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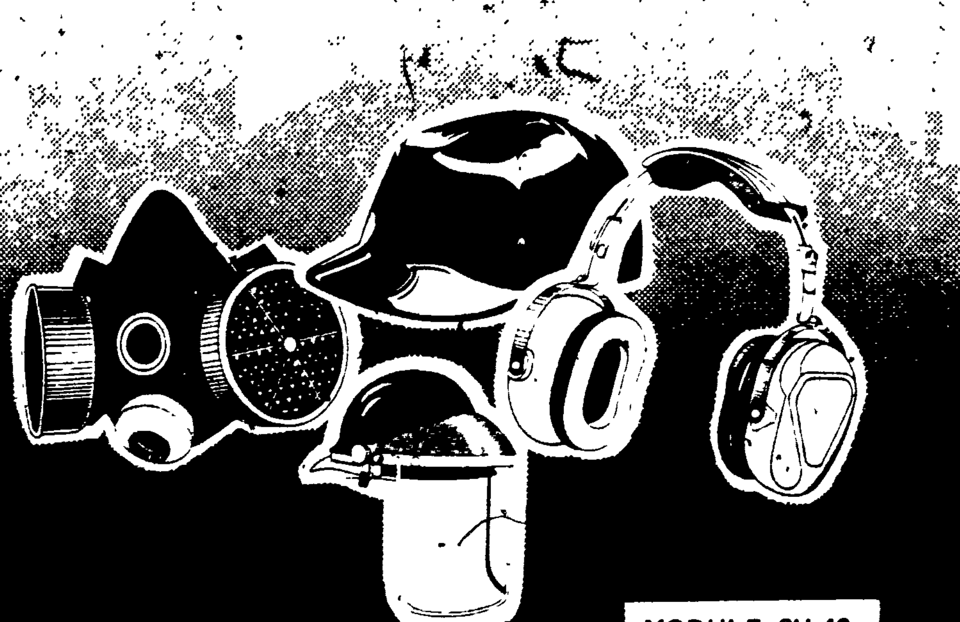
ABSTRACT

This student module on electrical power transmission and distribution safety is one of 50 modules concerned with job safety and health. This module focuses on some of the general safety rules, techniques, and procedures that are essential in establishing a safe environment for the electrical power transmission worker. Following the introduction, nine objectives (each keyed to a page in the text) the student is expected to accomplish are listed (e.g., Outline the proper safety steps for erecting power transmission lines). Then each objective is taught in detail, sometimes accompanied by illustrations. Learning activities are included. A list of references and answers to learning activities complete the module. (CT)

ED213874

SAFETY AND HEALTH

ELECTRICAL POWER TRANSMISSION AND DISTRIBUTION SAFETY



MODULE SH-40

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INTRODUCTION

The modern technological world depends very heavily on electrical power. This dependence magnifies the importance of the transmission and distribution of electrical power for both the domestic and the industrial communities. Today's electrical power transmission and distribution systems are very complex and require a high degree of safety consciousness on the part of the worker involved in the construction and maintenance of these systems.

A prior understanding of the basic principles of electricity and of electrical protective devices is necessary before the student begins this module. Module SH-03, "Fundamentals of Electrical Safety," and Module SH-31, "Overcurrent and Electrical Shock Protection," contain information that will provide the needed foundation.

This module will focus on some of the general safety rules, techniques, and procedures that are essential in establishing a safe environment for the electrical worker. In addition, the text will cover the most common tools and personal protective equipment used by workers involved in the transmission and distribution of electrical power.

OBJECTIVES

Upon completion of this module, the student should be able to:

1. Describe the proper use and the safety precautions that need to be taken in using hand tools. (Page 3)
2. Cite the special precautions needed in the use of power, hydraulic and pneumatic tools. (Page 7)
3. Identify at least five items of rubber protective equipment used to work on power transmission lines. (Page 10)
4. Describe pole climbing equipment and explain how it is used to perform work on power transmission and distribution lines. (Page 14)
5. Outline the proper safety steps for erecting power transmission lines. (Page 20)

6. Describe the live-line and hand tool requirements, inspections and precautions that need to be adhered to by those working with power transmission lines. (Page 23)

7. Cite the type of tests and inspections to be performed on mechanical equipment, such as aerial-lifts, derrick trucks, and cranes before it is used. (Page 26)

8. List the types of medical and first aid precautions associated with power transmission work and the priority of action in aiding an injured worker. (Page 28)

9. List the major hazards and recommended precautions for working with underground transmission-line distribution systems. (Page 30)

OBJECTIVE 1: Describe the proper use and the safety precautions that need to be taken in using hand tools.

Figure 1 shows the most common hand tools used by the electrical utility worker in construction and maintainence of electrical power transmission and distribution lines. These hand tools can be expected to perform dependably if the user remembers a few important rules in mind.

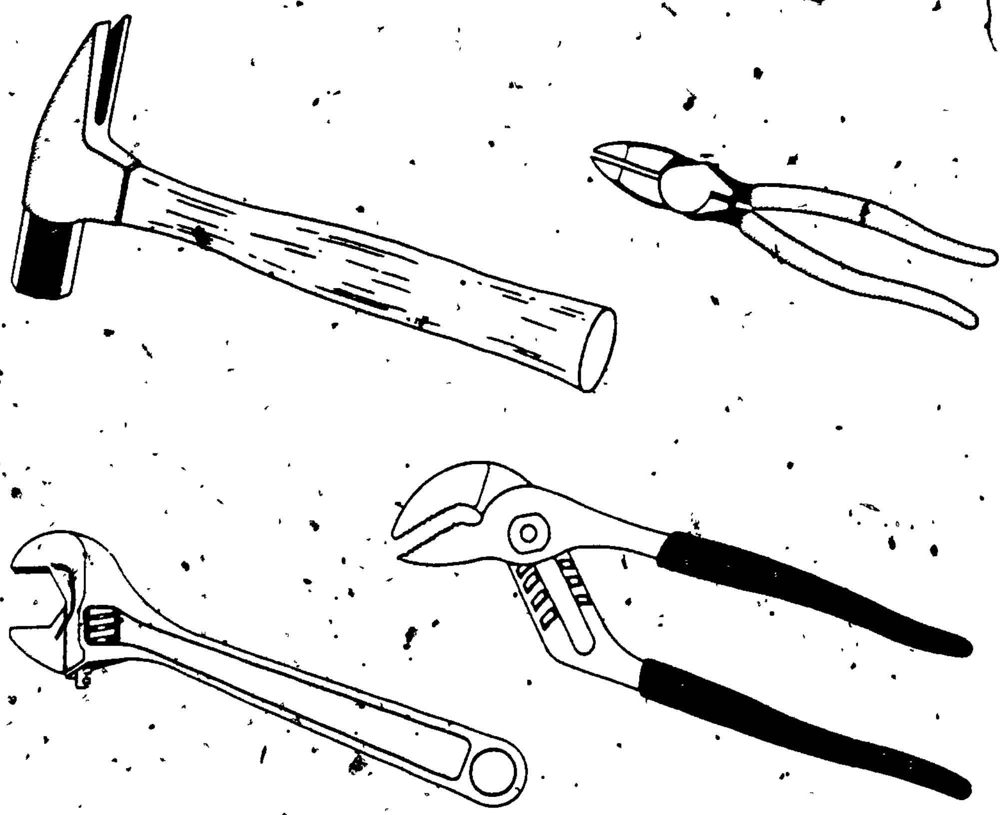

Figure 1. Common hand tools used by electric utility workers.

- Use the proper tool for the job.
- Before use, inspect the tool to be sure that there are no structural faults that would cause the tool to fail in operation or in its protective function.
- Be sure that you know the limits of the tool.
- Keep the tool in good repair through proper lubrication and adjustment.

In addition to these general rules that can be applied to common hand tools, some specific rules associated with individual tools need to be examined.

Figure 1a shows a common 16-ounce claw hammer. Depending upon the manufacturer, it may have a wood handle or a fiber-glass handle with a rubber grip. Regardless of the manufacturer, you should always follow these rules in its use:

1. Make sure the handle fits tightly.
2. Never strike hardened steel with a steel hammer.
3. Never carry hammer in the middle back loop of your body belt.
4. Never attempt to repair a cracked hammer handle by taping it; always replace the handle.

There is a reason behind each of these safety rules. If the hammer handle is loose, the head can fly off and hit you, a fellow worker, or a piece of equipment. Striking hardened steel with a steel hammer produces sparks and fine metal particles that can fly with sufficient velocity to penetrate clothing, skin, or possibly an eye. Should you fall and land on your back, a hammer in the middle back loop of your body belt could cause severe damage to the spine or kidneys. A cracked hammer handle can lead to the same result as the loose hammer head. Hammer handles can become loose and/or cracked through extended use, material failure, or by misuse of the hammer; do not use the hammer as a pry or as anything except a hammer. In each of these instances, prevention of pain and incapacitation is the principal motivation for the rule.

The nine-inch lineman pliers shown in Figure 1b have the potential of making contact with currents and voltages that would prove lethal to you should they pass through your body; that is why insulated handles are provided. Be sure that the insulation is in good condition, that it is not cracked or checkered, and that it is not saturated with any oils or fluids.

A small amount of lubricant applied to the moving parts of the plier head is acceptable. And, just as a hammer is not used as a pry, the pliers should not be used as a hammer.

Adjustable end wrenches and channel lock pliers, as shown in Figures 1c and 1d, are both widely used by linemen. These tools require proper adjustment to fit snugly on specific bolt heads or nuts. In turning bolt heads or nuts, be sure that you always pull the wrench or pliers towards you; do not push away - you could be pushing yourself into danger, throwing your body weight off-balance.

Figure 1e shows a six-inch folding wooden rule commonly used by linemen. The wooden rule provides a measure of safety from hazardous voltages and currents that is absent with metal tape rules. However, you must keep the rule clean of any dirt or conductive contaminants to maintain that measure of safety.

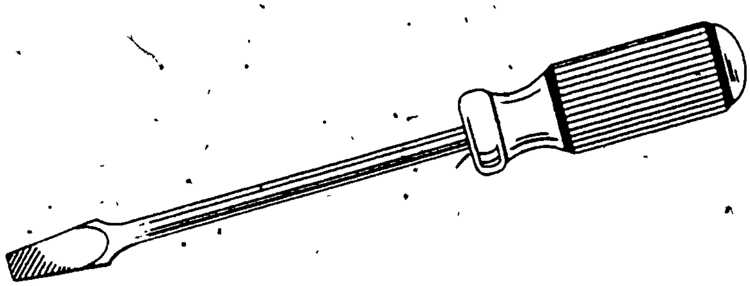

Figure 2. A eight-inch straight blade screwdriver.

Figure 2 shows a straight-bladed, eight-inch screwdriver that is commonly carried in the body belt of many linemen. The screwdriver is one of the most basic hand tools, and one of the most frequently abused. It should not be used as a scraper, chisel, punch, or circuit tester. Scraping and use as a punch destroys the tip; chiselingcan cause breakage with subsequent flying splinters. The use of the screwdriver as a circuit tester can result in flying pieces of molten metal and a ruined shaft or blade tip. You should never use a pair of pliers to turn the screwdriver due to the danger of breakage of the screwdriver and possible accidental exposure to other hazards, such as falling or making contact with lethal currents or sharp protrusions. When you are using a screwdriver, do not hold the work in your hand. Should the point of the screwdriver slip, it could cause a very bad cut or puncture wound in the hand holding the work. Always hold the work in a vice, with a clamp, or against a solid surface. If these precautions are impossible, you can normally be safe by following this rule: never allow any part of your body to be in front of the screwdriver blade tip.

ACTIVITY 1:*

Answer the following questions; indicate your choice in space provided.

___ 1. Upon arriving at a job, a fellow worker hands you a claw hammer with a crack in the handle. What should you do?

a. Throw the hammer away and order a new one.

b. Make temporary repairs by making several wraps of tape around handle.

c. Replace the handle or the hammer.

d. Set the hammer aside and use your pliers as a substitution.

___ 2. What hazards are presented by insulation on the handles of your nine-inch pliers that are saturated with oil?

a. Oil could cause the grip on the tool to slip.

b. Oil could be conductive and allow current flow through your body.

c. Neither a or b.

d. Both a and b.

___ 3. Why should you always pull pliers or wrenches toward you in turning a bolt head or nut?

a. Pushing could cause you to lose balance and fall into the work.

*Answers to Actiities appear on page 33.

b. Pulling allows you to see what you are doing.

c. The bolt always turns in that direction.

OBJECTIVE 2: Cite the special precautions needed in the use of electric, hydraulic, and pneumatic powered tools.

There are many applications where the force exerted by the human body alone is insufficient or too slow to perform the needed job. In these cases, externally powered tools provide the working action, and workers act as the controlling agents. The external power sources may be electrical, fluidal (hydraulic), or pressurized air (pneumatic) in nature. Safe practices are essential with each of these power sources. Careless actions, negligent maintenence, and improper use of power tools can pose serious hazards to those who use them. To avoid or minimize the hazards posed by powered tools, some general common sense provisions should be followed.

1. All power tools should be examined prior to use, to ensure general serviceability and the presence of all applicable safety devices.
2. Power tools should be used only within their capability and operated in accordance with the instructions issued by the manufacturer.
3. All power tools should be kept in good repair and when being repaired or serviced, should be disconnected from their power sources.

Electrically powered tools can pose a threat to workers not only from the action of the tools, but also from the electrical current. The hazard of electric current calls for some special guidelines:

1. The non-current carrying metal parts of portable electric tools (such as drills, saws, and grinders) must be effectively grounded when connected to a power source, unless -
   - The tool is an approved double insulated type.
   - The tool is connected to the power source by means of an isolation transformer or other isolated power supply such as a 24 volt d.c. system.
2. Electric power tools must not be used where there is a hazard of flammable dusts, vapors, or gases.

In addition to these precautionary steps, electrical power tools that use commercial 120 volt or 240 volt a.c. power should be connected to their sources through a GFCI (Ground Fault Circuit Interrupter). The GFCI is a device that detects situations where there is current flowing in conductors not intended for current flow and stops current flow to the tool. More information concerning this device and the hazards of electricity can be found in Module SH-31, "Overcurrent and Electrical Shock Protection."

Pneumatic tools, powered by compressed or pressurized air, have as their power source a compressor or compressed air tank. Compressed air should always be used with great caution, with attention to the following guidelines:

1. Pneumatic tools should never be pointed at people.
2. A positive means of connection between the tool and the supply hose is a necessity to avoid accidental disconnection.
3. Only those individuals who are competent and have received training in the use of pneumatic tools should operate them.

The first two rules are important because a jet of compressed air can act as a propellant, turning ordinary objects into bullets. In addition, a loose air hose can whip around like a deadly snake damaging anything in its path. Compressed air directed at persons has been known to puncture eardrums and cause other serious injuries.

Hydraulic tools use fluids under pressure to provide power for mechanical action. Hazards from hydraulics can arise not only from the mechanical actions, but also from the fluids used. Hydraulic fluids have many undesirable characteristics when examined from a safety and health standpoint. Some of these fluids are fire hazards; some are corrosive to flesh; often they are toxic; and all are extremely dangerous to the eyes. If hydraulic fluids are under a great amount of pressure, a fine hole can emit a stream that is nearly invisible but can cut like a knife. Thus, hydraulic fluids and hydraulically powered tools must be treated with respect and the utmost care.

Metal-reinforced hoses are often used to carry hydraulic fluids under high pressure from their pump to the tool being powered. Care should be taken to ensure that all equipment involved is in good repair and that all couplings are secure and leak free. In addition, these metal-reinforced hoses should be kept from contact with electrically energized equipment.

Neither pneumatic nor hydraulic equipment should ever be subjected to pressures that exceed the manufacturer's safe operating limits. The safe operator of power tools is the operator who -

- Familiarizes himself or herself with the tools and the job before beginning work.
- Maintains equipment in the proper state of repair, making sure that all the safety features built into the equipment are in proper working order.
- Knows and follows safe procedures.

ACTIVITY 2:

Select the type of hazard (from the headings provided) that is represented by each of the numbered items below. Some headings may be used more than once, some not at all.

A. POSSIBLE ELECTRICAL SHOCK
B. POSSIBLE CUTTING OR PUNCTURE HAZARD
C. POSSIBLE PROJECTILE HAZARD
D. POSSIBLE HEALTH HAZARD
E. POSSIBLE BIOLOGICAL HEALTH HAZARD
F. POSSIBLE FIRE HAZARD

___ 1. Pneumatic tool with faulty connection between the tool and the supply hose.

___ 2. Hydraulic tool with a tiny hole in the metal-reinforced hose.

___ 3. Ungrounded tool without insulation.

___ 4. Compressed air hose pointed toward a person.

___ 5. Powered tools in a dusty environment.

OBJECTIVE 3: Identify at least five items of rubber protective equipment used to work on power transmission lines.

The best protection from the hazards presented in working on power transmission lines is to avoid contact with the dangers. This means avoidance of direct contact with current-carrying conductors, splinters, sharp edges, or hot metal. To prevent such contact, the electric utility industry has encouraged the development and use of the following equipment:

- Rubber gloves.
- Rubber sleeves.
- Rubber insulating insulator hoods.
- Rubber insulating blankets.
- Insulator and conductor covers.

The rubber used for these items is a synthetic rubber, which exhibits insulating ability, flexibility, and stability with age superior to that of natural rubber.

RUBBER GLOVES

The most important item of protection for the lineman is a good pair of rubber gloves. These gloves must have the proper dielectric strength (insulating ability) for the voltage of the circuit to be worked on and must be in good repair (no holes, rips, or thinned sections). In addition, leather protector gloves must be worn over the rubber gloves to prevent any physical damage to the rubber gloves during the course of work.

A common method of checking for holes or thin sections in the rubber gloves is to perform an "air test" before their use. This test is accomplished by filling the glove with air, then securely closing the cuff so that the air cannot escape. The individual then holds the glove close to his or her face and squeezes it, while listening and feeling for any fine air leaks.

There are four basic classes of rubber gloves manufactured. The American National Standards Insititute ANSI J6.6-1971, entitled "Rubber

Insulating Gloves" covers the specifications for the lineman's rubber gloves; these are summarized in Table 1.

TABLE 1: SPECIFICATIONS OF RUBBER GLOVES.

Class	Proof Test, Minimums
0	5,000 volts for 3 minutes
I	10,000 volts for 3 minutes
II	15,000 volts for 3 minutes
III	20,000 volts for 3 minutes

Proof test voltages should not be considered the safe voltage at which the glove can be used. Many factors, such as care in handling, storage, inspection of the gloves in the field, age of the gloves, and weather conditions during usage affect the maximum voltage at which the gloves can be safely used. The quality and thickness of the rubber and the design of the gloves can also affect the safe voltage limit for gloves.

Gloves should be periodically cleaned and inspected in a facility intended for inspection of protective equipment. The rubber gloves are cleaned in a washing machine using warm water and a mild detergent. After washing, the gloves should be air dried completely, tested for insulating ability, and tagged with the dates of cleaning, testing, and inspection.

RUBBER SLEEVES

Rubber gloves alone will not protect or provide a reasonable tolerance for error for the lineman. To prevent electrical contacts on the arms or shoulders, rubber sleeves should always be worn together with the gloves when work is being performed on high-voltage distribution circuits.

Inspection, testing, and cleaning is as important in the care of rubber sleeving as it is in the care of rubber gloves. The lineman should take the time to closely inspect the rubber sleeves that he or she will be using. In addition to the inspection by users (who are safeguarding their own lives by such attention), a competent person should have the responsibility of cleaning, inspecting, and testing the rubber sleeves at regular intervals.

RUBBER INSULATING LINE HOSE

Figure 3 shows the structure of a typical rubber insulating line hose. These protective devices are manufactured in various lengths for attachment to lines of from one inch to one and one-half inches in diameter.

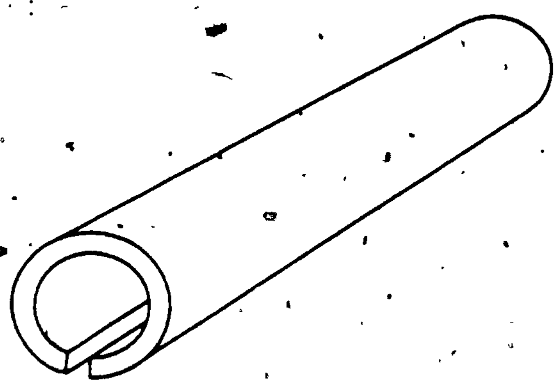

Figure 3. Rubber insulating line hose.

The lineman should be sure that there is an ample safety factor provided by use of the line hose; that is, the voltage rating of the hose should exceed the voltage applied to the conductors. The reason for the line hose is to ensure that the lineman does not come in contact with any live current-carrying line, even accidentally.

The rubber insulating line hose should be cleaned and inspected on a regular basis to ensure that it will function as intended if it is ever needed. After washing, the inside of the hose should be inspected for any type of damage that would downgrade its voltage rating, such as cuts, punctures, or corona damage. (Corona damage occurs when the potential of the line exceeds the ionization potential of the air surrounding the conductor and results in the ionized air reacting with the rubber and changing its characteristics.)

RUBBER INSULATING HOODS AND BLANKETS

Insulators on the power poles exhibit exposed conductors, even with the use of the rubber insulating line hose; thus special hoods designed to fit over the pin-type or post-type primary insulators has been developed. These hoods are manufactured from rubber and are designed to fit over the insulators in such a way that they will overlap the line hose.

As with the previously mentioned rubber insulating materials, periodic cleaning, inspection, and testing is a must. Clean and undamaged, the rubber insulating hood can provide the lineman with maximum shielding from the energized conductors when it is used with the other insulating materials.

Electrical equipment and conductors that do not conform to a regular arrangement or form are best covered with a rubber insulated blanket for protection. These blankets, like the other protective equipment, should receive careful treatment. The blankets should be cleaned and inspected on a regular basis, and subjected to both dry and wet conductive tests.

Storage of the rubber insulating blankets is accomplished by rolling them up in canvas and placing them in metal canisters. Because the rubber blanket is not form fitting, it must be held in place by ropes or large wooden clamps when used on the power poles.

Other Insulating Protective Equipment

In addition to the rubber insulating protective equipment mentioned above, protective devices fabricated from high-dielectric plastics are coming into use. These new devices are insulator covers, pole covers, and conductor covers. The plastic insulating equipment presents advantages in chemical stability, resistance to physical damage, and cost; thus they are likely to be used more widely as time progresses.

ACTIVITY 3:

Match the numbered hazardous situation listed in Column A with the appropriate lettered item or items of protective equipment found in Column B.

COLUMN A	COLUMN B
___ 1. A post-type insulator for a live 13,000 volt transmission line.	a. Rubber gloves.
___ 2. A conductor carrying in excess of 7,000 volts hung from a pole.	b. Rubber sleeves.
___ 3. A bank of capacitors mounted on a pole and carrying 13,000 volts.	c. Rubber insulating blankets.
	d. Rubber insulating hoods.
	e. Rubber insulating line hose.

> **OBJECTIVE 4:** Describe pole climbing equipment and how it is used to perform the work on power transmission and distribution lines.

POLE CLIMBING EQUIPMENT

The equipment needed to perform work on power transmission and distribution poles is influenced by the type of pole and the type of work to be performed. Generally, the worker always needs a leather or fabric body belt and a pylon or leather safety strap. In addition to these two items of equipment, the worker needs a pair of climbers if the pole is made of wood.

The Body Belt

The body belt consists of a cushion section, a belt section with tongue and buckle ends, a tool saddle and D-ring belts attached firmly to a D-ring saddle. Attached to the body belt, a holster is normally used for carrying a pair of lineman pliers, a pair of channel lock pliers, a wooden ruler, a screwdriver, and a fold up skinning knife. The body belt is provided with tool loops to carry additional tools, such as a hammer, crescent wrenches, etc. No tool loop should be within two inches of either side of the center in the back (in accordance with the Edison Electric Institute specifications for lineman climbing equipment, AP-2-2957).

Figure 4. Lineman with protective equipment.

Figure 4 shows a lineman outfitted with a body belt and safety strap for working on a transmission line.

The Safety Strap

Safety straps provide body-support for linemen while their hands are busy performing required tasks. While up a pole, tower, or on a platform, the lineman obviously needs a strap that has sufficient strength and ease of use. Safety straps should be treated with leather cleaners and preservatives periodically.

The safety strap is designed with safety snap hooks on each end and a buckle in the strap to provide a means of adjustment. The safety strap must be adjustable to allow for the different sizes of poles as well as for the different sizes of lineman.

The safety snap hoods at each end of the strap are connected to the body belt via D-rings as shown in Figure 4. When climbing a pole under normal conditions, both snaps should be engaged in the same D-ring. To secure the lineman and free his or her arms, one end of the safety strap is disconnected, passed around the pole or structural member, and connected to the D-ring on the other side of the safety belt.

Remember to use your safety strap when you are stopped to perform work. When using the safety strap, a few steps should be remembered:

1. Both climber gaffs should be placed firmly in the pole at or near the same level.
2. Keep knees and hips away from the pole so that the alignment of the gaffs with respect to the pole is correct.
3. Be sure that both snap keepers face outward and that the strap lies flat without twists against the pole.
4. Be sure to perform a visual check on the safety strap whenever you have had to change its position or unsnap and resnap it. Don't trust your weight to testing the security of the hookup, you might be betting your life.
5. Keep plier pockets and other objects well clear of the D-rings to avoid accidentally hooking the safety belt to them. There should be a minimum of four inches of clearances between D-rings and tool pockets, and there should be no wire hooks used on body belts.

The Climber

Climbers, shown in Figure 5, are used for ascension, descension, and the maintenance of the working position on poles when no other means of support is available. The condition, length, and shape of the gaffs of the climbers are of great importance. They must be kept sharpened and shaped. The gaffs are the essential working part of the climbers that make contact with the pole.

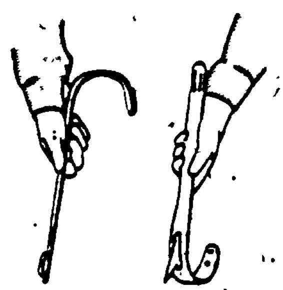

Figure 5. Climbers.

Figure 6 shows climbers attached to the legs of a lineman. Climbers are made in adjustable or fixed lengths from 14 to 20 inches in steps of 1/2 inch. Proper fit requires the leg iron to reach about 1/2 inch below the inside prominence of the knee joint.

Straps are used to secure the climbers to worker's leg as shown in Figure 6. These straps should be drawn to a snug fit. High top shoes with heavy soles and heels are recommended for use with climbers. It is important that the buckle on the foot strap lie just outside the shoe lacing. All leg and foot strap ends should be snugged down in their keepers after buckling, and the strap ends should point to the rear and the outside.

Figure 6. Climbers properly fit.

CLIMBING ACCIDENTS

Climbing and working at elevated distances off the ground is hazardous and presents many opportunities for an unwary worker to be injured or killed. Following are a few case histories of climbing accidents.

Case 1

A lineman had asended a distribution pole, performed the needed tasks, and was descending when his climber gaff cut out (failure of gaff to hold in wood). The lineman fell ten feet to the ground and broke the ankle of one foot. The surface of the distribution pole was badly checked and scarred with deep gaff cuts from previous climbers.

Case 2

A lineman helped fellow crew members to lay a hoist cable to be used in raising a new transformer up the pole; the cable was heavily greased. Without changing gloves, the lineman then proceeded to climb the distribution pole; he had reached the 15 foot level when he fell. The lineman suffered a broken leg and dislocated hip.

Case 3

A lineman had climbed 18 feet up a power distribution pole when she cut out and fell, breaking her right leg and several bones in her right arm. Upon inspection of her climbers, it was found that the gaffs had been sharpened into the shape of a duckbill, and there were several wood splinters wedged under the gaff.

Case 4

The day had been extremely hot and the lineman had already climbed more poles that day than had any lineman on any previous day for that utility company. The lineman had been checking transformer nameplates for the previous two weeks and had kept a record of the number of poles climbed each day. As he was descending this last pole, his left gaff cut out and he fell 20 feet fracturing several bones in his left foot and leg while seriously injuring his back and left shoulder.

CLIMBING

Each of these climbing accidents on the preceding page were avoidable, as are most accidents. There are some definite lessons to be learned from reading these cases; they can be summed up by these common sense rules:

1. Arms and hands should be properly covered with long sleeve shirts and long gauntlet gloves when climbing.

2. Gloves used for climbing should be in good repair and clean of any slippery material.

3. The gaffs of the climbers should be sharpened to the correct shape and length for their intended use.

4. All safety belts, climber straps, hard hats, and gloves should be worn properly and to their proper degree of snugness.

5. Before ascending a pole, a lineman should inspect it very carefully for any unsafe conditions, including -

   - Excessive rake (leans).
   - Rotted places.
   - Nails, tacks, cracks, knots, or foreign attachments, such as signs, pole steps, notices, or ice.
   - Surface of pole in poor condition, excessively damaged.

Remove rocks or other objects from the ground at the base of the pole. All unauthorized attachments such as signs, radio aerials, clotheslines, etc. should be reported to the worker's supervisor or removed if company policy permits.

Inspect the pole as you are ascending or descending to avoid placement of a gaff in cracks, knots, woodpecker holes, or other rough areas that may cause a fall.

When climbing any pole, it is best to keep the body and arms relaxed with the hip, shoulders, and knees a comfortable distance from the pole. Climb easily, taking short steps (step length should be natural for each worker). Use your legs to climb, do not pull yourself up with your arms. Use your arms and hands for maintaining your balance only. As you climb, be sure that one gaff is securely placed and holding before moving the other gaff or releasing a handhold.

The great majority of accidents to linemen could be avoided through inspection of equipment and job site conditions, use of proper procedures in climbing, adequate maintenance of equipment, and careful prior consideration about what the job entails.

ACTIVITY 4:

Read each of the following accident examples. Identify which ones of the five headings the accident could be classed under; then underline the major factor given for causing the accident; list at least one unstated fact that could have contributed to the accident.

CONDITION OF POLES • CONDITIONS ON POLES • CLOTHING • CLIMBING PRACTICES • CLIMBERS •

1. A lineman was climbing a 40 foot cedar pole which was stepped nearly all the way up. She said she was climbing as was customary on a stepped pole; that is she used the steps for handholds and placed her gaffs between the pole steps. She guessed that she cut out at a time when she was reaching for a new handhold with her right hand and fell 15 feet to the ground. ______________

____

____

2. A lineman rearranging dead ends on a pole unfastened his safety belt to swing around to the other side of the pole. When he had almost reached his new working position, his right climber gaff apparently cut out and he fell. He struck the ground on his neck, shoulders, and back, suffering a broken neck and left shoulder blade, fractured ribs, punctured lungs, internal hemorrhages, and many other bruises. He died a few minutes after the accident. The gaff of one climber was found to be loose; otherwise his equipment was in good condition. ______________

____

3. A lineman's gaff struck a knot in a chestnut pole as he was climbing and he cut out and fell 12 feet. He injured his right leg so severely that he may have a permanent disablement.

____

____

OBJECTIVE 5: Outline the proper safety steps for erecting power transmission lines.

The erection and setting of power transmission poles requires many steps, each of which involves specific safety considerations. After the location of each pole is determined, digging takes place; then the pole has to be raised, placed into position, set, and guyed. Finally, the wires and other components are added.

DIGGING POLE HOLES

At one time most pole holes were dug by hand with the aid of a shovel, digging bar, and spoon shovel. Today most pole holes are dug by machine. Regardless of how the holes are dug, several safety considerations are associated with the task:

- The area to be dug should be checked out ahead of time for the possibility of buried telephone cables, gas lines, water or sewer lines, etc.
- Proper pole depth should be decided upon to ensure that there is sufficient holding. The pole setting formula is: 10% of pole length + 2 feet, not to equal less than 5 feet.
- Pole diameter should be sufficient to allow tamping of soil around pole once it is sitting in the hole.
- A pole hole should be clearly marked and barricaded if it must remain empty overnight.

RAISING POLES

Electrical power transmission and distribution poles are heavy and can present a definite hazard to those who have the task of raising them. The hazard is too great to be overcome merely by wearing a hard hat. Poles maybe raised manually, a process known as piking, or by use of a crane, helicopter, or other mechanical means.

The first prerequisite to raising a pole is to be sure that there are enough workers present to do the job. Table 2 shows the average crew size needed to raise poles according to different pole lengths.

TABLE 2. AVERAGE CREW SIZE FOR PIKING A POLE.

Pole Length in Feet	Size of Crew	No. of Pikers	No. of Jennymen	No. of Workers at Butt
25	5	3	1	1
30	6	4	1	1
35	7	5	1	1
40	8	6	1	1
45	10	8	1	1
50	10	8	1	1

The piking method of raising a pole consists of using a long, steel-tipped pole to shove the transmission pole up and guide it into the dug hole. Besides the pikers, there is a need of a jennyman or jennymen to move a pole support which holds the pole in a cradle and keeps it from falling should a pike come loose or break. In addition to the pikers and the jennymen, a person or persons are stationed at the bottom (butt) end of the pole. The workers use a special tool called a "cant hook" to keep the pole from rolling and to turn the pole if necessary.

The pole may be raised by use of machinery, ranging from a simple block and tackle arrangement to a helicopter. The important safety items to remember in each of these methods are as follows:

1. All vital equipment, any equipment which must bear weight, should be inspected to ensure that it is in good condition and that it works properly and has the proper amount of lubrication.

2. Everyone involved in the task should have a clear picture of what hazards exist and what their particular responsibility is in the operation.
3. No one should be located in an area where a falling pole or piece of equipment could land.
4. Once the operation begins, everyone at the site should stay aware of what is going on.

SETTING THE POLE

Once the pole has been raised, it is important to make sure that it stays erect. Important factors such as soil composition, depth of hole, and the stresses exerted on the pole must be considered in accomplishing the task of setting the pole. Each circumstance will be different; thus no set rules of safety can be given for this operation beyond these general rules:

1. Keep your eyes and ears open and your mind on the job.
2. Be sure that you know your role in the task and have identified all potential hazards.
3. Watch out for your fellow workers as well as for yourself, their safety could affect yours.
4. Do not take unproven short cuts.

GUYING POLES

Guys are either push braces or wire guys. A push brace is a pole set to push against the principal pole to oppose any unbalanced stress placed on the pole by conditions of use. A wire guy pulls to balance the stresses on the power transmission pole.

The important safety considerations in guying a power pole are as follows:

1. Be sure to wear all proper safety equipment - hard hats, gloves, good shoes, etc.
2. Inspect the job and the materials involved to eliminate any unexpected and potential equipment or material failures that could endanger you.
3. Maintain proper clearances of metal wire guys to current-carrying power lines.
4. Follow the correct procedures and practices involved in setting a guy.
5. Use insulators where necessary.

6. If an anchor must be used, be sure the proper one is used and is properly installed.

7. Do not overstress guy wires.

ACTIVITY 5:

1. A main precaution required with the erection of power poles is -
   a. Coordinating efforts of other workers.
   b. Measuring pole diameter.
   c. Calibrating the length of guy wires.
   d. None of the above.

2. The piking method of raising a pole consists of -
   a. Using a jennyman to shove the pole into the pole hole.
   b. Using a long steel-tipped pole to push up and guide the pole into the pole hole.
   c. Stationing a special cradle at the butt end of the pole keeps it from moving.
   d. None of the above.

OBJECTIVE 6: Describe the live-line and hand tool requirements, inspections, and precautions that need to be taken when working with power lines.

Maintenance of power transmission lines is conducted while lines are energized more routinely today than in the past. The tendency to work on lines while they are carrying current is due to the desire to reduce the number of service interruptions.

The tasks handled under live line conditions may range from replacing insulators to replacing entire poles or the crossarms on poles. The work may involve the splicing of conductors, removing or adding slack in a line, or connecting a new line to an existing one. Often components such as vibration dampers or armor rods must be installed without power being shut off from the lines. The lineman is able to perform these tasks safely and efficiently due to the development of special tools and procedures throughout the power industry.

The tools used in working on live-lines must meet three general requirements to ensure safety:

- They must be non-conductive.
- They must have sufficient structural strength to perform their intended function.
- By virtue of their design, these tools should not pose any additional hazard to the user or fellow workers.

Generally, the live-line tools have fiberglass or wood handles and metal working parts where the structural strength of metal is needed. The non-conductive parts of the tools (the wood and fiberglass) must be kept clean, dry, and in good repair so that they remain non-conductive. Particular care should be given to the wood-handled tools; scratches and cuts into the surface of the wood can be the sources of moisture and dirt buildup that can result in the formation of conductive pathways through the handle. Should any non-conductive part become cracked, it should be replaced. Do not attempt to repair any wooden or fiberglass handle with tape. In addition to the non-conductive parts of the live-line tools, the worker should be sure to inspect any metal working parts of the tools for excessive wear or damage before use, and to lubricate when needed.

Each task perfomed on a live-line is different each time it is performed because of changes in location, voltage, conductor sizes, weather, or many other factors. Because each situation is unique, the first step in performing any task on a live-line is to inspect the situation and get a clear picture of what the problem is, what tools will be needed and in what order, and what special circumstances may present a hazard in performing the task. Once each worker has gotten a clear mental picture of the job, everyone involved must understand clearly what portion of the job is his or her responsibility and what relationship that portion has to the whole job. A clear plan of action must be identified and followed. One step out of sequence or the wrong use of a tool could cause injury or loss of life when one is dealing with the high voltages of transmission lines.

The differing high voltages create special problems for the lineman, who must adjust planning and procedures to accommodate the differences. Sufficient clearance must be maintained between conductors and conductive pathways (such as other conductors, metal structural parts, trees, buildings, people). Table 3 shows the effect of voltage on minimum clearances.

TABLE 3. CLEARANCE REQUIRED FOR SPECIFIED VOLTAGES.

Line Voltage, Volts	Minimum Clearance	Line Voltage, Volts	Minimum Clearance
2,100 to 15,000	2 ft 0 in	161,000 to 169,000	3 ft 8 in
15,100 to 35,000	2 ft 4 in	230,000 to 242,000	5 ft 0 in
35,000 to 46,000	2 ft 6 in	345,000 to 362,000	7 ft 0 in
46,100 to 72,500	3 ft 0 in	500,000 to 552,000	11 ft 0 in
72,600 to 121,000	3 ft 4 in	700,000 to 765,000	15 ft 0 in
138,000 to 145,000	3 ft 6 in		

A good general rule to follow concerning clearances and live conductors is given here: If a live conductor is within reach of a workman, it is too close.

The specifics of tools, procedures, and tasks involved in transmission line work are very complicated and require a greater depth of knowledge than can be addressed here. The tasks of working with live-lines present many hazards of great magnitude, but they can be accomplished with safety by those who have received special training and who are properly equipped and experienced in the use of the special tools needed.

ACTIVITY 6:

Place the following list of procedures in the order that affords the greatest security for anyone performing any live-line task.

___ a. Climb the pole.

___ b. Clean and stow away gear and tools.

___ c. Inspect the location of the job.

___ d. Perform your portion of the job with the proper tools and methods.

___ e. Lay out a clear plan of action with any fellow workers.

___ f. Identify tool and equipment requirements.

___ g. Descend from pool.

___ h. Inspect, clean, dry, lubricate working parts, and prepare all tools that will be necessary for the completion of the job.

___ i. Tape the handles of any cracked or broken live-line tools.

OBJECTIVE 7: Cite the types of tests and inspections to be performed on mechanical equipment such as aerial lifts, derrick trucks, and cranes before they are used.

Hydraulic and electrically powered equipment is often used for lifting and moving equipment at cites of transmission line construction. Each different type and model of lifting equipment has its own special operating considerations with which the operator must be familiar. However, some general safety considerations apply to all types and kinds of equipment.

Prior to use, the equipment should be inspected to see that the machine is properly lubricated, and that brakes, clutch, and controls function correctly. All load bearing parts should be visually inspected for possible damage and wear. When possible, all lifting machinery should be tested with load prior to accomplishing the task. The crane, derrick truck, or aerial lift must not be operated beyond its particular designed load limit, known as the "rated load." Loads should never be suspended over workers, regardless of how safe the hoisting equipment is considered to be.

Wire ropes or fiber ropes should be inspected for wear and condition. No rope showing broken strands or a noticeable degree of unwrap should be used. Wire ropes showing rust should be replaced. Safety factors for wire ropes are not to be exceeded. Any wire rope that is used as part of a hoisting apparatus is part of the lifting machine and should be kept lubricated. A chain used as part of hoisting apparatus is no stronger than its weakest link. Thus, chains should be inspected link by link on a frequent basis and discarded when signs of wear or damage appear. Slings should be inspected carefully for wear and damage and removed from service if fittings are loose. Any hook used with lifting chains, wire ropes, etc., should have a latch or other device to prevent the link from slipping and allowing the load to fall.

If the equipment is of hydraulic nature, all hoses, fittings, gaskets, and cylinders should be carefully inspected for fluid leaks. Any leak should be considered a danger sign and appropriate action taken to repair the difficulty. Reservoirs should be kept at their proper levels and pumps should be inspected and tested to ensure proper operation. The fluid used should be checked periodically for moisture or contaminants and only the type of fluid designated by the manufacturer should be used in the device.

Electrical equipment should be checked for loose connections at switches and terminals so that there can be no untimely failure of equipment due to loss of current. Power sources (batteries or generators) should be checked for proper maintenance.

Inspect the job site area carefully and position the truck on solid and level ground so that the unit is within easy reach of the job, but allow room for safe rotation and overhead operation.

Aerial devices should be operated from the hoist controls on the truck platform prior to use of the aerial basket. These devices should be operated through one complete cycle to ensure that the ground operator could retrieve the worker in the basket if the controls in the basket should fail. Maintain proper clearances from energized lines in operating the lifting devices. No individual working at the site should be in contact with the ground and any part of the lift at the same time. Any unusual noise or improper operation on any unit should be reported immediately to to persons responsible for maintenance of the equipment.

ACTIVITY 7:

Mark each statement True or False.

___ 1. A wire rope which shows evidence of rust is safe to use, as long as no broken strands are evident.

___ 2. A chain is as strong as its strongest link.

___ 3. Lubrication schedules for all hoisting machinery are advisable.

___ 4. A winch on a derrick truck has picked up a new sound, but the winch was inspected last week so it's nothing to worry about.

___ 5. A sling used to lift poles has been used for 15 years and its attachment eyelets are well worn; therefore, it should be replaced.

OBJECTIVE 8: List the types of medical and first aid precautions associated with power transmission work and the priority of action in aiding an injured worker.

The hazardous nature of the lineman's job makes a knowledge of first aid procedures especially important for persons in this occupation. This module is not intended to provide instruction in first aid or other life-saving procedures but is meant to inform you about what kind of first aid training is important for electrical power transmission workers.

The falling hazard associated with electrical transmission work calls for workers to know first aid procedures for cuts, burns, abrasions, broken bones, as well as for the shock that can occur with such injuries.

The more unique threat to the electrical transmission worker is electrical shock. Table 4 illustrates the dangers presented by different levels of current.

TABLE 4. EFFECTS OF 60 HERTZ A.C.

0.001 ampere - The shock is barely felt. The major hazard is high probability that the person will make a sudden, involuntary movement that will cause him or her to fall or to come into contact with something more hazardous.

0.002 to 0.025 amperes - Muscles will be paralyzed if the current path is through the body. With muscle control paralyzed, a person will be unable to break contact. Men's muscles become paralyzed at a minimum current of 0.009 amperes, and women's muscles become paralyzed at a minimum current of 0.006 amperes on the average.

0.025 to 0.075 amperes - The electrical shock can be very painful, and severe muscular contractions can occur that are strong enough to break bones. Prolonged contact will produce unconsciousness and death in approximately three minutes if paralysis of respiratory muscles occurs.

0.075 to 0.3 amperes - Death is a near certainty if exposure to this level of current extends to longer than one-quarter of a second.

2.5 amperes or greater - The heartbeat of a person exposed to this level of current will stop immediately, with severe tissue damage a certainty.

Because of the hazards presented by electrical shock, it is strongly recommended that linemen learn the correct methods of Cardiopulmonary Resusitation (CPR). Classes in CPR and first aid are conducted nationwide by the American Red Cross.

In case of electrical shock, there are certain steps that should be followed to maximize the victim's chance of survival; these are -

1. Separate the victim from the source of current. This is done by pulling either the victim or the source of current away with an insulated item, which ensures that the rescuer will not receive the same shock.
2. Check the victim for breathing.
3. Perform the ABCs of life support -
   - A - Open Airway.
   - B - Assist with Breathing.
   - C - Restore Circulation.

The faster these steps are performed, the greater the victim's chance of surviving. While one or two individuals are performing the above tasks, another person should be contacting professional help for aid. The above steps could well take place up a power pole; if so, at some point it will become necessary to get the victim to the ground to continue lifesaving efforts or to get the victim to professional help. Therefore, each lineman should receive training in methods of pole top rescue; ask about such training.

ACTIVITY 8:

Order the following list of actions taken in the instance of a person receiving an electric shock.

___ 1. Perform CPR.

___ 2. Open airway.

___ 3. Separate injured person from source of current.

___ 4. Check injured for breathing.

___ 5. Assist injured person with breathing.

OBJECTIVE 9: List the major hazards and recommended precautions for working with underground transmission line distribution systems.

For many practical reasons as well as aesthetic ones, more and more electrical power lines are being installed below ground. The installation of these power distribution lines presents an entirely new set of hazards and methods of combatting these hazards for those involved in performing construction and maintenance.

Figure 7 shows the preferred layout for underground cables and lines, consisting of conduit linking a series of pits that provide access through manholes.

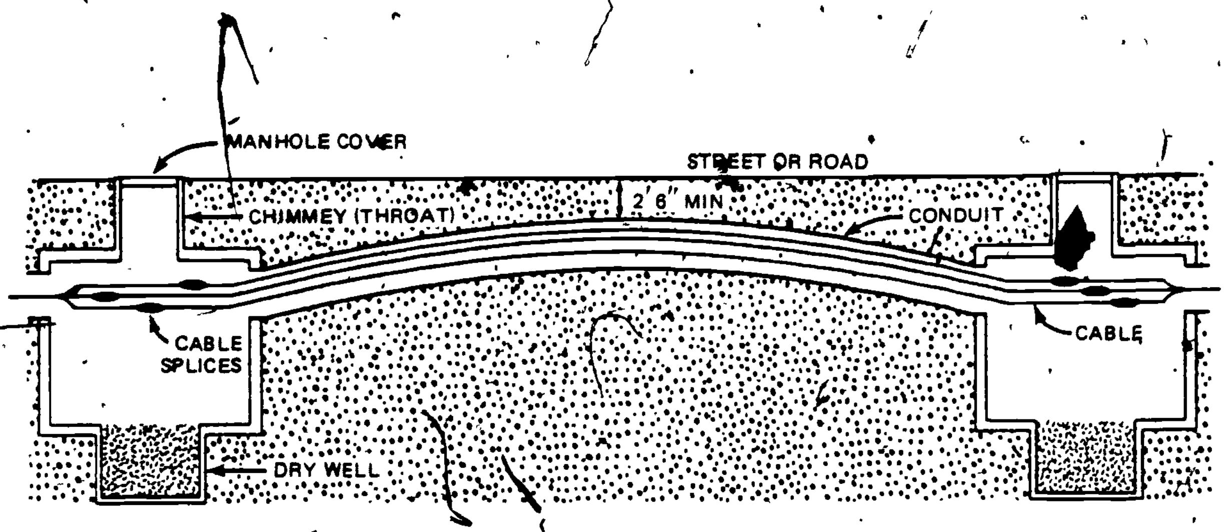

Figure 7. Recommended grading of a conduit between manholes.

The grading of the conduits is to ensure that any moisture seeping into the conduit does not pool at some point inaccessible to workers, but collects at the manholes. Thus, the manholes can be pumped out.

With respect to safety the construction of underground lines presents special problems for the worker involved. The path along which the lines are to be buried may cross buried telephone, water, gas, sewer, or other power lines. The equipment used to accomplish the work is entirely different than that used for construction of the overhead lines. A great deal of excavation is encountered with the underground power line; thus hazards of cave-ins and heavy equipment hazards are ever present. The best strategies for minimizing the hazards encountered are to remain alert, inspect the job, coordinate your efforts with fellow crew members, and be sure that all equipment and tools are in good condition.

The hazards presented in maintenance of the underground lines include not only the hazards of electrical shock and mechanical hazards of sharp and heavy objects but some additional hazards unique to underground work. The manholes are small, dimly-lit, confined spaces. They can contain sharp-edged protrusions, water, flammable or toxic gases, and animal pests.

The manhole is normally the location of splice points in transmission lines and a certain amount of organization is necessary to accomplish work on the lines. For this reason, the manholes are frequently equipped with racks set into the walls to hold the cables and their splice casings.

Because the manhole and the conduits that carry the power cables are set below ground level, it is possible for water to seep into the system and collect in the manholes. There are various means used to combat this occurrence: a dry well can be installed at the bottom of the manhole; the manhole may be equipped with a connection to storm sewers; or it may be necessary to pump the manhole out with sump pumps periodically.

Toxic and flammable gases are a very serious danger in manholes. A natural gas line could rupture nearby the manhole or conduit and seep fumes into it. Because of extremely poor ventilation in the manhole, accumulations of carbon monoxide or carbon dioxide can develop. Natural biological or geological action can also cause the manhole to receive and maintain a dangerous level of harmful gases.

The animal pests that might be found in a manhole could be anything from spiders to snakes to rodents. Certain spiders do present a danger to individuals, the black widow and brown recluse are two of the most prominent. Linemen should be aware of the types of harmful snakes that may be encountered in their part of the country. Rodents such as the rat, prairie dog, or mice could be encountered. Another animal to beware of meeting in manholes is the skunk.

Common methods for protecting workers from flammable and toxic gases is routine atmospheric testing and the use of portable ventilation equipment. Not only will the portable ventilators aid in exhaustion of toxic gases, but they will also help cool and freshen the close quarters of the manhole. In some cases, portable ventilation may not be adequate and the use of respirators may be necessary.

Not all the hazards to the lineman who must work in or around manholes come from the manhole. A major health hazard to line crews is found above ground on the roads and highways near to the manholes. Many automobile drivers are inattentive to the people who must work near or on the roads and streets and the resulting accidents sometimes result in fatalities or injuries among the unprotected workers. To minimize the dangers posed by traffic, it is essential to place warning signs, barricades, and markers leading up to and around the manholes in which people are working. The barricades, signs, and markers are colored with bright, high visibility colors. Yet accidents still occur. Thus, it is of utmost importance that the workers who are above ground near a manhole stay aware of the traffic in the area.

ACTIVITY 9:

List all those hazards that are not obvious and the preventive measures necessary to minimize their threat to those who work with underground transmission systems.

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Pansini, Anthony J. Basic Electrical Power Distribution. Vol. 2. Rochelle Park, NJ: Hayden Book Company, Inc., 1971.

ANSWERS TO ACTIVITIES

ACTIVITY 1

1. c.
2. d.
3. a.

ACTIVITY 2

1. B, C
2. B, D, F
3. A, F
4. B.
5. F

ACTIVITY 3

1. d.
2. e.
3. c.

ACTIVITY 4

1. Major Heading; Climbing Practices
   cut out at a time when was reaching for a new handhold
   Lineman was a fast climber and had not secured foothold or new handhold before going for new foot and handholds.
2. Major Heading; Climbers, and Climbing Practices
   gaff of one climber was found to be loose
   Lineman had not taken care to inspect equipment prior to ascent and did not have secure handhold when safety strap was disconnected.
3. Major Heading; Conditions of Poles
   gaff struck a knot
   Lineman had not examined pole during climb so that he could have avoided hitting the knot.

ACTIVITY 5

1. a.
2. b.

ACTIVITY 6

1. h.
2. c.
3. f.
4. e.
5. a.
6. d.
7. g.
8. b.

ACTIVITY 7

1. False.
2. False.
3. True.

4. False.
5. True.

ACTIVITY 8

1. c.
2. d.
3. b.
4. e.
5. a.

ACTIVITY 9

Traffic Hazards - Erection of signs, markers, and barricades to provide control of traffic flow away from personnel. Awareness on the part of exposed workmen to traffic conditions.

Toxic and Explosive Gases - Do not enter manholes until ventilation for such has been established.

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