

High Voltage Electric Safety

Safety Precautions for Working on or near High Voltage Power Lines

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Introduction

Many employees are exposed to electricity daily in their work environments. It can be very safe as long as employees understand the basic principles of electricity and the safety precautions that must be taken when working around energized lines and equipment. According to NIOSH an average of 411 deaths occurs each year in the workplace due to contact with electrical energy. Electrocutions are the fifth leading cause of death, accounting for 7% of all workplace fatalities.

The number of people who believe that normal household current is not lethal or that overhead power lines are insulated and do not pose a hazard is alarming. This presentation discusses the basic principles of high voltage and includes high voltage work rules for both electric utility employees and others who may work near energized high voltage lines to include clothing and PPE requirements and electrical protective equipment and grounding requirements.

Basic facts about electricity

Electricity is always looking to travel to the ground and it is constantly seeking the shortest path to ground. It will take the path of least resistance and it may take multiple least resistant paths to ground. Electric shock occurs when the path of least resistance is through the human body. The human body is composed of approximately 80% water and water is a great conductor of electricity.

Electricity travels at the speed of light (186,000 miles per second) and is three to four times hotter than a burning building. (6,000 to 8,000 degrees). Electric arc temperatures can melt steel. When a short circuit occurs or current flow is interrupted, an arc is often created. If the current involved is great enough, these arcs can cause injury or can start a fire. Fires can also be caused by overheating equipment or by conductors carrying too much current. Extremely high-energy arcs can damage equipment causing fragmented metal to fly in all directions. In explosive or combustible atmospheres, even low-energy arcs can cause violent explosions

Overhead power lines have no insulation except being isolated in air. The air serves as an insulator because air has less free electrons than the wire conductor. For this reason overhead bare metal conductor is installed on insulators made of porcelain, glass or synthetic polymer materials.

High Voltage/Low Voltage

Voltages over 600 volts are considered high voltage. High voltage electric shock is very powerful and normally pushes (or blows) the person away from the source due to the high voltage pressure. It can rupture human skin, greatly reducing the resistance of the human body, allowing more current to flow, causing greater damage to internal organs.

Electrical injuries

Electrical injuries consist of four main types:

- Electrocution (fatal)
- Electric Shock
- Electrical Burns
- Falls caused as a result of contact with electrical energy.

Electrical injuries may occur in various ways:

- Direct contact with electrical energy
- Injuries that occur when electricity arcs to a victim.
- Flash burns generated by an electrical arc.
- Flame burns from the ignition of clothing or other combustible material.

The effect that electricity has on an individual depends on four factors:

- The voltage of the circuit
- Internal body resistance
- The amount of current that flows through the body.
- The path electricity takes through the body

Body resistance

The average body resistance with dry skin is about 100,000 ohms. As the body starts the sweating process the resistance of the body decreases, as skin becomes moist through sweat or contact with water. Mild sweating can reduce the skin resistance to 10,000 ohms and excessive sweating can reduce the skin resistance to 1,000 ohms. This resistance of the body becomes very important in hot or wet work environments.

Ohms Law states “the current equals the voltage divided by the resistance”. When the body resistance decreases the current flow through the body increases. An application of ohms law with 15,000 volts and a normal body resistance would result in 150 milliamps of current flow through the body. An application of 15,000 volts and excessive sweating would result in 15,000 milliamps of current flow through the body. An application of 120 volts and excessive sweating would result in 120 milliamps of current flow through the body. Many people are killed with low voltage because of the amount of current flow through the body with the body resistance conditions.

Physiological effects of current at different intensities

1 amp	No sensation felt
2 amps	Numbness of hand
5 amps	Tremor of hand and spasm of forearm
10 amps	Voluntary "let-go" current
20 amps	Painful muscular contractions
50-100 amps	Possible ventricular fibrillation
100-200 amps	Certain ventricular fibrillation
4 amps	Heart stops

Circuit path through the body

The amount of current flow and the entry and exit sites on the body will help determine the consequences of the electrical contact. Contact burns are a common result of current passing through the body. Burns are found where the current entered and left the body. The seriousness of the burns may not be immediately evident because their appearance may not indicate the depth they have penetrated.

Burns suffered in electrical accidents can be of three basic types: electrical burns, arc burns, and thermal contact burns. In electrical burns, tissue damage (whether skin deep or deeper) is caused by the heat from the current flow. The body is unable to dissipate this heat. Typically, electrical burns are slow to heal. Arc burns, caused by electric arcs, are heat burns similar to burns from high-temperature sources. The temperatures generated by electric arcs can melt material nearby, vaporize metal in close vicinity, and burn flesh and ignite clothing at distances up to 10 feet (3 meters). Lastly, thermal contact burns are those normally experienced from the skin's contact with hot surfaces of overheated electric conductors.

Damage to the internal tissues may not be immediately apparent after contact with the current. Internal tissue swelling and irritation are also possible. Prompt medical attention can help minimize these effects and avoid possible death.

Accident victims can incur the following from an electrical shock:

- Low voltage contact wounds
- High voltage contact wounds from entry and exit of electrical current
- Burns
- Respiratory difficulties (the tongue may swell and obstruct the airway)
- Infectious complications
- Injury to bone through falls, fat necrosis, and muscle contraction
- Injury to the heart such as ventricular fibrillation or cardiac standstill
- Internal and organ injuries
- Neurological injury
- Injury to the eyes

Shock Rescue Procedures

- Call for help
- De-energize the circuit
- Use pole top or bucket rescue emergency procedures. (Mayday procedures)
- Separate the person from the energy source
 - Make sure you and the victim are in a safe place- not in contact with any electrical source, away from downed or broken lines.
 - Never grab the person or pull the person off the current with your hands; you might become part of the circuit and become injured as well.
- Administer first aid
- Make sure the victim receives professional medical attention.

Electric Arcs and Flame Resistant Clothing

Each day electric utility workers are exposed to the hazards of electric arc. Workers include:

- Line Technicians
- Meter Technicians
- Substation and switching technicians
- Field Engineers
- Etc.

These workers have the potential to be exposed to electric arc blasts during their workday. Workers must be trained to understand the hazards of flames or electric arcs when working in high voltage locations. When an electric arc occurs it can cause any or all of the following conditions:

- Electrocution or severe burns from electricity
- Severe burns from clothing igniting
- Severe burns from clothing blasting apart
- Severe burns from synthetic undergarments.

Due to the nature of burns that have been incurred due to electric arc blasts, OSHA requires the employer to ensure that each employee who is exposed to the hazards of flames or electric arc does not wear clothing that, when exposed to flames or electric arcs could increase the extent of injury that would be sustained by the employee. Many employers require their employees to wear flame resistant clothing because the clothing is designed to help extinguish the clothing fire. Everyday street clothes can ignite and continue to burn. Cotton and synthetic materials like nylon and polyester support combustion. Synthetics melt and drip into the skin. Many types of flame resistant clothing are presently in the marketplace to meet the demands of the electric utility industry.

Minimum Approach Distances

The minimum approach distance is the closest an employee is permitted to approach an energized or grounded object. Employees must adhere to the minimum approach distance requirement which varies with the operating voltages on the power lines. Employers must ensure that no employee approaches or takes any conductive object closer to exposed energized parts than listed in the OSHA 1910.269 Approach Distance table.

The minimum approach distance is intended to:

- Provide a sufficient gap between the worker and the energized line or equipment so that current cannot arc to the employee under the most adverse transient voltages that could be imposed for the line.
- Plus an extra amount for the inadvertent movement on the part of the employee.

Electrical Protective Equipment

Electrical protective equipment includes high voltage rubber gloves and rubber sleeves, line hose, insulating covers and blankets, etc. Each employee should be trained regularly on equipment to include details on the design of the equipment, electrical protection requirements, and electrical testing procedures and in service care and use.

Protective Grounds

Proper grounding for electrical systems is very important for the safety of utility workers and the general public. “If it is not grounded---It is not dead” is a very valuable rule for the utility worker. Precautions must be taken to be sure the lines and equipment is de-energized before the work starts and remains de-energized until the work is complete.

Using the correct grounds for the application is very important. Grounds must be appropriately sized for the anticipated fault current and duration. Overhead lines and underground lines must be treated the same for grounding purposes. The size of the grounding cables and the grounding clamps must be selected to handle the anticipated fault current. Cables and clamps should be sized equally.

An equipotential zone shall be maintained when applying protective grounds. Temporary grounds shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to hazardous differences in electrical potential.

The requirements of a ground include:

- A low resistant path to earth
- Clean connections
- Tight connections
- Connections made to proper points
- Adequate current-carrying capacity of grounding equipment

Controlling Electric Hazards for Others (Non- Electric Utility)

Understanding the nature of electricity will help in preventing electric contacts. Conduct a job safety analysis of all tasks that might expose workers to the hazards associated with electrical lines and equipment. Identify potential electrical hazards and appropriate safety procedures that must be followed during the planning phase of construction or maintenance projects.

When operating equipment near electric power lines and equipment a safe zone/boundary must be marked to ensure the driver will not cross into the unsafe zone. The OSHA standards require a 10-foot clearance from power lines of 50 KV or less and even more for higher voltages. **This is a minimum standard and should never be violated.** Companies should train all drivers in the hazards of step and touch potentials. When marking the safety zone/boundary a good rule of thumb is to measure on the ground and mark a line with chalk or tape and require the driver not to cross the line.

Always call the local utility or cable locator service to mark underground lines. Electric lines in the ground can be very hazardous and could have the potential of causing dangerous step and touch potentials if equipment hits the lines. Always treat all overhead and underground lines as energized.

Ensure compliance with existing OSHA regulations. OSHA addresses electrical safety in Subpart S 29 CFR 1910.302 through 1910.399 and 1910.269. Additionally, the National Electrical Code and the National Electric Safety Code comprehensively address electrical safety regulations.

Develop and implement procedures to control hazardous electrical energy, which include lockout/tagout procedures and ensure that workers follow these procedures.

Provide additional specialized electrical safety training to those workers working around energized lines or equipment. Training should include, but not be limited to, training in basic electrical theory, proper safe work procedures, hazard awareness and identification, proper use of PPE, proper lockout/tagout procedures, first aid including CPR, and proper rescue procedures.

Conduct scheduled and unscheduled safety inspections at worksites.

Summary

Electrical hazards are present in practically every workplace. Many workers are unaware of the potentials electrical hazards, which makes them more vulnerable to the danger of electrocution. A strong commitment to safety by both management and workers is essential in the prevention of severe occupational injuries and death due to contact with electrical energy.

References

NIOSH Worker Deaths by Electrocution <http://www.cdc.gov/niosh/elecprev.html>

National Electrical Safety Code C2-2002

Cableman's and Lineman's Handbook, 9th edition