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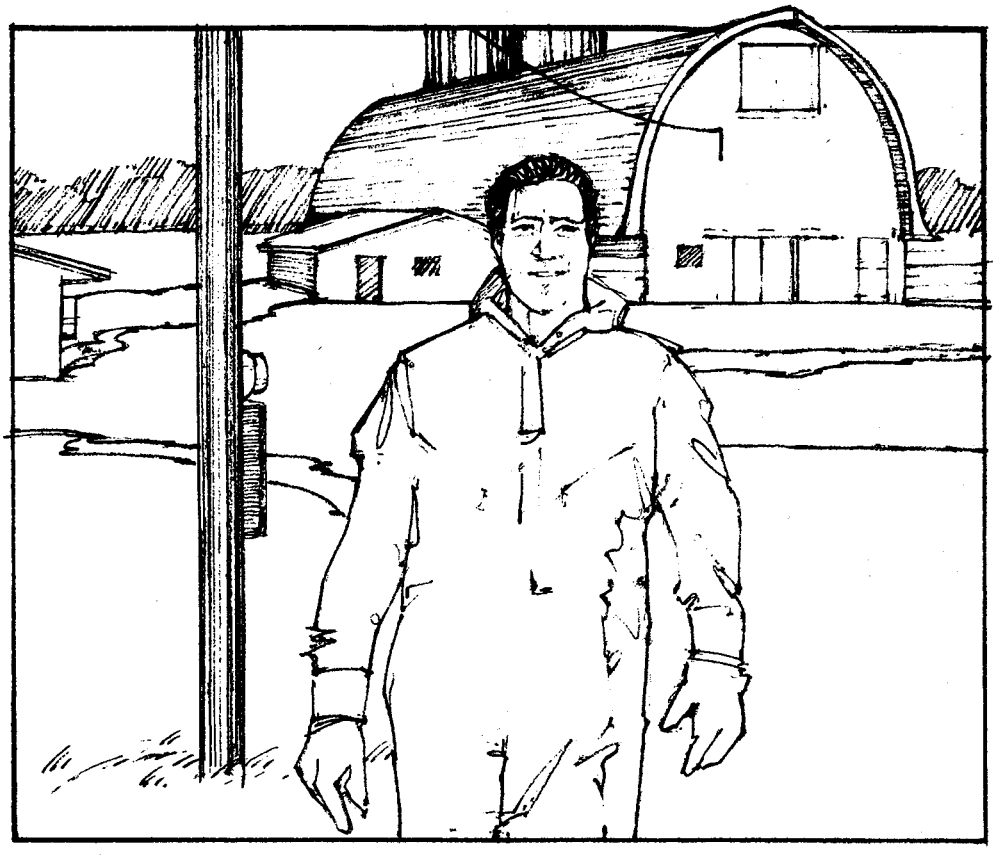
ELECTRICAL SAFETY ON THE FARM



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ELECTRICAL SAFETY ON THE FARM

Electricity is one of the most versatile and widely used forms of energy transfer. Almost every farm relies heavily on it to provide power for automatic, labor-saving equipment. In addition, electricity provides power for other services such as heating, cooling, and lighting.

Many people assume electricity is very complicated and do not attempt to understand the basics of this unique means of energy transfer. But lack of knowledge regarding electrical systems may lead to serious, if not fatal, accidents. Therefore, it is important that you have a basic understanding of electricity and that your system is designed to protect people and property from electrical hazards.

Each year workers suffer injuries and fatalities from electric shock. The National Center for Health Statistics reports approximately 250 fatalities from electric shock each year in industry- and farm-related accidents. In our state, exposure to electric shock involves three to eight fatalities each year on farms.

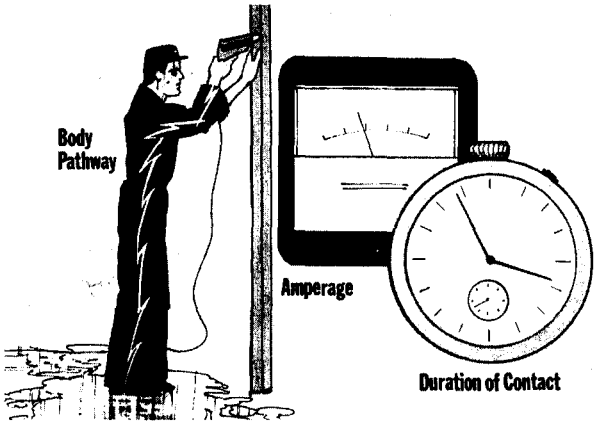
Besides helping avoid personal injury, electrical safety makes good business sense. Livestock losses from electric shock, including lightning, reduce farm income. Fires from electrical sources cause injuries and damage property.

Principles of Electrical Safety

Electrical safety can be divided into two categories: protection of people from shock or burns and protection of the electrical system and equipment from damage due to high current levels and surge voltages.

Understanding the basic principles of electricity can help you appreciate the importance of electrical safety. Voltage, current, and resistance are commonly used electrical terms. Voltage, measured in volts, is the pressure or force pushing current, measured in amps, through a circuit. Opposition to current flow is called resistance and is measured in ohms.

Standards as presented in the National Electric Code (NEC) provide for safety. If you maintain your equipment properly and practice safe work habits, you can have an essentially hazard-free installation. The Code sets minimal standards, however. In many instances, it may be wise to use higher standards than those suggested.



Pathway through the body, level of amperage, and length of contact determine shock effect.

Electrical Hazards

Every measure should be taken to prevent exposure to electric shock, which occurs when a person makes contact with any live or energized part and at the same time makes contact with another surface of different potential, such as ground. Current then passes between the points of contact.

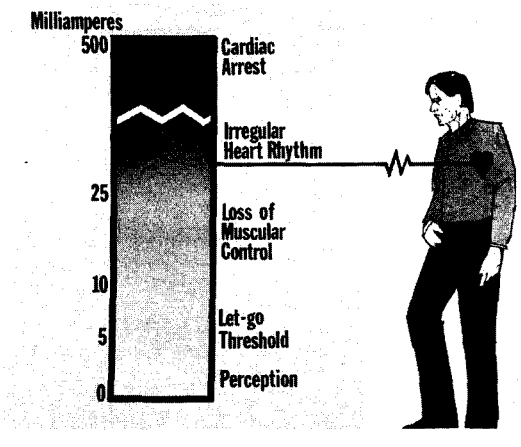
The effect that electric shock has on a person depends on resistance of the pathway through the body, amperage, and duration of contact. Body resistance to current flow is lowered when the skin is damp. This emphasizes the importance of maintaining a dry environment when working with electrical equipment.

The actual pathway through the body determines the seriousness of the shock effect. For example, a small current passing through the heart area can be much more critical than current passing between two fingers of the same hand.

The effect that increasing levels of current have on humans and animals is shown in the graph below. The level of perception at approximately 1 milliamp (mA) will produce a slight stinging feeling. Increasing amounts of current above the let-go threshold (approximately 5 mA) cause loss of muscular control, irregular heart rhythm, and, finally, cardiac arrest. A 60-watt bulb will draw about ½ amp. That is 100 times more current than the 5 mA that can be fatal.

One of the basic factors contributing to shock is the use of unsafe electrical equipment such as improperly grounded equipment, improperly used adapter plugs, faulty insulation, loose connections, defective parts, ground fault present in the equipment, and unguarded live parts.

Another basic factor that contributes to electric shock is unsafe work habits. Examples of this are intentional use of obviously defective and unsafe tools or equipment and failing to lock electrical equipment in the off position so that it will remain deenergized during repair or maintenance.



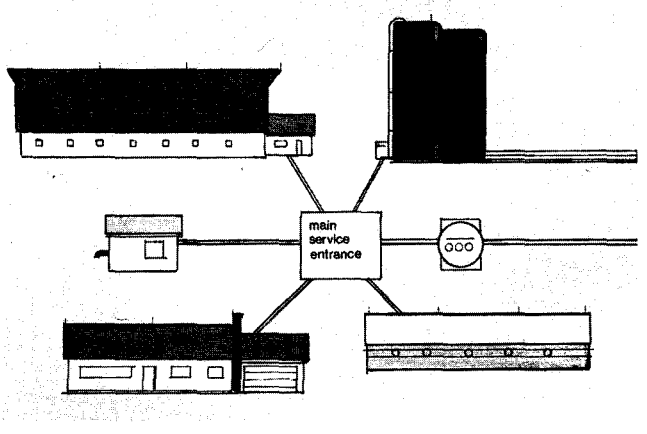
Increasing levels of current above the let-go threshold cause loss of muscular control, irregular heart rhythm, and, finally, cardiac arrest.

Farm Distribution System

Electrical safety on the farm starts with the planning of the electrical distribution system. A sound plan is essential to provide a safe, efficient, and expandable system capable of meeting present and future demand loads. The most common design is a centrally located distribution center supplying 120/240 volt, three-wire, single-phase power. This system starts at the secondary side of the supplier's distribution transformer with a main service drop (a set of conductors) leading to the metering or main distribution center on the farmstead.

A disconnect is recommended at the main service entrance to provide a means of manually shutting off all the power on your farm. The disconnect should be a lock-out switch to assure it remains off during emergency or maintenance work.

Service conductors extend from the main distribution service center to farm buildings. A



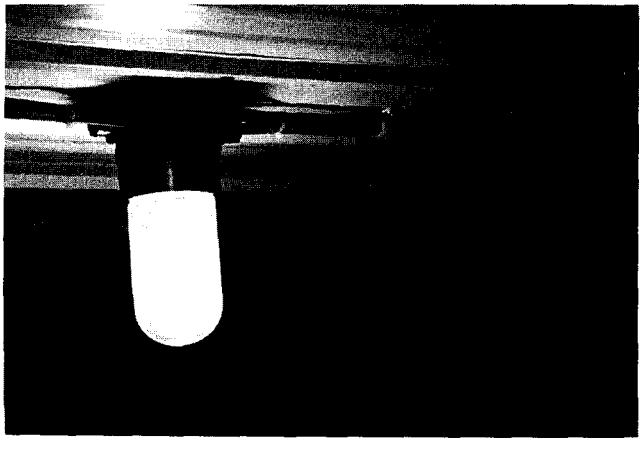
Central metering and distribution are part of a common design for a farmstead.

disconnect must be installed at the point of entrance of service to each building so that power can be shut off at any one building without affecting the total system. No building should be supplied with more than one service.

Service conductors can be installed overhead or underground. Overhead installations (service drops), although easily installed and lower in cost, present potential shock hazards such as downed lines due to storms or contact with augers and other tall equipment passing underneath. Underground installations (service laterals) are becoming more common. They have the advantage of improving the appearance of the farmstead and eliminating the hazards of downed lines and contact with tall equipment.

Determining demand load for each building and the total farmstead is a necessary part of designing a safe electrical system. A demand load calculation procedure suggested by the NEC (Art. 220-40) can be used to anticipate the demand from permanently connected equipment as well as convenience and lighting outlets. The NEC (Art. 220-41) also suggests a system for calculating demand load for the whole farmstead. Knowing your demand load and allowing for future expansion can help avoid overloading the service.

The NEC has special provisions (Art. 547) that apply to certain agricultural buildings—including livestock confinement systems where excessive dust and moisture may accumulate; areas with a corrosive atmosphere, such as in a manure pit; or areas where it is damp, due to cleaning and sanitizing. According to NEC standards, switches and outlets in these buildings must be water- and dust-tight enclosures and made of corrosive-resistant material to minimize entrance of foreign material. Conductors must be nonmetallic and moisture-resistant. Installing the building service entrance panel and disconnect switch cabinet in a dry, dust-free area such as an office, vestibule, entryway, or outside the building will effectively reduce exposure to these problems.



Special requirements for fixtures apply to agricultural buildings.

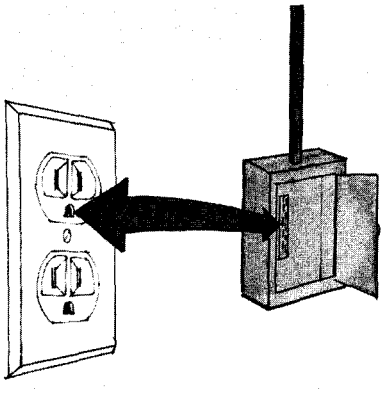
Grounding

Grounding is crucial to safety and must be provided on every electrical system. It reduces the electric shock potential of the entire system by connecting it directly or indirectly to earth. Grounding is divided into two categories: system grounding and equipment grounding.

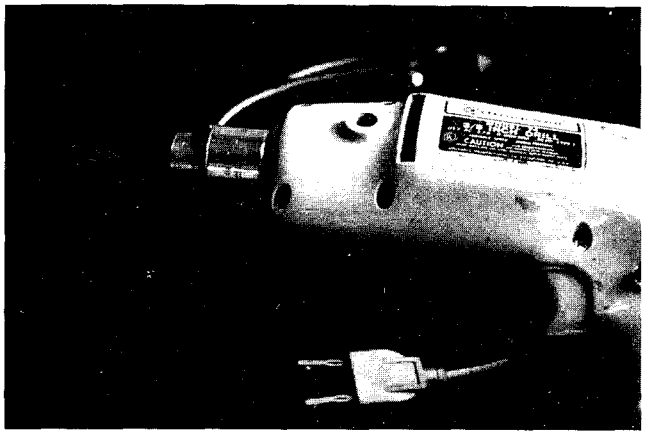
System grounding is accomplished by connecting the main service entrance neutral to a grounding electrode, which can be an all-metal waterpipe or ground rod driven into the earth. This must be done at the service entrance of each building to maintain the integrity of the grounding system.

Equipment grounding is necessary to protect workers against a ground fault. A ground fault, which can cause a fatal shock, occurs when a person comes in contact with an energized or live part of the electrical system that is not grounded. The person may provide a path of low resistance for fault current. The best protection against ground fault entails grounding all equipment and using tools with a three-wire power cord. The third wire, which is green or bare, is the ground wire which connects

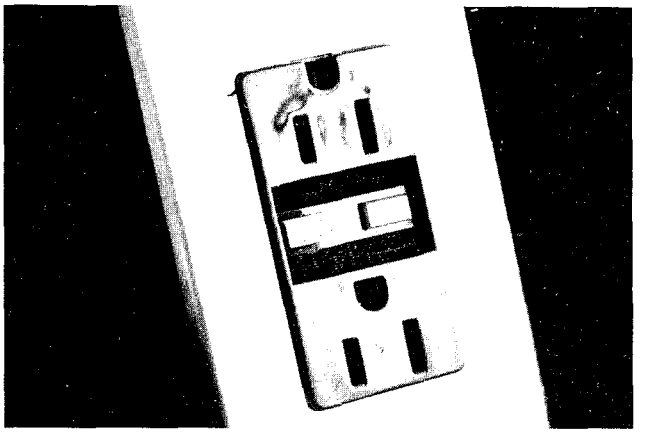
System grounding entails grounding the main service neutral and connecting the neutral wire of all feeder and branch circuits.



Equipment grounding protects workers from ground faults by connecting the third wire to the grounded service neutral.



Double-insulated tools protect workers from ground faults.



GFCIs protect workers by tripping off power at current leakage levels above 5 mA.

the equipment to the system ground and provides a low resistance for current in case a fault occurs.

Protection against ground faults also can be accomplished by using double-insulated hand tools, which have two separate insulation systems to reduce the risk of shock. This system is not considered as safe as the third-wire grounding method because the insulation can fail if it becomes wet.

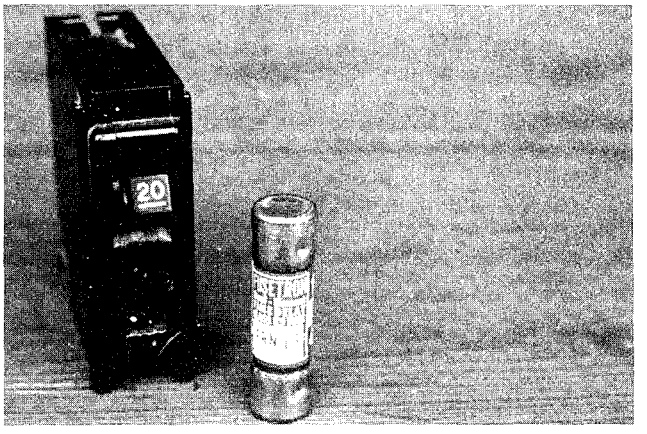
A third method of protection against ground fault is through the use of ground fault circuit interrupters (GFCIs), which will detect low levels of leaking current and trip or cut-off power at a leakage level of greater than 5 mA. There are three types of GFCIs available on the market today. One type is built into the system circuit breaker. A second type replaces the standard receptacle, and a third type is portable and plugs into any standard receptacle.

System Protection and Maintenance

Safeguard your electrical system against excessive levels of current by installing fuses and circuit breakers. They will open the circuit at predetermined levels and protect the system. Remember, fuses and circuit breakers, which pass high levels of current, do not directly protect against shock.

A surge arrester is another device designed to protect the system and equipment from high voltages of short duration, such as lightning strikes, by discharging or bypassing the current to ground.

Routine maintenance of electrical equipment and devices can reduce risk of shock and downtime. Parts become defective through age, abuse, neglect, and adverse conditions such as dust, dampness, and corrosive atmospheres. Visually check the components of your electrical system at regular intervals to be sure broken equipment, missing cover plates, loose connections, and other defects are repaired or replaced. Keeping the components clean



Fuses and circuit breakers protect the system from excessive levels of current.

is essential to a good maintenance program. Make sure the power is off before working on the equipment.

Updating your electrical system can reduce the chance of a shock to you, your co-workers, or family members. If you still have two-slot outlets or plan to enlarge your farm operation by adding new equipment or buildings, now may be a good time to have a qualified electrician survey and update your total electrical system.

Standby Power

Standby and portable power units, considered essential on many farms, can be dangerous if not installed properly. The NEC requires that transfer equipment be designed and installed to prevent any possible interconnection of the normal and standby power sources when the standby unit is providing emergency power. A double pole/double throw switch meets this requirement and will protect servicepeople working on the line as well as protecting the standby unit. Shield all rotating parts on the generator and ground the generator.

If the standby power unit is located in a room, provide proper ventilation; wear hearing protection; provide ABC, all-purpose, dry chemical fire extinguishers; and post operating instructions nearby.

If you use a portable generator to provide power in a remote location on the farm, the generator should be grounded by using a temporary ground rod. Grounding the generator in conjunction with equipment grounding can protect you from shock, if you are working in a damp location.

Common Shock Hazards on the Farm

Typically, farm workers are exposed to more potential electrical hazards than are people who work in other industries. The farm has a large number of electrically-powered pieces of equipment and power tools. Farm workers are alone a great deal of the time while operating equipment and performing repair and installation jobs. Also, the work environment can be damp and dusty.

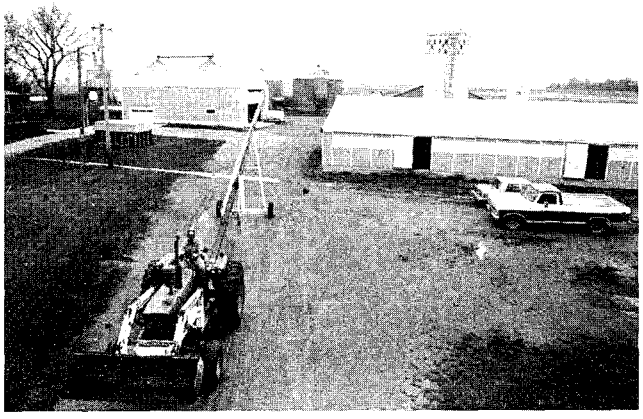
One of the most frequent causes of death by electrocution on the farm involves the use of portable power tools. Make sure you buy only Underwriter's Laboratory (UL) listed equipment and tools. This label means the equipment has gone through extensive testing and that you are buying a safe product. Older model tools with a two-wire power cord are not properly grounded. If the tool cannot be grounded with a third wire, discard it rather than risk exposure to shock.

Overhead electrical lines also are involved in numerous fatal accidents each year. When you drive under lines, make sure grain augers and other pieces of tall equipment are in the lowered position to provide safe clearance. If you make contact or a line is broken, you can save yourself and others by knowing what to do. Stay on the tractor or truck unless you can jump clear of the wire. You could be electrocuted if you touch anything in contact with the line. Do not let others come near. Shut off the main farm power supply or call the power supplier for help.

Pruning trees, stacking hay, and installing antennas too near electrical lines are other activities that lead to fatalities.

Motors that power feed augers, conveyors, and other equipment may lack proper grounding. When a ground fault develops in the motor, current is conducted to the frame and anyone making contact with the frame while standing in a damp or wet area can receive a fatal shock. Have your motors that power equipment checked for grounding by a qualified electrician.

Metal ladders are used for many maintenance jobs on the farm, but because they conduct electricity, you are risking the chance of a fatal shock when working near electrical power. Use a dry, wooden ladder when working with electricity, and



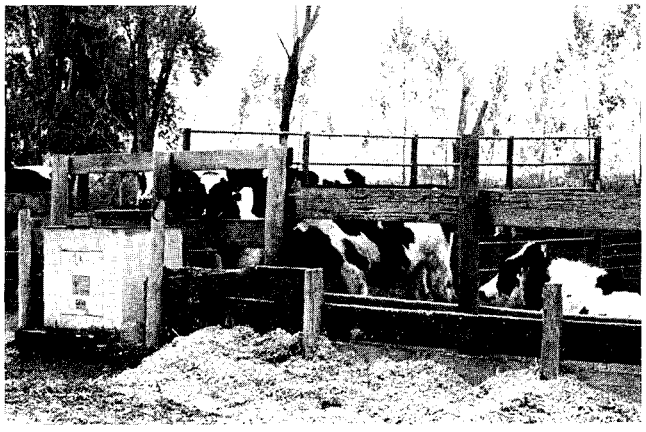
Make sure tall pieces of equipment can pass safely under electrical lines.

be sure the power source has been shut off and locked in the off position before you start working.

Farms utilizing irrigation systems pose shock risks due to the presence of high voltage and current in a wet environment. To provide a safe work place, it is important that the integrity of the grounding system be maintained. The main electrical disconnect should be a fused safety switch, not a circuit breaker, since circuit breakers are infrequently used and may not operate properly because of dust and moisture. Make sure all drive shafts and pulleys at the pumping station are shielded. Alert your workers to the dangers of contacting overhead electrical lines with irrigation pipe. Be particularly alert to the location of distribution and service lines during the operation and servicing of equipment.

Electric controllers used for fencing and cow trainers should bear the UL label. Controllers for fencing should be separately grounded and located in a clean, dry, and protected location outside and away from any farm building to reduce the chance of lightning striking and damaging the building or electrical system.

Electrically heated livestock waterers must be grounded to avoid potential shock. The equipment



Grounding conductors for electrically heated waterers must be securely bonded to provide a low resistance path to ground.

grounding conductor to the waterer must be securely bonded to provide a low resistance path to ground.

Lightning Protection

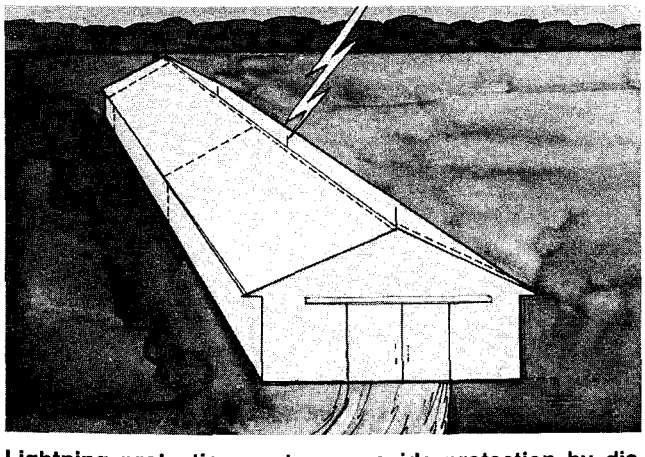
Lightning, another form of electricity, is one of nature's most destructive forces. Its ability to travel long distances with high voltages and amperages provides its destructive power.

Lightning protective systems are designed to provide ready-made paths of low resistance to ground. Lightning strikes to protected buildings are discharged to ground safely. The system consists of air terminals (also called points), conductors and grounding rods. Copper and aluminum can be used for the air points and conductors. The grounding rod must be of copper, copper-clad steel, galvanized steel, or stainless steel.

In most soils, the ground rod is driven at least 10 feet into the ground. In lighter, sandy soils, two or three ground rods, connected in parallel, are driven about 6 feet apart and at least 10 feet deep.

When aluminum conductors are used, a special bimetallic connector is required. Because aluminum corrodes in contact with soil, make the connection at least 1 foot above ground level to the copper conductor leading to the ground rod. Periodically, inspect the system for loose, broken, or corroded connections. Remember, a bad connection means no protection.

If you are caught outside in an electrical storm, get down in a low area. Stay off machinery and away from hills and trees.



Lightning protection systems provide protection by discharging lightning strikes safely to ground.

A surge arrester protects the electrical system and equipment. High voltages of short duration, such as lightning strikes, are discharged or bypassed to the grounding system. Install surge arresters on the buildings' incoming service entrance lines or panel. If computerized or solid state equipment is present, additional low voltage surge protection may be necessary.

Have qualified personnel listed with UL or the Lightning Protection Institute (LPI) install your system.

During an electrical storm stay indoors. If you are caught outdoors, get down in a ditch or low area. Staying off farm machinery and away from hills, trees, fences, or sheds could save your life.

Emergency Procedures

Emergency first-aid after exposure to electric shock can save a victim's life. Avoid having a second accident by keeping others away. The main power source should be turned off—only then can the victim be moved—and someone should call for additional help.

Shock victims may suffer heart fibrillation, which is failure of the heart muscles. Administer artificial respiration if needed. You generally have 4 to 6 minutes to restore heart action and breathing before irreversible brain damage occurs. Burn victims should receive medical attention immediately. Contact your local Red Cross chapter, hospital, or police or fire department for available training in emergency first-aid.

The ABC, all-purpose, dry chemical fire extinguisher is recommended for electrical fires. The powder is nonconductive and can be used directly on equipment to smother the fire. Power should be shut off to minimize shock hazards and eliminate any heat source feeding the fire. Do not use water on electrical fires. Water conducts electricity and you may receive a fatal shock.

Summary

You should now have a better understanding of electricity and the seriousness of exposure to shock. By avoiding unsafe equipment and unsafe work habits, you can reduce your risk of shock exposure. Plan and maintain your farm electrical distribution system. Make sure your electrical system and equipment are properly grounded. Have the recommended fire extinguishers available. And be able to provide first-aid, so that if necessary you can save the life of a co-worker or a member of your family.

REFERENCES

National Electric Code (1981)
National Fire Protection Association
Batterymarch Park, Quincy, MA 02269

Federal Register, Vol. 46, No. 11
Department of Labor
Occupational Safety and Health Administration
Electrical Standards (January 16,1981)

Electrical Safety on the Farm and Ranch (1978)
William J. Fletcher, Farm Department
National Safety Council
444 North Michigan Ave.
Chicago, IL 60611

Fundamentals of Electricity for Agriculture (1980)
Robert J. Gustafson, associate professor
University of Minnesota
St. Paul, MN 55108

Agricultural Wiring Handbook (1978)
Agricultural Marketing Division
Edison Electric Institute
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New York, NY 10016

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