Electrical Safety

Electrically powered equipment can pose a significant hazard to workers, particularly when mishandled or not maintained. Many electrical devices have high voltage or high power requirements, carrying even more risk.

Electrical Shock Hazards

The major hazards associated with electricity are electrical shock, fire and arc flash. Electrical shock occurs when the body becomes part of the electric circuit, either when an individual comes in contact with both wires of an electrical circuit, one wire of an energized circuit and the ground, or a metallic part that has become energized by contact with an electrical conductor.

The severity and effects of an electrical shock depend on a number of factors, such as the pathway through the body, the amount of current, the length of time of the exposure, and whether the skin is wet or dry. Water is a great conductor of electricity, allowing current to flow more easily in wet conditions and through wet skin.

The effect of the shock may range from a slight tingle to severe burns to cardiac arrest. The chart below shows the general relationship between the degree of injury and amount of current for a 60-cycle hand-to-foot path of one second's duration of shock. While reading this chart, keep in mind that most electrical circuits can provide, under normal conditions, up to 20,000 milliamperes of current flow.

Current	**Reaction**
1 Milliampere	Perception level
5 Milliamperes	Slight shock felt; not painful but disturbing
6-30 Milliamperes	Painful shock; “let-go” range
50-150 Milliamperes	Extreme pain, respiratory arrest, severe muscular contraction
1000-4,300 Milliamperes	Ventricular fibrillation
10,000+ Milliamperes	Cardiac arrest, severe burns and probable death

In addition to the electrical shock hazards, sparks from electrical equipment can serve as an ignition source for flammable or explosive vapors.

Arc Flash

A hazardous arc flash can occur in any electrical device, regardless of voltage, in which the energy is high enough to sustain an arc. Potential places where this can happen include:

- Panel boards and switchboards
- Motor control centers
- Metal clad switch gear
- Transformers
- Motor starters and drive cabinets
- Fused disconnects
- Any place that can have equipment failure

In an arc flash incident, an enormous amount of concentrated radiant energy explodes outward from electrical equipment. The explosion creates pressure waves that can damage a person’s hearing, a high-intensity flash that can damage their eyesight and a superheated ball of gas that can severely burn a worker’s body and melt metal.

Electrical Safety-Related Work Practices

Only qualified workers who have been trained in the avoidance of electrical hazards are permitted to work on or near exposed energized parts. Safety related work practices are employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contact when work is performed near or on equipment or circuits which are or may be energized. The specific safety-related work practices must be consistent with the nature and extent of the associated electrical hazards.

Qualified Personnel vs. Unqualified Personnel

For the purposes of electrical safety related work practices, there are two types of employees in the work place that may come in contact with electrical equipment on a jobsite: qualified and unqualified. A Qualified employee is defined as a worker who

- Has been trained to avoid electrical hazards when working on or near exposed energized parts.
- Is familiar with the safety related work practices as required by OSHA standards.
- Is able to distinguish exposed live parts of electrical equipment.
- Is knowledgeable of the skills and techniques used to determine the nominal voltages of exposed parts and components.

An Unqualified employee is defined as a worker who has little or no training regarding electrical hazards. Even though unqualified persons should not be exposed to energized parts, they should be provided with information and training necessary to perform their job in a safe manner and understand the following:

- Be familiar with any electrical hazards in the workplace.
- Understand procedures to follow and to protect themselves when they work around electricity.
- Understand which tasks that can only be performed by qualified workers (e.g. maintenance and repairs).
- Know when and how to report electrical problems.
- Know what to do in the event of emergency involving electricity.
- Know how to inspect electrical tools and equipment before use to make sure insulation and wiring are in good condition.

Live parts to which an employee may be exposed must be deenergized before the employee works on or near them unless deenergizing the parts introduces additional or increased hazards or is unfeasible due to equipment design or operational limitations. 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. Live parts that operate at less than 50 volts to ground need not be deenergized if there are no increased exposures to electrical burns or to explosions due to electric arcs

Working On or Near Energized Circuits

Live parts to which an employee may be exposed must be deenergized before the employee works on or near them unless deenergizing the parts introduces additional or increased hazards or is unfeasible due to equipment design or operational limitations. 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. Live parts that operate at less than 50 volts to ground need not be deenergized if there are no increased exposures to electrical burns or to explosions due to electric arcs.

Deenergized Parts

When employees work on deenergized parts or near enough to them to expose the employees to any electrical hazard they present, the following safety related work practices must be followed:

- Treat as energized any conductors and parts of electrical equipment that have been deenergized, but have not been properly locked out or tagged.
- While any employee is exposed to contact with parts of fixed electric equipment or circuits which have been deenergized, the circuits energizing the parts shall be locked out or tagged or both. In addition, electrical hazards must be controlled; a qualified person must test the circuit to verify deenergization from all voltage sources.
- Safe procedures for deenergizing circuits and equipment must be determined before circuits or equipment are deenergized. All electric energy sources must be disconnected. Control circuit devices, such as push buttons, electric switches, and interlocks must not be used as the sole means of deenergizing circuits or equipment. Interlocks must not be used as a substitute for lockout and tagging procedures.

Energized Parts

Employees are considered working on or near exposed energized parts when working on exposed live parts either by direct contact or contact be means of tools or materials or when working near enough to energized parts to be exposed to any hazard they present. Only qualified persons are permitted to work on electric circuit parts or equipment that have not been deenergized (lockout/tag out). Qualified persons are capable of working safely on energized circuits and are familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools.

Approach distances for qualified person to alternating current

Voltage Range (Phase to Phase)	Minimum Approach Distance
300V and less	Avoid contact
Over 300V, not over 750V	1 foot
Over 750V, not over 2kV	1 ft. 6 in.
Over 2kV, not over 15kV	2 feet
Over 15kV, not over 37kV	3 feet
Over 37kV, not over 87.5kV	3 ft. 6 in.
Over 87.5kV, not over 121kV	4 feet

Overhead Lines

When work is to be performed near overhead lines, the lines must be deenergized and grounded, or other protective measures taken before the work is started. Such protective measures, such as guarding, isolating or insulating, shall prevent the qualified person performing the work from contacting the lines with any part of their body or indirectly through conductive material, tools, or equipment.

Unqualified persons working in an elevated location near overhead lines are not allowed to come closer or to handle the conductive objects which may contact or come closer to any unguarded, energized overhead line than the following distances:

Voltage to Ground	**Distance**
50kV or below	10 feet
Over 50kV	10 feet (plus 4 in. for each 10kV over 50kV)

Unqualified persons working on the ground in the vicinity of overhead lines are not allowed to bring a conductive object or any insulated object which does not have the proper insulating rating closer to unguarded, energized overhead lines that the distance specified above.

Qualified persons working in the vicinity of overhead lines, whether in an elevated position or on the ground, are not allowed to approach or take any conductive object without an approved insulating handle closer to exposed energized parts that in the table above, Approach Distance for Qualified Persons, unless a.) The person is insulated from the energized part by using the proper gloves, with sleeves if necessary, rated for the voltage involved, or b.) The energized part is insulated from all the person, or c.) The person is insulated from all conductive objects at the potential different from the energized part.

Electrical Safety Protective Methods

Use of Protective Equipment

Employees working in areas where there are potential electrical hazards must be provided with and use electrical protective equipment appropriate for the parts of the body to be protected and the work performed. Protective equipment must be maintained in a safe, reliable condition and be periodically inspected or tested as required by 29 CFR 1910.137, Electrical Protective Devices. Where the insulating capability of protective equipment is subject to damage during use, the insulating material must be protected by covering with leather or other appropriate materials. Nonconductive head protection must be worn wherever there is danger of head injury from electrical shock or burns due to contact with exposed energized parts. Protective equipment for the eyes must be worn where there is danger of eye and/or face injury from electric arcs and flashes or flying objects resulting from electrical.

General Protective Equipment and Tools

Insulated tools and handling equipment must be used by employees working near exposed energized conductors or circuit parts if the tools and/or equipment may make contact with the conductors or parts. The insulating material of tools and equipment must be protected where it is subject to damage. Fuse handling equipment, insulated for the circuit voltage, must be used to remove or install fuses when the fuse terminals are energized. All ropes and hand lines used near exposed energized parts must be nonconductive. Protective shields, protective barriers, or insulating material must be used to protect employees from shock, burns, or other electrical related injuries while employees are working near exposed energized parts which might be contacted or where dangerous electric heating or arcing might occur. When normal enclosed live parts are exposed for maintenance or repair, the parts must be guarded to protect unqualified persons from contact with the live parts.

Alerting Techniques

Alerting techniques must be used to warn and protect employees from electrical shock hazards, burns, or failure of electric equipment parts. Safety signs, safety symbols, or accident prevention tags must be used where necessary to warn employees about electrical hazards which may endanger them. Barricades should be used in conjunction with safety signs where necessary to prevent or limit employee access to work areas exposing employees to un-insulated energized conductors or circuit parts. Conductive barricades must not be used where they might cause an electrical contact hazard. An attendant should be stationed to warn and protect employees where signs and barricades do not provide sufficient warning and protection.

Arc Flash Personal Protective Equipment

This Personal Protective Equipment provides protection after an arc flash incident has occurred and should be viewed as the last line of protection. Selection of the appropriate PPE for the task to be performed is based upon hazard categories found in ***NFPA 70E – 2004,*** which should appear on labeled electrical panels and equipment.

The following table is provided as a quick reference. Workers must ensure that they have reviewed all appropriate safety requirements before work begins.

Personal Protective Equipment Requirements for Arc Flash Protection

Category	Energy Level	PPE Requirements
0	≤2 cal/cm²	Non-melting or untreated natural fiber
1	4 cal/cm²	Fire Resistant (FR) shirt and pants
2	8 cal/cm²	Fire Resistant shirt and pants, cotton underwear
3	25 cal/cm²	Two layers Fire Resistant clothing, cotton underwear
4	40 cal/cm²	Fire Resistant shirt and pants, multilayer flash suit, cotton underwear.

Face protection includes face shield and/or safety glasses. Hand protection includes leather over rubber for arc flash protection. Leather work boots above 4 cal/cm².

Working Outdoors and Extension Cords

Working Outdoors

Electrical hazards on construction or renovation sites or work performed outdoors must be controlled through the use of Ground Fault Circuit Interrupters (GFCIs).

- All 120-volt, single-phase, 15 or 20 ampere receptacles that are not part of permanent wiring must be protected by GFCIs. (Receptacles on smaller generators are exempt under certain situations. Consult with your supervisor or EHS with any questions.).
- Light bulbs used for general illumination must be protected from breakage.
- Temporary lights must not be suspended by their cords, unless so designed.
- Portable lights or tools used in wet or conductive locations must be protected by GFCIs or operate at 12 volts or less.

Extension Cords

- Workers must visually inspect extension cords and cord and plug connected equipment daily before use. Damaged extension cords must be removed from service and destroyed. Damaged or defective equipment must be removed from service and destroyed or repaired by a qualified electrician.
- Extension cords must be three-wire type. Extension cords or flexible cords used for lighting must be designed for hard or extra hard usage (e.g., types S, ST, SO)
- Flexible cords must be connected to devices and fittings so that strain relief is provided and prevents pull from being directly transmitted to joints or terminal screws.