HAZARDOUS ENERGY SOURCES & MECHANICAL HAZARDS

1.0 INTRODUCTION

Electrical hazards can exist at waste sites, emergency responses, and industrial plants because of downed power lines, improper use of electrical equipment, unguarded electrical parts, electrical fires, etc. These field operations may also present dangers associated with other hazardous energy sources such as hydraulic, chemical, pneumatic, or stored energy. In addition, servicing and maintenance of field equipment may expose EPA personnel to hazardous energy sources. Mechanical hazards are another type of hazard which may be encountered by EPA personnel during the course of field activities. Examples of these types of hazards include moving parts on compressors, drill rigs, grinding wheels, moving belts, meshing gears, cutting teeth, and any parts that impact or shear.

Learning Objectives

At the end of this module, you will be able to:

- Provide information on OSHA standards related to power sources and electrical hazards
- Describe the types of hazardous energy sources
- Explain the general principles and effects of electricity
- Provide a system for lockout/tagout of machines and equipment to prevent injuries from release of stored energy during servicing and maintenance activities
- Describe personal protective equipment, safety equipment and safe work practices appropriate for work on or near systems which present electrical hazards
- Describe potential mechanical hazards and the appropriate control methods.

2.0 OVERVIEW OF APPLICABLE OSHA STANDARDS

The U.S. Occupational Safety and Health Administration (OSHA) has developed standards which address electrical energy in three distinct areas: electrical design, lockout/tagout, and electrical safety-related work practices. The lockout/tagout standard also addresses other types of hazardous energy (e.g., chemical, pneumatic, hydraulic, stored, thermal, etc.) in addition to electrical energy. The OSHA electrical standards are based on the National Fire Protection Association's (NFPA) standard NFPA 70E, Electrical Safety Requirements for Employee Workplaces. Part 1 of NFPA 70 is based on the 1978 edition of the National Electric Code (NEC).

In addition to OSHA's General Industry Standards, regulations regarding electrical safety on construction sites can be found in 29 CFR 1926.400-449.

2.1 Electrical Design

OSHA's electrical design standards, 1910.301-308 address the design of electrical installations and utilization of equipment. These standards focus on the safety features built into the system rather than on safe work practices. The following elements are addressed within the design standards:

- General requirements:
  - Approval
  - Examination, installation, and use of equipment
  - Splices
  - Arcing parts
  - Marking and identification
  - Working clearances
  - Guarding of live parts
  - Illumination.

- Wiring design, protection, and grounding

- Wiring methods, components, and equipment

- Specific purpose equipment and installations

- Hazardous (classified) locations

- Special systems.

2.2 Lockout/Tagout

The OSHA Control of Hazardous Energy (Lockout/Tagout) standard, 29 CFR 1910.147 addresses procedures for deenergizing machines and equipment prior to servicing and maintenance activities in order to protect employees from unexpected energization or release of stored energy. The standard not only applies to electrical energy, but also includes hydraulic, pneumatic, chemical, thermal, mechanical, stored, and other types of hazardous energy that may be encountered during servicing or maintenance activities. The standard addresses the following general topics:

- Energy control program
- Equipment-specific energy control procedures
- Protective materials and hardware
- Periodic program inspections
- Training and communication requirements
- Energy isolation steps
- Procedures for release from lockout or tagout
- Testing or positioning machines
- Contractors

- Group lockout or tagout
- Shift or personnel changes.

2.3 Electrical Safety-Related Work Practices

The OSHA Electrical Safety-Related Work Practices standard, 29 CFR 1910.331-335, is a regulation which provides work practices and other administrative controls to supplement design standards for electrical systems. The standard was developed to provide additional protection for personnel who face a risk of injury from electrical shock which is not adequately controlled through the design and guarding of the system. The standard includes the following elements:

- Identification of employees and types of work which are covered by the standard
- Training requirements
- Selection and use of work practices
- Safe use of electrical equipment
- Personal protective equipment and general protective equipment and tools.

3.0 ELECTRICITY: GENERAL PRINCIPLES AND EFFECTS

Electricity is a class of physical occurrences resulting from the interactions of charged particles. Lightning and static shocks are both examples of electrical interactions, although they differ in the magnitude of interaction.

3.1 General Definitions

Some basic definitions are helpful in understanding how electricity works:

- <u>Arc</u>: A flow of electrons across a non-conductor, such as air. Every insulator has its limit,and if the voltage is high enough to exceed the limit, electrons will arc across the insulator

- <u>Conductor</u>: A material through which electricity (electrons) can travel (e.g., gold, silver, copper, iron)

- <u>Insulator</u>: A material through which electricity cannot freely flow (e.g., glass, plastic, rubber, wood)

- <u>Resistance</u>: Opposition to the movement of electrons. Conductors have a low resistance and insulators have a high resistance

- <u>Voltage</u>: An electrical force that causes electrons to flow through a conductor

- <u>Electrical current</u>: A flow of electrons from a region of high charge density (high potential) to a region of low charge density (low potential)

- Electrical circuit: Any arrangement of electrical components and interconnecting wires that permit an electrical current to flow

- Electrical ground: A connection between an electrical circuit or equipment and the earth, which is defined as having zero potential

- Short circuit: An unintentional "short cut" that electricity takes from a point of high potential to a point of lower potential via a conductor.

3.2 Ohm's Law

The basic equation relating current, voltage, and resistance is called Ohm's Law. Ohm's Law states that:

Voltage = Current x Resistance

Voltage is measured in volts, current in amperes (amps) and resistance in ohms. By definition, a potential difference of one volt will force a current of one amp through a resistance of one ohm. Power is the work performed by an electric current and is measured in watts. A turbine is an example of a power generating piece of equipment.

3.3 Hazards of Electricity

- Shock
- Burns
- Arcs
- Explosions
- Fires.

Electrical shock may result in contraction of the chest muscles, temporary paralysis of the nerve center, ventricular fibrillation, suspension of heart beat or damage or destruction of tissues, nerves or muscles. Other injuries may result from slips or falls that are caused by startling due to slight electric shocks.

3.4 Effects of Electricity on Humans

The severity of electrical shock is determined by three primary factors:

- The amount of current
- The path the current takes through the body
- The time during which the victim is part of the electrical circuit.

The frequency of the current also impacts the effect of the electrical current. As the resistance offered by wet or damp skin is less than that of dry skin, wet skin may increase the severity of electrical shock. In addition, physical factors such as age, size, and physical condition of the victim also play a role in the severity of an electrical shock. Studies and experiments have been performed that indicate that an alternative current of 100 mA at a frequency of 60 cycles per second - Hertz (Hz) may be fatal in humans if it passes through vital organs. Table 1 illustrates the effects of electrical current on humans.

The levels of current for perception, let-go and ventricular fibrillation vary from person to person. The information presented is based on normal, healthy individuals.

Table 1. Effects of Electric Current on Humans

Effect	Current in Milliamperes (mA)					
	Direct Current		60 Hz		10,000 Hz	
	Men	Women	Men	Women	Men	Women
Slight sensation on hand	1	.06	0.4	0.3	7	5
Perception threshold - tingling sensation	5.2	3.5	1.1	0.7	12	8
Shock - not painful, muscular control maintained	9	6	1.8	1.2	17	11
Shock - painful, muscular control maintained	62	41	9	6	55	37
Shock - painful, let go threshold	76	51	16	10.5	75	50
Shock - painful and severe, muscular contractions, breathing difficult	90	60	23	15	94	63
Shock - possible ventricular fibrillation effect from 3-second shocks	500	500	100	100		

(Adapted from the National Safety Council and studies performed by Charles Dalziel)

According to Ohm's Law, the amount of current flow depends upon voltage and resistance. Electrical current will pass through wet or damp skin more readily, so the resistance offered by wet or damp skin is less than that of dry skin. Table 2 illustrates human resistance to electrical current.

Table 2. Human Resistance to Electrical Current

Body Area	Resistance (ohms)

Dry skin	100,000 to 600,000
Wet skin	1,000
Internal body (hand to foot)	400 to 600
Ear to ear	approximately 100

(Adapted from the National Safety Council)

3.5 Causes of Electrical-Related Accidents

Unsafe work practices have been found to be a factor in over 75 percent of the occupational electrocutions reported to OSHA. These unsafe practices can be divided into six general categories:

- Use of conductive equipment or materials too close to exposed energized lines
- Failure to use personal protective equipment
- Assuming an unsafe position
- Failure to deenergize equipment prior to servicing or maintenance
- Use of defective equipment
- Blind reaching, drilling, trenching, or excavating.

While these types of unsafe practices were found to be common causes of electrical-related incidents, they may also be applied to incidents involving other types of hazardous energy (e.g., chemical release due to contacting buried pipes during excavations, thermal burns from contacting steam pipes, etc.).

4.0 LOCKOUT/TAGOUT

Live parts to which an employee may be exposed must be deenergized before the equipment or system is serviced or maintained or work is conducted nearby, unless the employer can demonstrate that deenergization introduces additional or increased hazards or is impossible due to equipment design or operational limitations. In those limited cases, appropriate safe work practices and procedures must be in place as described in section 5. Conductors and parts of electric equipment that have been deenergized, but have not been locked or tagged out should be treated as energized parts.

Where EPA personnel perform servicing or maintenance activities, the requirements of 29 CFR 1910.147 must be followed, including development of a lockout/tagout program and associated equipment-specific lockout/tagout procedures, provision of appropriate training and performance of periodic program inspections. Where lockout/tagout is performed by contractors and/or site representatives to facilitate EPA activities, EPA personnel should comply with the requirements of the site's lockout/tagout program.

4.1 Deenergization

Prior to servicing or maintaining machines or equipment, the following lockout/tagout sequence of procedures must be implemented by an authorized employee along with any applicable equipment-specific procedures:

- Locate all energy sources
- Notify all affected employees that a lockout/tagout is being performed and the reason for it
- Shut down the machine or equipment using the normal stopping procedure (e.g, depress stop button, open toggle switch)
- Isolate the machine or equipment from all energy sources (e.g., electrical isolation, blocking, purging vessels, blanking/blinding, etc.)
- Apply the lock and tag to each energy isolating device
- Dissipate or restrain all stored or residual energy
- Verify that the machine has been isolated.

4.2 Restoring Machines/Equipment to Service

After servicing or maintenance has been completed and the equipment is ready for normal operations, the following release sequence must be performed:

- Check the area around the machine or equipment to ensure that tools and other materials are removed and that all components and guards have been reinstalled
- Ensure that all personnel are in a safe position
- Notify affected personnel that the lockout/tagout devices will be removed.

Where it is necessary to temporarily remove lockout/tagout devices and energize the equipment for testing or positioning purposes, the above procedure must be followed for returning equipment to service. The machines or equipment can then be energized to perform testing or positioning. In order to continue with servicing or maintenance activities, the equipment must again be deenergized following the sequence of steps outlined in section 4.1.

4.3 Special Considerations

Special procedures are required to ensure the continuity of lockout/tagout during group lockout/tagout activities and when it is necessary to extend lockout/tagout operations beyond a shift or when personnel changes are necessary. In most cases, locks and tags will be removed by the authorized person who applied them. However, procedures should be in place for removal of locks by supervision when the employee is absent from the workplace. The procedure must ensure that the employee who applied the lock is informed that their lock has been removed before they return to work.

Where contractors are used to conduct servicing or maintenance activities, the contractor and employer must inform each other of their respective lockout/tagout programs. The employer must ensure that their personnel comply with the restrictions and prohibitions of the contractor's lockout/tagout program.

5.0 ELECTRICAL SAFETY-RELATED WORK PRACTICES

Injuries can result from accessing or working in areas where there are "live" electrical wires or transformers. If exposed live parts are not deenergized (e.g., for reasons of increased or additional hazards or infeasibility), other safety-related work practices must be used to protect personnel who may be exposed to electrical hazards. Such work practices must protect personnel against direct contact with energized parts or indirect exposure through conductive objects or arcing. Only qualified persons may work on electric parts or installations that have not been deenergized and locked/tagged out.

Where EPA personnel work on or near electrical systems or installations, appropriate safety-related work practices and training programs must be provided. In addition, EPA field personnel should also adhere to any site-specific electrical safe work practices.

5.1 General Safety-Related Work Practices

Safety-related work practices must be employed to prevent electric shocks or other injuries resulting from direct or indirect exposure to electrical energy. The safety-related work practices must be consistent with the nature and extent of the associated hazards. Some general safety-related work practices include:

- Deenergizing and locking out equipment that is being serviced or maintained
- Learning rescue procedures and CPR for helping victims of apparent electrocution
- Not wearing conductive jewelry, accessories, or articles of clothing
- Prohibiting conductive materials and equipment around exposed, energized parts (e.g., metal ladders or tape measures, uninsulated tools)
- Carrying long conductive materials such as pipes or ducts horizontally or covering them with insulating material when used around energized overhead lines or parts
- Avoiding the use of electrical equipment with wet or damp hands or in wet or damp locations
- Providing appropriate levels of illumination when performing work on or near exposed energized parts or systems
- Maintaining a high level of housekeeping in electrical rooms and control areas to ensure unobstructed access and to prevent fires
- Using only one hand when working on a circuit or control device
- Receiving authorization prior to drilling, trenching, or excavating in areas that may contain electrical installations.

5.2 Overhead Lines

When working on or near overhead lines, the lines must be deenergized and grounded, or other protective measures such as guarding, isolating, or insulation must be provided. If protective measures are used, they must prevent personnel from contacting the lines directly with any part of their bodies or indirectly through conductive equipment or materials. Vehicular and mechanical equipment to be elevated near energized overhead lines must be located at proper clearance distances or be appropriately insulated. Employees must not stand near the point of grounding for vehicles/mechanical equipment that are intentionally grounded if there is a possibility of overhead line contact.

5.3 Portable Electric Equipment

Portable electrical equipment must be used in a safe manner and only for its designated application. The abuse or misuse of portable electrical equipment can damage the equipment, resulting in potential electrical hazards. The following general safe work practices should be adhered to when using or handling portable electric equipment:

- Shut off equipment before unplugging it from the receptacle
- Remove plugs from the receptacle using the insulated molded plug rather than jerking the cord
- Do not use the flexible cord for lifting or carrying the equipment
- Do not fasten extension cords with staples or locate cords in areas where they may be pinched or run over
- Do not disable the equipment grounding feature by clipping the grounding plug or using non-approved adapters
- Use properly rated extension cords to avoid overloading
- Do not use extension cords as a substitute for fixed wiring
- Use only approved electrical equipment in hazardous locations (e.g., flammable atmospheres) or in wet or damp locations
- Include portable electric equipment in an inspection and preventive maintenance program and remove damaged or defective equipment from service until repairs have been made.

5.4 Static Electricity

Static electricity is "electricity at rest" and consists of opposite electrical charges that are usually kept apart by insulators. Static electricity is generated by the contact and separation of dissimilar material. Due to the molecular structure of matter itself, any type of movement is capable of producing static electricity. It can occur under the following circumstances:

- During mixing and agitation of materials
- While a liquid flows through a pipe or from an orifice into a tank
- During splash filling
- By the movement of air through a blower or hose (ventilation).

Static electricity can be prevented from causing a spark during flammable liquid transfers by:

- Bonding - the permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed
- Grounding - the conducting connection between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

5.5 Personal Protective and Safety Equipment

The following should be observed regarding the use of personal protective and safety equipment:

- 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.
- Protective equipment shall be maintained in a safe, reliable condition and shall be periodically inspected or tested, as required by 29 CFR §1910.137.
- Insulating mats should be used at work benches or in areas where work is performed on energized equipment and all insulating blankets, mats, tools, etc., must be approved for the particular electrical hazard present and properly stored, tested, and inspected according to the American National Standard Institute (ANSI) and the American Society for Testing and Materials (ASTM) standards.
- Personal bonding and grounding equipment should be used when "sticking" tanks to determine chemical contents/quantity.
- If the insulating capability of protective equipment may be subject to damage during use, the insulating material shall be protected.
- Employees shall wear non-conductive 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.
- Shoes with nonconductive soles must be worn in areas where electrical hazards are present.
- All protective gear and equipment must be approved for the particular hazard present and conform to the appropriate ANSI standard.

The following should be observed regarding the use of general protective equipment and tools:

- When working near exposed energized conductors or circuit parts, each employee shall use insulated tools or handling equipment if the tools or handling equipment might make contact with such conductors or parts.
- Fuse handling equipment, insulated for the circuit voltage, shall be used to remove or install fuses when the fuse terminals are energized.
- Ropes and handlines used near exposed energized parts shall be non-conductive.
- Protective shields, protective barriers, or insulating materials shall be used to protect each employee from shock, burns, or other electrically-related injuries while that

employee is working near exposed energized parts which might be accidentally contacted or where dangerous electric heating or arcing might occur.

The following alerting techniques shall be used to protect employees from hazards which could cause injury due to electric shock, burns, or failure of electric equipment parts:

- Safety signs and tags
- Barricades
- Attendants.

6.0 MECHANICAL HAZARDS

The types of mechanical hazards that may be encountered by EPA personnel during field activities include contact with moving parts, grinding wheels, meshing gears, cutting teeth, and impacting and shearing parts. This can cause serious injury to workers, such as crushing, cutting, impacting, or severing body parts. The types of mechanical motions and actions which present potential hazards to workers are described in the section below.

6.1 Types of Hazardous Mechanical Motions and Actions

Different types of hazardous mechanical motions and actions are present in varying combinations in nearly all machines. The basic types of hazardous mechanical motions include:

- Rotating
- Reciprocating
- Transversing.

The types of hazardous mechanical actions include:

- Cutting
- Punching
- Shearing.

Recognizing these hazards is the first step toward protecting workers from the potential dangers.

6.2 Safeguarding of Mechanical Hazards

To protect workers from the hazards of dangerous moving parts, safeguarding is required in three general areas:

- Point of operation
- Power transmission apparatus
- Other moving parts.

The point of operation refers to the area where work is performed on the material, such as with cutting, shaping, boring, or forming of stock. Additionally, all components of the mechanical system that transmit energy to the part of the machine performing the work must be safeguarded. These components include flywheels, pulleys, belts, connecting rods, couplings, cams, spindles, chains, cranks, and gears. Any other parts of the machine that move during the operation must also be safeguarded. These can include reciprocating, rotating, and transverse moving parts, as well as feed mechanisms and auxiliary parts of the machine.

Choose the most effective and practical method to safeguard a machine. These are four general classifications of safeguarding methods:

- Guards
- Devices
- Safety trip controls
- Gates.

These types of safeguarding mechanisms are discussed in the following sections.

6.2.1 Guards

Guards are barriers that prevent access to dangerous areas. There are four general types of guards:

- Fixed
- Interlock
- Adjustable
- Self-adjusting.

A fixed guard, as the name implies, is a permanent part of the machine. It is not dependent upon moving parts to perform its intended function. A fixed guard may be constructed of sheet metal, screen, wire cloth, bars, plastic, or any other material that is substantial enough to withstand the impact it may receive and to endure prolonged use. The fixed guard is usually preferable to other types because of its simplicity and permanence.

When an interlocking guard is opened or removed, the tripping mechanism and/or power automatically shuts off or disengages, and the machine cannot cycle or be started until the guard is back in place. An interlock guard may use electrical, mechanical, hydraulic, pneumatic, or any combination of these power sources.
Adjustable guards are useful because they allow flexibility in accommodating various sizes of stock.

With self-adjusting guards, the openings of the barriers are determined by the movement of the stock. As the operator moves the stock into the danger area, the guard is pushed away, providing an opening that is only large enough to admit the stock. After the stock is removed, the guard returns to the rest position. The guards may be constructed of plastic, metal, or other substantial material, and offer different degrees of protection depending upon the specific model and application.

6.2.2 Devices

A safety device may perform one of several functions:

- Stop the machine if a hand or any part of the body is inadvertently placed in the danger area
- Restrain or withdraw the operator's hands from the danger area during operation
- Require the operator to use both hands on machine controls, thus keeping both hands and body out of danger
- Provide a barrier which is synchronized with the operating cycle of the machine in order to prevent entry into the danger area during the hazardous part of the cycle.

There are three basic types of safeguarding devices:

- Presence-sensing
- Pullback
- Restraint.

The photoelectric (optical) presence-sensing device uses a system of light sources and controls that can interrupt the machine's operating cycle. If the light field is broken, the machine stops and will not cycle. This device must be used only on machines that can be stopped before the worker can reach the danger area. The design and placement of the safeguard depends upon the time it takes to stop the mechanism and the speed at which the employee's hand can reach across the distance from the guard to the danger zone.

Pullback devices use a series of cables attached to the operator's hands, wrists, and/or arms. This type of device is primarily used on machines with stroking actions. When the slide/ram is up between cycles, the operator is allowed access to the point of operation. When the slide/ram begins to cycle by starting its descent, a mechanical linkage automatically assures withdrawal of the hands from the point of operation.

The restraint (holdout) device uses cables or straps that are attached to the operator's hands and a fixed point. The cables or straps must be adjusted to let the operator's hands travel within a predetermined safe area. There is no extending or retracting action involved. Consequently, hand-feeding tools are often necessary if the operation involves placing material into the danger area.

6.2.3 Safety Trip Controls

Safety trip controls consist of a pressure-sensitive body bar which, when depressed, will deactivate the machine. If the operator or anyone trips, loses balance, or is drawn toward the machine, applying pressure to the bar will stop the operation. The positioning of the bar, therefore, is critical. It must stop the machine before a part of the employee's body reaches the danger area.

There are two basic types of safety trip controls:

- Two-hand control
- Two-hand trip.

The two-hand control requires constant, concurrent pressure by the operator to activate the machine. The two-hand trip requires concurrent application of both the operator's control buttons to activate the machine cycle, after which the hands are free.

6.2.4 Gates

A gate is a moveable barrier that protects the operator at the point of operation before the machine cycle can be started. Gates are, in many instances, designed to be operated with each machine cycle.

6.3 Additional Control Measures

Although safeguards are most often effective and reliable methods of protecting workers from the hazards of dangerous moving parts, additional controls measures should also be taken. This will ensure that, even in the event of safeguard failure, workers will not be injured by mechanical hazards. Additional measures that should be taken include:

- Always follow standard operating procedures when operating machinery.
- Ensure that you have received the appropriate instruction or training before operating machinery.
- Do not wear loose clothing, jewelry, or accessories around moving parts. Ensure that long hair is tied back.
- If safeguards appear to be malfunctioning, stop work and inform your supervisor.
- When on-site (where you can not always be sure safeguards are being used properly), keep a safe distance between yourself and moving parts.

7.0 SUMMARY

This module has presented an overview of OSHA standards which address electrical energy in electrical design, lockout/tagout and electrical safety related work practices. An explanation of the general principles and effects of electricity was then provided, with definitions to aid in understanding how electricity works. Personal protective equipment, safety equipment and safe work practices appropriate for work on or near systems which present electrical hazards were also discussed.

Key concepts presented in this module are:

- EPA personnel may encounter hazardous energy sources/electrical hazards at hazardous waste sites, emergency responses, and in industrial plants.
- OSHA, the National Fire Protection Association and the National Electric Code have developed standards for ensuring safety around electrical hazards.
- Lockout/tagout programs ensure that machines and equipment are deenergized prior to and during servicing or maintenance.
- In addition to electrical energy, hydraulic, pneumatic, chemical, and thermal energy must be controlled.
- Hazards of electricity include shock, burns, arc-blasts, explosions, and fires. Injuries may result from falls caused by startling due to slight electric shock.
- Prohibit conductive materials and equipment around exposed, energized parts (e.g., metal ladders, tape measures, or uninsulated tools).
- Personal protective equipment, such as non-conductive head protection, eye protection, and non-conductive soled shoes may be required where electrical hazards exist.
- Where electrical hazards exist, safety signs and tags, barricades and/or attendants shall be used to protect employees.
- Moving parts of machinery may present mechanical hazards.
- Various types of safeguards can be used to protect workers from mechanical hazards:
    - Guards
    - Devices
    - Safety-control trips
    - Gates.

Measures you can take to protect yourself from electrical hazards include:

- Familiarize yourself with applicable OSHA and NFPA electrical standards.
- Be aware of the hazards associated with electricity and its use:
    - Shock
    - Burns
    - Arcs
    - Explosions
    - Fires.
- Understand that the severity of electrical shock is determined by the amount of current, the path the current takes through the body, and the time during which the victim is part of the electrical circuit. Wet skin may increase the severity of electrical shock and physical factors such as age, size, and physical condition may also have an impact.
- Always ensure that equipment is deenergized prior to servicing or maintenance. Apply the lock and tag to each energy isolating device.
- Use only one hand when working on a circuit or control device.
- Avoid using electrical equipment with wet or damp hands or in wet or damp locations.
- Do not wear conductive jewelry, accessories or clothing when working near energized parts, lines, or systems.

- Use only approved electrical equipment in hazardous locations.
- Wear the appropriate PPE (e.g., head, eyes, face, feet).
- Follow "dig-safe" procedures and ensure proper notifications have been made prior to drilling, trenching, excavating, or other invasive work operations.
- Be aware of the hazards presented by moving parts.
- Ensure that loose clothing, jewelry, accessories, and long hair are kept away from moving parts.

EXERCISE

Answer the following as True or False.

1. _____ The three areas where OSHA has developed standards which address electrical energy are: electrical design, lockout/tagout, and electrical safety-related work practices.

2. _____ OSHA's lockout/tagout standard applies only to electrical energy.

3. _____ OSHA's Electrical Safety-Related Work Practices standard includes the following elements: training, safe use of electrical equipment, personal protective equipment, and selection and use of work practices.

4. _____ Bonding of a container to the transfer vessel will prevent static discharge.

5. _____ Examples of conductors are glass, plastic and rubber.

6. _____ An electrical force that causes electrons to flow through a conductor is called voltage.

7. _____ Ohm's Law is the basic equation relating current, voltage, and capacitance.

8. _____ Electrical shock may result in damage or destruction of tissues, nerves or muscles.

9. _____ The severity of electrical shock is determined by the amount of current, the path the current takes through the body, the time during which the victim is a part of the electrical circuit and the frequency of the current.

10. _____ Conductors and parts of electric equipment that have been deenergized, but have not been locked or tagged out do not have to be treated as energized parts.

Choose the best answer to the following:

11. _____ The first step in the deenergization procedure included in lockout/tagout is:

    A. Notify all affected employees
    B. Shut down the machine or equipment
    C. Locate all energy sources
    D. None of the above

12. _____ Safety-related work practices include all but the following:

    A. Using two hands when working on a circuit or control device

B. Not wearing conductive jewelry
C. Learning rescue procedures
D. Deenergizing and locking out equipment

13. _____ The following are examples of protective measures to be followed when working on overhead lines:

A. Deenergize lines
B. Ground lines
C. Guard and isolate lines
D. All of the above

14. _____ Safe work practices to be adhered to when using or handling portable electric equipment include all but the following:

A. Shut off equipment after unplugging from the receptacle
B. Use properly rated extension cords
C. Use only approved electrical equipment in hazardous locations
D. None of the above

15. _____ The following should be observed regarding the use of personal protective equipment:

A. Maintain in a safe, reliable condition
B. Use insulating mats where appropriate
C. Wear shoes with non-conductive soles where appropriate
D. All of the above

EXERCISE KEY

Answer the following as True or False.

1. ***T*** The three areas where OSHA has developed standards which address electrical energy are: electrical design, lockout/tagout, and electrical safety-related work practices.

2. ***F*** OSHA's lockout/tagout standard applies only to electrical energy.

3. ***T*** OSHA's Electrical Safety-Related Work Practices standard includes the following elements: training, safe use of electrical equipment, personal protective equipment, and selection and use of work practices.

4. ***F*** Bonding of a container to the transfer vessel will prevent static discharge.

5. ***F*** Examples of conductors are glass, plastic and rubber.

6. ***T*** An electrical force that causes electrons to flow through a conductor is called voltage.

7. ***F*** Ohm's Law is the basic equation relating current, voltage, and capacitance.

8. ***T*** Electrical shock may result in damage or destruction of tissues, nerves or muscles.

9. ***T*** The severity of electrical shock is determined by the amount of current, the path the current takes through the body, the time during which the victim is a part of the electrical circuit and the frequency of the current.

10. ***F*** Conductors and parts of electric equipment that have been deenergized, but have not been locked or tagged out do not have to be treated as energized parts.

Choose the best answer to the following:

11. **_____** The first step in the deenergization procedure included in lockout/tagout is:

    A. Notify all affected employees
    B. Shut down the machine or equipment
    C. Locate all energy sources
    D. None of the above

12. **_____** Safety-related work practices include all but the following:

    A. Using two hands when working on a circuit or control device
    B. Not wearing conductive jewelry
    C. Learning rescue procedures

D. Deenergizing and locking out equipment

13. _____ The following are examples of protective measures to be followed when working on overhead lines:

A. Deenergize lines
B. Ground lines
C. Guard and isolate lines
D. All of the above

14. _____ Safe work practices to be adhered to when using or handling portable electric equipment include all but the following:

A. Shut off equipment after unplugging from the receptacle
B. Use properly rated extension cords
C. Use only approved electrical equipment in hazardous locations
D. None of the above

15. _____ The following should be observed regarding the use of personal protective equipment:

A. Maintain in a safe, reliable condition
B. Use insulating mats where appropriate
C. Wear shoes with non-conductive soles where appropriate
D. All of the above