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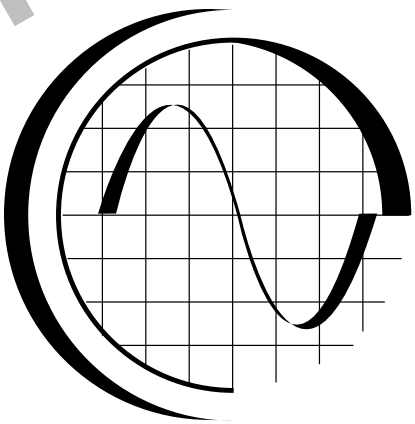
ELECTRICAL SAFETY AND PROTECTION

Lesson One

Electrical Hazards



TPC Training Systems

205.101

Lesson

1 Electrical Hazards

TOPICS

The Importance of Electrical Safety
The Electric Circuit
Electric Shock
Electric Arc
Basic Rules of Electrical Safety
Hazardous Electrical Locations
Additional Hazards

OBJECTIVES

After studying this lesson, you should be able to…

- List the three main factors that determine the effect of electric current on the human body.
- Explain what to do if a person is a victim of electric shock.
- Name four precautions you can take to guard against electric shock.
- Define the term *qualified person*.
- Summarize the basic rules of electrical safety.

KEY TECHNICAL TERMS

Ventricular fibrillation 1.17 condition in which the heart flutters uselessly and fails to pump blood
Cardiopulmonary resuscitation (CPR) 1.19 technique used to maintain circulation and respiration
Electric arc 1.26 discharge of electricity through a gas
Qualified person 1.30 one familiar with the construction and operation of electrical equipment and the hazards involved
Intrinsically safe equipment 1.41 equipment designed to release only low levels of electrical energy

Electrical safety is important for all workers, but it should be a major concern for the electrical maintenance worker. It is important that you be able to recognize electrical hazards and know how to protect yourself. Prevention is the best way to avoid electric shock, arc, and blast injuries. If you understand and respect electricity, always follow safety procedures, and use personal protective equipment, risk to you and your co-workers will be minimized.

This lesson explains the importance of electrical safety and the possible hazards that exist when working around electricity. It then provides information on equipment use and rules to observe when working with electricity on the job.

The Importance of Electrical Safety

1.01 Approximately 1100 people die from electric shock each year in the United States. During your daily routine, you are probably exposed to many potentially dangerous situations involving electricity. Modern life depends on electricity to run machinery, to provide heat and light, and to do many of the jobs people take for granted. Handled with care and respect, electricity is safe and useful, but when handled carelessly, it can be a killer.

1.02 Ignorance of safety regulations is no excuse for violating them. In fact, you can be fired from a job for doing so. If you are unsure about the meaning of a rule or how to follow a procedure, ask your instructor or supervisor for help.

1.03 Keep in mind that accidents seldom "just happen." In most cases, they are the result of unsafe acts rather than unsafe conditions. Common causes include fatigue, stress, carelessness, or ignorance. If you have an accident while on the job, notify your supervisor and the plant medical department. You should also report any unsafe condition or near-accident promptly.

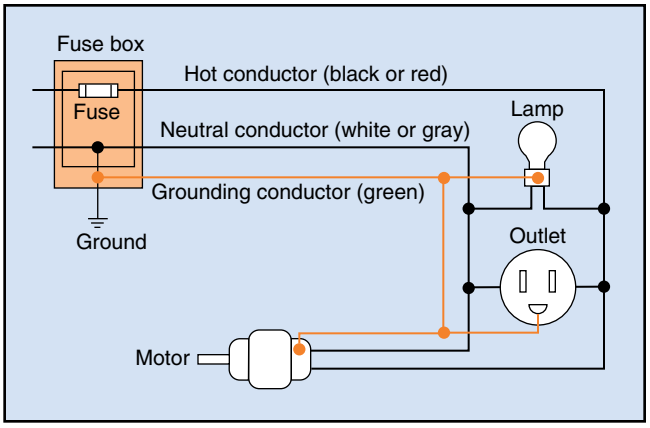
The Electric Circuit

1.04 Many of you are probably familiar with the theory of electricity. Some of you, however, might benefit from a review of some basic principles. The following paragraphs cover points that are important to your understanding of electrical safety.

1.05 Electricity flows through a conducting path in much the same way that water flows through a pipe. This path is called a *circuit*. *Current* is the amount of charge carried by the electrons flowing past a given point in a given time. Energy is required to move the charge through a conductor. The energy that moves the charge comes from a generator or battery. The source does not produce any electrons. It only supplies the energy to move the electrons that are present—much as pressure supplies the energy in a piping system. As the electrons move through a conductor, they encounter resistance and lose energy. The loss in energy, per unit of charge, is measured in *volts* (V).

1.06 In a simple electric circuit, electricity is delivered to a lamp or other device through a wire, often called the *hot wire*, and leaves through a wire that is connected to the ground. These two wires complete the circuit. A third wire, called a *grounding conductor*, connects the metal housing of the device to the ground to prevent it from being energized. Electrical wires are coded by standard colors of their insulation. A hot wire is either black or red. A neutral wire is white or gray. The grounding wire is green or green with a yellow stripe. Figure 1-1 shows these wire colors in a simple circuit.

Fig. 1-1. Grounded electric circuit



1.07 An open circuit cannot conduct current. When you turn off a switch or disconnect a line cord, you create a gap in the conducting path of the circuit. When the gap is closed, the circuit is said to be closed. If your body closes the gap, you become part of the circuit.

1.08 Every complete path in a circuit can conduct current. The amount of current depends on how much resistance is in each path of the circuit and on the voltage of the source. Electric current is measured in amperes (A) and milliamperes (mA). A milliampere is one one-thousandth of an ampere.

1.09 A circuit that supplies 2 A to a soldering iron and 5 A to a grinder must supply a total of 7 A. The current is divided as shown in Fig. 1-2. If an electric heater is added to the circuit and it draws an additional 10 A, the total current increases to 17 A. The larger current due to the additional load will blow a 15 A fuse in the circuit.

1.10 Electric circuits are described by their voltages and by their current capacity. The most common voltages for homes are 120 V for lights and small appliances, and 208 or 240 V for electric ranges, clothes dryers, and air conditioners. The most common voltages for industrial plants are 120, 208 and 240 V for small appliances and 480 V for motors and other equipment. Other voltages are also used in plants.

1.11 The 120 V circuits usually have current capacities of either 15 or 20 A, although 30 or 40 A circuits are possible if large enough wires are used. The 240 V circuits usually have capacities of 20 to 70 A. The 480 V circuits have capacities of 20 to hundreds of amperes. In all circuits, the size of the wire used depends on the current the circuit must carry. The wire size does not depend on the voltage of the circuit.

Electric Shock

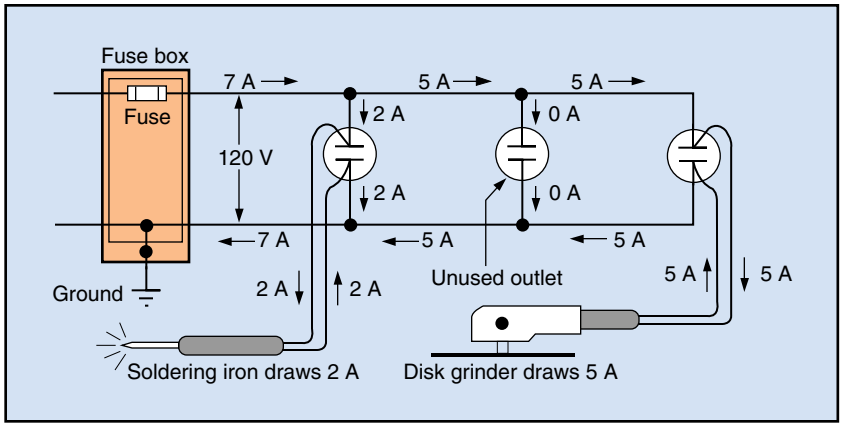
1.12 When working with any electric circuit, you are always exposed to the potential for shock. Some shock hazards are obvious—assuming a circuit is dead without testing (or testing it with your finger to see if it is live), using an electric tool that gives you a tingle when you touch it, or using a device with a frayed cord or a cracked plug. Other shock hazards, however, are not so obvious. Avoiding shock hazards requires regular inspections, good preventive maintenance, and common sense. You should have a healthy respect for all electrical equipment. Always follow safety procedures and use the required personal protective equipment.

1.13 Electric shock occurs when current passes through the body. The effect of the current on the human body depends on several factors:

- the amount of current passing through the body
- the path of the current through the body
- the length of time the body conducts the current.

Secondary factors include age, size, physical condition, and the frequency of the current (ac is slightly more dangerous than dc).

Fig. 1-2. Every complete path can conduct current



1.14 You can receive a shock or burn from any common electric circuit. The current needed to cause a serious or fatal injury is a small fraction of an ampere. An ordinary 120 V circuit can deliver 20 A of current or more before the circuit breaker trips or the fuse blows. This current is many times the amount that can kill a person.

1.15 When current passes through the human body, the effect can range from a mild tingle to death. Even a small and harmless shock can startle you and make you pull back suddenly, sometimes striking something or falling from a height. An electric shock is particularly dangerous when you are unable to let go of the source of the shock and the current tightens your chest muscles so that you cannot breathe. Other results of shock are burns and severe internal bleeding.

1.16 Electric current affects different body parts differently. For example, 30 mA can paralyze the diaphragm, making breathing impossible. A current as low as 75 mA can affect the rhythm of the heart. Current can also cause severe burns. Table 1-1 is a list of the kinds of damage small currents can cause in the human body.

Table 1-1. Effect of alternating electric current on the human body

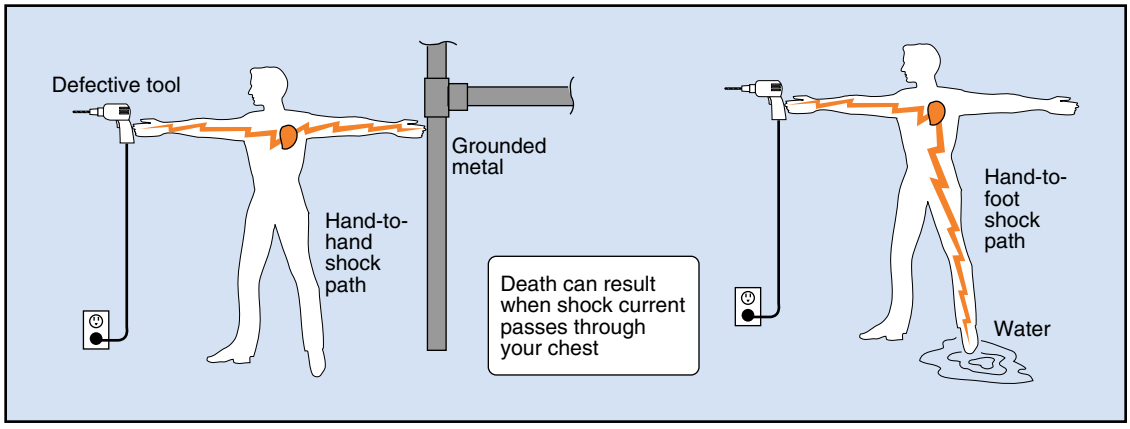
Milliamperes	Effect
1 or less	Shock probably is not even felt.
1 to 3	Shock is felt, but is not painful.
3 to 10	Shock is painful. Individual can let go at will. Muscular control is not lost.
10 to 20	Some individuals cannot let go at will because muscular control is lost.
20 to 75	Individual cannot let go. Breathing is difficult or impossible.
75 to 4000	Possible ventricular fibrillation of the heart, causing death. Severe muscular contraction and nerve damage.
Over 4000	Possible heart paralysis and/or severe burns.

1.17 Most fatal shocks occur when the current passes through or near the heart. If the path is through both arms, or through an arm and a leg, as shown in Fig. 1-3, the current passes through the chest and near the heart. A current of 100 mA that passes through the heart for only one-third of a second can cause *ventricular fibrillation*, a condition that causes the heart to flutter uselessly and blood circulation to stop. Unless the heart returns to its normal beat and blood flow resumes quickly, the brain is damaged and a short time later the victim dies. Restoring a normal heartbeat usually requires immediate use of special equipment by a trained medical technician. Such assistance is often not available soon enough to help the victim.

1.18 Although shocks over 200 mA are not necessarily fatal, these more severe shocks cause the chest muscles to contract so hard that they stop the heart completely. If this severe shock does not last too long, first aid measures sometimes can be used to restart the heart.

1.19 If a person becomes the victim of electric shock, prompt and proper first aid can mean the differ-

Fig. 1-3. How electric shock reaches the heart



ence between life and death. Sufficient circulation can sometimes be maintained by heart compression, which should always be supported with mouth-to-mouth resuscitation. This combination of treatments is commonly known as *cardiopulmonary resuscitation* (CPR). First aid and CPR are covered in Lesson Three.

1.20 Your body can become part of an electric circuit in the following ways:

- when you contact the hot and neutral conductors at the same time. In this situation, your body is like a light bulb filament or the windings in a motor. It becomes a current path between the wires.

- when you contact a hot conductor while you are in contact with the ground or a grounded structure. This unintentional grounding is described in more detail in Lesson Four.

- when you contact two hot wires with different voltages on them.

- when a ground fault occurs. This situation occurs when a hot conductor touches the metal housing or frame, causing it to become energized. If you are touching the metal housing when it becomes energized and another part of your body is in contact with ground, you will receive a shock.

1.21 The path of least resistance always conducts the most current. Table 1-2 gives some typical electrical resistances. As you can see from Table 1-2, electrical resistance varies widely between materials and within the human body.

1.22 Three factors determine electrical resistance:

- **Physical size of the substance.** Resistance varies directly with length, and inversely with cross-sectional area.

- **Properties of the substance.** Some substances conduct electricity easily. Others offer great resistance to the flow of electrons.

- **Purity of the substance.** Pure water does not conduct electricity. Small amounts of dissolved minerals and salts, however, make water a good conductor. Perspiration contains salts and minerals, and therefore increases the ability of the human body to conduct electricity.

1.23 Dry, nonmetallic materials generally resist electricity well. However, these same materials become better electrical conductors if they become damp. This rule applies to your body as well. Dry skin has greater electrical resistance than wet skin. Therefore your body will conduct less current if your skin is dry. However, if a body becomes part of a high-voltage circuit, the skin may be punctured. The current is then limited only

Table 1-2. Electrical resistance of common materials

Material	Resistance in ohms	Current produced by 120 V
Wood		
1 in. dry	200,000 to 200 million	0.6 to 0.0006 mA
1 in. wet	2000 to 100,000	60 to 1.2 mA
Metal		
1000 ft No. 10 copper wire	1	120 A
Human body		
Dry skin	100,000 to 600,000	1.2 to 0.2 mA
Damp skin	Down to 1000	Up to 120 mA
Wet skin	Down to 150	Up to 800 mA
Hand-to-foot	400 to 600	300 to 200 mA
Ear-to-ear	100	1200 mA

by the internal resistance of the body, and the current is much higher because of lower resistance.

1.24 When the skin is dry, the shock from a 120 V circuit might be less than 1 mA. Consequently, it produces little or no sensation. But even a small amount of perspiration or moisture greatly reduces the skin's resistance. When skin is moist, a 120 V circuit can produce a deadly shock. A person standing in water or leaning against a wet object can receive a shock of 800 mA—far above the lethal level.

1.25 You can take several precautions to guard against electric shock:

- *Insulation* provides electrical separation between you and the conductor.
- *Grounding* provides a low-resistance electrical path to earth.
- *GFCIs* detect current leaking to ground and turn off the circuit.
- *Lockout* prevents a circuit from being energized while you are working on it.

These and other safeguards are covered in detail in later lessons.

Electric Arc

1.26 An *electric arc* is a discharge of electricity through a gas. Electric arcing most often occurs when two conductors in an electric circuit are separated. For an arc to form, enough electrical energy must be available to maintain the current through the separation. Air itself cannot conduct current. It is vaporized material at the arc terminal and ionized particles of air that actually conduct the current. The mixture of materials through which the arc travels is called *plasma*.

1.27 Electric arcs are extremely hot and can cause serious burns. They can ignite clothing and cause fatal burns from a distance of several feet. The closer you are to the arc and the longer you are exposed to it, the more severe your injuries will be.

1.28 Electric arcing can also cause an increase in pressure that can cause violent explosions and send bullet-like fragments and molten metal flying. These blasts can be so powerful that they can blow out walls. Eye damage, severe burns, and many other injures can be the direct result of these explosions. Whenever there is the possibility of an electric arc, you should:

- wear appropriate face, eye, and ear protection
- wear flash resistant clothing
- maintain as much distance as possible between yourself and the potential source of the arc.

The Programmed Exercises on the following page will tell you how well you understand the material you have just read. Before starting the exercises, remove the Reveal Key from the back of your book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

1-1. In most cases, accidents are the result of unsafe _____.	1-1. ACTS Ref: 1.03
1-2. What color is the insulation on a grounding wire?	1-2. GREEN or GREEN WITH A YELLOW STRIPE Ref: 1.06
1-3. The effect of an electric current on the human body depends on what three main factors?	1-3. AMOUNT OF CURRENT, PATH OF CURRENT, LENGTH OF TIME IN CONTACT Ref: 1.13
1-4. A current as low as _____ mA can affect the rhythm of the heart.	1-4. 75 mA Ref: 1.16
1-5. Breathing and circulation can sometimes be restored to a victim of electric shock if _____ is performed without delay.	1-5. CARDIOPULMONARY RESUSCITATION (CPR) Ref: 1.19
1-6. The path of least _____ always conducts the most current.	1-6. RESISTANCE Ref: 1.21
1-7. Name four precautions you can take to guard against electric shock.	1-7. INSULATION, GROUNDING, GFCIs, LOCKOUT Ref: 1.25
1-8. Electric arcing most often occurs when two conductors in an electric circuit are _____.	1-8. SEPARATED Ref: 1.26

Basic Rules of Electrical Safety

1.29 To avoid the hazards of electric shock and arcing, safety must be planned into every job. If you are not sure how to perform a certain task (or how to perform it safely), ask your supervisor or an experienced fellow worker. Never take chances that could endanger you or others.

1.30 The Occupational Safety and Health Administration (OSHA) has established procedures or *standards* for working safely with or near electrical equipment and wiring. OSHA standards differ from all other industry standards in that they are enforceable under United States law. All workers should follow these procedures, whether or not they are qualified persons. The National Electrical Code (NEC) defines a *qualified person* as "one familiar with the construction and operation of the equipment and the hazards involved." All electrical installation and repair work in a plant should be performed by, or under the direction of, a qualified person and should follow NEC installation and design standards.

1.31 **Clothing.** Wearing the proper clothing and protective equipment when working around electricity can help you work safely. Some basic rules follow:

- Do not wear rings, watches, or any metal jewelry or ornaments. Not only can these articles come into contact with electric circuits, they can become caught in moving machinery.
- Wear a nonconducting, plastic, ANSI Class G or E hard hat (formerly Class A or B).
- Wear safety glasses.
- Wear shoes with nonconducting rubber soles.
- Wear heavy cotton clothing. In the event of an explosion or fire, clothing made of polyester or other synthetic fabrics can melt onto your skin and cause serious burns.
- Even if the power is locked out, wear protective equipment (insulating gloves and sleeve covers) if there is any chance of it becoming inadvertantly re-energized. To protect yourself against arcing, wear flash/flame resistant clothing, a flash suit, eye protection, and a face shield.

1.32 **Equipment.** The precautions that follow apply to equipment and tools used on or near electric circuits:

- Use the proper devices and tools for the job. Examine safety devices before using them to make sure they are in good condition. Examine all electric power tools and other electrical equipment for signs of damage or wear. Never use faulty power tools. When tools or their cords are damaged, replace them at once.
- Use insulated tools rather than non-insulated tools when working on electrical equipment. Use only intrinsically safe or explosion-proof tools and hand lamps in hazardous locations. In metal tanks, use 6 or 12 V equipment.
- Keep all electric machinery free of dust, dirt, oil, and stray tools and parts. Do not store your lunch, tools, or anything else in switch boxes.
- Where appropriate, make sure all equipment meets the requirements of a recognized testing laboratory. Underwriters Laboratory (UL) and Factory Mutual (FM) are the two best-known certifying agencies.
- Never overload a circuit, even when all equipment is laboratory-certified.
- Do not clean or repair machinery while it is in motion without specific directions from your supervisor, or unless precautions have been taken to allow you to do the work safely.
- Do not use metal ladders near electricity.

1.33 **Enclosures.** Keep electrical enclosure doors secured and locked. Industrial and commercial enclosure doors are often hinged and held closed with a latch that allows for the use of a padlock. In addition to the latch, equipment doors are sometimes held closed with screws or bolts that help hold the door closed if an internal explosion occurs. For your safety, it is important that door screws be tightened when equipment is energized, as shown in Fig. 1-4, on the following page.

Fig. 1-4. Electrical enclosure door

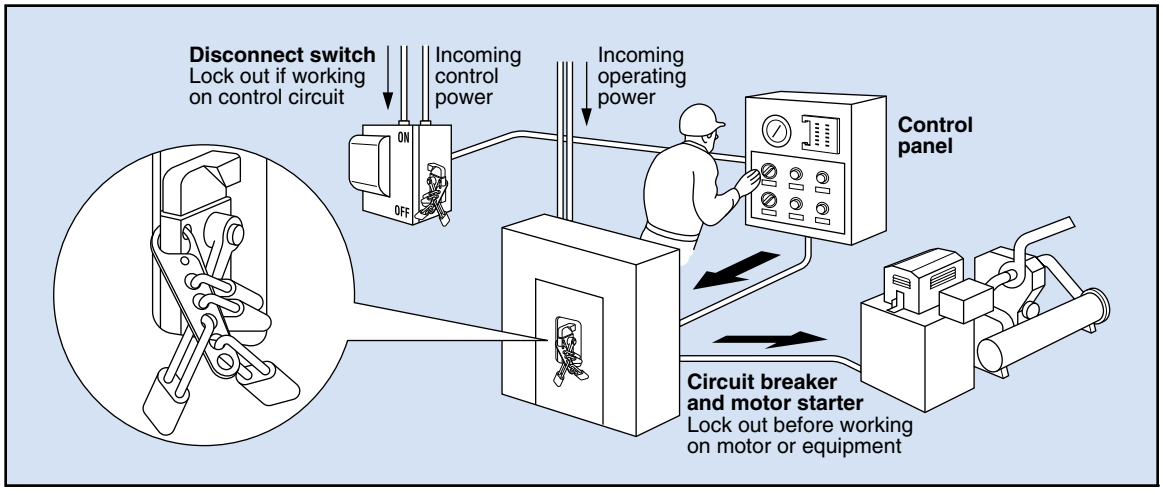
Fig. 1-5. Lock out power before working on equipment

1.34 Circuit breakers or disconnect switches should be opened or closed only when equipment doors are secured (closed and bolted). When you open or close a circuit with a circuit breaker or disconnect, there is a possibility that a circuit fault might exist, causing an overload, arcing, and/or explosion. Therefore, when opening or closing a circuit, be alert, wear protective equipment, stand to the side of the switch as much as possible, and operate the switch with a quick positive motion.

1.35 **Wiring.** Wires with damaged or deteriorating insulation must be replaced. Only in an emergency should a wire be wrapped temporarily with electrical tape. As a general rule, leave wiring jobs for a qualified electrician.

1.36 **Water.** Water and electricity make a deadly combination. Check your work area for puddles and wet surfaces. Do not energize electrical equipment when it is wet or damp with condensation. If equipment is stored outdoors in cold weather and brought indoors for use, make sure that all condensation has evaporated from the insulation before the equipment is used. If electrical equipment is wet, dry it in the sun or in a warm, dry room. If heat is applied for drying, the temperature should be limited to 200°F. De-energize all electrical equipment in the area

Fig. 1-6. Lock out every power source



before attempting to extinguish a fire with water. Do not try to put out an electrical fire with water. Use only an extinguisher designed for electrical (Class C) fires.

1.37 **Lockout.** If the unexpected start-up of equipment is likely to endanger people, you must lock out power to the equipment. When equipment is to be worked on, each worker involved should have his or her own padlock to lock out power. If you will be working on a motor control center, for example, use a lockout device like the one in Fig. 1-5. You must have a lock for every power source supplying the electrical equipment. Figure 1-6 shows two possible lockout locations. Lockout/tagout procedures are covered in greater detail in Lesson Three.

1.38 Even when the power is locked out, wear protective equipment and use insulated tools. To prevent an accident, treat dead circuits as though they are live. Test every circuit at the point where you will be exposed before starting work. Alert all persons who might be endangered by the work you are doing.

Hazardous Electrical Locations

1.39 If flammable materials or explosive gases are normally present near electrical equipment, special safety measures are needed. In these situations, explosion-proof or intrinsically safe equipment is installed to minimize the hazard. Examples of typical hazardous electrical locations include petrochemical plants, oil-based paint manufacturing facilities, mines, sewers, and grain storage facilities.

1.40 *Explosion-proof enclosures* for equipment can contain sparks, high temperatures, and explosions so that the atmosphere outside the enclosure cannot be ignited. For example, gasoline fumes might leak into an equipment enclosure and cause an internal explosion. With an explosion-proof enclosure, however, the explosion is contained inside the enclosure, and no external damage results from the detonation of the explosive atmosphere.

1.41 Some electrical equipment is referred to as *intrinsically safe* because it is designed to release only low levels of electrical energy. This kind of equipment cannot cause an explosion or fire of the specific hazardous material.

1.42 Explosion-proof and intrinsically safe electrical equipment is usually designed, selected, and installed for a particular hazardous condition that is expected at a location. This equipment must be installed, used, and maintained with care, or the hazard will remain and the equipment will not be safe to use. If an accidental leak or spill occurs during use, for example, the hazardous material can escape into unexpected areas where general-purpose electrical equipment is installed. Special precautions then must be taken to turn off the electric power without igniting the liquid, gas, dust, or other material.

Additional Hazards

1.43 **Confined spaces.** A *confined space* is an area that has poor natural ventilation and is not designed for occupancy by workers on a continuous basis. Although work in a confined space is not a common part of the workday for most electrical maintenance workers, deaths involving confined spaces occur all too frequently. The information in this lesson offers only brief guidelines. The full OSHA guidelines are much more extensive. As a general rule, never enter a confined space without following the complete OSHA required procedure.

1.44 The most important safety consideration for workers in a confined space is the atmosphere within the space. Not only must there be enough oxygen to support life, but the atmosphere must not be flammable, toxic, or explosive. Although testing the air in confined spaces is important, mechanical ventilation is also needed to maintain a safe atmosphere.

1.45 **Lifting.** When performing electrical work, it might be necessary for you to do some heavy lifting. If at all possible, use material-handling equipment. Use your muscles only as a last resort. Make sure you know your own limits and know how to lift safely. Many workers have been seriously injured while lifting too much or lifting improperly.

1.46 **Fire.** Everyone should take every precaution possible to prevent fires. Fires can be started by burning cigarettes, combustible trash, careless use of matches, improperly installed electrical equipment, or improper storage of oily rags or gasoline.

1.47 Become acquainted with the location and operation of all fire-fighting equipment within your

work area. In case of a fire, first consider the safety of the people in the plant. Next, make sure you report the fire. Only after everyone is safe and the fire has been reported should you become concerned about saving property. Do not attempt to save property if doing so will endanger your life.

1.48 **Falls.** Falls from any height can be dangerous. Working surfaces covered with dust, oil, or grease are dangerous at ground level. Your job might require you to work on walls, ceilings, roofs, or other elevated areas. Falls can be far more dangerous at raised elevations. Falls rank second only to motor-vehicle accidents as the most frequent cause of fatal injuries in the United States.

1.49 When working at heights, you must consider not only your own safety but the safety of others. Dropped tools or materials can do great damage below. Place signs and barricades to warn others of the danger of falling objects.

1.50 Do not overreach when you are on a ladder. Get down and move the ladder to a better position, if necessary. Reaching too far to the side can cause a portable ladder to shift and fall. Keep your hips in position over the ladder so that your center of gravity is always over its base. Never use a metal ladder when working with electricity. Use extreme care when handling or using any ladder near electricity.

1.51 **Moving parts.** At some time, you will probably be required to work near moving machinery. Become familiar with the safety rules involving the guarding of moving parts. Make sure that all guards are in place before you start work. Barriers are placed around a job for your protection. Respect them. If you must work near the moving equipment, turn off the machine and lock out the power.

1.52 **Noise.** Because noise seldom causes pain, most people do not realize just how sensitive their ears are to loud noises. Noise is measured in decibels (dB). In a very quiet room, a person with good hearing can just barely hear a sound measuring 1 dB. In the average factory, the noise level measures 80 to 85 dB. You can stand this level of noise for 8 hours without damaging your hearing. But if you work longer hours or if the noise level is greater than 85 dB, you need to protect your hearing. A typical punch press measures over 100 dB. At 110 dB, sound becomes painful to the normal ear.

1.53 Earplugs and earmuffs are commonly used to protect hearing in noisy work areas. Some earplugs are disposable and are made of fiber or foam that fits into the ear canal. Reusable plugs are made of soft rubber or plastic. Earmuffs are designed to fit over the entire ear. The outsides of the earmuffs are hard, cup-shaped shells. They are lined with material that absorbs sound and sealed around the edges with a soft, cushioning material. They are mounted on an adjustable headband that fits over the head (or under the chin when worn with a safety hat).

1-9. When working around electricity, wear shoes with _____ soles and a _____ hard hat.	1-9. RUBBER; PLASTIC Ref: 1.31
1-10. When working around electricity, you should wear _____ clothing.	1-10. COTTON Ref: 1.31
1-11. Use _____ tools when working on electrical equipment.	1-11. INSULATED Ref: 1.32
1-12. To fight an electrical fire, use an extinguisher designed for Class _____ fires.	1-12. C Ref: 1.36
1-13. If the unexpected start-up of equipment could endanger you or others, you must _____ the power to the equipment before beginning work.	1-13. LOCK OUT Ref: 1.37
1-14. Electrical equipment designed to release only low levels of electrical energy is called _____.	1-14. INTRINSICALLY SAFE Ref: 1.41
1-15. The major safety consideration for workers in a confined space is the _____.	1-15. ATMOSPHERE Ref: 1.44
1-16. Never use a(n) _____ ladder when working near electricity.	1-16. METAL Ref: 1.50

Answer the following questions by marking an "X" in the box next to the best answer.

1-1. In electrical equipment, the grounding wire is usually

- ☐ a. black
- ☐ b. green
- ☐ c. red
- ☐ d. white

1-2. The amount of current a circuit can conduct depends on the voltage of the source and on the

- ☐ a. location of the grounding wire
- ☐ b. number of current paths
- ☐ c. power rating of the connected device
- ☐ d. resistance of the conductor

1-3. An electric current as low as _____ mA can affect the rhythm of the heart.

- ☐ a. 25
- ☐ b. 50
- ☐ c. 75
- ☐ d. 100

1-4. When your skin is dry, it has

- ☐ a. less resistance than when wet
- ☐ b. greater resistance then when wet
- ☐ c. no resistance
- ☐ d. the same resistance as when wet

1-5. Electric arc is a discharge of electricity through a

- ☐ a. gas
- ☐ b. grounding wire
- ☐ c. human body
- ☐ d. metal enclosure

1-6. The National Electrical Code defines a "qualified person" as someone who

- ☐ a. has been on the job a minimum of one year
- ☐ b. is a supervisor or manager
- ☐ c. is certified by a testing laboratory
- ☐ d. is familiar with equipment operation and hazards

1-7. When working around electricity, wear clothing made of

- ☐ a. cotton
- ☐ b. nylon
- ☐ c. polyester
- ☐ d. rayon

1-8. When the insulation on wiring is damaged, the wiring should be

- ☐ a. replaced
- ☐ b. stripped
- ☐ c. taped
- ☐ d. tested

1-9. To extinguish an electrical fire, use

- ☐ a. a Class A extinguisher
- ☐ b. a Class B extinguisher
- ☐ c. a Class C extinguisher
- ☐ d. water

1-10. If the unexpected start-up of equipment could endanger you, you must _____ before beginning work.

- ☐ a. ground the equipment
- ☐ b. insulate the equipment
- ☐ c. lock out the power
- ☐ d. turn off the power

SUMMARY

Knowing and following safety rules is a major job responsibility for anyone who works with electricity. If you are ever unsure of a rule or procedure, ask your supervisor.

Electricity flows through a conducting path called a circuit. Current is the amount of charge carried by the flowing electrons. In a simple electric circuit, electricity is delivered through a red or black hot wire and leaves through a white or gray neutral wire. A third wire, the green grounding wire, connects the metal housing of the device to the ground to keep it from becoming energized. An open circuit cannot conduct current, but every complete path in a circuit can conduct current.

When working with electricity, there is always the potential for electric shock. Shock occurs when current passes through the body. The effect of the current depends largely on the amount of current, the path of the current, and the length of time the body conducts the current. A current of 30 mA can make breathing impossible, and as few as 75 mA can disrupt the rhythm of the heart. Prompt first aid and cardiopulmonary resuscitation (CPR) can mean the difference between life and death for a victim of electric shock. Insulation, grounding, GFCIs and lockout can all protect against electric shock. Electric arc is a discharge of electricity through a gas. Electric arcs are very hot and can cause serious burns.

To avoid the hazards of working with electricity, safety must be considered in all your actions when working with electricity. Wear proper clothing and protective equipment. Use the proper tools. Keep electrical enclosure doors secured and replace damaged wiring. Learn and follow proper lockout procedures. If flammable materials or explosive gases are present near electrical equipment, use explosion-proof or intrinsically safe equipment to minimize the hazard.

Other hazards you might encounter, although not specifically related to electrical work, deserve mention. Use care and follow OSHA guidelines if you are working in a confined space. Become familiar with fire prevention techniques and the location of fire-fighting equipment. Use extreme caution when working at heights, especially when on a ladder. Finally, protect your hearing from the excessive noise that is often present in an industrial setting.

Answers to Self-Check Quiz

1-1. b. Green. Ref: 1.06

1-2. d. Resistance of the conductor. Ref: 1.08

1-3. c. 75. Ref: 1.16

1-4. b. Greater resistance then when wet. Ref: 1.24

1-5. a. Gas. Ref: 1.26

1-6. d. Is familiar with equipment operation and hazards. Ref: 1.30

1-7. a. Cotton. Ref: 1.31

1-8. a. Replaced. Ref: 1.35

1-9. c. A Class C extinguisher. Ref: 1.36

1-10. c. Lock out the power. Ref: 1.37

Contributions from the following sources are appreciated:

Figure 1-4. Square D Company
Figure 1-5. Square D Company