Electrical Safe Work Practices

OSHA 29CFR1910 Subpart S

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It's the Law. **Design safety related work practices for persons who install, maintain and repair electrical circuits or equipment, as well as those who work on or near this equipment.**

A change made in U.S. labor laws has seemed to have gone unnoticed by many facility professionals. OSHA 29CFRI910 Subpart S - Electrical (1910.302 to 1910.335) is a labor law, which spells out safety related work practices on electrical equipment. To their peril, many facilities are not in compliance or have simply ignored this law. As of August 1990, all persons who install, maintain, repair, or just work near electrical power equipment must be trained in the hazards these systems may present. Additionally, many existing lockout procedures based only on 1910.147 requirements may now have to be updated to comply with the electrical safe work practices described in Subpart S. Also, previously "unwritten rules," such as not wearing conductive jewelry while performing electrical tests, are now expressly forbidden in this law.

The first section of Subpart S (paragraphs 1910.302 through 1910.308) has been in effect for a number of years. This part deals primarily with design safety standards for electrical systems. As of August 1990, paragraphs 1910.331 through 1910.335 were added to include safety-related work practices for electrical equipment. These paragraphs cover persons who install, maintain, and repair electrical circuits or equipment, as well as those who work on or near this equipment. Prior to this addition, a National Fire Protection Association standard on "Electrical Safety Requirements for Employee Workplaces," NFPA 70E was used by many employers seeking to improve their company's electrical safety performance. The NFPA standard was used as a guide in the development of the new OSHA requirements.

Workers and supervisors who work closely enough to exposed parts of circuits operating at or above 50 volts must be trained under this law. OSHA provides the following list as a guide to determining what may be included at your site.

- Occupation
- Blue Collar Supervisors
- Electrical and electronic engineers
- Electrical and electronic equipment assemblers
- Electrical and electronic technicians
- Electricians
- Industrial machine operators
- Material handling equipment operators
- Mechanics and repairers
- Painters
- Riggers and roustabouts
- Stationary engineers
- Welders

OSHA also states that, "Other employees who also may be reasonably expected to face a comparable risk of injury due to electric shock or other electrical hazards must be trained."

next page ▶

The main thrust of the work practices section covers:

- Work on de-energized electrical equipment
- Work near exposed energized parts
- Work on energized electrical equipment
- Safe use of electrical equipment
- Personal protective equipment for electrical work

Electrical Hazard

Persons appraising the hazards that can be presented by electricity often only think of the potential for electric shock or electrocution. An electrical hazard can also cause blasts, heat, projectiles or pressure waves from short circuits or arcs in an electric circuit. Indirect electrical hazards can include consequences from loss of power such as interruption of life support equipment, deactivation of emergency systems, shutdown of ventilation equipment in hazardous locations, or loss of lighting in important areas. The failure of electrical interlocks in process plants during a power loss may also present a hazard.

Hazards exist because of unsafe conditions and/or unsafe acts. Industrial safety professionals have determined that eliminating both of these in the workplace is good business. OSHA has determined that it is the employer's responsibility to reduce the potential for accidents from both unsafe conditions and unsafe acts.

Identifying an unsafe condition is the first defense in preventing an accident caused by an electrical hazard. It should be noted that the presence of a hazard does not necessarily mean that work cannot continue. Temporary hazards exist at many otherwise safe industrial sites. However, a worker needs to be aware or made aware of the hazard and should be capable of protecting themselves and others from the hazard. Unsafe conditions in electrical equipment can be the result of wiring failure, mechanical failure, insulation breakdown, improperly installed equipment, or exposed energized electrical equipment. OSHA suggests the following questions are asked by an employee about an area and job they are about to perform:

- Is the equipment suitable for the task? Is the equipment mechanically strong and durable enough?
- Is electrical insulation present?
- Does heat emit from the equipment at levels that may cause a hazard?
- What kind of hazard is presented by arcing in the equipment?
- Do you understand the class of equipment you are about to work on?
- Are there any other hazards with the equipment that may effect other employees and equipment?

Unsafe acts are usually the result of improper training or gross negligence. Unsafe acts can present a hazard if an employee works in an unsafe manner, such as working on energized equipment with improper tools or working near energized and exposed equipment without first rendering it safe.

OSHA conducted a study of electrical fatalities by unsafe acts for the period of April 1984 to December 1986. The results are summarized in the following table.

OSHA Study of Electrical Fatalities	
Unsafe Event	**% Fatal**
Use of equipment or material too close to exposed energized lines	37%
Failure to use electrical protective equipment	4%
Assuming an unsafe position	16%
Failure to de-energize, lock and tag equipment	10%
Use of visibly defective electric equipment	9%
Blind reaching, drilling, digging, etc	2%
Other	22%
Total	**100%**
These unsafe acts resulted in the deaths of 128 people in the workplace. Over 1,000 people are killed on the U.S. by electrocution every year; most are caused by unsafe acts	

Getting Energized

A perception problem arises on the part of many people with respect to the word "energized." Energized is defined as electrically connected to a voltage source. Energized is also called, in the colloquial, hot or live.

OSHA Subpart S states that, "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 SO volts to ground need not to be de-energized if there will be no increased exposure to electrical burns or to explosion due to electric arcs."

OSHA gives some examples of exceptions to this requirement, which include:

- Testing of electric circuits that can only be performed with the circuit energized.
- Work on circuits, which 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.

Qualified Persons

The terms "qualified person" and "unqualified person" are used throughout the OSHA Subpart S rule. Qualified persons, per OSHA and the NFPA, are "one familiar with the construction and operation of the equipment and the hazards involved."

Subpart S also states that, "Whether an employee is considered to be a qualified person or not will depend upon various circumstances in the work place. It is possible and, in fact, likely for an individual to be considered 'qualified' with regard to certain equipment in the work place, but 'unqualified' as to other equipment." For example, an employee can be qualified to work on low voltage motor circuits but not on higher voltage circuits.

"An employee who is undergoing on the job training and who, in the course of such training, has demonstrated the 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."

Lock Out and Tag Out Procedures

Mechanical lock out and tag out requirements identified in 1910.147 have been in force for a number of years. These requirements have been amended by a new requirement for electrical lock out in the Safe Work Practices paragraph 1910.333(b)(2). The safe use of electrical equipment and protective equipment are also covered.

The lock out and tag out requirements specified in 1910.147 address practices and procedures that are necessary to de-energize machinery or equipment. The rule was developed as a guide to prevent the release of potentially hazardous energy while maintenance and servicing activities are being performed.

Contrary to popular belief, the lock out and tag out rules discussed in 1910.147 did not cover exposure to electrical hazards. Although some of the lockout activities described are related to electrical energy, this requirement is mostly geared toward mechanical or fluid discharge hazards.

A lock out and tag out procedure that complies with 1910.147 can apply to electrical work as well if it includes the requirements spelled out in Subpart S -Electrical, 1910.333 (b)(2). A typical job covered by this procedure would be the disconnecting and reconnecting of an electric motor. It is has never been sufficient and is no longer legal, to just open a disconnect and lock out a motor starter before electrically disconnecting a motor. The circuit must be checked with voltage testers before any exposed contact work can proceed.

Assuming a facility's lock out and tag procedure satisfies the requirements of 1910.147, requirements of 1910.333 should be amended to the procedure. The part of a lockout procedure that pertains to work on or near exposed electrical parts, should have the following as a minimum.

- The safest method for de-energizing circuits must be determined before circuits or equipment are de-energized.
- Conductors and parts of electric equipment that have been de-energized, but have not been locked out or tagged, must be treated as energized until proven otherwise.
- While any employee is exposed to contact with parts of electric equipment or circuits, which have been de-energized, the circuits energizing the parts must be locked out and tagged.
- A "Positive disconnecting means" such as a fused disconnect switch or circuit breaker, should be used to disconnect circuits and equipment from all electric energy sources. (The all too common and illegal practice of using control circuit devices such as push buttons, selector switches, and interlocks as a disconnecting means must never be allowed.)
- Stored electrical energy that might endanger personnel must be released before work can begin. Capacitors are the most common device that can contain stored electrical energy. Power factor correction capacitors are sometimes used in a motor circuit. These capacitors usually have a resistor that discharges the capacitor quickly. AC voltage testers cannot detect the remaining charge on a capacitor. A DC voltage check is required. High capacitance elements, such as very long, shielded cables, must be short-circuited and grounded. A capacitor can be discharged by connecting all the phases together and to ground. A suitable grounding device must be used.
- Block or relieve stored non-electrical energy in devices that could re-energize electric circuit parts or that can injure an employee in any other way.
- A lock and tag must be placed on each disconnecting means used to de-energize circuits and equipment on which work is to be performed. The lock must be attached so as to prevent persons from operating the disconnecting means unless they resort to undue force or the use of tools. Each tag must contain a statement prohibiting unauthorized operation of the disconnecting means and removal of the tag.

- A person qualified in the operation of the equipment, such as a chemical plant operator, must attempt to start the equipment once it has been locked out and tagged to verify the equipment cannot be restarted.

- A person qualified in electrical testing methods must test the circuit elements and electrical parts of the equipment to which employees will be exposed. The circuit elements and equipment parts must be verified as de-energized. Two forms of testing should be used:

    - A voltage sensor should be used first to find all energized parts. Voltage sensors detect an electrostatic field around AC circuits. They are often used as a first check of an electric circuit to assess hazards prior to using other voltage testers. Voltage sensors cannot be used to detect DC voltage. They also cannot detect voltage through metal enclosures, shielded cables, or metal connector jackets. A voltage will not be sensed if the sensor is held on the ground-side of a multi-conductor cable.

    - A voltmeter should be used to verify the voltage level of any energized parts. The test equipment must be checked for proper operation immediately before and immediately after this test. (This is an OSHA requirement for above 600 volts only, but is a good practice at any voltage.) This is best accomplished by testing the device on a known energized source, such as the line side of the breaker or disconnect.

Any sensed voltage may feed back from a source on the load side of the circuit. Faulty insulation in a disconnect can allow current to "leak" through to the load side of a disconnect. If the current leaks through the disconnect and generates a significant voltage on the load side, the main disconnect that feeds the entire system must be turned off and locked out. The faulty disconnect must be repaired before other work can be performed.

Load carrying conductors can be grounded. If the protective ground connection is inadvertently energized, all current will flow through the path of least resistance - the ground conductor. A circuit breaker may trip or a fuse may blow if this occurs, but personnel are protected from the effects of the voltage. Fuses should be removed as an extra measure if there is any remaining question about the positive disconnecting means.

The following requirements must be met, in the order given, before circuits or equipment are re-energized, even temporarily.

- A qualified person must conduct tests and visual inspections, as necessary, to verify that all tools, electrical jumpers, shorts, grounds and other such devices have been removed, so that the circuits and equipment can be safely energized.

- Employees exposed to the hazards associated with re-energizing the circuit or equipment must be warned to stay clear of circuits and equipment.

- Each lock and tag must be removed by the employee who applied it or by someone else under that employee's direct supervision.

- A visual determination that all employees are clear of the circuits and equipment must be made.

Exposed Energized Parts

The electrical lock out procedure described above requires that electrical tests be performed on energized equipment using voltage sensors and testers. OSHA 1910.333 (2) (c) provides some rules for this activity. All work performed on, and employees working near, exposed live parts are included in this rule. Only qualified persons may work on electric circuit parts or equipment that have not been de-energized under an electrical lock out procedure.

Unqualified persons working near exposed energized overhead lines, with voltages less than 50,000 volts, must come no closer than 10 ft. to the lines. No object that an unqualified person carries must come any closer than this distance. This distance limit increases by 4" for every 10,000 volts over 50,000 volts.

Qualified persons working near exposed energized overhead lines may not approach or take any object without an approved insulating handle closer to exposed energized parts than the distances shown in Table 2.

Approach Distances for Qualified Employees - Alternating Current	
Voltage Range (phase to phase)	**Minimum Approach Distance**
300V and less	Avoid contact
Over 30OV, not over 750V	1 ft. 0 in. (30.5 cm)
Over 750V, not over 2kV	1 ft. 6 in. (46 cm)
Over 2kV, not over 37kV	2 ft. 0 in. (61 W cm)
Over 15kV, not over 37kV	3 ft. 0 in. (91 cm)
Over 37kV, not over 87.5kV	3 ft. 6 in. (107 cm)
Over 87.5kV, not over 121 kV	4 ft. 0 in. (122 cm)
Over 121 kV, not over 1 40kV	4 ft. 6 in. (137 cm)

It is acceptable for a qualified person to come close to the above voltages under the following conditions:

- The person is wearing insulated gloves with the proper voltage rating.
- The energized part is insulated.
- The person is insulated from all conductive objects (for example, by an insulated mat with the proper voltage rating).

The above rules and clearance distances apply to vehicular or mechanical equipment, such as a man-lift, which may approach the lines. Since this equipment may become energized down to the ground level, all overhead distance restrictions apply at the ground level as well. Warning signs should be used to keep people away from any vehicle operating near overhead lines.

As stated earlier, treat all exposed circuits as live and dangerous until proven otherwise. OSHA and the NFPA suggest the following work practices as a minimum when working around energized parts.

Alertness (NFPA 70E) - Ill, fatigued or otherwise impaired - employees should not stay on the job. Stop all work if you are distracted by unrelated activity.

Illumination - Do not enter any area of exposed energized parts unless adequate illumination is provided to work safely. Employees may not reach blindly into areas that may contain energized parts.

Conductive Apparel - Keep conductive apparel away from exposed energized parts. Conductive apparel includes jewelry, watch bands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread or metal headgear. Wear suitable insulating gloves if the conductive articles cannot be removed.

Conductive Materials and Equipment - Conductive materials and equipment, such as ducts, pipes, tubes, conductive hose, conductive rope, metal rules, metal scales, steel tapes and chains held by an employee must not be handled in a way that will cause them to come in contact with exposed or energized parts. A screwdriver without an insulated handle and shank must not be used around energized equipment. Carrying conduit, piping or tubing in a vertical position is dangerous. Many employees have been injured while carrying conduit or piping through seemingly safe areas.

Insulated Tools and Equipment (NFPA 70E) - The use of insulated tools is required when working with energized or exposed parts. The voltage present must not exceed the rated voltage of the tool under use.

Protective Shields - An employee should take additional precautions when there is a possibility that they may come in contact with exposed energized parts. Protective shields, protective barriers, or insulating materials must be used to protect each employee from shock burns, or other electrically related injuries while that employee is working near exposed energized parts.

Portable Ladders - Portable ladders must be non-conductive if they are used where the employee or the ladder could contact exposed energized parts. Do not use metal ladders.

Confined or Enclosed Work Spaces - A confined space is any space with a restricted means of entry and regress or a space where natural ventilation through openings does not prevent dangerous gasses or vapors from accumulating. Examples include a manhole or a vault.

When an employee works in a confined or enclosed space that contains exposed energized parts, the employer must provide, and the employee must use, protective shields, protective barriers, or insulating materials as necessary to avoid inadvertent contact with these parts. Housekeeping and Janitorial Duties - Do not perform housekeeping duties near live exposed parts. Do not use solvents around exposed energized equipment. The vapors may conduct across the phases or to ground.

Interlocks - Only a qualified person can defeat an electrical safety interlock. This work must be performed in accordance with the preceding safe work practices. Disconnecting interlocks is only allowed temporarily while an employee is working on the equipment. The interlock system must be returned to its operable condition when this work is completed.

Use of Equipment and Safeguards for Personnel Protection

The requirements in 1910.334 and .335 apply to qualified and unqualified employees. Section 1910.334 defines rules for the use of portable electric equipment, electric power and lighting circuits, test instruments and equipment, and the occasional use of flammable or ignitable materials. Section 1910.33S applies to qualified and unqualified employees with regard to personal protective equipment, general protective equipment and tools, as well as alerting techniques (such as signs and barricades). Both of these sections may already be covered under some existing safety policy at a facility, but should be reviewed by facility management and included in any training session.

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go to first page