA
www.osha.gov

OSHA 3165-12-06R

Refusing to Work Because Conditions are Dangerous

Workers have the right to refuse to perform a task if they believe in good faith that they are exposed to an *imminent danger*. "Good faith" means that even if an imminent danger is not found to exist, the worker had reasonable grounds to believe that it did exist.

Your right to refuse to perform a task is protected if all of the following conditions are met:

- ☐ Where possible, you have asked the employer to eliminate the danger, and the employer failed to do so; and
- ☐ You refused to work in "good faith." This means that you must genuinely believe that an imminent danger exists. Your refusal cannot be a disguised attempt to harass your employer or disrupt business; and
- ☐ A reasonable person would agree that there is a real danger of death or serious injury (illness); and
- ☐ There isn't enough time, due to the urgency of the hazard, to get it corrected through regular enforcement channels, such as requesting an OSHA inspection.

When all of these conditions are met, then you may take the following steps:

- ☐ Ask your employer to correct the hazard;
- ☐ Ask your employer for other work;
- ☐ Tell your employer that you won't perform the work unless and until the hazard is corrected; and
- ☐ Remain at the worksite until ordered to leave by your employer.

OSHA's Multi-Employer Worksite Citation Policy

When on a construction jobsite, multiple employers and employees are exposed to a variety of hazards that may or may not have been created or under the control of any one employer. In this *"multi-employer"* environment, more than one employer may be citable for a hazardous condition that violates an OSHA standard.

OSHA classifies employers into one or more of four categories – the ***creating, exposing, correcting, and controlling employers*** – to determine if a citation will be issued.

The Creating Employer: an employer who causes a hazardous condition that violates an OSHA standard. An employer who creates the hazard is citable even if the only employees exposed in the workplace are those who work for other employers.

The Exposing Employer: an employer whose own employees are exposed to the hazard.

If the exposing employer created the violation, he/she is citable for the violation as a creating employer.

If the violation was created by another employer, the exposing employer is citable if he/she:

1) Knew of the hazardous condition or failed to exercise reasonable diligence to discover the condition, and
2) Failed to take steps to protect his/her employees.

If the exposing employer has the authority to correct the hazard, he/she must do so.

If he/she lacks the authority to correct the hazard, he/she is citable if he/she fails to do each of the following:

1) Ask the creating and/or controlling employer to correct the hazard
2) Inform his/her employees of the hazard, and
3) Take reasonable alternative protective measures.

   NOTE: In some circumstances, the employer is citable for failing to remove his/her employees from the job to avoid the hazard.

The Correcting Employer: an employer who is responsible for correcting a hazard on the exposing employer's worksite, usually occurring while the correcting employer is installing and/or maintaining safety/health equipment. The correcting employer must exercise reasonable care in preventing and discovering violations and meet his/her obligation of correcting the hazard.

The Controlling Employer: an employer who has general supervisory authority over the worksite, including the power to correct safety and health violations or requiring others to correct them. A controlling employer must exercise reasonable care to prevent and detect violations on the site.

Rights as a Whistleblower

You may file a complaint with OSHA if your employer retaliates against you by taking unfavorable personnel action because you engaged in protected activity relating to workplace safety and health, commercial motor carrier safety, pipeline safety, air carrier safety, nuclear safety, the environment, asbestos in schools, corporate fraud, SEC rules or regulations, railroad carrier safety or security, or public transportation agency safety or security.

Whistleblower Laws Enforced by OSHA

Each law requires that complaints be filed within a certain number of days after the alleged retaliation.

You may file complaints by telephone or in writing under the:

- Occupational Safety and Health Act (30 days)
- Surface Transportation Assistance Act (180 days)
- Asbestos Hazard Emergency Response Act (90 days)
- International Safe Container Act (60 days)
- Federal Rail Safety Act (180 days)
- National Transit Systems Security Act (180 days)

Under the following laws, complaints must be filed in writing:

- Clean Air Act (30 days)
- Comprehensive Environmental Response, Compensation and Liability Act (30 days)
- Energy Reorganization Act (180 days)
- Federal Water Pollution Control Act (30 days)
- Pipeline Safety Improvement Act (180 days)
- Safe Drinking Water Act (30 days)
- Sarbanes-Oxley Act (90 days)
- Solid Waste Disposal Act (30 days)
- Toxic Substances Control Act (30 days)
- Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (90 days)

Unfavorable Personnel Actions

Your employer may be found to have retaliated against you if your protected activity was a contributing or motivating factor in its decision to take unfavorable personnel action against you. Such actions may include:

- Firing or laying off
- Blacklisting
- Demoting
- Denying overtime or promotion
- Disciplining
- Denying benefits
- Failing to hire or rehire
- Intimidation
- Reassignment affecting promotion prospects
- Reducing pay or hours

Filing a Complaint

If you believe that your employer retaliated against you because you exercised your legal rights as an employee, contact your local OSHA office as soon as possible, because you must file your complaint within the legal time limits. OSHA conducts an in-depth interview with each complainant to determine whether to conduct an investigation.

For more information, call your closest OSHA Regional Office. Addresses, fax numbers and other contact information for these offices can be found on OSHA's website, www.osha.gov, and in local directories. Some complaints must be filed in writing and some may be filed verbally (call your local OSHA office for assistance).

Written complaints may be filed by mail (recommend certified mail), fax, or hand-delivered during business hours. The date postmarked, faxed or hand delivered is considered the date filed.

If retaliation for protected activity relating to occupational safety and health issues takes place in a state that operates an OSHA-approved state plan, the complaint should be filed with the state agency, although persons in those states may file with Federal OSHA at the same time. Although the Occupational Safety and Health Act covers only private sector employees, state plans also cover state and local government employees.

Rights as a Whistleblower

How OSHA Determines Whether Retaliation Took Place

The investigation must reveal that:

- The employee engaged in protected activity;
- The employer knew about the protected activity;
- The employer took an adverse action; and
- The protected activity was the motivating factor (or under some laws, a contributing factor) in the decision to take the adverse action against the employee.

If the evidence supports the employee's allegation and a settlement cannot be reached, OSHA will issue an order requiring the employer to reinstate the employee, pay back wages, restore benefits, and other possible remedies to make the employee whole.

Limited Protections for Employees Who Refuse to Work

You have a limited right under the OSH Act to refuse to do a job because conditions are hazardous. You may do so under the OSH Act only when (1) you believe that you face death or serious injury (and the situation is so clearly hazardous that any reasonable person would believe the same thing); (2) you have tried to get your employer to correct the condition, and there is no other way to do the job safely; and (3) the situation is so urgent that you do not have time to eliminate the hazard through regulatory channels such as calling OSHA.

Regardless of the unsafe condition, you are not protected if you simply walk off the job. For details, see www.osha.gov. OSHA cannot enforce union contracts or state laws that give employees the right to refuse to work.

Whistleblower Protections in the Transportation Industry

Employees whose jobs directly affect commercial motor vehicle safety are protected from retaliation by their employers for refusing to violate or for reporting violations of Department of Transportation (DOT) motor carrier safety standards or regulations, or refusing to operate a vehicle because of such violations or because they have a reasonable apprehension of death or serious injury.

Similarly, employees of air carriers, their contractors or subcontractors who raise safety concerns or report violations of FAA rules and regulations are protected from retaliation, as are employees of owners and operators of pipelines, their contractors and subcontractors who report violations of pipeline safety rules and regulations. Employees involved in international shipping who report unsafe shipping containers are also protected. In addition, employees of railroad carriers or public transportation agencies, their contractors or subcontractors who report safety or security conditions or violations of federal rules and regulations relating to railroad or public transportation safety or security are protected from retaliation.

Whistleblower Protections for Voicing Environmental Concerns

A number of laws protect employees who report violations of environmental laws related to drinking water and water pollution, toxic substances, solid waste disposal, air quality and air pollution, asbestos in schools, and hazardous waste disposal sites. The Energy Reorganization Act protects employees who raise safety concerns in the nuclear power industry and in nuclear medicine.

Whistleblower Protections When Reporting Corporate Fraud

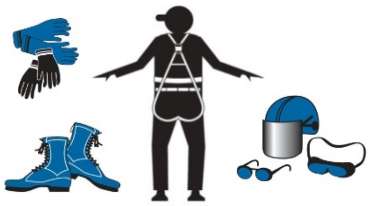
Employees who work for publicly traded companies or companies required to file certain reports with the Securities and Exchange Commission are protected from retaliation for reporting alleged mail, wire, or bank fraud; violations of rules or regulations of the SEC, or federal laws relating to fraud against shareholders.

More Information

To obtain more information on whistleblower laws, go to www.osha.gov, and click on the link for "Whistleblower Protection."

Personal Protective Equipment (PPE)

PPE is equipment worn to minimize exposure to a variety of hazards. Examples include items such as personal fall arrest systems, gloves, foot and eye protection, hearing protection, hard hats and respirators.



Employer Obligations for PPE:

- ☐ Perform a "hazard assessment" of the workplace to identify and control physical and health hazards.
- ☐ Identify and provide appropriate PPE for employees.
- ☐ Train employees in the use and care of the PPE.
- ☐ Maintain PPE, including replacing worn or damaged PPE.

Worker Responsibility for PPE:

- ☐ Properly wear PPE.
- ☐ Attend training sessions on PPE.
- ☐ Care for, clean and maintain PPE.
- ☐ Inform a supervisor of the need to repair or replace PPE.

NOTE: The employer must pay for replacement PPE, except when the employee has lost or intentionally damaged the PPE.

Employers Must Pay for Personal Protective Equipment (PPE)

With few exceptions, OSHA requires employers to pay for personal protective equipment used to comply with OSHA standards; employers cannot require workers to provide their own PPE. Even when a worker provides his or her own PPE, the employer must ensure that the equipment is adequate to protect the worker from hazards at the workplace.

Employers are not required to pay for:

- ***Everyday clothing;*** such as long-sleeve shirts, long pants and normal work boots (including protective toe).
- ***Ordinary clothing;*** such as winter coats, jackets and gloves.

Reporting of Fatalities and Catastrophes

OSHA Standard, 29 CFR Subpart 1904.39, *Reporting Fatality, Injury and Illness Information to the Government* requires that employers report all work related fatalities within eight (8) hours and all work-related inpatient hospitalizations, all amputations and all losses of an eye within 24 hours. Employers must orally report the fatality/hospitalization by telephone or in-person to the OSHA Area Office or to the State Plan Office that is nearest to the site of the incident. Employers may also use the OSHA toll-free central telephone number:

1-800-321-OSHA (1-800-321-6742).

OSHA Electrical Standards

Occupational Safety and Health (OSHA) regulations for electrical work are referenced in both general industry and construction standards:

- 29 CFR 1910 Subpart S
- 29 CFR 1926 Subpart K

29 CFR 1926.403(i)(2). Guarding of Live Parts (50 volts or more)

The primary rule for electrical safety is the 50 volt rule, which requires live parts of electric equipment operating at 50 volts or more to be guarded against accidental contact. This means that all equipment operating at 50 volts or more must be enclosed in a cabinet or other form of approved insulation.

Furthermore, anyone who is in close proximity to or working on exposed live electrical equipment operating at 50 volts or more must be qualified to perform the job or task and wear appropriate personal protective equipment (PPE).

NFPA 70E: Standard for Electrical Safety in the Workplace

Originally developed at OSHA's request, *NFPA 70E* responds to the latest information about the effects of arc flash, arc blast, and direct current (dc) hazards, and recent developments in electrical design and Personal Protective Equipment (PPE). It provides vital information that helps employers comply with OSHA 1910 Subpart S and OSHA 1926 Subpart K.

Qualified Person (OSHA) – 29 CFR 1910.399

One who has received training in and has demonstrated skills and knowledge in the construction and operation of electric equipment and installations and the hazards involved.

- **Note:** Whether an employee is considered to be a "qualified person" will depend upon various circumstances in the workplace. For example, it is possible and, in fact, likely for an individual to be considered "qualified" with regard to certain equipment in the workplace, but "unqualified" as to other equipment.
- **Note:** An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a qualified person is considered to be a qualified person for the performance of those duties.

OSHA Lockout/Tagout (Control of Hazardous Energy) – 29 CFR 1910.147(b)

Within OSHA's Lockout/Tagout standards, the terms **Authorized Employee** and **Affected Employee** are used to describe persons of interest.

***Affected employee*.** An employee whose job requires him/her to operate or use a machine or equipment on which servicing or maintenance is being performed under lockout or tagout, or whose job requires him/her to work in an area in which such servicing or maintenance is being performed.

***Authorized employee*.** A person who locks out or tags out machines or equipment in order to perform servicing or maintenance on that machine or equipment. An affected employee becomes an authorized employee when that employee's duties include performing servicing or maintenance covered under this section.

Qualified Person (NFPA 70E)

One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.

A qualified person shall be trained and knowledgeable in the construction and operation of equipment or a specific work method and be trained to identify and avoid the electrical hazards that might be present with respect to that equipment or work method.

- Such persons shall also be familiar with the proper use of the special precautionary techniques, applicable electrical policies and procedures, PPE, insulating and shielding materials, and insulated tools and test equipment.

Qualified Person (NFPA 70E) – Continued

Such persons permitted to work within the limited approach boundary shall, at a minimum, be additionally trained in all of the following:

1) Skills and techniques necessary to distinguish exposed energized electrical conductors and circuit parts from other parts of electrical equipment.
2) Skills and techniques necessary to determine the nominal voltage of exposed energized electrical conductors and circuit parts.
3) Approach distances specified in NFPA 70E Tables and the corresponding voltages to which the qualified person will be exposed.
4) Decision-making process necessary to be able to do the following:
    a. Perform the job safety planning
    b. Identify electrical hazards
    c. Assess the associated risk
    d. Select the appropriate risk control methods from the hierarchy of controls, including personal protective equipment.

Approach Boundaries (NFPA 70E – 2018)

Reference: Table 130.4(D)(a) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems

Nominal System Voltage (AC) Range	Limited Approach Boundary		Restricted Approach Boundary[2]
	Exposed Movable Conductor[1]	Exposed Fixed Circuit Part	
Less than 50 volts	Not Specified	Not Specified	Not Specified
50 – 150 volts	10 ft 0 in.	3 ft 6 in.	Avoid Contact
151 – 750 volts	10 ft 0 in.	3 ft 6 in.	1 ft 0 in.
751 – 15,000 volts	10 ft 0 in.	5 ft 0 in.	2 ft 2 in.

[1] *Exposed movable conductors* describe a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

[2] An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

Overhead & Underground Power Lines

Discussion Points

- Identify OSHA's power line safety standards, specifically those related to clearance distances for both known and unknown voltages.
- List the options for compliance if working in close proximity to an overhead power line.
- Prepare planning documentation that complies with OSHA's encroachment/electrocution prevention requirements to include procedures to be followed in the event of a power line contact.

Power lines are lethal weapons. Although equipment operators are responsible for keeping themselves safe from overhead dangers, it's only through employer commitment and supervision that the hazards of power lines can be properly managed.

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 elevations are also hazards. Using tools and equipment that can come into contact with power lines increases these risks.

Equipment Risks near Power Lines:

- Aluminum paint rollers
- Backhoes
- Concrete pumpers
- Cranes
- Long-handled cement finishing floats
- Metal building materials
- Metal ladders
- Raised dump truck beds
- Scaffolds

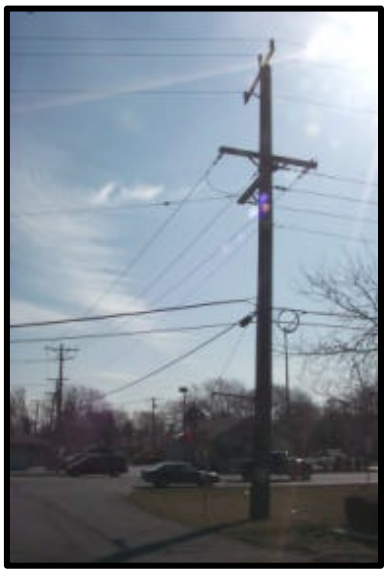
The primary rule for power line safety is **STAY AWAY!** NFPA 70E establishes 10 feet as the minimum safe distance approach boundary for work around exposed movable conductors supported by poles (power lines). In some cases, when the voltages are high, or when working with cranes, the power line clearance distance may be further.

Also, per **29 CFR 1926.416(a)(1)**, no employer shall permit an employee to work in such proximity to any part of an electric power circuit that the employee could contact the electric power circuit in the course of work, unless the employee is protected against electric shock by deenergizing the circuit and grounding it or by guarding it effectively by insulation or other means.

Types of Power Lines

Electrical power is brought to us through a three part system: "high power transmission lines" running from generating stations to substations, "distribution lines", the same lines that run through most of our neighborhoods and job sites, and "service drops" running from poles to utility customers. The majority of the power line contacts reported to OSHA involved overhead "distribution" lines. This is due to their proximity to most construction work and their frequency on the landscape.

Transmission Line



Distribution Line

Service Drop Line

Power Line Myth

Power lines are insulated…

Wrong! Any covering you see on an overhead line is generally there for weather protection, not insulation.

Underground Power Lines – Call Before you Dig!

29 CFR 1926.651(b)(1). The estimated location of utility installations or any other underground installation that may be encountered during excavation work must be determined prior to opening an excavation.

29 CFR 1926.416(a)(2). In work areas where the exact location of underground electric powerlines is unknown, employees using jack-hammers, bars, or other hand tools which may contact a line shall be provided with insulated protective gloves.

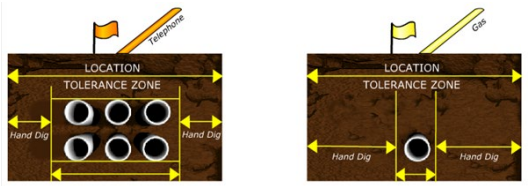
29 CFR 1926.416(a)(3). Before work is begun the employer shall ascertain by inquiry or direct observation, or by instruments, whether any part of an energized electric power circuit, exposed or concealed, is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact with the electric power circuit. The employer shall post and maintain proper warning signs where such a circuit exists. The employer shall advise employees of the location of such lines, the hazards involved, and the protective measures to be taken.

Underground Utility Marking Codes/Colors

Utility color codes are used to identify existing underground utilities in construction areas, to protect them from damage during excavation. Colored lines, flags, or both are used to mark the location and denote the type of underground utility.

Gas, Oil or Petroleum	High Visibility Yellow
Electric	Fire Protection Red
Communication, Telephone, TV	Alert Orange
Potable Water	Precaution Blue
Sewer	Safety Green
Reclaimed Water	Safety Purple
Proposed Area of Excavation	Safety White

- Hand dig or use other non-intrusive means within required “Tolerance Zone” (varies by State), 18” – 24” on either side of the utility.
- Watch out for utility corridors, utilities buried side-by-side and take into consideration diameter of large pipes.
- Use the National **811 phone number** to call for utility locates.



Mobile Cranes and Power Lines

Additional OSHA rules apply to power-operated equipment, when used in construction that can hoist, lower and horizontally move a suspended load.

Such equipment includes, but is not limited to:

- Articulating cranes (such as knuckle-boom cranes)
- Crawler cranes
- Mobile truck cranes

Mobile Truck C

Articulating Crane

Crawler Crane

Crane Work Zone (Power Line Safety)

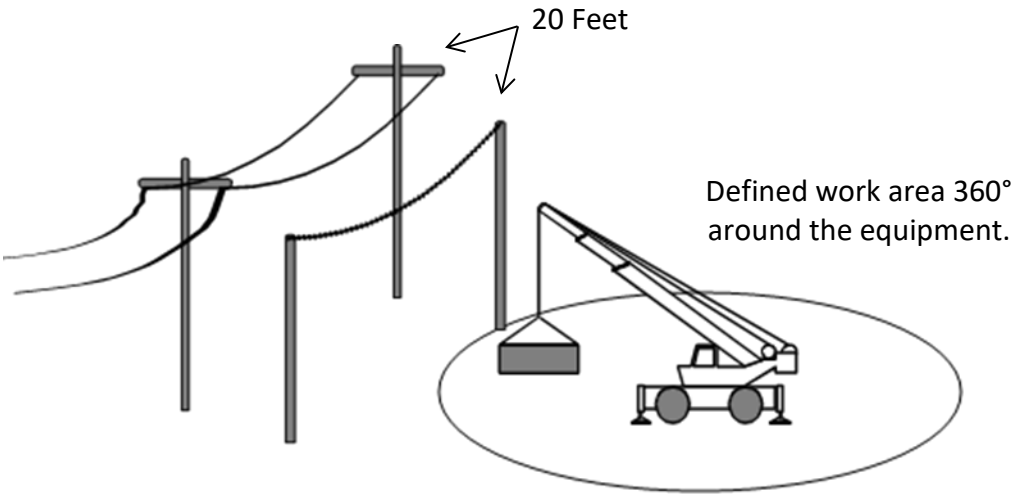
Pursuant to **29 CFR 1926.1408(a)(1)**, before beginning equipment (crane) operations, the employer must identify the work zone by either:

- Demarcating boundaries (for example, with flags, or a device such as a range limit device or range control warning device) and prohibiting the operator from operating the equipment past those boundaries, or
- Defining the work zone as the area 360 degrees around the equipment, up to the equipment's maximum working radius.

Crane Work Zone (Power Line Safety) – Continued

20 Foot Rule…

If any part of the equipment, load line or load (including rigging and lifting accessories), when operated up to the equipment's maximum working radius in the work zone, cannot get closer than 20 feet to an overhead power line, then no further precautions may be taken.



Closer than 20 feet…

29 CFR 1926.1408(a)(2). If power-operated equipment could get closer than 20 feet to a power line, then the employer must meet the requirements in Option (1), Option (2), or Option (3) as follows:

- ***Option (1)--Deenergize and ground*.** Confirm from the utility owner/operator that the power line has been deenergized and visibly grounded at the worksite.
- ***Option (2)--20 foot clearance*.** Ensure that no part of the equipment, load line, or load (including rigging and lifting accessories), gets closer than 20 feet to the power line by implementing the procedures in ***"Preventing Encroachment/Electrocution" (next page)***.
- ***Option (3)--Table A clearance*.** Determine the line's voltage (must get line voltage from utility company) and the minimum approach distance permitted under Table A (next page). If this option is used, then the employer must implement the procedures in ***"Preventing Encroachment/Electrocution" (next page)***.

Cranes and Power Lines Table A (29 CFR 1926 Subpart CC – Cranes)

Table A - Minimum Clearance Distances	
Voltage (nominal, kV, alternating current)	Minimum clearance distance (feet)
up to 50	10
over 50 to 200	15
over 200 to 350	20
over 350 to 500	25
over 500 to 750	35
over 750 to 1,000	45
over 1,000	(as established by the utility owner/ operator or registered professional engineer who is a qualified person with respect to electrical power transmission and distribution)
Note: The value that follows "to" is up to and includes that value. For example, over 50 to 200 means up to and including 200kV.	

Preventing Encroachment/Electrocution

Where encroachment precautions are required under Option (2) or Option (3), all of the following requirements must be met:

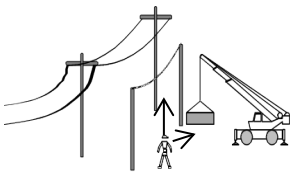
(1) Conduct a planning meeting with the operator and the other workers who will be in the area of the equipment or load to review the location of the power line(s), and the steps that will be implemented to prevent encroachment/electrocution.

(2) If tag lines are used, they must be nonconductive.

(3) Erect and maintain an elevated warning line, barricade, or line of signs, in view of the operator, equipped with flags or similar high-visibility markings, at 20 feet from the power line [if using Option (2) – 20 foot clearance] or at the minimum approach distance under Table A (if using Option (3) of this section [Table A clearance]). If the operator is unable to see the elevated warning line, a dedicated spotter must be used.

The dedicated spotter must:

- Be equipped with a visual aid to assist in identifying the minimum clearance distance.
- Be positioned to effectively gauge the clearance distance.
- Give timely information to the operator so that the required clearance distance can be maintained.



Training and Emergency Response (Cranes and Power Lines)

29 CFR 1926.1408(g). Training. Power line safety training and emergency response procedures include:

(A) Information regarding the danger of electrocution from the operator simultaneously touching the equipment and the ground.

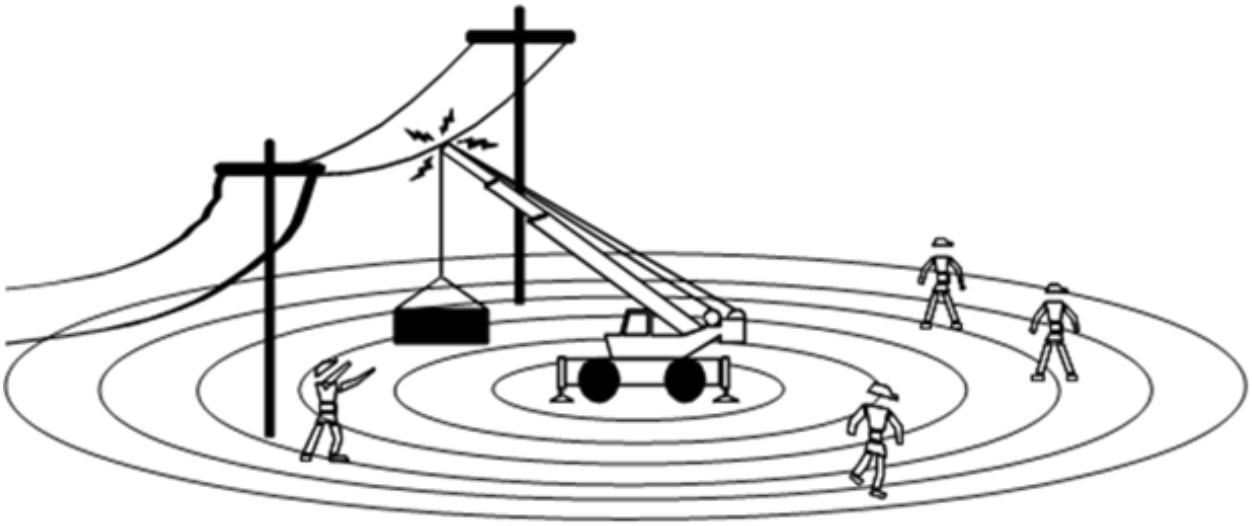
(B) The importance to the operator's safety of remaining inside the cab except where there is an imminent danger of fire, explosion, or other emergency that necessitates leaving the cab.

(C) The safest means of evacuating from equipment that may be energized.

(D) The danger of the potentially energized zone around the equipment (step potential).

(E) The need for crew in the area to avoid approaching or touching the equipment and the load.

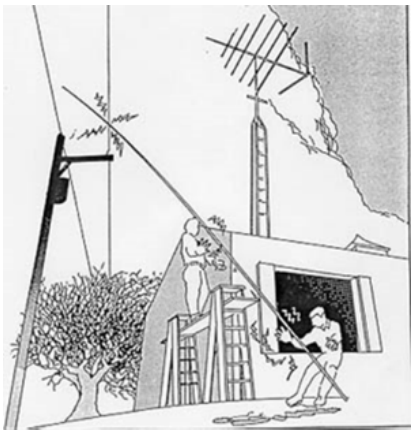
(F) Safe clearance distance from power lines.



Current can flow outward through the ground in a ripple pattern from the equipment in contact with a power line (step potential).

Fatal Fact – Discussion #1

Two employees were installing aluminum siding on a farmhouse when it became necessary to remove a 36-foot high metal pole CB antenna. One employee stood on a metal pick board between two ladders and unfastened the antenna at the top of the house. The other employee, who was standing on the ground, took the antenna to lay it down in the yard. The antenna made electrical contact with a 7200-volt power transmission tine 30 feet 10 inches from the house and 23 feet 9 inches above the ground. The employee handling the antenna received a fatal shock and the other employee a minor shock.



INSPECTION RESULTS

Following its investigation, OSHA issued one citation for two alleged serious violations of its construction standards. Had these standards been adhered to, the fatality might have been prevented.

ACCIDENT PREVENTION RECOMMENDATIONS

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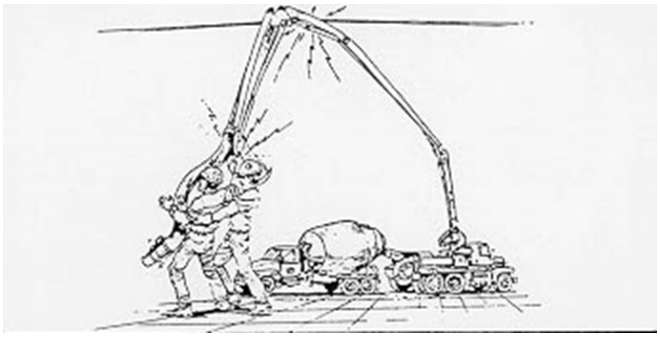
Fatal Fact – Discussion #2

Two employees were spreading concrete as it was being delivered by a concrete pumper truck boom. The truck was parked across the street from the work site. Overhead power lines ran perpendicular to the boom on the pumper truck.

One employee was moving the hose to pour the concrete when the boom of the pumper truck came in contact with the overhead power line carrying 7,620 volts. One employee received a fatal electric shock and fell on the other employee who was assisting him. The second employee received massive electrical shock and burns.



INSPECTION RESULTS

OSHA cited the employer for not instructing each employee to recognize and avoid unsafe conditions which apply to the work and work areas. The employer was also cited for operating equipment within ten feet of an energized electrical, ungrounded transmission lines rated 50 kV or less and not erecting insulating barriers.

ACCIDENT PREVENTION RECOMMENDATIONS

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Fatal Fact – Discussion #3

Employees were moving a steel canopy structure using a "boom crane" truck. The boom cable made contact with a 7200-volt electrical power distribution line electrocuting the operator of the crane who was the foreman at the site.

INSPECTION RESULTS

As a result of its investigation, OSHA issued citations for four serious violations of its construction standards dealing with training, protective equipment, and working too close to power lines. OSHA's construction safety standards include several requirements which, if they had been followed here, might have prevented this fatality.

ACCIDENT PREVENTION RECOMMENDATIONS

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Ground Fault Protection

Discussion Points

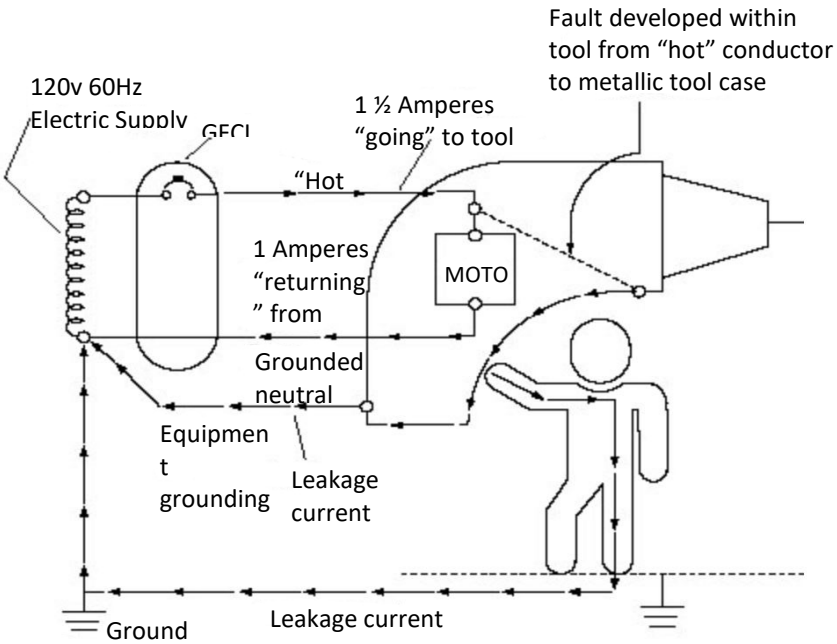
- Explain what a ground fault is and what makes it a dangerous condition
- Employer's responsibility for providing ground fault protection on job sites
- Requirements for ground fault circuit interrupter use, limitations and testing

Am I in Danger?

Due to the dynamic, rugged nature of construction work, normal use of electrical equipment at a job site causes wear and tear that results in insulation breaks, short-circuits, and exposed wires. If there is no ground fault protection, then miss-use of flexible cords and power tools can cause a ground fault that sends electrical current through the worker's body, resulting in burns, explosions, fire, or death.

What is a GFCI?

A ground fault circuit interrupter (GFCI) is a fast-acting circuit breaker that senses small imbalances in the circuit caused by current leakage to ground and, in a fraction of a second, shuts off the electricity. The GFCI continually matches the amount of current going to an electrical device against the amount of current returning from the device along the electrical path. Whenever the amount "going" differs from the amount "returning" by approximately 5 milliamps, the GFCI interrupts the electric power within as little as 1/40 of a second. (See diagram.)

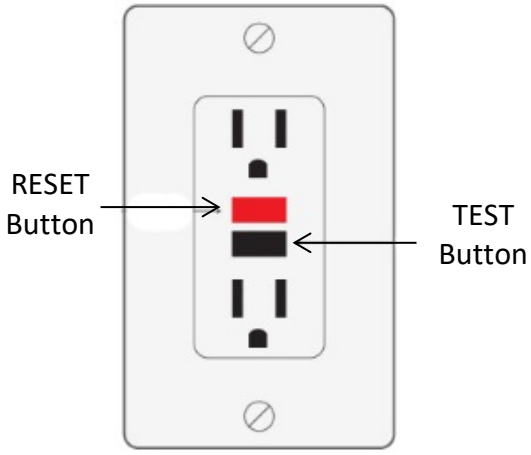


What is a GFCI? – Continued

The GFCI, however, does not protect from line-to-line contact hazards—such as a worker holding two "hot" wires or a hot and a neutral wire in each hand. It protects against the most common form of electrical shock hazard—the ground fault, and protects against fires, overheating, and destruction of insulation on wiring.

GFCIs can be used successfully to reduce electrical hazards on construction sites. Tripping of GFCIs—interrupting current flow—is sometimes caused by wet connectors and tools. It is good practice to limit exposure of connectors and tools to excessive moisture by using water-tight or sealable connectors.

Providing more GFCIs or shorter circuits can prevent tripping caused by the cumulative leakage from several tools or by leakages from extremely long circuits.



Outlet-type GFCI

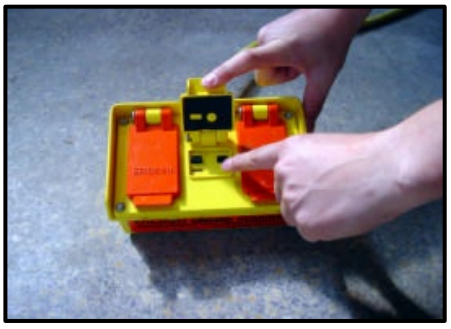
How Do I Avoid Hazards?

- Use GFCIs on all 120-volt, single-phase, 15- and 20-ampere receptacles.
- 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.

OSHA Policy on Testing Ground-Fault on Job Sites

29 CFR 1926.404(b)(1). Ground fault protection is required on all 120-volt, single-phase 15- and 20-ampere receptacle outlets on construction sites where the outlets are not a part of the permanent wiring of the building or structure and which are in use by construction employees. To ensure that the proper protection is in place, perform the following visual and manual tests:

- Determine if the branch circuit is equipped with a GFCI device. If there is no outlet-type GFCI (the type that is installed in the outlet box) or cord-connected GFCI visible, then there may be a GFCI installed further up the circuit. Use an approved external GFCI tester at the outlet to see if there is a **positive** reading (indicating that the circuit is GFCI protected).
- If a **negative** reading (a reading that indicates that the circuit is not GFCI protected) is obtained, then further investigation is required to determine whether the circuit is protected. Reliance must not be placed solely on a negative external GFCI tester reading to establish a violation of the standard. This is because there are some circumstances where a negative reading on an external tester can result even though there is a functioning GFCI protecting the circuit. Consult a qualified electrical worker.



GFCI "TEST" Button

Approved External GFCI Tester

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, then an electric shock occurs.

Assured Equipment Grounding Conductor Program

If a contractor chooses not to use a ground fault circuit interrupter, then the alternative is to implement an "*assured equipment grounding conductor program.*"

OSHA requires that a written description of the employer's assured equipment grounding conductor program, including the specific procedures adopted, be kept at the job site. This program should outline the employer's specific procedures for the required equipment inspections, tests, and test schedule.

The required tests must be recorded, and the record maintained until replaced by a more current record. The written program description and the recorded tests must be made available, at the job site, to OSHA and to any affected employee upon request. The employer is required to designate one or more **competent persons** to implement the program.

Electrical equipment noted in the assured equipment grounding conductor program must be visually inspected for damage or defects before each day's use. If there is evidence of damage or defect, then the equipment must not be used.

OSHA requires the following two tests as part of an assured equipment grounding conductor program:

1. A ***continuity test*** to ensure that the equipment-grounding conductor is electrically continuous. This test must be performed on all cord sets and receptacles that are not part of the permanent wiring of the building or structure, and on cord- and plug-connected equipment that is required to be grounded. This test may be performed using a simple continuity tester, such as a lamp and battery, a bell and battery, an ohmmeter, or a receptacle tester.
2. A ***polarity test*** to ensure that the equipment-grounding conductor is connected to its proper terminal. This test can be performed with the same equipment used in the continuity test.

Frequency of Tests

Assured equipment grounding conductor tests are required before first use, after any repairs, after damage is suspected to have occurred, and at 3-month intervals.

3-Wire Receptacle Tester

Fatal Fact – Discussion #4

One employee was climbing a metal ladder to hand an electric drill to the journeyman installer on a scaffold about five feet above him. When the victim reached the third rung from the bottom of the ladder he received an electric shock that killed him.

INSPECTION RESULTS

The investigation revealed that the extension cord had a missing grounding prong and that a conductor on the green grounding wire was making intermittent contact with the energizing black wire thereby energizing the entire length of the grounding wire and the drill's frame. The drill was not double insulated.

ACCIDENT PREVENTION RECOMMENDATIONS

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Extension Cords & Other Electrical Equipment

Discussion Points

- Types of extension cords, their markings, proper use and how to inspect for damage
- Path to ground missing or discontinuous
- Improper use of flexible and extension cords
- Common misuses of equipment

Selecting and Using the Right Extension Cord

In the U.S., American Wire Gauge (AWG) indicates the size of the copper wire inside a cord. Cords in common use range from #18 AWG to #10 AWG. (Only even numbered sizes are normally used.) The higher the AWG number, the smaller the wire size.

Here is a rough indication of AWG uses:

#18 AWG -	Lamp cords (sometimes #16).
#16 AWG -	A step up from lamp cords. The most commonly used general-purpose cord gauge (used for work lights, electric trimmers, etc.). Not for use with high-power loads, and not recommended for construction work.
#14 AWG -	Minimum size recommended for construction work.
#12 AWG -	Heavy use, such as large power tools.
#10 AWG -	Large loads.

29 CFR 1926.405(a)(2)(ii)(J). Extension cord sets used with portable tools and appliances must be of the three-wire, grounding type; and flexible cords must be designed for hard or extra-hard usage.

Three-wire (Prong) Flexible Cord

Extension Cord Marking

Extension cords larger than lamp cord size are marked continuously along their length with several items of information. The most important marking item is the one that tells the size of the wires inside the cord.

This marking usually appears in a form such as "14/3," which indicates a three conductor #14 AWG cord.

The marking item that usually follows the wire gauge tells the type of cord, meaning the physical construction. The two types of construction likely to be found are "S" (hard service) and "SJ" (J is for "junior") which is a lighter duty, less-rugged version of the type S cord.

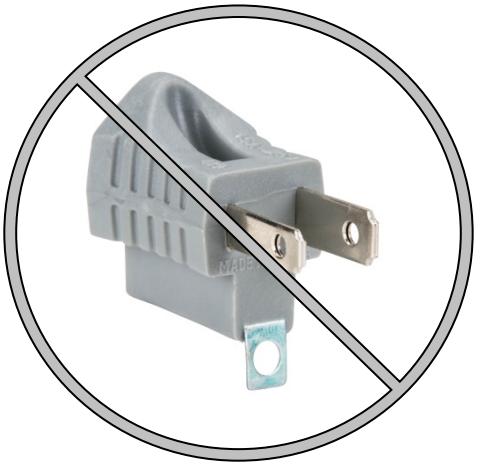
Additional letters may follow the S or SJ. The additional letters indicate other performance characteristics.

Additional Letters on Cords and Their Meaning…

T	Thermoplastic insulation, instead of a rubber-type material
E	Thermoplastic elastomer insulation (more rubber-like than thermoplastic)
O	Oil resistant
W	Moisture and sunlight resistant

Do not repair extension cords by replacing the ends. This will cause the cord to not maintain its approval for its intended use. For example, what was once "W" *(moisture and sunlight resistant)* will no longer be water-tight if the plug was replaced.

Never use an adapter that will make a three-prong cord fit into a two prong receptacle.

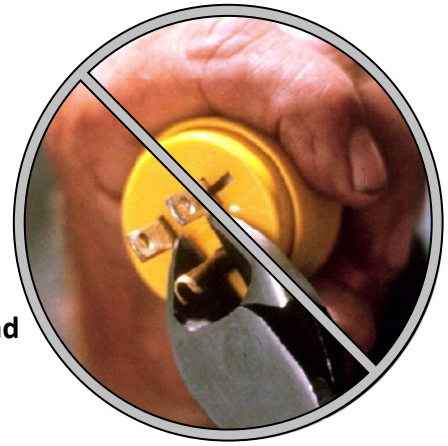


Path to Ground Missing or Discontinuous

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

29 CFR 1926.404(f)(6). Grounding path. The path to ground from circuits, equipment, and enclosures shall be permanent and continuous.

Never Remove the Ground Pin!



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. Even when the power system is properly grounded, electrical equipment can instantly change from safe to hazardous because of extreme conditions and rough treatment.

How Do I Avoid Hazards?

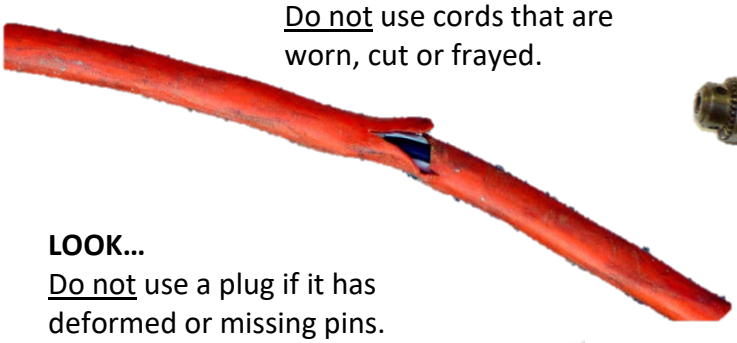
- Ground all power supply systems, electrical circuits, and electrical equipment.
- Frequently inspect electrical systems to insure that the path to ground is continuous.
- Visually inspect all electrical equipment before use. Take any defective equipment out of service.
- Do not remove ground prongs from cord- and plug-connected equipment or extension cords.
- Use double-insulated tools and equipment, distinctively marked.
- Ground all exposed metal parts of equipment.

Cord and Tool Inspection

Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as deformed or missing pins or insulation damage, and for indications of possible internal damage.

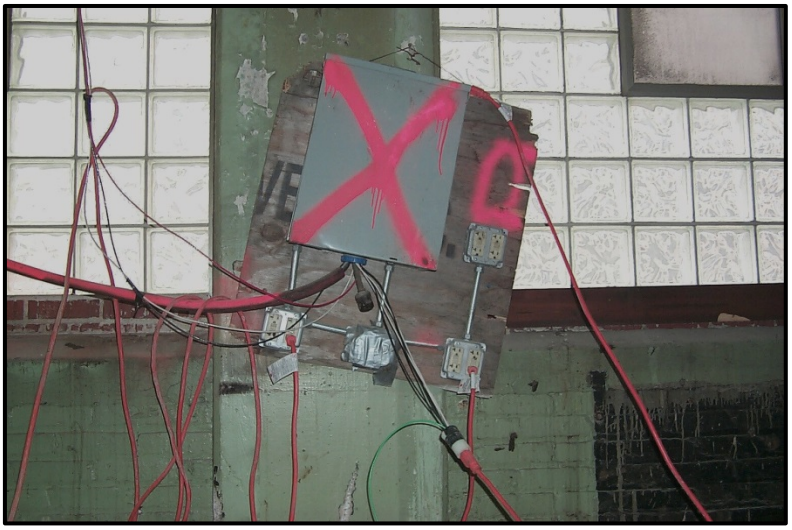
Equipment found damaged or defective **shall not be used**.

LOOK…
Do not use cords that are worn, cut or frayed.



LOOK…
Do not use a plug if it has deformed or missing pins.

LOOK…
Do not use tools that have cords pulled out from strain relief.



LOOK…
Do not use a receptacle if there is evidence of damage.

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Equipment Not Used in Manner Prescribed

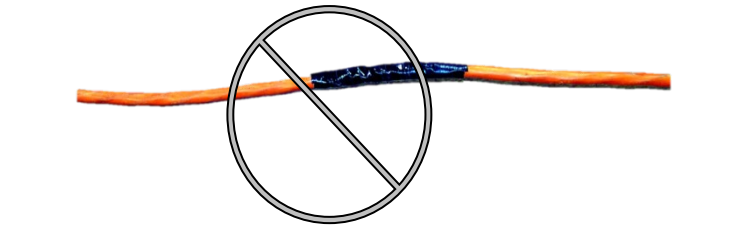
If electrical equipment is used in ways for which it is not designed, then the safety features built in by the manufacturer are unreliable. This may damage equipment and cause employee injuries.

Am I in Danger?

- 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.
- Use all equipment according to the manufacturer's instructions.
- Do not modify cords or use them incorrectly.
- Be sure equipment that has been shop-fabricated or altered is in compliance.



Do not repair electrical cords with tape! Any repairs must return the equipment to the state in which it was initially approved.

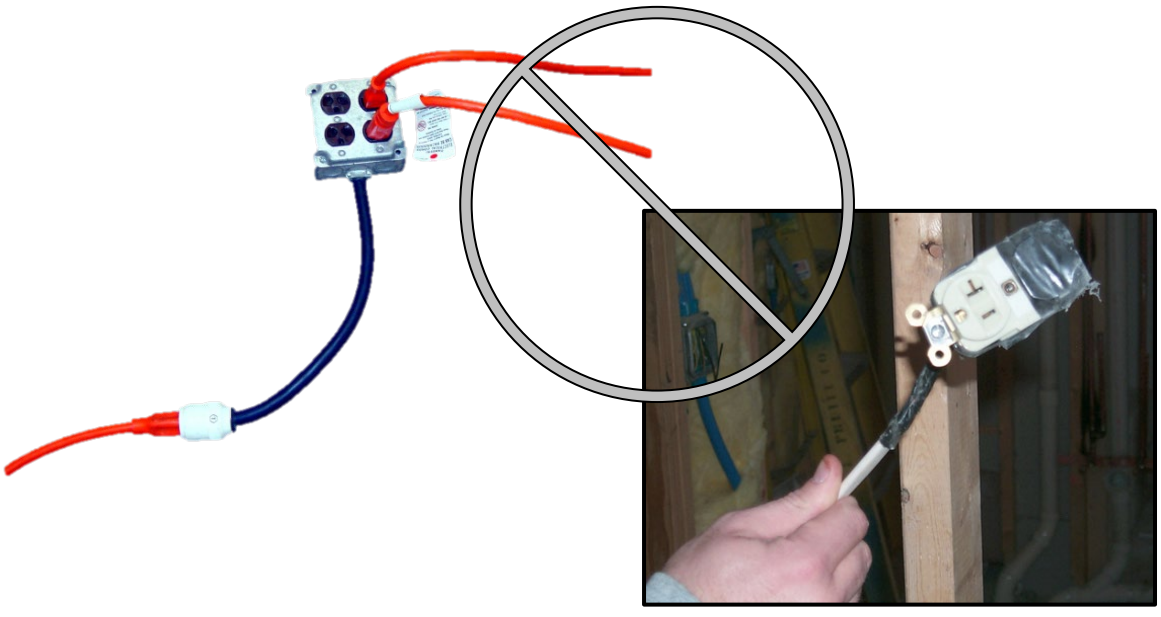
Am I in Danger?

The normal wear and tear on extension and flexible cords at a job site can loosen or expose wires, creating hazardous conditions. Cords that are not 3-wire type, not designed for hard usage, or that have been modified, increase the risk of contact with electrical current.

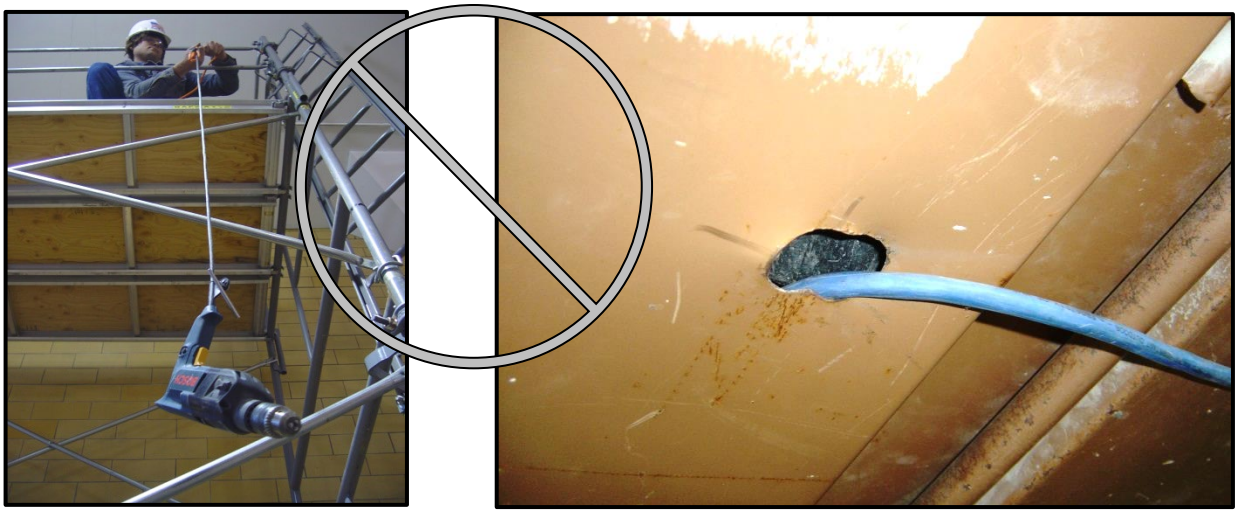
How Do I Avoid Hazards?

- 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.

Do not use multi-receptacle boxes designed to be *mounted* by fitting them with a power cord and placing them on the floor.



Do not fabricate extension cords using ROMEX® wire.



29 CFR 1926.302(a)(2). The use of electric cords for hoisting or lowering tools shall not be permitted.

29 CFR 1926.405(a)(2)(ii)(I). Flexible cords and cables shall be protected from damage. Sharp corners and projections shall be avoided.

OSHA's Nationally Recognized Testing Laboratory (NRTL) Program

29 CFR 1926.403(a). Approval. All electrical conductors and equipment shall be approved.

OSHA recognizes private sector organizations to perform certification for certain products to ensure that they meet the requirements of both the construction and general industry OSHA electrical standards. Each NRTL has a scope of test standards that it is recognized for, and each NRTL uses its own unique registered certification mark(s) to designate product conformance to the applicable product safety test standards. After certifying a product, the NRTL authorizes the manufacturer to apply a registered certification mark to the product. If the certification is done under the NRTL program, this mark signifies that the NRTL has tested and certified the product, and that the product complies with the requirements of one or more appropriate product safety test standards.

CSA Group Testing and Certification Inc.
178 Rexdale Boulevard
Etobicoke, Ontario M9W 1R3
Canada

Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, Illinois 60062
United States

Power Tools

Because power tools are so common in construction, workers are constantly exposed to a variety of hazards. The very tool that makes a 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.

Accident Prevention Tags

29 CFR 1926.200(h). Accident prevention tags shall be used as a temporary means of warning employees of an existing hazard, such as defective tools (picture).

As part of an ongoing accident prevention program, employers should have a system in place that allows employees to identify tools that are in disrepair. Without such a program, employees may grab a tool that is defective and try to use it.

Lockout/Tagout

Discussion Points

- What is hazardous energy?
- What are the harmful effects of hazardous energy?
- Elements of a Lockout/Tagout program (OSHA)
- Electrical Safety-Related Work Practices (NFPA 70E)

What is Hazardous Energy?

Energy sources, including electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other sources in machines and equipment can be hazardous to workers. During the servicing and maintenance of machines and equipment, the unexpected startup or release of stored energy can result in serious injury or death to workers.

What are the Harmful Effects of Hazardous Energy?

Workers servicing or maintaining machines or equipment may be seriously injured or killed if hazardous energy is not properly controlled. Injuries may include electrocution, burns, crushing, cutting, lacerating, amputating, or fracturing body parts. For example:

- A jammed conveyor system suddenly releases, crushing a worker who is trying to clear the jam.
- Internal wiring on a piece of factory equipment electrically shorts, shocking a worker who is repairing the equipment.

Craft workers, electricians, machine operators, and laborers are among the 3 million workers who service equipment routinely and face the greatest risk of injury. Workers injured on the job from exposure to hazardous energy lose an average of 24 workdays for recuperation.

Construction Industry Standards (OSHA)

29 CFR 1926.417(a). Controls that are to be deactivated during the course of work on energized or deenergized equipment or circuits shall be tagged.

29 CFR 1926.417(b). Equipment or circuits that are deenergized shall be rendered inoperative and shall have tags attached at all points where such equipment or circuits can be energized.

29 CFR 1926.417(c). Tags shall be placed to identify plainly the equipment or circuits being worked on.

Energy Control Program (OSHA) – 29 CFR 1910.147

The employer shall establish a program consisting of energy control procedures, employee training and periodic inspections to ensure that before any employee performs any servicing or maintenance on a machine or equipment where the unexpected energizing, startup or release of stored energy could occur and cause injury, the machine or equipment shall be isolated from the energy source and rendered inoperative.

Lockout/Tagout program requirements:

- If an energy isolating device is capable of being locked out, the employer's energy control program shall utilize lockout, unless the employer can demonstrate that the utilization of a tagout system will provide full employee protection.
- If an energy isolating device is not capable of being locked out, the employer's energy control program shall utilize a tagout system.
- When a tagout device is used on an energy isolating device which is capable of being locked out, the tagout device shall be attached at the same location that the lockout device would have been attached, and the employer shall demonstrate that the tagout program will provide a level of safety equivalent to that obtained by using a lockout program.

Capable of Being Locked Out

An energy isolating device is capable of being locked out if it has a hasp or other means of attachment to which, or through which, a lock can be affixed, or it has a locking mechanism built into it. Other energy isolating devices are capable of being locked out, if lockout can be achieved without the need to dismantle, rebuild, or replace the energy isolating device or permanently alter its energy control capability.

Examples of Lockout Devices – Capable of Being Locked Out

Energy Control Procedure

Procedures shall be developed, documented and utilized for the control of potentially hazardous energy when employees are servicing and maintaining machines and equipment during which the unexpected energization or startup of the machines or equipment, or release of stored energy, could harm employees.

Typical Minimal Lockout Procedures – 29 CFR 1910.147 Appendix A

The following simple lockout procedure is provided to assist employers in developing their procedures so that they meet the requirements of this standard. When the energy-isolating devices are not lockable, tagout may be used, provided the employer complies with the provisions of the standard (1910.147), which requires additional training and more rigorous periodic inspections. When tagout is used and the energy-isolating devices are lockable, the employer must provide full employee protection and additional training and more rigorous periodic inspections. For more complex systems, more comprehensive procedures may need to be developed, documented, and utilized.

General

Lockout Procedure for:

(Name of Company for single procedure or identification of equipment if multiple procedures are used)

Purpose

This procedure establishes the minimum requirements for the lockout of energy-isolating devices whenever maintenance or servicing is done on machines or equipment. It shall be used to ensure that the machine or equipment is stopped, isolated from all potentially hazardous energy sources and locked out before employees perform any servicing or maintenance where the unexpected energization or start-up of the machine or equipment or release of stored energy could cause injury.

Compliance with This Program

All employees are required to comply with the restrictions and limitations imposed upon them during the use of lockout. The authorized employees are required to perform the lockout in accordance with this procedure. All employees, upon observing a machine or piece of equipment which is locked out to perform servicing or maintenance, shall not attempt to start, energize, or use that machine or equipment.

Type of compliance enforcement to be taken for violation of the above:

Sequence of Lockout

1) Notify all affected employees that servicing or maintenance is required on a machine or equipment and that the machine or equipment must be shut down and locked out to perform the servicing or maintenance.

   Name(s)/Job Title(s) of affected employees and how to notify:

   The authorized employee shall refer to the company procedure to identify the type and magnitude of the energy that the machine or equipment utilizes, shall understand the hazards of the energy, and shall know the methods to control the energy.

   Type(s) and magnitude(s) of energy, its hazards and the methods to control the energy:

   If the machine or equipment is operating, shut it down by the normal stopping procedure (depress the stop button, open switch, close valve, etc.).

   Type(s) and location(s) of machine or equipment operating controls:

   ---

2) De-activate the energy-isolating device(s) so that the machine or equipment is isolated from the energy source(s).

   Type(s) and location(s) of energy-isolating devices:

   ---

3) Lock out the energy-isolating device(s) with assigned individual lock(s).

4) Stored or residual energy (such as that in capacitors, springs, elevated machine members, rotating flywheels, hydraulic systems, and air, gas, steam, or water pressure, etc.) must be dissipated or restrained by methods such as grounding, repositioning, blocking, bleeding down, etc.

   Type(s) of stored energy - methods to dissipate or restrain:

   ---

5) Ensure that the equipment is disconnected from the energy source(s) by first checking that no personnel are exposed, then verify the isolation of the equipment by operating the push button or other normal operating control(s) or by testing to make certain the equipment will not operate.

   Caution: Return operating control(s) to neutral or "off" position after verifying the isolation of the equipment.

   Method of verifying the isolation of the equipment:

   ---

6) The machine or equipment is now locked out.

Restoring Equipment to Service

When the servicing or maintenance is completed and the machine or equipment is ready to return to normal operating condition, the following steps shall be taken.

1) Check the machine or equipment and the immediate area around the machine to ensure that nonessential items have been removed and that the machine or equipment components are operationally intact.
2) Check the work area to ensure that all employees have been safely positioned or removed from the area.
3) Verify that the controls are in neutral.
4) Remove the lockout devices and reenergize the machine or equipment.

   Note: The removal of some forms of blocking may require reenergization of the machine before safe removal.
5) Notify affected employees that the servicing or maintenance is completed and the machine or equipment is ready for use.

Lockout/Tagout Devices

***Lockout device*.** A device that utilizes a positive means such as a lock, either key or combination type, to hold an energy-isolating device in the safe position and prevent the energizing of a machine or equipment. Included are blank flanges and bolted slip blinds.

***Tagout device*.** A prominent warning device, such as a tag and a means of attachment, which can be securely fastened to an energy-isolating device in accordance with an established procedure, to indicate that the energy-isolating device and the equipment being controlled may not be operated until the tagout device is removed.

29 CFR 1910.147(c)(5)(iii). Tagout devices shall warn against hazardous conditions if the machine or equipment is energized and shall include a legend such as the following: *Do Not Start. Do Not Open. Do Not Close. Do Not Energize. Do Not Operate*.

Tagout Device

Lockout Device

Lockout/Tagout Protective Materials and Hardware

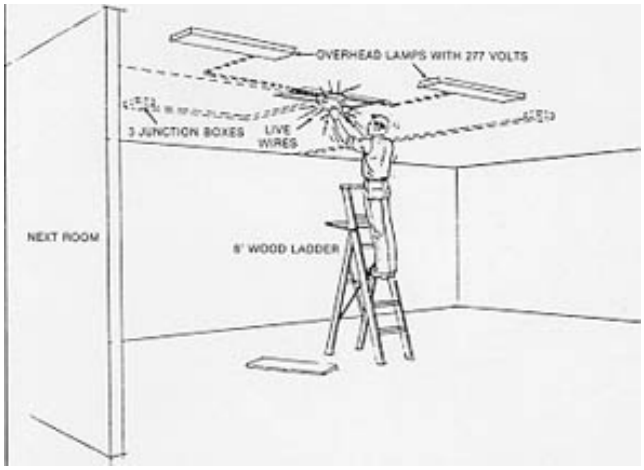
Locks, tags, chains, wedges, key blocks, adapter pins, self-locking fasteners, or other hardware shall be provided by the employer for isolating, securing or blocking of machines or equipment from energy sources.

Lockout devices and tagout devices shall be singularly identified; shall be the only devices(s) used for controlling energy; shall not be used for other purposes; and shall meet the following requirements:

- **Durable**
    - Lockout and tagout devices shall be capable of withstanding the environment to which they are exposed for the maximum period of time that exposure is expected.
    - Tagout devices shall be constructed and printed so that exposure to weather conditions or wet and damp locations will not cause the tag to deteriorate or the message on the tag to become illegible.
    - Tags shall not deteriorate when used in corrosive environments such as areas where acid and alkali chemicals are handled and stored.
- **Standardized.** Lockout and tagout devices shall be standardized within the facility in at least one of the following criteria: color; shape; or size; and additionally, in the case of tagout devices, print and format shall be standardized.
- **Substantial**
    - *Lockout devices*. Lockout devices shall be substantial enough to prevent removal without the use of excessive force or unusual techniques, such as with the use of bolt cutters or other metal cutting tools.
    - *Tagout devices*. Tagout devices, including their means of attachment, shall be substantial enough to prevent inadvertent or accidental removal. Tagout device attachment means shall be of a non-reusable type, attachable by hand, self-locking, and non-releasable with a minimum unlocking strength of no less than 50 pounds and having the general design and basic characteristics of being at least equivalent to a one-piece, all environment-tolerant nylon cable tie.
- ***Identifiable*.** Lockout devices and tagout devices shall indicate the identity of the employee applying the device(s).

Fatal Fact – Discussion #5

The employee was attempting to correct an electrical problem involving two non-operational lamps. He proceeded to the area where he thought the problem was. He had not shut off the power at the circuit breaker panel nor had he tested the wires to see if they were live. He was electrocuted when he grabbed the two live wires with his left hand and then fell from the ladder.



INSPECTION RESULTS

The investigation revealed that the employer had not locked out/tagged out the circuit, nor did the employer have an electrical safety program for work on or near energized electrical equipment.

ACCIDENT PREVENTION RECOMMENDATIONS

_____

_____

_____

_____

_____

Notes

Electrical Safety-Related Work Practices

Discussion Points

- Hierarchy of risk control methods
- Job safety planning and job briefing
- Host and contract employers' responsibilities
- Shock risk assessment
- Arc flash risk assessment and equipment labeling
- Emergency response training
- Test instruments and equipment – *ABC's of Multimeter Safety*
- Energized electrical work permit

Electrical safety-related work practices apply to qualified persons (those who have training in avoiding the hazards of working on or near exposed energized parts) and unqualified persons (those with little or no such training) working on, near, or with electrical equipment.

29 CFR 1910.333(a). "General." Safety-related work practices shall be employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts, when work is performed near or on equipment or circuits which are or may be energized. The specific safety-related work practices shall be consistent with the nature and extent of the associated electrical hazards.

In establishing an electrical safety-related work program, employers must consider the hierarchy of risk control methods.

Hierarchy of Risk Control Methods

Safety-related work practices must include the hierarchy of risk control methods:

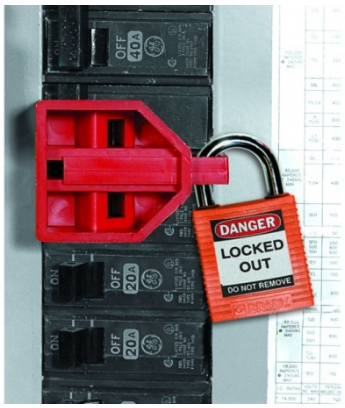
1) Elimination
2) Substitution
3) Engineering controls
4) Awareness
5) Administrative controls
6) Personal Protective Equipment

Note: Elimination, Substitution, and Engineering controls are the most effective methods to reduce risk, as they are usually applied at the source of possible injury or damage to health. They are also less likely to be affected by human error. Awareness, Administrative controls, and PPE are the least effective methods to reduce risk, as they are not applied at the source. They are also more likely to be affected by human error.

Option 1: De-energize (Lockout/Tagout)

29 CFR 1910.333(a)(1). Live parts to which an employee may be exposed shall be de-energized before the employee works on or near them, unless the employer can demonstrate that de-energizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. Live parts that operate at less than 50 volts to ground need not be de-energized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.

Eliminating the hazard (de-energize) is always the first option for protecting workers.



Note 1: Examples of increased or additional hazards include interruption of life support equipment, deactivation of emergency alarm systems, shutdown of hazardous location ventilation equipment, or removal of illumination for an area.

Note 2: Examples of work that may be performed on or near energized circuit parts because of infeasibility due to equipment design or operational limitations include testing of electric circuits that can only be performed with the circuit energized and work on circuits that form an integral part of a continuous industrial process in a chemical plant that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.

Option 2: Work On or Near Energized Parts

29 CFR 1910.333(a)(2). If the exposed live parts are not de-energized (i.e., for reasons of increased or additional hazards or infeasibility), other safety-related work practices shall be used to protect employees who may be exposed to the electrical hazards involved. Such work practices shall protect employees against contact with energized circuit parts directly with any part of their body or indirectly through some other conductive object. The work practices that are used shall be suitable for the conditions under which the work is to be performed and for the voltage level of the exposed electric conductors or circuit parts.

Job Safety Planning

Before starting each job that involves exposure to electrical hazards, the employee in charge shall complete a job safety plan and conduct a job briefing with the employees involved.

The job safety plan shall:

1) Be completed by a qualified person
2) Be documented
3) Include the following information:
    a. Description of the job and the individual tasks
    b. Identification of the electrical hazards associated with each task
    c. A shock risk assessment for tasks involving a shock hazard
    d. An arc flash risk assessment for tasks involving an arc flash hazard
    e. Work procedures involved, special precautions, and energy source controls

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Job Briefing

The job briefing shall cover the job safety plan and the information on the energized electrical work permit, if a permit is required.

Host and Contract Employers' Responsibilities

Host Employer

- The host employer must inform contract employers of the known hazards related to the contract employer's work. Additional information about hazards that might not be recognized by the contract employer or its employees must also be provided.
- The host employer shall report observed contract employer-related violations to the contract employer.

Contract Employer

- The contract employer must ensure that each of its employees is informed about the hazards communicated to the contract employer by the host employer. This shall be in addition to the qualified person training already received.
- The contract employer shall ensure that each of its employees follows the work practices and safety-related work rules required by the host employer.

Sample Job Briefing and Planning Checklist

Reference: NFPA 70E (2018) – Informative Annex I

Identify

- ☐ Hazards associated with work
- ☐ Voltage levels involved
- ☐ Skills required to perform job
- ☐ Any "foreign" (secondary source) voltage source present
- ☐ Any unusual work conditions observed
- ☐ Number of people needed to do the job
- ☐ Shock protection boundaries
- ☐ Available incident energy analysis
- ☐ Potential for arc flash considered
- ☐ Conduct an arc flash risk assessment
- ☐ Arc flash boundary established
- ☐ Any evidence of impending failure?

Ask

- ☐ Can the equipment be de-energized (LOTO)?
- ☐ Are backfeeds of the circuits to be worked on possible?
- ☐ Is an energized electrical work permit required?
- ☐ Justification for energized work established
- ☐ Is a standby person available and trained?
- ☐ Is the equipment properly installed and maintained?

Check

- ☐ Job plans reviewed and available
- ☐ Single-line diagrams and vendor prints
- ☐ Status board
- ☐ Information on plant and vendor resources is up to date
- ☐ Safety procedures in place
- ☐ Vendor information available
- ☐ Individuals are familiar with the facility and orientated on emergency procedures

Know

- ☐ What is the scope of the job (project)
- ☐ Who else needs to know – Communicate!
- ☐ Who is in charge
- ☐ Critical function to perform

Think

- ☐ About the unexpected event… What if?
- ☐ Lock – Tag – Test – Try
- ☐ Test for voltage – FIRST
- ☐ Use the right tools and equipment, including PPE
- ☐ Install and remove temporary protective grounding equipment
- ☐ Install barriers and barricades

Prepare for an emergency

- ☐ Is the standby person CPR/AED trained?
- ☐ Is the required emergency equipment available? Where is it?
- ☐ Where is the fire alarm?
- ☐ Is confined space rescue available?
- ☐ What is the exact work location?
- ☐ How is the equipment shut off in an emergency?
- ☐ Are the emergency telephone numbers known?
- ☐ Where is the fire extinguisher?
- ☐ Are radio communications available?

- ☐ Is an AED available?

Shock Risk Assessment (NFPA 70E – 2018)

A *shock hazard* is a source of possible injury or damage to health associated with current through the body caused by contact or approach to energized electrical conductors or circuit parts.

Only qualified persons are allowed to work on or near live electrical equipment. To establish what a safe work distance is to an exposed energized conductor, the NFPA 70E standard provides a limited and restricted approach boundary table. Working within these approach boundaries requires specialized training, tools and personal protective equipment.

Approach Boundaries (NFPA 70E – 2018)

Reference: Table 130.4(D)(a) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems

[1] *Exposed movable conductors* describe a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

[2] An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

Limited Approach Boundary (NFPA 70E – 2018)

The limited approach boundary is an approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.

For a person to cross the limited approach boundary and enter the limited space, a person should meet the following criteria:

- Be qualified to perform the job/task.
- Be able to identify the hazards and associated risks with the tasks to be performed.

Restricted Approach Boundary (NFPA 70E – 2018)

The restricted approach boundary is an approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

For a person to cross the restricted approach boundary and enter the restricted space, a person should meet the following criteria:

- As applicable, have an energized electrical work permit authorized by management.
- Use personal protective equipment (PPE) that is rated for the voltage and energy level involved.
- Minimize the likelihood of bodily contact with exposed energized conductors and circuit parts from inadvertent movement by keeping as much of the body out of the restricted space as possible and using only protected body parts in the space as necessary to accomplish the work.
- Use insulated tools and equipment.

Arc Flash Risk Assessment (NFPA 70E – 2018)

An arc flash hazard exists when working within a distance at which incident energy equals 1.2 cal/cm² (5 J/cm²).

Note: According to the Stoll skin burn injury model, the onset of a second degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm² (5 J/cm²) for one second.

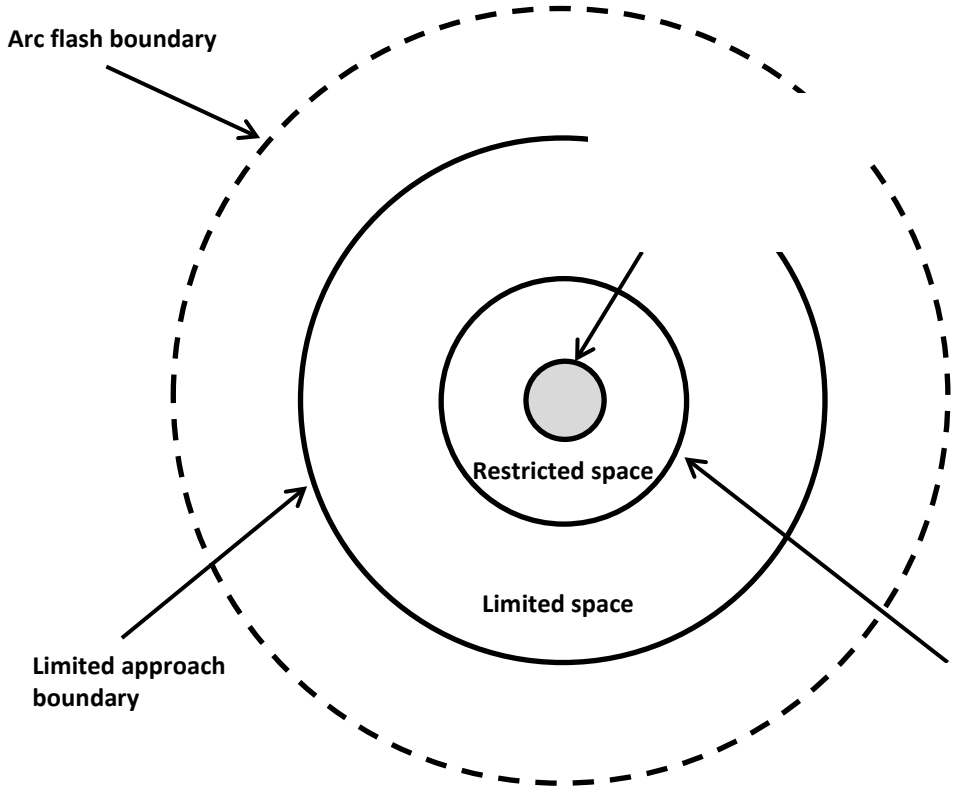
There are three main reasons for performing an arc flash risk assessment:

1. To identify arc flash hazards.
2. To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health.
3. To determine if additional protective measures are required, including the use of PPE.

For a person to cross the arc flash boundary, a person must be wearing appropriate arc-rated clothing.

Limits of Approach (NFPA 70E – 2018)

Reference: NFPA 70E (2018) – Informative Annex C

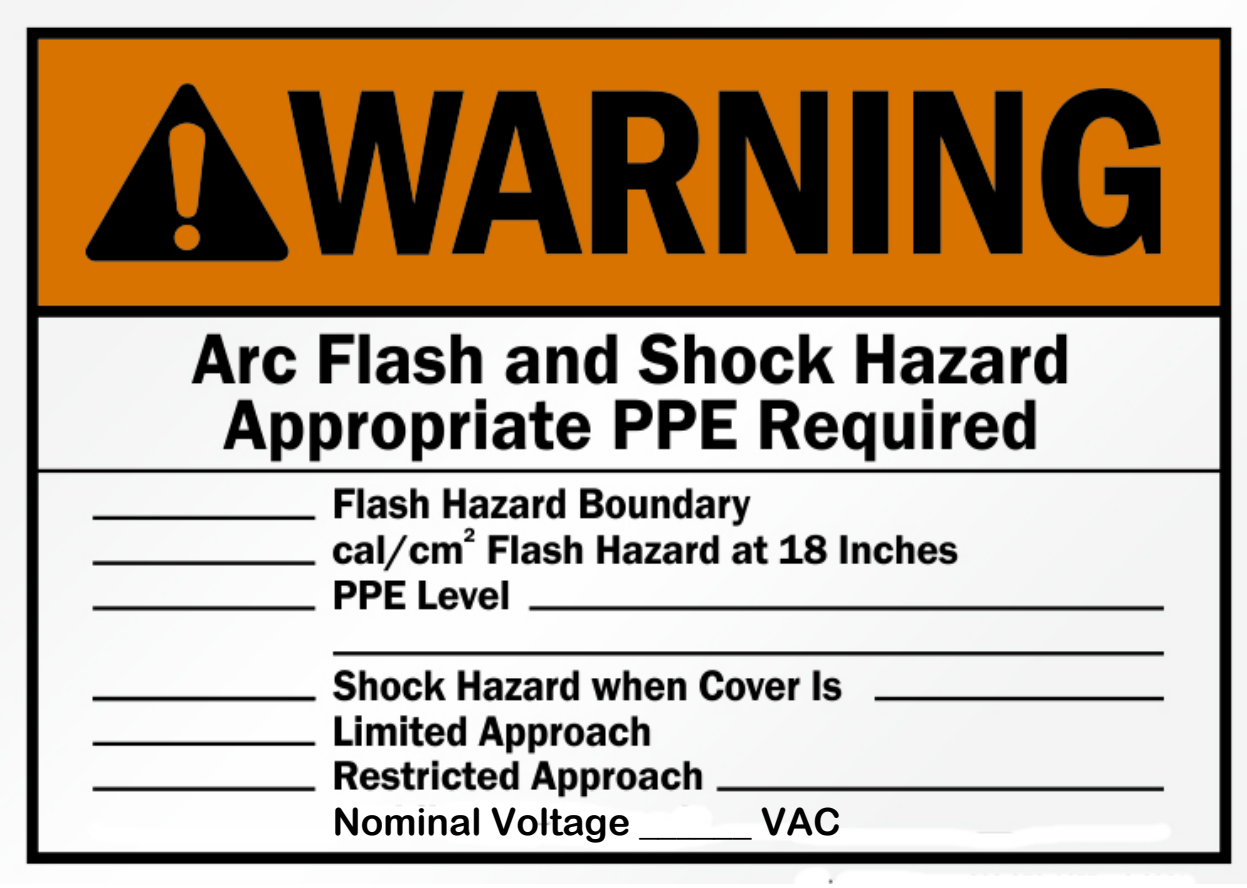


Equipment Labeling (NFPA 70E – 2018)

Electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers, that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be marked with a label containing the following information:

1) Nominal system voltage
2) Arc flash boundary
3) At least one of the following:
    a. Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) for the equipment, but not both.
    b. Minimum arc rating of clothing.
    c. Site-specific level of PPE.

Equipment Label Example



Emergency Response Training (NFPA 70E – 2018)

Contact Release

- Employees who are exposed to shock hazards, and those who are responsible for the safe release of victims from contact with energized electrical conductors or circuit parts, shall be trained in methods of safe release.

Stand-by electrical worker wearing arc- rated clothing and holding a non-conductive pole for contact release.

First Aid, Emergency Response, and Resuscitation

- Employees who are responsible for responding to medical emergencies shall be trained in first aid and emergency procedures.
- Employees who are responsible for responding to medical emergencies shall be trained in cardiopulmonary resuscitation (CPR).
- Employees who are responsible for responding to medical emergencies shall be trained in the use of an automated external defibrilator (AED) if an employer's emergency response plan includes the use of this device.

American Heart Association – Chain of Survival

- Immediate **recognition** of cardiac arrest and **activation** of the emergency response system
- Early **cardiopulmonary resuscitation (CPR)** with an emphasis on chest compressions
- Rapid **defibrillation**
- Effective **advanced life support**
- Integrated **post-cardiac arrest care**

Test Instruments and Equipment

- ***Use***

29 CFR 1910.334(c)(1). Only qualified persons may perform testing work on electric circuits or equipment.

- ***Visual Inspection***

29 CFR 1910.334(c)(2). Test instruments and equipment, as well as all associated test leads, cables, power cords, probes, and connectors, shall be visually inspected for external defects and damage before the equipment is used. If there is a defect or evidence of damage that might expose an employee to injury, then the defective or damaged item shall be removed from service, and no employee shall use it until repairs and tests necessary to render the equipment safe have been made.

- ***Rating of Equipment***

29 CFR 1910.334(c)(3). Test instruments and equipment (and their accessories) shall be rated for the circuits and equipment to which they will be connected and shall be designed for the environment in which they will be used.

Multimeter Safety Checklist

- ☐ Check for cracked or oily cases
- ☐ Check for broken input jacks
- ☐ Check category rating
- ☐ Check that any replacement fuses and leads are approved by the manufacturer

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Tool Tip

Non-contact voltage detectors are a quick, inexpensive way to check for the presence of live voltage on AC circuits, switches and outlets before working on them.

1) Verify that the voltage detector function is working properly.
2) Make sure that the detector is rated for the level of voltage being measured and is sensitive enough for your application.
3) Make sure employee is grounded (from hand to floor) to complete the capacitive voltage connection.

VoltAlert

ABC's of Multi-meter Safety

Reference: From the Fluke Digital Library @ www.fluke.com/library

The most important single concept to understand about multi-meter safety is the Overvoltage Installation Category. The standard defines Categories I through IV, often abbreviated as CAT I, CAT II, etc. (See Figure 1.)

- A higher CAT number refers to an electrical environment with higher power available and higher energy. Thus, a multi-meter designed to a CAT III standard is resistant to higher energy than one designed to CAT II standards.
- The general rule-of-thumb is that the closer you are to the power source, the higher the category number, and the greater the potential danger.

Image source: Fluke.com/library

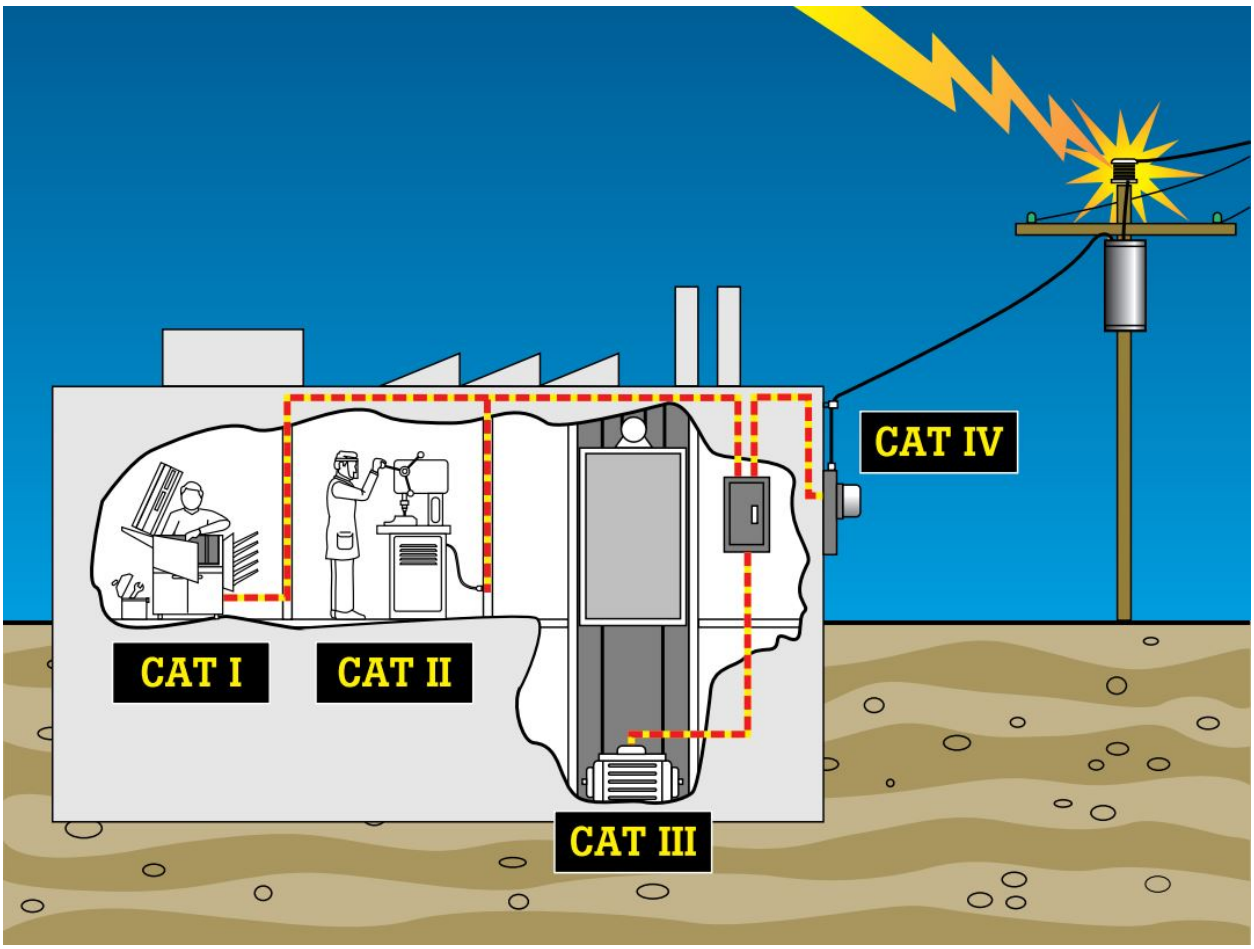


Figure 1. Location, location, location.

Energized Electrical Work Permit (NFPA 70E – 2018)

When work is performed on energized electrical equipment, an energized electrical work permit shall be required and documented under any of the following conditions:

- When work is performed within the restricted approach boundary.
- When an employee interacts with the equipment when conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.

The work permit shall include, but not be limited to, the following items:

1) Description of the circuit / equipment to be worked on and its location.
2) Description of the work to be performed.
3) Justification for why the work must be performed in an energized condition.
4) Description of the safe work practices to be employed.
5) Results of the shock risk assessment:
    a. Voltage to which personnel will be exposed.
    b. Limited approach boundary.
    c. Restricted approach boundary.
    d. Personal and other protective equipment required by this standard to safely perform the assigned task and to protect against the shock hazard.
6) Results of the arc flash risk assessment:
    a. Available incident energy at the working distance or arc flash PPE category.
    b. Personal and other protective equipment required to protect against the arc flash hazard.
    c. Arc flash boundary.
7) Means employed to restrict the access of unqualified persons to the work area.
8) Evidence of completion of a job briefing, including a discussion of any job-specific hazards.
9) Energized work approval (authorizing or responsible management, safety officer, or owner, etc.) signature(s).

Personal Protective Equipment

Discussion Points

- Safeguards for personnel protection
- Arc flash suit – arc rating
- Arc flash PPE categories
- Care and maintenance of arc-rated clothing and arc-rated arc flash suits
- Voltage-rated tools

Personal protective equipment (PPE) is equipment worn to minimize exposure to hazards that cause serious workplace injuries. These injuries may result from contact with electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, and arc-rated clothing.

Safeguards for Personnel Protection (OSHA) – 29 CFR 1910.335

- Rubber insulating protective equipment shall be maintained in a safe, reliable condition and shall be periodically inspected or tested. *(See next page: OSHA TABLE I-5-RUBBER INSULATING EQUIPMENT, TEST INTERVALS.)*
- If the insulating capability of protective equipment may be subject to damage during use, the insulating material shall be protected. (For example, an outer covering of leather is required for the protection of rubber insulating material.)
- Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with exposed energized parts.
- Employees shall wear protective equipment for the eyes or face wherever there is danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion.

Insulating Gloves with Leather Protectors

Non-conductive Class "E" Hardhat

Eye and Face Protection (ANSI Z87)

OSHA Table I-5-Rubber Insulating Equipment, Test Intervals

Employers shall certify that equipment has been tested. The certification shall identify the equipment that passed the test and the date it was tested and shall be made available upon request to the Assistant Secretary for Occupational Safety and Health and to employees or their authorized representatives.

[1] If the insulating equipment has been electrically tested but not issued for service, the insulating equipment may not be placed into service unless it has been electrically tested within the previous 12 months.

Arc Flash Suit – Arc Rating

Arc Flash Suit (NFPA 70E – 2018) is a complete arc-rated clothing and equipment system that covers the entire body, except for the hands and feet. An arc flash suit may include pants or overalls, a jacket or a coverall, and a beekeeper-type hood fitted with a face shield.

Arc Rating (NFPA 70E – 2018). Arc rating is the value attributed to materials that describes their performance during exposure to an electrical arc discharge. The arc rating is expressed in cal/cm² and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakopen threshold (EBT) (should a material system exhibit a breakopen response below the ATPV value). Arc rating is reported as either ATPV or EBT, whichever is the lower value.

Arc Flash PPE Categories (NFPA 70E – 2018)

See next page: Footnotes for Arc Flash PPE Category Table

Footnotes for Arc Flash PPE Category Table

AN: As needed (optional).

AR: As required.

SR: Selection required.

Face shields are to have wrap-around guarding to protect not only the face, but also the forehead, ears, and neck, or, alternatively, an arc-rated arc flash suit hood is required to be worn.

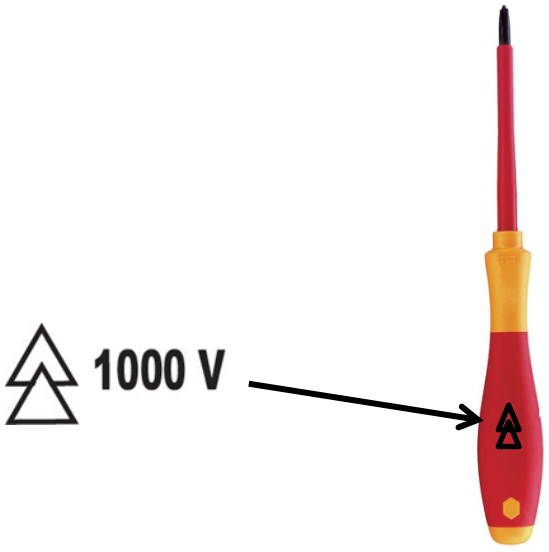
Other types of hearing protection are permitted to be used in lieu of, or in addition to, ear canal inserts, provided they are worn under an arc-rated arc flash suit hood.

If rubber insulating gloves with leather protectors are used, then additional leather or arc-rated gloves are not required. The combination of rubber insulating gloves with leather protectors satisfies the arc flash protection requirement.

Voltage Rated Tools

Insulated tools are hand tools used to help protect them from and reduce electrical-related incidents such as: electrocution, arc flash, and arc blasts. The use and application of insulated tools and appropriate PPE (Personal Protection Equipment) is required by OSHA. Insulated tools are rated at 1,000 volts, but subjected to 10,000 volts before distribution (mandated by the ASTM F1505 standard). Insulated tools comply with the International Electrotechnical Commission (IEC) 60900 standard and The National Fire Protection Association (NFPA) 70E standard.

Most hand tools are manufactured with a rubber coating over the handle (or handles). However, this does not mean that they are insulated tools. Therefore, they are not necessarily suitable for electrical-related work. The rubber coating on common hand tools is for comfort and grip. It is not to provide protection from electrical current.



Fatal Fact – Discussion #6

An electrician was removing metal fish tape from a hole at the base of a metal light pole. The fish tape became energized, electrocuting him.

INSPECTION RESULTS

The investigation revealed that the employer had not locked out/tagged out the circuit, nor did the employer have an electrical safety program for work on or near energized electrical equipment.

ACCIDENT PREVENTION RECOMMENDATIONS

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