Chapter 6

Protective Equipment, Safety, and First Aid

Installing and operating electric generating equipment is hazardous work. Equipment operators and maintenance personnel must understand how protective equipment on the generator set functions. They must use safe work methods and know how to rescue accident victims.

PROTECTIVE EQUIPMENT FOR ELECTRIC CIRCUITS

Generators in military power plants and feeders (auxiliary circuits) are protected from electrical overloads and faults with circuit breakers or fuses. Circuit breakers are preferred in most power plants because they disconnect all phase conductors at once. Fuses protect each phase independently. Thus, a fuse may blow to protect one phase, but the other phases remain energized and cause a phase imbalance.

Circuit Breakers

Circuit breakers are operated by tripping relays, tripping reactors, or thermal elements. Most circuit breakers have thermally operated tripping devices or AC reactor tripping devices plus a relay.

Operators can adjust circuit breakers to trip quickly or slowly. Adjust the breakers to trip quickly to protect against heavy overloads and faults near the power plant and on the station bus (terminal point for all circuits). Adjust for a delayed tripping to protect against light overloads and distant faults. Circuit breakers on feeder lines are adjusted to trip quickly for overloads at or beyond the feeder lines. This allows the circuit breaker for the main line to remain closed when the one for the feeder line opens.

Generator sets in military power plants usually have high internal impedance (resistance to flow of an alternating current) to limit the amount of current that can be obtained from the sets under short-circuited conditions. The maximum amount of current available is approximately

2 1/2 times the full–load amperage rating of the generator. Operators can set circuit breakers for current up to the output rating of the generator. Never set circuit breakers for current higher than the output rating of the generator.

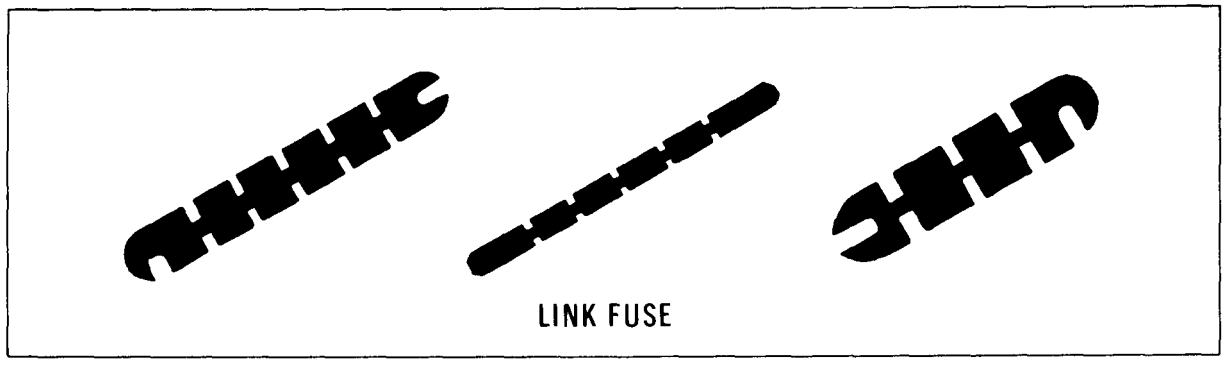
Three–phase, three-wire generator sets require two tripping elements. One element is put into action by two of the three phases. Overcurrent taken from one phase affects one or both of the other phases.

Three-phase, four–wire generator sets require three tripping elements for complete protection. An overload on one phase causes all three phases to disconnect at once.

Fuses

A fuse is an electrical safety valve. It guards electrical and electronic equipment against destructive current flow. A fuse opens the circuit when too much current flows or when there is a sudden surge of high current caused by a short circuit or an overload. The right fuse, properly installed, provides safe, dependable, and trouble–free protection. It is important to use the right type of fuse. Descriptions of the types of fuses available and their uses follow:

Link. The first type developed, link fuses are also the simplest. They consist of short, flat metal sections connected by necks. Link fuses either are soldered into the circuit with special low–melting solder or they are fastened under two binding screws in uncovered fuse holders. The links in these fuses often are used to replace links in cartridge fuses.

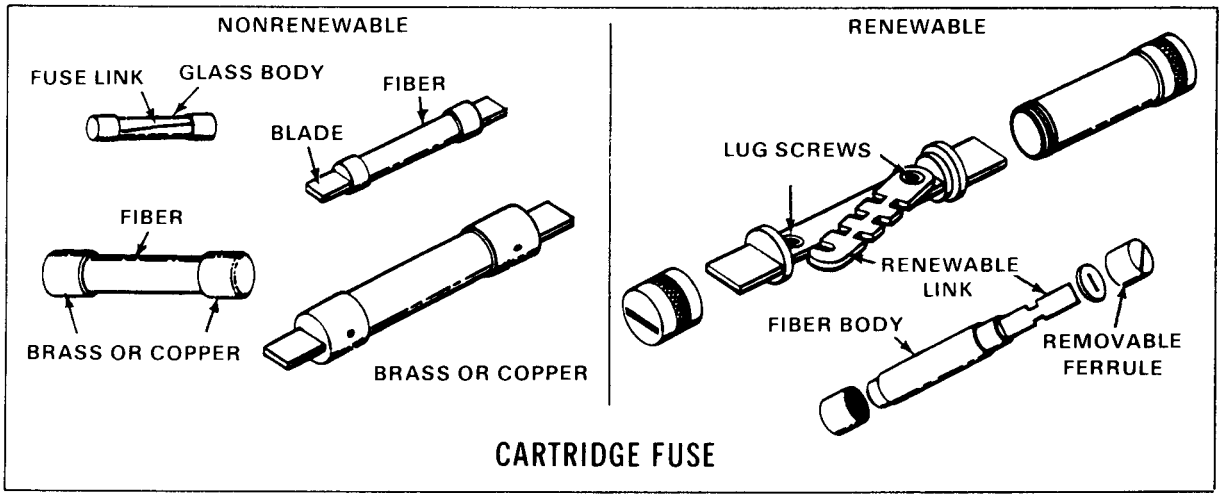


LINK FUSE

Cartridge. Cartridge fuses are the most common type. There are two kinds of cartridge fuses--ferrule and knife-blade (figure at the top of page 86. Both kinds consist of a fuse link within a hollow tube made of glass, ceramic, fiber, or other insulating material. The ends of the link connect to metal contacts (caps) at each end of the tube (cartridge). Cartridge fuses are designed for either one-time or multitime operation. One-time operation fuses cannot be repaired and are discarded when

blown. Multitime operation fuses are repaired by replacing the link each time the fuse is blown.

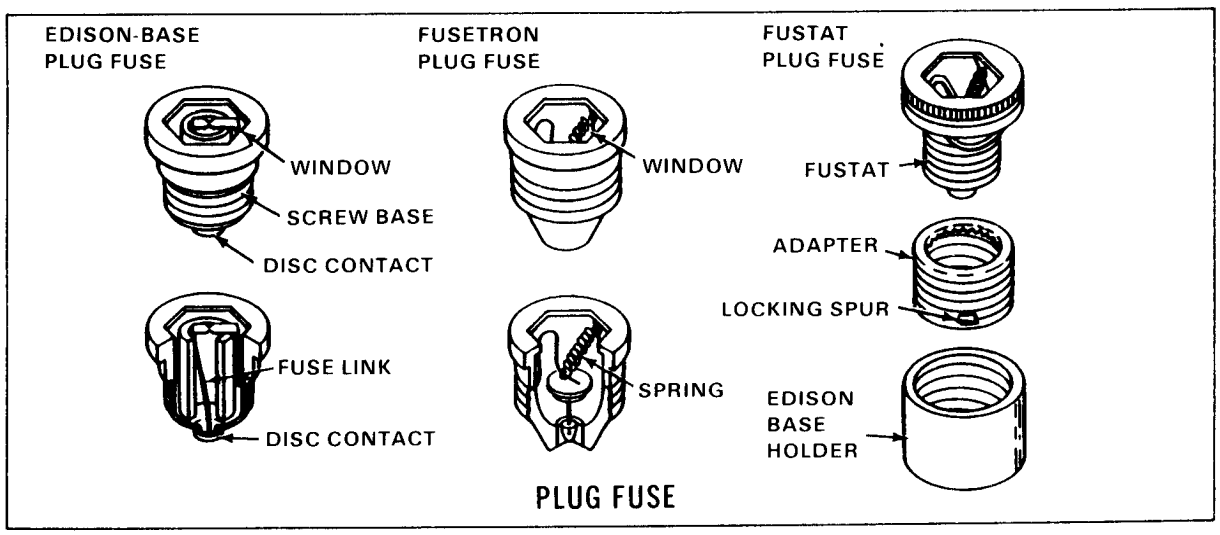
- Ferrule cartridge fuses have low-current capacities that range from about 0.002 ampere to 60 amperes. They are used in low-powered circuits in test equipment, radios, radar sets, and vehicles.
- Knife-blade cartridge fuses have high–current capacities that range from 60 amperes to more than 600 amperes. They are used in high-powered circuits such as the main circuits in homes, factories, and power plants.



CARTRIDGE FUSE

Plug. Plug fuses are often called house fuses because they are used in the 110-volt AC circuits found in most homes. A plug fuse consists of a fuse link mounted within a porcelain screw-type base. The link is connected between the metal screw threads and the metal disc contact at the bottom of the plug (figure on page 87). The link is visible through a window at the top of the fuse. Operators can look through the window to see if the fuse is blown. Some of the windows tarnish or cloud over when the fuse is blown. This feature enables operators to quickly find which one of a large bank of fuses is blown.

The current capacities of plug fuses range from 0.3 ampere to 30 amperes. They are designed to operate in low-powered circuits up to 125 volts. The fusetron and Edison-base plug fuses fit in the same standard base inside the fuse box. The fustat type requires a special adapter that fits inside an Edison base holder. While the fusetron and fustat types are designed to withstand momentary surges of excessive current, such as electric motor circuits, the Edison-base type cannot. Discard an Edison-base fuse when it is unserviceable.



Fuse Replacement

Replace a blown fuse with an exact duplicate whenever possible. If an exact duplicate is not available, operators may need to substitute another type. Substitutions can be made in noncritical circuits only if the--

- Replacement fuse is the correct size.
- Current rating of the replacement fuse does not exceed the current rating of the original.
- Voltage rating of the replacement fuse does not exceed the voltage rating of the original.

WARNING

Turn off the power before replacing a fuse to prevent shock and injury.

SAFETY

Working with electrical circuits and equipment is dangerous. Accidents to equipment operators and maintenance workers often result in loss of work time, partial or permanent disabilities, or death. Most such accidents can be prevented if operators have safe work habits and use safety equipment properly.

Repairing and Installing Electrical Equipment

The following safety tips can help prevent accidents when repairing and installing electrical equipment:

- Insulate all exposed lines with rubber shielding or other nonconductive material when installing generators, motors, control equipment, and conductors.
- Install proper guards on all rotating or moving parts so clothing and limbs cannot catch in them.
- Leave enough space around equipment for inspections and repairs.
- Install main feeder lines and branch wiring that carries 400 volts or more in conduits or shielded cables. Cables coated with neoprene or other modern covering may be used.
- Attach a numbered, nonferrous metal Identification tag to each cable.
- Attach a tag marked with the line voltage to the line.
- Wear rubber gloves covered with a pair of leather gloves when working on electrical circuits.

Repairing and Installing Electrical Circuits

Care is required when working with or near any electrical circuit. The following tips can help prevent accidents to operators and maintenance personnel:

- Consider all voltage dangerous, even if the amount of voltage is not high enough to produce a serious shock. High voltage can transfer from circuits or operating equipment to an individual and cause a shock without actual physical contact.
- Shut off the current before examining or repairing any light or power circuits, regardless of the voltage.
- Treat dead circuits the same as live circuits: Shut off the current before examining or repairing any circuit. Remove all main circuit breaker fuses so the power cannot be turned on accidently. Attach a note to the fuse box indicating work is in progress.
- Turn off the power to the conductors before working on a live circuit remote from the control switch.

- Inspect the entire circuit before applying power to it for the first time. Ensure no personnel are in contact with operating equipment when power is applied.
- Install a grounding circuit on large capacitors to eliminate voltage charges.
- Shut off the main circuit breaker before servicing any part of a generator set and before connecting a load. Ensure the set is not connected to an energized line.
- Stop both generator sets before making a parallel connection between them. Ensure neither of them is connected to an energized line.
- Ensure the load does not exceed the rated capacity of the operating generator before placing the main circuit breaker in the on position.
- Stop the generator set and disconnect it from all external lines before starting any maintenance procedures on the controls, instruments, or wiring.

Grounding

All electrical equipment such as generator sets, motors, conduits, switch boxes, transformers, and portable power tools must be adequately grounded when in use. Never operate a generator set until the grounding terminal is connected to a suitable ground. Electrical faults in the generator set, load lines, or load equipment may cause death by electrocution if the operator makes contact with an ungrounded system or circuit.

Grounding prevents shocks caused by improper insulation, insulation failure, or current from other line circuits that is in contact with the equipment. Remember that current will flow to the ground if voltage or a circuit is present. Therefore, operators and maintenance personnel must take precautions and be properly insulated at all times when working on electric wires, cables, or equipment.

Extra precautions are needed when working in damp or wet areas because water conducts electricity. To prevent shock injury from a live circuit under these conditions, use additional insulation such as rubber mats.

Safety Procedures

The following procedures will help operators and maintenance personnel avoid accidents while using or repairing electrical equipment:

- Use the right safety device for the work being performed. Do not rely entirely on a safety device to prevent an accident because it may fail.

- Rope off an area around the equipment being serviced to protect people who are not involved in the operation.
- Write a note with adequate instructions about the equipment and possible job hazards before leaving the work site for any reason.
- Use rubber mats or other insulating material to protect against shocks when working on the circuits for high-tension switches.
- Stand or sit on a wooden platform or stool when working in damp or wet areas. Place a rubber mat or other nonconductive material on top of the wood.
- Open and close switches quickly. Arcs may occur at the contacts if the switch is opened or closed slowly. Do not touch the contacts to determine if the power is on.
- Keep metal objects such as tools and oil cans away from field magnets. Otherwise, they may be magnetized and drawn into moving equipment parts or electric circuits.
- Ensure the exhaust gases from a generator operating within an enclosed area are piped outside.
- Provide a metal-to-metal contact between the container and tank when refueling equipment. Otherwise, sparks may be generated as the fuel flows across the metal.
- Remove all jewelry and metal items before working on electrical equipment. Ensure clothing has no exposed metal zippers, buttons, or other metal fasteners. Electrical contact with a metal object may cause a severe burn.
- Keep the work area around electrical equipment and cables dry at all times. If the work area is damp, use insulated materials to avoid serious shocks.
- Use caution when removing the cap from a radiator that contains hot engine coolant. Rotate the cap slowly to reduce pressure in the cooling system. Quick removal may allow hot engine coolant to escape and injure personnel.
- Never smoke or use an open flame when servicing batteries because batteries generate hydrogen, a highly explosive gas.
- Rinse clean water over any skin, clothing, or work area that comes in contact with the electrolyte in a battery. Electrolyte contains sulfuric acid, which causes serious burns.

- Use only distilled water in nickel-cadmium batteries. To add the distilled water, use a hydrometer or dropper that has had no contact with a lead acid battery.
- Wear ear protectors when operating a generator set to avoid hearing problems.
- Keep objects away from the air intake on gas turbine engine–driven generator sets. High vacuum may cause objects to be sucked into it.
- Keep personnel away from the exhaust gas flow and the plane of rotation when operating a gas turbine engine-driven generator set. The extreme heat may cause burns, and centrifugal force may cause the generator to break apart at the plane of rotation.
- Ensure the lifting device used to move a generator set has a capacity equal to the weight of the set. Lift the set only as high as necessary to get the job done. Do not allow the set to swing back and forth when it is suspended.
- Use only a carbon dioxide fire extinguisher to combat electrical fires. Direct the nozzle toward the-base of the flame.

FIRST AID FOR ELECTRIC SHOCK VICTIMS

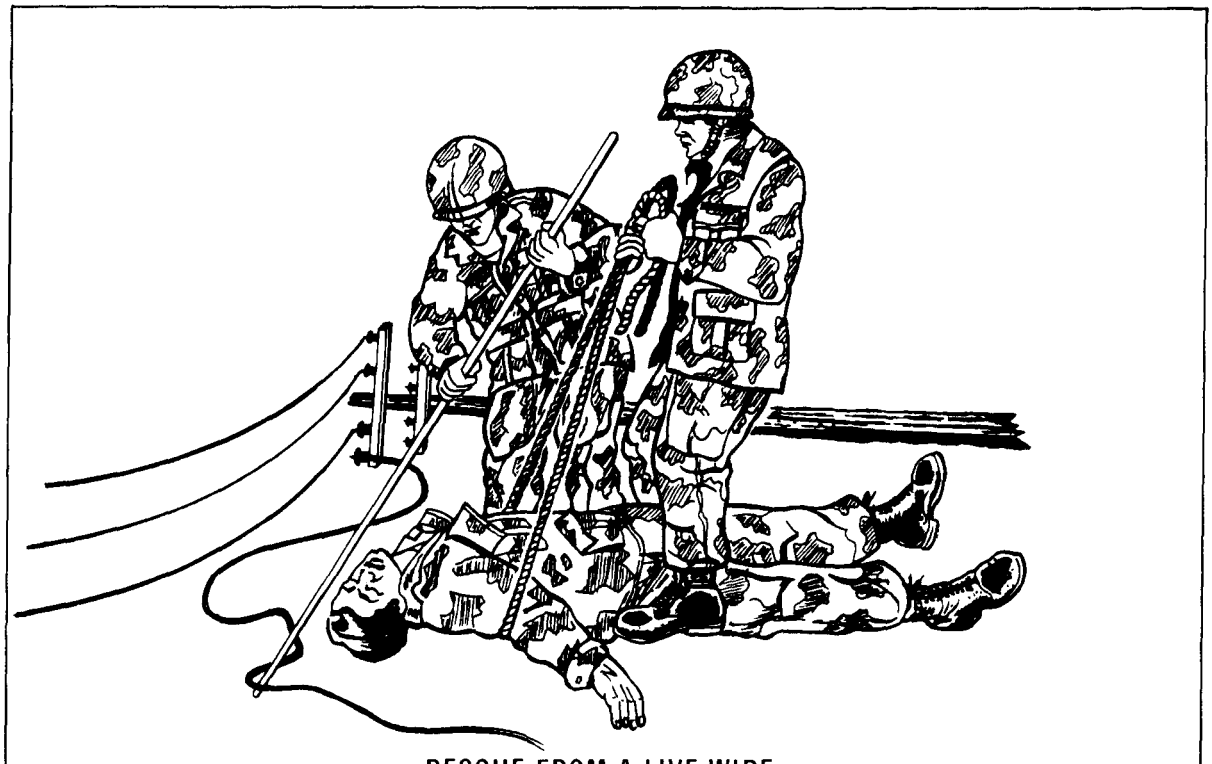
Electric shock is life-threatening and victims require immediate treatment. Operators and maintenance personnel must know how to rescue and treat a shock victim at a moment's notice.

Accidents involving electric shock sometimes result from lightning strikes but most often result from contact with a live wire. The shock may cause the victim to stop breathing and the heart to stop beating. Treatment is divided into two tasks: rescue and revive.

Rescue

Complete the following steps to free a victim from a live wire:

1. Turn off the current if the switch is nearby. Do not waste time looking for the switch if its location is unknown or if it is far from the accident.
2. Use a dry wooden pole to remove the victim from the wire. If a pole is not handy, throw a loop of dry rope or cloth around the victim and drag him off the wire (figure on page 92). Any material that is dry and will not conduct electricity may be used. Do not touch the wire or the victim with bare hands or you, too, will receive a shock.



RESCUE FROM A LIVE WIRE

Revive

Complete the following steps to revive a shock victim:

1. Administer artificial respiration as soon as the victim is freed from the wire. Artificial respiration for electric shock victims must be started within a few seconds. There is little chance of recovery if the victim is not treated within 4 minutes.

2. Check the victim's pulse. If you do not feel a pulse immediately, administer cardiovascular pulmonary resuscitation (CPR) along with the artificial respiration.

3. Get medical assistance. Call or send someone for help.

4. Cover the victim if it is cold, and loosen tight clothing such as a belt or tie. Continue CPR until a qualified first-aid technician or medical authority arrives, or until you are physically exhausted.

Accident prevention and first-aid for shock victims is important to everyone concerned with electric power generation. Equipment operators and maintenance personnel must have current safety information available and be able to perform the first-aid procedures properly.