CHAPTER 15

TOOLS AND EQUIPMENT

Section I-USE

15-1. Electrical tools and equipment standards.

Industry standards describe the requirements for electrical protective equipment and for tools. These standards were developed so that the tools, equipment, materials, and test methods used by electrical workers will provide protection from electrical hazards. Electrical protective equipment is included in the ASTM F 18 series specifications. Tool and equipment terminology and in-service maintenance and electrical testing are included in ANSI/IEEE 935 and IEEE 978 respectively. Safety manuals TM 5-682, NAVFAC P-1060, and AFM 32-1078 also contain tool and equipment requirements. In case of conflict, always use the most stringent safety requirement.

15-2. Tools and equipment classification.

For simplicity and convenience, the tools and equipment required for electrical inspection and maintenance are classified as follows:

a. Tools. Tools include hand tools, digging tools, hot line tools, miscellaneous and special tools, and tackle.

b. Protective equipment. Protective equipment includes rubber gloves, lie hose, matting, blankets, insulator hoods, sleeves, barricades and warning devices.

c. Climbing equipment. Climbing equipment includes body belts, safety and climber straps, climbers, and ladders.

d. Electrical inspecting and testing equipment. Electrical inspecting and testing equipment includes electrical and mechanical devices used to test the operation of electrical equipment, such as voltmeters, ammeters, ohmmeters, tachometers, and similar devices.

e. Large portable and mobile equipment. Large portable and mobile equipment includes relatively large and easily transportable equipment for use in maintenance work, such as line trucks, aerial lift trucks, motor-generator sets, pole hole diggers, and similar apparatus.

15-3. Tool and equipment safe use.

All hand and mechanically operated tools, must be used in a manner to comply with all applicable safety rules. Each worker is responsible for observing safety rules and preventing accidents.

a. Energized lines. The methods used when working on energized lines, such as gloving, use of hot line tools, provision of electrically insulated buckets, will be in accordance with the applicable services' safety manuals. Safety rules governing the use of such tools and equipment are given in these manuals and in applicable OSHA regulations, 29 CFR 1910 and 29 CFR 1926.

b. Material use. An insulating type hydraulic fluid is required in all hydraulic handtools used on or near energized lines and in insulated sections of aerial lift trucks. Hazardous material procedures must be followed when dealing with such substances.

Section II-HAZARDOUS MATERIAL PROCEDURES

15-4. Hazardous substances.

A hazard communication program should be implemented in accordance with 29 CFR 1910.1200 or 1926.59. AI1 maintenance personnel, prior to handling equipment or materials containing hazardous substances, will be advised of information in the Material Safety Data Sheet (MSDS) for that substance. A copy of the MSDS for each hazardous substance should be readily available to workers for referral to the manufacturer's instructions for use, storage, labeling, disposal, and for dealing with emergencies arising from that material's use. The major hazardous items to which electrical workers may be exposed are asbestos, polychlorinated biphenyls (PCB's), sulfur hexifluoride (SF,) and some of the chemicals used to control undesirable brush or pests or to preserve wood.

15-5. Asbestos containing materials.

Asbestos is no longer used for insulation or fire protection purposes or as a material in the fabrication of conduit or piping. Any present danger which workers may encounter will be from cutting existing asbestos materials which release asbestos fibers to

the atmosphere. If fibers are suspended in the air in significant quantities, their inhalation can damage respiratory functions. Electrical workers are normally exposed to such fibers, only if existing cement-asbestos conduits or asbestos fire-proofing are cut either accidentally or knowingly without proper precautions. Some older circuit breakers may have asbestos-containing arc chutes and should be handled carefully, using approved gloves, and wearing approved respirators. Otherwise, any handling of asbestos-containing materials should only be done by authorized trained personnel.

15-6. polychlorinated biphenyl (PCB) insulated equipment.

Items with PCB insulation, such as transformers or regulators, should have already been removed in accordance with facility directives or should at least have been identified in accordance with EPA regulations. However, PCB traces have been reported in older bushings installed on nonPCB-insulated units. In the past, PCB insulation was distributed by several equipment manufacturers under such trade names as Inerteen, Pyranol, Chlorextol, Safe-T-Kuhl, No-Flamol, etc.

15-7. Sulfur hexifluoride (SF_6) insulated equipment.

In its pure state, SF, is a colorless, odorless, tasteless, nonflammable, nontoxic, and noncorrosive gas. It is shipped in a liquid form. As it is five times heavier than air, it can act as an asphyxiant and, in the liquid state, it can cause tissue freezing similar to frost bite. Decomposition products of SF,, produced by electric arcs or faults, can be toxic. Normal arc products recombine to form SF, gas, or are removed by an absorber provided for that purpose within equipment such as circuit breakers and switches. However, gas-insulated items such as busway and cable, as well as circuit breakers and switches, can rupture and leak gas. Always treat SF, as hazardous.

15-8. Chemicals used for outside maintenance.

Herbicides, pesticides, and wood preservative treatments are designed to exterminate or control living organisms. They provide potential health hazards, if MSDS requirements for special handling and personal protective equipment are not followed. Special training may be required to meet applicable agency requirements or certification.

Section III-PROTECTIVE EQUIPMENT

15-9. Protective electrical rubber goods.

Rubber goods are used in clothing designed to provide insulation from an energized part or line. Rubber is a generic term that includes elastomers and elastomeric compounds, regardless of origin. Rubber goods are used by electrical worker when work requires handling energized lines.

a. Inspection. Rubber protective equipment must be visually inspected prior to each use and should be given electrical and mechanical tests at the frequencies stipulated in departmental publications. Unserviceable rubber goods should be plainly marked and turned in for replacement. Familiarity with the visual inspection methods and techniques listed in ASTM F 1236 is advisable.

(1) *Rubber gloves and sleeves.* Rubber gloves and sleeves should be inspected on the outside and then turned inside out for inspection on the reverse side. They must be free of defects or damage impairing electrical or mechanical properties, and must meet test requirements.

(a) Air test and inspection for rubber gloves. Rubber gloves should be tested prior to each use. Grasp the cuff at opposite points and twirl the glove, trapping air inside. Hold the end closed with one hand so that air cannot escape. Then squeeze the glove with the other hand to force air into the thumb, fingers, and palm. Listen and feel for escaping air. Inspect the entire glove surface for imbedded foreign material, cuts, deep scratches, or punctures. Gloves found to be defective should be tagged and turned in for replacement.

(b) Electrical test for rubber sleeves and gloves. Rubber gloves and sleeves in service should be given an electrical proof test periodically. If possible, the test should be accomplished by a local utility company or an independent testing laboratory, who should also provide electrical testing for all other rubber goods used. If independent testing is not possible, then test equipment and test voltage should comply with ASTM F 496, which also covers in-service care. The Lineman's and Cableman's Handbook covers the procedure and shows the complexity and expertise required for in-service testing of rubber goods.

(2) *Line hose.* The outside of line hose should be inspected for checks and cracks by bending the hose 180 degrees. at successive points along its length to stretch the rubber enough to expose possible defects. The inside of line hose is inspected by opening and spreading. Periodic electrical in-service tests should be given in accordance with ASTM F 478 which also covers in-service care.

(3) *Other equipment.* All other rubber protective equipment should be inspected for cuts, tears,

snags, or other defects that could impair safety. Rubber blankets are inspected by placing them on a flat surface, rolling each corner diagonally, and checking the outer surface as it is rolled. Insulator hoods are spread open at the bottom just enough to permit a view of the inner surface. Attempting to force the sides back to any great extent should be avoided, since this causes cracks or splits the hood. These inspections will be made, even if equipment has not been used since the last inspection. Periodic electrical testing of other rubber protective equipment should be conducted to ensure their adequacy as insulators. In-service care and testing is covered for line covers (hoods) in ASTM F 478 and for insulating blankets in ASTM F 479. There is no industry in-service care provision for matting, which is designed to meet ASTM D 178.

b. Storage. The following procedures govern storage of rubber protective equipment:

(1) *Storage of equipment in line trucks.* Store rubber protective equipment in readily accessible compartments and in an efficient manner. Gloves should be stored in individual bags and covers should be nested to conserve space. Permit no other equipment in compartments in which rubber goods are stored.

(a) Provide separate compartments for each class of equipment. Each compartment should be large enough to allow articles to lie in an unbent position.

(b) Never fold gloves and blankets.

(c) Be sure doors of compartments are tight enough to protect rubber goods against sun, rain, and dust.

(d) Rubber blankets must be protected from damaging contact with other equipment. Roll loosely and place in metal canisters. Canisters are available in sizes to accommodate from one to six blankets.

(e) If linemen's rubber coats and boots are carried in the truck, provide special compartments. If coats cannot be carried on hangers, roll them. Do not fold.

(2) *Warehouse storage.* All rubber protective materials not stored on the truck should be stored in a warehouse, in a clean, cool, dark, place having an approximately 50 percent relative humidity. Since heat, light, oil, and distortion are natural enemies of rubber, protective equipment should be guarded against these dangers as much as possible.

(a) Do not store rubber equipment near boiler rooms, steam pipes, or radiators. Protect it against exposure to direct sunlight.

(b) Rubber ages or oxidizes quickest at points held under distortion. A blanket allowed to remain folded for a period of time cracks or punctures in the crease. Never leave rubber gloves inside out because distention at fingertips and glove body connections to finger and thumb pieces hastens deterioration.

(c) Provide separate bins in the warehouse to store each class of equipment. Store gloves, coats, and hoods in original containers. Blankets and line hose should lie flat.

(d) Do not store any tools or other material in the same bins with rubber protective equipment.

(e) Give all rubber protective equipment in storage a thorough visual inspection and an electrical test before using.

15-10. Helmets for electrical work.

Protective hats shall be in accordance with the provisions of ANSI 289.1, Class B requirements (meetings a 20,000 volts ac test for 3 minutes) and shall be worn at the job-site by all workers who are exposed to potential hazards, such as falling objects, electric shock, or burns.

15-11. Barrier protection for electrical work.

Barriers are required adjacent to electrical installations for the protection of equipment and personnel. Permanent installations are normally protected by metal fences, however materials should be available for erection of suitable temporary barriers.

a. Preformed barriers. Preformed barriers are available that are portable and readily assembled. Maintenance consists essentially of rust prevention by periodic painting.

b. Temporary barriers. A temporary barrier can be constructed using hazard area warning tape in conjunction with stanchions. This type of barrier is effective only when indicating a boundary, and should be used only where the limitations imposed by such a barrier are within established safety practices. Stanchions should be periodically cleaned and painted as required.

15-12. Visual warnings for electrical work.

In addition to providing barriers, it is often necessary to install some type of visual warning. The generally used types include warning signs, flags, flares, and flashing lights. Since these are often required on an emergency basis, they should be readily available to electrical maintenance personnel. Extra batteries and bulbs or complete lights should be carried on an electric maintenance truck. Signs should be kept in readable condition, clean, and free of rust or corrosion.

15-13. Protective grounding of deenergized lines.

When work is to be done on a deenergized line, protective grounding sets must be applied to the

line. These sets consist of clamps connected together with insulated wire. A set is applied to a circuit in such a way that all conductors of the circuit may be effectively shorted together and grounded. All equipment must meet the requirements of ASTM F 855.

a. Clamps. The clamps of a grounding set are designed to be manipulated with hot-line sticks. These clamps should be visually inspected each time that they are to be used to ascertain that the wire is securely fastened and that each clamp is in sound condition. Check to see that clamps function properly and to ensure that a tight connection can be made to the conductors on which they will be used.

b. Wire. Insulated wire is used to connect the clamps together and to ground. Wires with insulation missing, cut, cracked, or otherwise in poor condition, should be replaced.

c. Safety aspects. Protective grounding is required to ensure worker safety. Follow the instructions given in your service safety manual in regard to the following grounding aspects.

(1) Where to apply grounds in relation to the work site.

(2) Size of ground wire. A minimum 2/0 AWG copper ground wire is recommended. Check ASTM F 855 for maximum fault current capabilities of grounding cables.

(3) Staying at least 10 feet (3 meters) clear of any protective grounds is recommended to avoid touch-and-step potentials. Otherwise, wear insulated footwear and provide other hazard minimizing measures.

Section IV-CLIMBING EQUIPMENT

15-14. Body belts, climber straps, and safety straps.

Personal climb equipment must meet the requirements of ASTM F 887 and OSHA Standard 1926.959. Only the best grade, smooth, pliable harness leather, or other material approved and conforming to government specifications, should be used in body belts and safety straps. Treat climber straps in the same manner as safety straps. If nylon fabric is used, as permitted by ASTM F 887, consult the manufacturer for proper cleaning procedures.

a. Cleaning and dressing. Body belts and safety straps should be cleaned and dressed every 3 months, or oftener if they become wet from rain or perspiration. If leather equipment has come in contact with paint, carefully remove the paint with a dry cloth as soon as possible. The following method is recommended for cleaning and dressing leather body belts and safety straps:

(1) Wipe off all surface dirt with a dampened (not wet) sponge.

(2) Rinse the sponge in clear water and squeeze nearly dry. Work up a creamy lather with a neutral soap (free from alkali), such as castile or white toilet soap.

(3) Wash the belt or strap thoroughly with a lathered sponge to remove imbedded dirt and perspiration. Remove any moisture by wiping dry with a cloth.

(4) Work up a lather of saddle soap in the same manner as for the neutral soap.

(5) Work the saddle soap lather well into all parts of the leather. Place the leather in a cool, nonhumid place to dry.

(6) When the leather has nearly dried, rub it vigorously with a soft cloth.

b. Oiling. Leather body belts and safety straps usually require oiling about every 6 months, or when the leather cannot be made soft and pliable with the saddle-soap dressing. The following method is recommended:

(1) Clean the leather with a neutral soap, as for cleaning and dressing.

(2) While the leather is still damp, gradually apply about 4 teaspoons (10 milliliters) of pure neatsfoot oil per set of equipment, with hands or rag, using long light strokes to work the oil into the leather. Be sure a light, even distribution is made. To avoid overoiling, never pour oil directly onto leather. Never use mineral oils or greases, such as machine oil or Vaseline. Leather should never look or feel greasy, which is an indication of excessive oil. Too much oil stretches the leather, which may then pick up damaging sand or grit.

(3) After oiling, set the belt or strap aside in a cool nonhumid place for about 24 hours to permit the leather to dry slowly. Never dry lather near a source of heat, since heat destroys leather.

(4) Rub vigorously with a soft cloth to remove excess oil.

c. *Storing.* The following precautions should be observed in storing body belts or safety straps:

(1) If the leather was insufficiently oiled when purchased, oil as previously described before placing in storage.

(2) Oil at least once every 6 months, when left for that period in storage.

(3) Never store the leather goods with sharp edged tools. Do not put belts or straps in the same compartment with climbers because of the possibility of cutting or puncturing the leather with gaffs.

(4) Never store where the leather may be subjected to excessive heat or dampness.

d. Safety inspection and tests. Body belts and safety straps should be inspected in conjunction with other regular tool inspections. If faulty conditions are found or suspected, the articles involved must be repaired or replaced at once.

(1) *Visual inspection of body belts.* Inspect body belts for the following:

(a) Edges and other parts of leather loops holding D-rings, which are crushed or worn sufficiently to reduce their strength or cause the leather to tear.

(b) Loose or broken rivets (particularly those in the loops holding the D-rings).

(c) Cracks and cuts tending to tear the leather or affect the strength of the belt.

(d) Leather which is hard and dry.

(e) A broken plier pouch.

(f) A broken or defective buckle.

(g) Any leather spot which is dry on the outside. If bending at that spot cracks the leather and small pieces between cracks may be easily removed with a fingernail, the leather has been burned.

(h) Torn or excessively enlarged holes for the buckle tongue.

(2) *Visual inspection of safety straps.* Inspect safety straps for the following:

(a) Cracks, cuts, nicks, and tears (particularly across or on the edges of the strap) that tend to affect the strength of the strap.

(b) Loose, worn, or broken rivets.

(c) Broken or badly worn steel reinforcing the strap.

(d) Leather which is hard and dry.

(e) Broken or defective snaps.

(f) Poor action of tongue on the snap. The tongue should work freely without side play and close securely under the spring tension.

(g) A broken or defective buckle.

(h) Torn holes for the tongue or buckle.

(i) Leather worn thin. If otherwise sound, the strap may be used as long as it is at least l/8 inch (3.175 millimeter) thick in any portion, other than the doubled part of the strap. In this portion, the leather may wear to a thickness slightly less than ⅛ inch (3.175 millimeter) because the doubled portion is approximately twice as strong as a single portion.

(j) Burnt leather indicated by dry spots which crack when bent.

(k) Grain (smooth side of leather) worn so fibers are plainly visible.

(3) *Bending test for leather.* Before the bending test is applied to a body belt or safety strap, the leather should contain enough oil to be soft and pliable. When the test is made, the leather should show no cracks other than slight surface cracks.

(a) Bend safety straps with the grain (smooth) side out over a %-inch (19 millimeter) mandrel. Make the test over the entire strap.

(b) Make a similar test for body belts wherever they can be bent, such as under tool loops and at tongue straps.

(c) Do not bend belts or straps sharply over too small a mandrel, as leather may develop cracks if excessive strain is put on the grain layer.

15-15. Climber gaffs.

The safety of a lineman using climbers depends largely on the use of properly sharpened gaffs of the correct length. Pole gaffs must measure at least 1.4375 inches (37 millimeters) on the underside. Tree gaffs must measure not more than 3.5 inches (89 millimeters) nor less than 2.25 inches (57 millimeters) on the underside.

a. Sharpening. Certain precautions must be observed in sharpening a gaff.

(1) To avoid the danger of removing the temper of the metal, do not sharpen a gaff with a grindstone or emery wheel.

(2) Never sharpen a gaff on the underside, except to make a shoulder, because it changes the angle to which the gaff is set and renders the gaff unsafe for use. When removing metal to make the shoulder, ensure that the underside remains straight as a rounded surface may cause the gaff to break out when climbing.

(3) Use the following procedure in sharpening a gaff:

(a) Put the climber in a vise with the gaff up.

(b) Sharpen the gaff on the two outer surfaces with a file. Take long strokes from the heel to the point of gaff. Remove only enough material to make a good point.

(c) Never sharpen a gaff to a needle point. Leave a shoulder about ⅛ inch (3.175 millimeter) back from the pint. The distance across a gaff at the shoulder should be about 5⁄32 inch (3.969 millimeters). This is to prevent the gaff from sinking too far into a pole.

b. Storage. Store gaffs in a manner such that other equipment will not be punctured, torn, or cut.

15-16. Ladders for electrical work.

Ladders are used frequently by electrical personnel and many accidents result from their misuse. All maintenance personnel should be familiar with the rules and regulations regarding their proper use. Portable metal ladders, or ladders with metal hardware, are prohibited from both indoor and outdoor use by personnel inspecting or working on electric lines, poles, wiring, or equipment.

a. Inspection and repair. Ladders should be inspected at frequent intervals to ensure that all rungs, braces, and side rails are secure and free of defects. If defects are noted that cannot be readily repaired, the ladder should be replaced. Ladders should not be painted, since paint will mask defects in the wood such as cracks and splits. Ladders should be kept clean, for the same reason.

b. Storage. Ladders should be stored indoors, when not in use, so harmful weathering cannot affect them. The storage area should have adequate ventilation and not be subject to excessive heat or dampness which might cause warping.

Section V-LIVE-LINE TOOLS

15-17. Certification of live-line tools.

Tools should be manufactured to meet ASTM F18 series specifications, as appropriate to the device and material. The insulating portion of a tool is made of fiberglass or wood. Facility workers should use fiberglass tools since it is stronger and does not absorb moisture; is impervious to oil-borne materials and solvents; and is a better insulator than wood. Like any insulator, fiberglass must be kept clean and dry to maintain its insulating ability. Only use live-line tools that have a manufacturer's test certification to meet the following minimum requirements.

a. Fiberglass. A fiberglass tool must have withstood 100,000 volts ac per foot (300 millimeters) of length for 5 minutes.

b. Wood. Wood tools should be phased out as soon as possible. If still in use, a wood tool must have withstood 75,000 volts ac per foot (300 millimeters) of length for 3 minutes.

15-18. Care of live-line tools.

Tools are only as safe as their continued care and inspection make them. ANSI/IEEE 516 and IEEE 978 provide additional information on maintenance and testing.

a. Records. Records will be maintained for all live-line tools and will indicate their shop or laboratory inspection and testing dates. Electrical shop and laboratory testing will be provided at intervals of not more than 6 months for tools in frequent use, and at intervals of not more than one year for tools stored for long periods of time. Arrange for tests with the manufacturer, serving utility, or local testing laboratory.

b. Tool inspection. OSHA requires that live-line tools be visually inspected daily before use. Tools to be used will be wiped clean. If any hazardous defects are indicated, tools will be removed from service. The following field observations warrant their removal from service.

(1) A tingling or fuzzy sensation when the tool is in contact with energized conductor or hardware.

(2) A mechanically overstressed tool showing such evidence as damaged, bent, worn, or cracked components; or a tool with deep cuts, scratches, nicks, gouges, dents, or delamination in the stick surface; or a tool with a deterioration of its glossy surface.

(3) An electrically overstressed tool showing evidence of electrical tracking, burn marks, or blisters caused from heat.

(4) Failure to pass an electronic test using portable electronic live-line tool testers; or failure to pass a moisture test using portable moisture meters developed to test live-line tools.

c. Tool cleaning. Clean live-line tools before each use with a clean absorbent paper towel or cloth and then wipe with a silicone-treated cloth. Waxing is not necessary after every use, but only as needed. Use cleaning and waxing kits manufactured for live-line tools and follow directions for their use. Never use cloths that have been washed in harsh solvents, soap, or detergents. Residues left on the tools will be conductive. Abrasives can destroy the surface gloss of the tool and cause water or moisture beads to form on the surface of the tool.

(1) *Fiberglass tools.* Clean, wax, and refinish in accordance with the manufacturer's directions.

(2) *Wood tools.* Replace with fiberglass tools as soon as possible. Wood tools with an excessive moisture meter reading should be treated with a moisture-resistant insulating wood preservative in the following manner:

(a) Preparation. Tools should be cleaned, dried, and smoothed with sandpaper. Emery cloth or other materials that might leave metallic particles must not be used for sanding.

(b) Drying. Use a drying cabinet, which permits tools to be suspended vertically and has small openings in the bottom and top for air circulation. Incandescent lamps may be used in the bottom to provide heat. Drying is recommended at 90 degrees F (32 degrees C) for approximately 48 hours at 31 to 38 percent relative' humidity. After drying, subject tools to a high-potential dielectric leakage or ac dielectric loss test.

(c) Prompt touch up. After drying, if the finish is worn or damaged, promptly apply two or three coats of clear preservative finish as recommended by the tool manufacturer. Tools should then be dried again in a drying cabinet for an additional 12 hours.

d. Handling and storage. Workers share responsibility with their foreman and supervisor for the continued safe condition of live-line tools.

(1) *Handling.* Keep tools dry and free from dirt. Before storing, thoroughly dry all tools that have been subjected to dampness. Protect tools transported in trucks to prevent formation of scars and abrasions. Use waterproof canvas bags, or compartments with padded hooks or bins built into the truck. Place tools not in use in their proper container, compartment, or rack. Never lay tools on the ground.

(2) *Storage.* All tools not being transported will be stored in a dry, warm location and will not be tampered with or handled by unauthorized personnel. Wood tools require special care as temperature changes can cause warping. Store tools in bins and racks away from dirt, moisture, and ultraviolet rays. Inspect tools, at least once a month, if they have not been in use.

15-19. Repair of live-line tools.

Major repairs to live-line tools, such as repairing split poles, damaged parts, and parts out of alignment, should be done by the manufacturer if the facility does not have competent and trained personnel. Generally, if there is no roughness on the surface of a live-line tool and it meets electronic and moisture tests, there is no need for repair. Small surface ruptures and small voids beneath the surface may need repair. Electrical tests, such as high-potential or dielectric-loss tests, should follow any such repairs. Tests should be performed either by qualified personnel either under contract, or by facility workers who are familiar with the test requirements of IEEE 978. Never repair damaged sticks with nails or friction tape.

Section VI-HAND TOOLS

15-20. Hand tool safety.

The following minimum safe practices have been abstracted from facility safety manuals. These include the general tool safety requirements which, when ignored, most frequently lead to accidents; and the specific practices required to prevent electrical shock hazards.

15-21. General requirements for hand tools.

The following tool removal safe practices and dos and don'ts should be observed in the use of hand tools:

a. Removal. Remove damaged tools and replace them with new ones. Replace cracked or splintered handles or grips.

b. Dos. Use hand lines and canvas tool bags, or other suitable containers, to raise or lower tools to or from the working position. Dress cold chisels and center punches, as required, to prevent dangerous mushrooming.

c. Don'ts. Do not raise or lower rubber protective equipment in the same bag with tools and materials. Do not use screw drivers with metal shanks extending through the handles, while performing electrical work. Do not use measuring tapes or measuring ropes, which are metal or contain conductive strands, while working on or near energized parts.

15-22. Power tool electric shock hazard avoidance.

The following safe practices should be followed for power tools.

a. Electrically-powered tools. All portable electric handtools shall:

(1) Be equipped with three-wire cord having the ground wire permanently connected to the tool frame and a means for grounding the other end: or

(2) Be connected to the power supply by means of an isolating transformer, or other isolated power supply: or

(3) Be of the double-insulated type and permanently labeled as "Double Insulated." (The use of double-insulated tools should comply with departmental policy.)

b. Hydraulically-powered tools. All hydraulic tools which are used on or around energized lines or equipment shall use nonconducting hoses having adequate strength for the normal operating pressures.

c. Pneumatically-powered tools. All pneumatic tools which are used on or around energized lines or equipment shall:

(1) Have nonconducting hoses with adequate strength for the normal operating pressures, and

(2) Have an accumulator on the compressor to collect moisture.

15-23. Care of rope.

Rope is an essential tool in construction and maintenance work. For maximum use and safety, the following dos and don'ts should be observed in the care and handling of rope.

a. Dos. Examine strands frequently for breaks and internal wear. When ropes are not in use, coil and hang them up. Use synthetic rope wherever possible.

b. Don'ts. Comply with the following requirements:

(1) Do not allow rope to kink, because fibers become overstressed at point of bend.

(2) Do not drag rope on the ground, because dirt and sand chafe the fibers.

(3) Do not use rope that is too small.

(4) Do not thread rope on sheaves having rusted or rough surfaces.

(5) Do not allow rope to unlay; whip the ends.

(6) Do not let rope come in contact with oil. This rapidly deteriorates fibers.

(7) When rope becomes wet, dry it at the first opportunity. Avoid using a wet rope near energized lines. Remember that a wet rope is not as strong as a dry one and breaks easily if frozen.

(8) Do not use tape, string, or marlin to repair defects in rope. When defective, turn in rope for replacement.

(9) Do not use natural fiber ropes.

15-24. Splicing rope.

All ropes used in construction work should have finished ends. The types most used are the backlash and whipped ends shown in figure 15-1, and the finishing of an eye splice as shown in figure 15-2. Splicing of rope is often required in maintenance work and is commonly done in one of the following ways:

a. Eye splice. When a permanent eye is desired at the end of a rope for ring fastening or for splicing around a block or thimble, an eye splice is used. The procedure for making an eye splice (shown pictorially in figure 15-2) is as follows:

(1) Unlay end of rope about six turns.

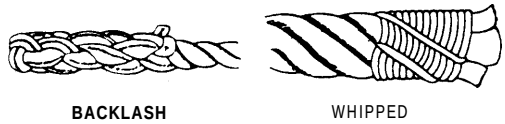
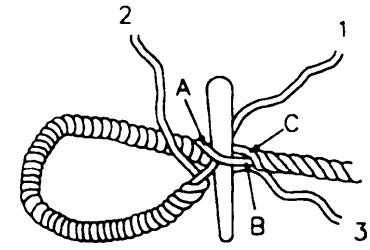
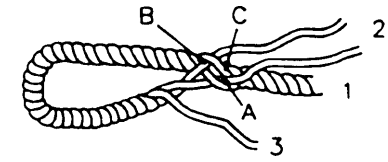


Figure 15-1. Methods of finishing rope ends



STEP 1



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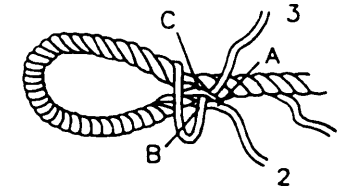
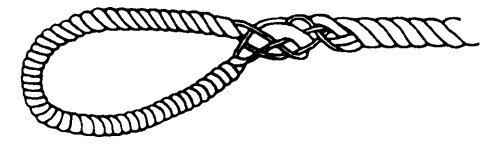


STEP 3



STEP 4

Figure 15-2. Making an eye splice

(2) Raise one strand of rope with a marlin spike at a point where the splice is to be made. The larger the eye, the farther down the rope the splice must be made.

(3) Tuck any one of the loose strands through opening diagonally upward to right. Call this strand 1.

(4) Tuck strand 2 under strand B of the main rope.

(5) Tuck strand 3 under strand C of the main rope in the same direction as the other two strands. To do this, turn the splice away.

(6) Pull strands in tightly.

(7) Pass each loose strand over the strand of the main rope nearest to it and under the one beyond. Always tuck strands in rotation, one tuck at a time. Continue for at least three tucks.

(8) If a tapered splice is desired, cut away some fibers in the strand after each tuck is made.

b. Short splice. This splice can be made quickly and is nearly as strong as the rope. Since the diameter of the rope is nearly doubled, this type of splice is too bulky to pass through a sheave block. Procedure for a short splice (shown in figure 15-3) is as follows:

(1) Unlay ends of two ropes for about six turns.

(2) Make one tuck with each set of loose strands at least three times to ensure maximum strength.

(3) If a taper is wanted, add one or two extra tucks at each end and cut away one-half of the fibers of each strand, for each tuck.

c. Long splice. When two ropes are to be spliced so that they will pass through the same size blocks as the unspliced rope, the long splice must be used. The procedure for long splice (shown in figure 15-4) is as follows:

(1) Unlay one strand of each rope for 10 or 12 turns.

(2) Lock and draw ends of ropes tightly together.

(3) Using care to see that the ends of rope do not separate, unlay strand A from the rope and follow it with strand B.

(4) Keep strand B tight and pull it down firmly into strand A's place.

(5) Continue until about 7 inches (175 millimeters) of strand B remains as shown.

(6) Untwist strands C, D, E, and F and lock them; strand C between strands D and F; strand F between strands C and E.

(7) Unlay strand D toward the left and lay strand C in its place. Strand C replaces strand D to the left, just as strand B replaced strand A to the right. Be sure that strand D is unlaid, not strand F. Replacement of strand D by strand C continues until strand C is about 7 inches (175 millimeters) long. At this point the breaks in the strands are separated by about 9 inches (230 millimeters).

(8) See that the break between strands E and F is in middle of splice; that the break between

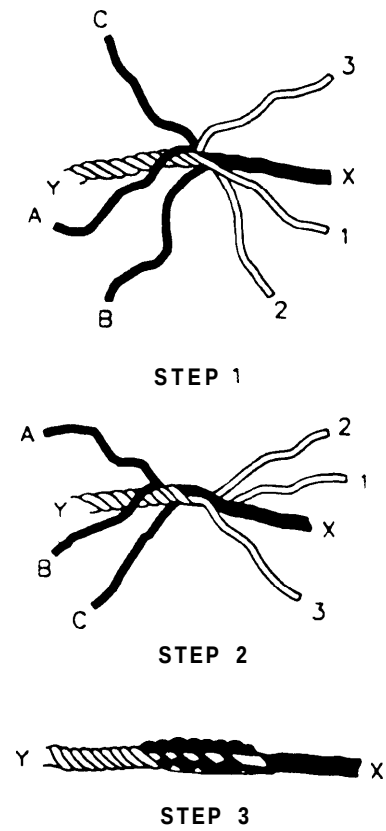


Figure 15-3. Making a short splice

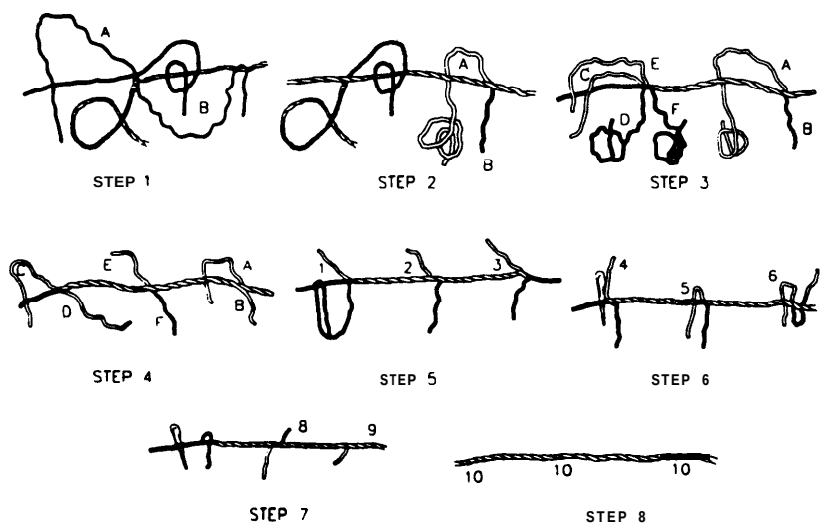


Figure 15-4. Making a long splice

strands A and B is at the right; and that the break between strands C and D is at the left.

(9) Tuck the strands at each break by cutting strands at least 7 inches (175 millimeters) long. To begin the tucking operation, tie each pair of strands together with the first half of a square knot to prevent unwinding of strands from the rope. Pull each knot down into the rope as sketched. Tuck in each strand twice, as in making the short splice.

(10) Untwist each strand a little before it is tucked to get a smoother job, because a loose strand flattens out and conforms to an oblong opening, reducing the diameter of the rope.

(11) To taper the splice, make two extra tucks and cut away some fibers from each strand after each extra tuck.

(12) After the splice has been completed, ends should be cut ½ inch (13 millimeters) long.

(13) Use a round stick to pound down each part of the splice and roll the splice underfoot to make it compact and pliant.

Section VIII-LARGE PORTABLE AND MOBILE EQUIPMENT

15-25. large portable and mobile equipment covered.

In addition to hand tools and protective, climbing, and testing equipment, large portable and mobile equipment is often required to perform maintenance work. Such equipment includes pole hole diggers, floodlights, portable/mobile substations, and aerial lifts.

15-26. large portable and mobile equipment maintenance.

The following maintenance instructions are necessarily general in nature. Applicable manufacturers' maintenance instructions should be followed.

a. Pole hole diggers. A digger is mounted on a truck or tractor and consists primarily of an engine-driven mechanism for imparting a rotary motion to a hole-digging auger. Maintenance of such apparatus is similar to automotive maintenance in terms of keeping gears, brake, clutch, and engine properly adjusted and lubricated.

b. Floodlights and spotlights. Chapter 6 gives procedures for maintaining outdoor lighting fixtures.

c. Portable / mobile substations. Portable and mobile substations, used primarily for continuity of service during maintenance and emergencies, are maintained in accordance with the general procedures of chapter 3.

d. Aerial lifts. OSHA requires that aerial lifts must conform to ANSI/SIA A92.2.

(1) *Electrical testing.* Since the working environment of an aerial device can be detrimental to the insulation characteristics of the boom and basket, electrical testing of these items is necessary at frequent intervals. The basic dielectric elements are: upper boom; basket liner and basket; lower boom insulator; and hydraulic lines and fluid, and leveling insulators. The different levels of periodic electrical test values and methods should conform to ANSI/SIA A92.2. For the Air Force, provide dielectric testing in accordance with AFTO 36C-1-4.

(2) *Boom cleaning.* If high leakage currents are revealed during periodic high-voltage testing, the boom should be thoroughly cleaned both inside and outside and provided with silicone replacement in accordance with the manufacturer's recommendations. Materials used in cleaning and coating must be approved by the equipment manufacturer. The boom should then be retested.

(3) *Mechanical and other tests and inspections.* These should be applied to the aerial device over its life to ensure continuing OSHA conformance.

(a) Visually inspect welds. Use liquid-penetrant and magnetic-particle testing to detect workmanship defects, or defects where overstressing or fatigue is suspected. Doubtful welds should also be x-rayed.

(b) Visually inspect fiberglass for structural and surface damage. Use strain-gage testers, dye and light-penetrant testing, or X-ray testing as appropriate to suspected damage.

(c) Provide hydraulic pressure-testing and setting to avoid pressures that might compromise the hydraulic component's burst safety factor.

(d) Visually inspect the ball-bearing turntable, pivot pins and bearings, drive gears, wear pads, and other power components for wear. Compare with original-equipment specifications to determine which components should be replaced to maintain the safe operation of the equipment.

(e) Provide vehicle safety tests on brakes, traveling lights, headlights, seat belts, and other vehicle components.

(f) Test special live-line tools used in the basket, including tests to determine they meet their electrical insulation and mechanical and hydraulic requirements.

Section IX-ELECTRICAL INSPECTING AND TESTING EQUIPMENT

15-27. Minimum facility field test equipment requirements.

Competent inspection is the first requirement for satisfactory maintenance of electric apparatus. The number and types of testing/inspection devices needed will depend on local needs. A suggested minimum list is given in table 15-1.

15-28. Maintenance of test equipment.

When available, the manufacturer's instructions for the care and maintenance of a test equipment should be followed.

a. Electrical instruments. The maintenance and care of electrical instrument test equipment are discussed in chapter 12, sections II and V.

b. Mechanical instruments. Mechanical instruments should be maintained and cared for with the same level of attention given to electrical instruments. In most cases, mechanical instruments are not as delicate as electrical instruments, and will primarily require mechanical adjustment, cleaning, oiling, and proper storage.

Table 15-l. Suggested list of minimum facility-wide field test equipment

Test equipment	Description
Automatic insulation tester.	Automatically performs insulation test routines in minutes, with high accuracy and sensitivity. Easy to operate, rugged and durable, the unit can be used on equipment or networks rated from low voltage to 400 kilovolts. The unit controls the dc voltage across the conductors and measures the leakage current through and over the insulation with one microprocessor and directs the display, control panel, and power supply via a second microprocessor. They communicate through a fiber-optic link. The unit combines basic and automatic insulation testing capabilities. Typical tests include: • Insulation resistance tests at 500, 1,000, 2,500, and 5,000 volts dc (with resistance readings up to 500,000 megohms at 5,000 volts dc). • Automatic polarization index (PI) tests at any of the voltages listed above. • Automatic step voltage (SV) tests in five equal steps up to 2,500 or 5,000 volts dc. The unit is powered by an internal rechargeable, sealed lead-acid battery (12 volt, 6.5 amperehour) or power supply cord (110/120 volts at 50/60 hertz or 2201240 volts at 50/60 hertz). Included Accessories: Power supply cord (1) High-voltage test leads-high, low, and guard terminal, 9 feet (3 meters) long Instruction manual (1) Optional Accessories: High-voltage test leads-high, low, and guard terminal, 30 feet (10 meters) long How to operate manual (1)
Channel disturbance waveform analyzer	Captures, displays, analyzes, and records power line disturbances. Digital sampling techniques have 512 kilobytes of nonvolatile random access memory. Waveforms are viewed on the built-in cathode ray tube display and stored on the dual 3.5-inch (90 millimeter) disk drives. Standard summary reports or custom reports are created using the attached keyboard. A built-in thermal graphics printer provides high-quality output of waveforms and reports. Four two-wire ac input channels are provided with selectable ranges of 0 to 60 volts and 60 to 600 volts. Frequency range is 45 hertz to 65 hertz. Impulses of greater than one microsecond can be recorded and the range is 25 to 6,000 volts peak.
Dielectric test set	Measures leakage current while applying a dc voltage at or above the insulation system's operating level. This measurement aids in determining the insulation system's ability to withstand overvoltages such as lightning strikes and switching surges. Unit is compact and portable, air-insulated, uses no oil, and has a plus or minus 2 percent accuracy. Unit measures current as low as 0.1 microamperes and has a continuously variable test voltage with zero-start safety interlock. Unit provides fast charging of high-capacitance samples. Includes a current guard circuit for highly accurate measurements. An optional strip chart recorder for hard copies is available.
Digital ground. resistance tester	Complete with separate measuring and charging modules. A Kelvin-type, four-wire measurement eliminates errors caused by lead and contact resistances Digital readout with automatic zero. Range: 0 to 6 ohms in 5 ranges. Resolution: 1.0 microhms. Includes a 7-foot (2 meter) helical lead set.

Table 15-1. Suggested list of minimum facility-wide field test equipment (continued)

Test equipment	Description
Infrared imager.....	Provides an infrared thermal measuring and imaging system with thermoelectric cooling. Temperature measurement range: 20 to 2,700 degrees F (minus 7 to 1,480 degrees C). Color images can be displayed using standard video equipment. Has a 3.5inch (90-millimeter) floppy disk drive and includes two battery packs and battery chargers, a 20 by 20 inch (500 by 500 millimeter) lens, a shoulder strap, and a high-temperature flame filter.
Null balance earth ..... tester	Megohmeter earth tester. Hand-cranked device for measuring resistance to earth ground connections. Null balance principle eliminates probe resistance from measurements. Four ranges from 0.01 to 9,990 ohms with digital readout. Self-contained and portable.
True rms clamp-on. ..... digital power meter	Provides true rms measurements for ac voltage and current to a crest factor of 3 (frequency wave form distortions less than 2.5 hertz). Measures ac and dc current to 1,000 amperes at frequencies to 2,000 hertz. Has a 3½ digit liquid crystal display (LCD) with 1.77 inch (45 millimeter) conductor jaw. Provides autoranging measurements, data hold and peak hold, zero adjust, and a millivolt recorder output of current input, low battery indication, a continuity check, a sampling time of 0.4 seconds and is complete with carrying case, test leads, alligator clips, wrist strap, and a 9-volt battery.