UNIFIED FACILITIES CRITERIA (UFC)

ELECTRICAL SAFETY

UNIFIED FACILITIES CRITERIA (UFC)

ELECTRICAL SAFETY

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

This UFC supercedes the following documents:

- Air Force Manual 32-1185, *Electrical Worker Safety.* This manual was prepared in draft form, but was not issued.
- TM 5-682, *Facilities Engineering, Electrical Facilities Safety.*
- UFC 3-560-10N (previously MIL-HDBK-1025/10), *Safety Of Electrical Transmission And Distribution Systems.*

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, operations and maintenance criteria, and applies to all service commands having military construction responsibilities. UFC will be used for all service projects and work for other customers where appropriate.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, United States Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Support Agency (AFCESA) are responsible for administration of the UFC system. Technical content of UFC is the responsibility of the preparing tri-service committee. Recommended changes with supporting rationale should be sent to the respective service proponent office, as follows:

- HQUSACE, ATTN: CECW-E, 441 G Street, NW, Washington, DC 20314-1000, by electronic Criteria Change Request (CCR) form on the TECHINFO site listed below.
- Commander, Atlantic Division, Naval Facilities Engineering Command, 1510 Gilbert Street (ATTN: NAVFAC Engineering Innovation and Criteria Office), Norfolk, Virginia 23511-2699, or ufc@efdlant.navfac.navy.mil, by commercial telephone (757) 322-4200 or DSN 262-4200, or by facsimile machine to (757) 322-4416
- Air Force Civil Engineer Support Agency, 139 Barnes Drive, Tyndall Air Force Base, Florida 32403-5319, or larry.spangler@Tyndall.af.mil.

UFC are effective upon issuance. UFC are distributed only in electronic media from the following sources:

- USACE TECHINFO Internet site http://www.hnd.usace.army.mil/techinfo.
- NAVFAC Engineering Innovation and Criteria Office Internet site http://criteria.navfac.navy.mil/criteria.
- Construction Criteria Base (CCB) system maintained by the National Institute of Building Sciences at Internet site http://www.nibs.org/ccb/.

Hard copies of UFC printed from electronic media should be checked against the current electronic version prior to use to ensure that they are current.

AUTHORIZED BY:

Dwight A. Beranek, P.E.
Chief, Engineering and Construction Division
U.S. Army Corps of Engineers

Dr. James W Wright, P.E.
Chief Engineer
Naval Facilities Engineering Command

Kathleen I. Ferguson, P.E.
The Deputy Civil Engineer
DCS/Installations & Logistics
Department of the Air Force

Frank Lane
Director of Analysis & Investment
Deputy Under Secretary of Defense
for Installations
Department of Defense

CONTENTS

CHAPTER 3 PRE-SITE SAFETY MANAGEMENT – GENERAL SAFETY PRACTICES

CHAPTER 4 PERSONAL PROTECTIVE EQUIPMENT

CHAPTER 9 SUBSTATIONS AND SWITCHGEAR

FIGURES

TABLES

CHAPTER 1

INTRODUCTION

1-1 **PURPOSE**. This Unified Facilities Criteria (UFC) manual has been issued to provide safety requirements for electrical workers. The requirements address various aspects associated with work safety for electrical workers. Wherever specific instructions are provided, the emphasis is on the job safety requirements; additional work instructions will likely be necessary related to the actual work being performed.

1-2 **SCOPE**. This manual provides safety requirements and guidance for electrical workers.

1-2.1 **Need**. Electrical personnel involved in operating and maintaining electrical facilities can be injured and equipment can be damaged whenever electrical systems and components are not handled safely. The adoption and enforcement of safe electrical practices will reduce the hazards to personnel.

1-2.2 **Familiarity and Requirements**. Each worker must understand and apply those safety requirements of this manual that apply to the work performed. A copy of these safety manuals must be readily available to each electrical worker for reference and study.

1-2.3 **Mishap Prevention**. Mishap prevention is a basic responsibility of every worker. Personal safety, fellow workers' safety, and the general public's safety depend upon compliance with this manual's requirements. Safety takes precedence over work production.

1-2.4 **Mishap Causes**. Most mishaps are caused by careless or thoughtless acts by workers. Workers must always be cautious and deliberate in their actions, and always notify coworkers before energizing or deenergizing a circuit. Unsafe equipment, tools, and conditions must be reported immediately and corrected. Good housekeeping is also important for safety.

1-2.5 **Unclear Conditions**. If this manual does not cover a specific working condition or job requirements are unclear, workers must obtain clear instructions from an authorized individual-in-charge before proceeding with the work.

1-2.6 **Applicability**. This manual applies to electrical workers involved in any facet of electrical maintenance, repair, or related utility activities. This manual covers the authorized individual-in-charge, crewmembers, and qualified and unqualified electrical workers. The authorized individual-in-charge might be a supervisor, a foreman, or a lead electrician depending upon local policy.

1-2.7 **Work Type**. The type of work covered includes electrical construction, installation, maintenance, operation, repair, and testing of base and facility electrical systems.

1-2.8 **Occupational Safety and Health Administration (OSHA)**. Comply with OSHA electrical system requirements, as applicable.

1-3 **REFERENCES**. Appendix A contains a list of references used in this manual.

1-4 **CODES, STANDARDS, AND PUBLICATIONS.**

1-4.1 Several codes, standards, and regulations apply to basic electrical practices; these documents cover electrical work rules, safety procedures, and requirements for electrical installations. Comply with all applicable provisions of the current issues of these codes. The applicable documents include:

- ANSI C2, *National Electrical Safety Code (NESC)*, American National Standards Institute.
- NFPA 70, *National Fire Protection Association (NFPA)*, *National Electrical Code (NEC)*.
- NFPA 70B, *Electrical Equipment Maintenance.*
- NFPA 70E, *Electrical Safety in the Workplace*.
- 29 CFR 1910, *Occupational Safety and Health, General Industry Standards*.
- 29 CFR 1926, *Occupational Safety and Health, Safety and Health Regulations for Construction*.

1-4.2 Each service has its own documents and criteria relating to occupational safety and health. Refer to the following documents as applicable for the issuing service:

- OPNAVINST 5100.23F, *Navy Occupational Safety and Health (NAVOSH) Program Manual*.
- Air Force Instruction (AFI) 91-302, *Air Force Occupational and Environmental Safety, Fire Protection, and Health (AFOSH) Standards*.
- AFI 32-1064, *Electrical Safe Practices*.
- US Army Corps of Engineers EM 385-1-1, *Safety and Health Requirements Manual*.

1-4.3 Safety procedures are referenced in other service publications, including:

- AFJMAN 32-1080 (TM 5-811-1), *Electrical Power Supply and Distribution*.
- UFC 3-520-01, *Interior Electrical Systems*.
- AFMAN 32-1280(I), *Facilities Engineering – Electrical Exterior Facilities*.
- AFMAN 32-1281(I), *Facilities Engineering – Electrical Interior Facilities*.

1-4.4 NAVFAC issues Standard Operating Procedures (SOPs) that address the safety aspects of various electrical tasks. For example, SOPs have been issued by the Navy Public Works Center (PWC) Norfolk and are available for review at http://www.navfac.navy.mil/safety.

1-5 VARIANCES FROM NORMAL SAFETY PRACTICES.

1-5.1 **Applicability**. The safety requirements of this manual apply to most commonly encountered working conditions. Occasionally, there might be a need to vary work practices from these requirements due to unusual or abnormal conditions. An example might be to permit work on energized equipment. In these cases, the authorized individual-in-charge must analyze and discuss alternatives with the crew prior to commencing work. Obtain required approvals according to local directives. For the Navy, all energized line work will require written, job specific procedures approved, in writing, by the appropriate command authority and considered necessary to support a critical mission, prevent human injury, or protect property.

1-5.2 **Compensatory Measures**. Any variation from normal safety requirements will require the establishment of compensatory measures. An example might be to assign additional electrical workers to the job site, or to preposition emergency response personnel for faster response.

1-5.3 **Documentation**. After any variation from normal safety requirements, a written statement must be prepared covering the reason for the variation, the alternative method used, and how compensatory protection was provided.

1-6 WARNINGS AND NOTES.

The following definitions apply to "Warnings," and "Notes" found throughout the handbook.

1-6.1 **Warning**. An operating procedure, practice, or condition that might result in injury or death or equipment damage if not carefully observed or followed.

WARNING

1-6.2 **Note**. An operating procedure, practice, or condition that is essential to emphasize.

Note: This is an example of a note.

CHAPTER 2

WORKER/CREW RESPONSIBILITIES

2-1 **RESPONSIBILITIES**. The following titles and responsibilities are typical assignments for electrical workers at most facilities or organizations. However, titles and responsibilities might be assigned differently in accordance with local directives.

Note: In other sections of this manual supervisors, foremen, and lead electricians will be referred to only as authorized individuals or authorized individuals-in-charge.

2-1.1 **Supervisor**. The supervisor has overall charge of electrical maintenance and operation. The general responsibilities include duties of a management nature. Supervisors have the principal responsibility for worker competency, personnel safety training, work procedure instructions, safety meetings, testing, job hazard responsibility, and must do a job safety analysis (JSA) or job hazard analysis (JHA). Another typical duty of the Supervisor is to ensure compliance with safety requirements on the job site. The Supervisor often delegates authority to a lead electrician to accomplish these duties on a particular project or job site. Specific responsibilities include:

Note: The terms JSA and JHA are used interchangeably in this manual.

- Establishing work crews and detailing workers who are qualified to perform the required work.

- Assigning an authorized individual-in-charge to each work crew and ensuring all crewmembers know the identity of the authorized individual-in-charge. The supervisor will normally issue orders and instructions only through the authorized individual-in-charge, especially when present at the job site. The authorized individual-in-charge must relay those orders and instructions to the workers. Only in emergencies, or in the absence of an authorized individual-in-charge, must the supervisor direct the actions of individual workers.

- Designating an individual to be in charge overall when two or more crews are engaged in work at one location or on one project.

- Establishing the minimum number of workers on a particular job site, with consideration to the nature of the work and the conditions under which it must be performed (such as confined areas where working clearances are restricted, remote or isolated locations, darkness, or inclement weather).

- Reporting of mishaps, and ensuring adequate first aid treatment is provided in case of injury.

- Conducting safety meetings. Maintaining safety training procedures and records.

- Testing the workers' knowledge of safety requirements.

- Conducting and documenting job hazards on potentially hazardous work using the JSA or JHA process.

2-1.2 **Lead Electrician**. The lead electrician provides worker instruction and direction at the job site, and is directly in charge of one work group or crew. The lead electrician is responsible for job site safety conditions, on-the-job training, mishap handling, and equipment use. The lead electrician must exercise close supervision over the work crew at all times, issue detailed instructions when necessary, and verify that all instructions are followed. Specific responsibilities for the lead electrician include:

- Carefully supervise the workers and issue necessary instructions pertaining to the work. Explain in detail the hazards applicable to the work, and inform them of safety instructions to be followed. Observe rather than engage in the actual work, except when the crew is small or, in emergencies when necessary to prevent further damage or injury.

- Assign only trained workers to perform work of a hazardous nature.

- Ensure that the work crew is physically able to do the work assigned. Relieve a worker who appears to be sick and or unfit for work from all duties and do not allow to return to work until recovered.

- Prevent unauthorized persons from approaching places where work is being done by supervising the placement of barricades, hole covers, warning signs, flags, red lanterns, and other means of protecting the public.

- Instruct workers in the inspection, use, and maintenance of all protective devices, tools, and equipment. Ensure that defects in equipment or apparatus are identified, that the defective equipment is not used on the job site, and take necessary steps to see that the defects are corrected as soon as possible.

- Coach and direct workers who are working near dangerous wires, equipment, or apparatus, and ensure that no person is permitted to confuse, startle, or alarm them.

- Establish cooperation among crewmembers at all times so that the crew works as a team.

- Be present at the job site whenever any work is being performed on energized equipment.

- Coordinate with each lead electrician when there is more than one lead electrician at the job site because two or more crews are working together.

- During extended hours of work, plan accordingly for shift change so crew members are not fatigued or overworked.

- Be vigilant for unsafe situations or conditions that could lead to work stoppage and notify superiors if these occur.

2-1.3 **Crewmembers**. The electrical crewmember will be assigned work depending on the training and abilities of the individual. No crewmember can be assigned work for which the crewmember is not trained, unless working under the direct supervision of another crewmember that is qualified on the task to be performed. Crewmembers must stop working immediately and report to the authorized individual-in-charge whenever they feel unable to work safely due to a health condition, the weather, identification of previously unrecognized safety hazards, or a similar problem. If more than one crewmember is assigned on a job, each crewmember must individually understand the safety hazards and the work procedure to be followed. So far as possible, each crewmember must check job conditions personally. Crewmembers are ultimately responsible for their own safety

2-2. **SAFETY COMPLIANCE**. A requirement of employment is compliance with safety requirements. Workers must not perform work they consider unduly hazardous based on their own capabilities; they are not trained or qualified; or they are not properly protected from injury. In a case where the safety requirements are not clear, the worker must obtain direction from the authorized individual-in-charge.

2-2.1 **Carelessness**. A worker must challenge a fellow worker who violates any of these rules or works in an unsafe manner, and must promptly report any violations of safety requirements to the authorized individual-in-charge.

2-2.2 **Enforcement**. Authorized individuals-in-charge will enforce compliance with safety requirements.

2-2.3 **Violations of Rules**. Each safety rule must be strictly enforced. Workers failing to observe the rules can be subject to penalties. Supervisors shall follow local guidelines and ensure the severity of the penalty is related to the seriousness of the offense.

2-3 **SAFETY MEETINGS**. Safety meetings must consist of scheduled meetings for all personnel and tailgate meetings as needed for specific jobs.

2-3.1 **Scheduled Meetings**. Safety meetings must be scheduled in accordance with local policy. Twice a month is recommended, but once a month is minimum; less frequent meetings tend to de-emphasize the importance of safety. Supervisory personnel must conduct these meetings, but encourage other knowledgeable

individuals to conduct training on specialized topics. Safety posters, mockups or actual equipment, pictures, and other training aids are essential in conducting successful safety meetings. Suggested topics include:

- Two or three safety rules from this manual until all rules are covered; then starting over again.
- Safety rules, methods, and hazards connected with present work in progress.
- Pole climbing.
- Use of lifts, platforms, and ladders.
- Inspecting protective equipment.
- Unsafe practices and consequences.
- A thorough discussion of recent mishaps at civilian or military facilities.
- Safe driving, and use of motorized equipment and trailers.
- Accident reports, safety bulletins, posters, and other material furnished by the installation safety director.
- Electrical safe clearance procedures.
- Work in underground facilities.
- Work on or near machinery.
- Work in elevated positions.
- Grounding systems and equipment.
- Electric shock procedures.
- Methods of artificial respiration applied pole-top and on the ground, as well as cardiopulmonary resuscitation (CPR). All workers must complete buddy care or standard first aid training (such as taught by the American Red Cross, Heart or Lung Association). Practice sessions for artificial respiration and CPR must be held annually. Check with local medical, fire, or safety authorities for class schedules and availability.
- Treatment for bee stings, spider bites, poisonous snakes, and poisonous plants.

2-3.2 **Tailgate Meetings**. Meetings at the job site prior to the commencement of work are commonly called tailgate meetings. This meeting covers all aspects of the planned work, site hazards, and safety precautions to be followed. Each crewmember must understand the precautions to be observed and the procedures to be followed before concluding this meeting. Tailgate meetings are also recommended at the beginning of each work shift for longer duration jobs so that all crew members understand what is to be done, how to accomplish the job, safety hazards present, and methods used to provide worker protection.

2-4 **SPECIAL HAZARD ANALYSIS**. Written work procedures must be prepared for unusual or complicated work activities. (Working with non-hazardous materials or deenergized equipment in accessible locations generally does not require written work procedures.) The special hazard analysis must include the following as a minimum:

- Identification of the work site.
- Description of the work to be done.
- Specific hazards and how to minimize or eliminate them by use of safety equipment.
- Instructions covering special practices for grounding, unusual equipment and tools, and first aid requirements for hazardous materials.
- Sequence of major steps or a detailed step-by-step work listing.
- A JHA or JSA.

2-5 **WORK SITE SAFETY**. Maintaining acceptable work site safety involves good housekeeping, fire prevention, and maintenance of protective measures.

2-5.1 **Good Housekeeping**. Good housekeeping is essential to safety and must be observed in all buildings, yards, enclosures, and mobile equipment. Authorized individuals-in-charge are responsible for good housekeeping practices in and around the work they are supervising. Each worker is also responsible for reporting to the authorized individual-in-charge unsafe housekeeping conditions. Good housekeeping practices include:

- Keep floors, stairways, walkways, driveways, aisles, and exit routes clear of obstacles, blocks, stacked material, and all slippery matter. Remove materials projecting into passageways or emphasize projections using brightly colored paint or signs. If necessary to obstruct passageways, barricades must be erected and alternate means of exiting identified for facility occupants. Keep outside walkways well sanded when icy. Remove snow and icicles from above walkways and work areas.

- Remove pieces of equipment, scraps, and refuse from floors, walks, balconies, and yards, and stack them in a safe and secure position upon completion or suspension of work.

- Place small parts in containers when dismantling equipment.

- Keep tools in chests or convenient racks when not in use, or otherwise store them so they can not pose a hazard.

- Do not exceed rated floor loading. Do not place material on or against any structural support unless it is known that it can carry the additional weight.

- Stack material so that it cannot be overturned easily. Fasten securely. When stacking materials, be sure that there is enough clearance to handle them safely. Inspect for loose material, or for objects that could fall or be dislodged.

- Use racks for storing pipe, piling, and other materials which otherwise cannot be easily formed into stable stacks.

- Place timbers, steel members, and other heavy objects on suitable blocks or sleepers to provide necessary hand holds.

- Stack empty wire reels with three strips of wood between reels. Wire spools shall be stored standing on the spool, not standing upright end-to-end. Standing them upright end-to-end can cause cable damage due to the weight of the wire compressing against it.

- Do not leave nails projecting from boards or walls where they may cause injuries.

- When removing materials from packing cases or when removing concrete forms, immediately remove all projecting nails.

- Keep motor vehicle tool compartments, cabs, and rear compartments clean and orderly at all times. Do not allow surplus or waste materials to accumulate in vehicles.

2-5.2 **Fire Prevention**. It is the workers responsibility to prevent accidental fires in the work place by complying with local fire prevention regulations. These regulations typically include the following:

- Workers will not smoke except in authorized smoking areas.

- Do not permit combustible material to accumulate since it creates a fire danger.

- Provide sufficient metal or noncombustible containers with self-closing lids for the disposal of combustible wastes, soiled rags, and other flammable materials. Dispose of contents according to approved hazardous waste disposal procedures. Contact the installation environmental management office for guidance. Use properly marked, covered metal containers for storing clean rags.

- Do not burn rubbish or waste within 15 meters (50 feet) of a combustible structure, or within 7.5 meters (25 feet) of any building. In burning waste and rubbish, heavy smoke must not be allowed to blow into energized equipment. No burning may be done out of doors during high winds. Obey local base and civilian regulations regulating open fires.

- Do not permit weeds or other vegetation to grow in substation yards, pole yards, or around oil tanks.

- Fire detection devices, including smoke detectors, heat detectors, alarm devices, or other components of fire alarm systems will not be disabled without prior notification to and permission of the base or local fire department.

- Ensure that fire extinguishers located in the work area are kept in their normal places, properly filled, and ready for immediate use.

2-5.3 **Protective Measures**. Machinery guards and warning signs must be provided to protect workers.

2-5.3.1 **Machinery Guards**. Guards must not be removed from any machine or piece of equipment except on approval of the authorized individual-in-charge, or as needed to maintain the equipment. If guards are removed, the machine must not be operated unless suitable temporary guards are provided pending replacement of the permanent guards. When maintenance is needed, whether it is done by the supervisor, operator, or a specialized technician, machines will be completely shut down and all energy isolating devices locked out in the **OFF** position. The appropriate warning tag will be affixed to the machine and (or) energy source. In cases where machine or equipment design prohibits lockout capability, a tagout procedure with a ***Do Not Start*** tag must be used. All guards, interlocks, and safety devices must be in place prior to restoring power, unless their removal is required by technical data for an operational check.

2-5.3.2 **Warning Signs**. Warning signs must be placed in areas where energized lines are exposed, or where abnormal operating conditions exist. Warning signs must be removed only after work is completed.

2-6 **PERSONAL CONDUCT**.

2-6.1 **General**. Normal electrical work practices are reasonably safe when all precautions are taken. However, the work can become dangerous through improper worker actions or when workers fail to respond appropriately. Careless actions can cause serious injuries to the worker and to others. Workers must be held accountable for their actions. All required safety procedures must be fully completed by each worker before starting the job, and appropriate safety precautions must be taken during the job. When working in a group, coworkers must be notified before energizing or deenergizing a circuit. Workers must stop working immediately when they feel unqualified for or unable to handle a job.

2-6.2 **Not Taking Chances**. Before starting a job, establish a safe procedure and determine what dangers exist. Where more than one worker is engaged in the same job, all workers must be briefed on the procedures to be followed. Workers working in or around hazardous places, or near energized equipment, must act deliberately and do nothing that might endanger themselves or others. Do not take chances with safety. Workers must always place themselves in a safe or secure position. Undue haste, inconsistent with established and proven safety procedures, must not be permitted.

2-6.3 **Practical Jokes**. Practical jokes, horseplay, scuffling, and wrestling while on the job site, or in transit to or from the job site, is prohibited.

2-6.4 **Intoxicating Beverages or Drugs**. The drinking of alcohol or other intoxicating beverages while on duty is prohibited. A worker who reports for duty under the influence of alcohol or whose job performance is impaired by prescription or over-the-counter drugs must not be permitted to work. Disciplinary action must be taken if a worker partakes of or reports for duty under the influence of any illegal drug. A worker on duty must not allow their relief from duty by another worker who is known or suspected to be under the influence of alcohol or drugs.

2-6.5 **Smoking and Open Flames**. Smoking and open flames are not permitted in areas where dangerous gas or combustible materials are kept, or where otherwise prohibited. The absence of “No Smoking” signs is not an excuse for smoking in unauthorized locations. Smoking at job sites will only be permitted in approved designated smoking areas and never while performing work.

2-6.6 **Wearing of Protective Equipment**. Supervisors must conduct and document hazard assessments in each workplace where their employees are performing duties. If personal protective equipment (PPE) is required, the supervisor will ensure that PPE is provided, used, and maintained in a sanitary serviceable condition. They are responsible for maintaining discipline with regard to personnel wearing properly fitted PPE, when required. It is each worker’s responsibility to wear PPE if determined necessary and appropriate for the work to be done. Consult with an industrial hygienist for additional sanitary and serviceable requirements.

2-6.7 **Consideration of Others**. Workers must be courteous and considerate of the public and of each other. Displays of temper and ill feeling are inappropriate and

lead to inattention to safety procedures. Workers must not enter the workspaces or facilities of other work groups where they have no business.

2-6.8 **Carelessness**. Workers must challenge the careless behavior of a fellow worker who violates any of the safety rules in this manual, or who works in an unsafe manner. Carelessness that is not corrected must be reported immediately by the worker to the authorized individual-in-charge.

CHAPTER 3

PRE-SITE SAFETY MANAGEMENT – GENERAL SAFETY PRACTICES

3-1 **BASIC SAFETY PRINCIPLES**. Be familiar with the fundamentals of electrical safety, normal precautions for hazardous materials, and general industrial work practices. Cultivate the habit of being deliberate and cautious in your actions.

3-2 **PREVENTION OF MISHAPS**. Cooperation by all workers is required to prevent mishaps. Mishaps do not "just happen." Mishaps are the result of unsafe acts, unsafe conditions, or both.

3-2.1 **Unsafe Acts**. Unsafe acts are estimated to cause nine out of every ten mishaps. Common unsafe acts include the following:

- Operating without authority or warning, such as: opening or closing switches without permission; operating hoists, trucks, or other motor-operated devices without giving a proper warning; failure to place warning signs or guards; failure to give signals where needed; and violation of lockout/tagout rules.

- Making safety devices inoperative unnecessarily or without an adequate reason, such as: removing guards; using oversize fuses; and blocking protective devices.

- Using unsafe equipment or using equipment improperly, such as: using tools and chisels that are damaged; using pipe extensions on wrenches not designed for them; using the wrong tools for the job; and using hands instead of hand tools.

- Unsafe loading or placing, such as: carrying or lifting heavy loads; placing objects where they are likely to fall; unstable packing of loads; and failure to block or guard equipment against unexpected movements.

- Taking unsafe positions, such as: working or lifting from an improper position; casual walking under suspended loads, through hazardous work areas, or close to openings; entering areas contaminated by gases or fumes without taking proper precautions; and riding in unsafe locations in or on motor vehicles.

- Working without required protective devices and equipment. Failure to use personal protective equipment or safe clothing where required, including rubber gloves, aprons, and leggings.

- Working near energized equipment, moving machinery, moving apparatus, or moving parts without observing prescribed safety precautions and regulations.

- Engaging in distracting or startling acts, including “practical jokes,” horseplay, teasing, quarreling, and annoying behavior.

- Wearing unsafe personal apparel, such as neckties, jewelry, or loose sleeves around moving machinery.

3-2.2 **Unsafe Conditions**. Unsafe conditions can also cause or contribute to mishaps. Commonly found unsafe conditions include:

- Lack of shields or guards.

- Unbarricaded or makeshift barriers for floor openings or excavations.

- Insufficient warning signs.

- Lockout/tagout not properly applied.

- Absent or inadequate grounding systems.

- Poor housekeeping.

- Inadequate illumination.

- Inadequate ventilation.

3-2.3 **General Precautions for Normal Industrial Work**. Observe the following general precautions for normal industrial work:

- Do not begin work around energized machinery or equipment, or at any place where a hazard exists until adequate lighting and all proper safety measures are provided.

- Treat all electric wires and apparatus as energized until tested.

- At the completion of a job, disconnect and remove all extension power cords.

- Place DANGER and other signs when conditions require their use. Do not use signs unnecessarily.

- Remove DANGER and signs from places when no longer needed.

- Inspect tools and equipment prior to use. Report promptly any defects noticed.

- Never work so closely to fellow workers that the swinging of picks, shovels, or similar tools may endanger them.
- Use nail pullers when removing nails from boxes or crates.
- Do not use wood or metal files without proper handles.
- Use cribbing or other approved means to support objects that are raised above the working position. Do not depend upon a lifting jack for support.
- Do not stand or allow others to stand near ropes or cables under strain.
- Turn off portable gasoline engines and electric motors propelling equipment, such as concrete mixers, compressors, pumps, blowers, and cranes, before refueling, greasing, oiling, or repairing.
- Report promptly and establish barriers or guards over any hazardous condition found that might cause injury, property damage, or interference with electric services. These conditions may include downed transmission or distribution wires, open holes or ditches, and broken poles or crossarms.
- Do not operate portable electric hand drills, hand grinders, hand buffing wheels, and other similar equipment, unless the motor casing is grounded or the tool is properly labeled as “double insulated”, and is suitable for outdoor work.
- Ensure the casings of electric motors mounted on workbenches or on metal bases fastened to the floor are grounded before operating the motors.
- Do not remove broken light bulbs in temporary lighting fixtures while working inside tanks, heaters, boilers, or other enclosed spaces, unless the power supply cord is disconnected from the power supply receptacle.

3-3 **TYPICAL WORK AREAS**. There are four locations where most electrical work is completed. These include inside work, outside work, underground work, and aerial work. Each requires a different safety approach. Correct grounding methods are required in all locations.

3-3.1 **Inside Work**. Inside work locations usually can be most easily shut off from access by the public or non-electrical workers. Most work is accessible without ladders and can be worked deenergized.

3-3.2 **Outside Work**. This work often requires protection from the weather. Protective apparel and tools are usually required. The work area usually needs to be fenced or guarded for public protection.

3-3.3 **Underground Work**. Underground work often includes work in a confined space. Comply with confined space entry requirements. Basement areas are not usually considered underground work when accessible by stairs and adequately ventilated. Openings to the work area must be fenced or guarded against accidental entry by the public. Supplemental ventilation or removal of water by pumping might be necessary prior to worker entry. Energized lines in the immediate vicinity of the work must be tagged so workers are aware of their location. Protective apparel and tools are usually required.

3-3.4 **Aerial Work**. Aerial work typically includes work on poles, trees, or aerial lifts. Each requires observance of the proper safety rules. Work on ladders or scaffolds is not normally considered aerial work but is considered inside or outside work accomplished in an elevated position. Aerial work is often done on energized lines or close to energized lines. Protective apparel and tools are almost always required.

3-4 **PUBLIC WARNINGS**. An important aspect of electrical safety consists of methods to warn and safely guide the public around the work area.

3-4.1 Warning devices. Barriers with warning signs, traffic cones, or lights must be located on the approaches to and around the work area, excavation, open manhole, parked vehicles and motorized equipment, and other hazards. Particular precautions must be taken in reduced visibility conditions, such as for work at night, in fog, or in inclement weather. Promptly remove warning devices when no longer needed.

3-4.2 Flagmen. Flagmen must be used whenever there is any doubt of the effectiveness of warning devices. This often occurs on busy roadways or during commuting hours on less traveled streets. Flagmen must wear brightly colored and highly reflective warning vests.

3-5 **NOISE CONTROL**. Noise protection is required whenever the sound level exceeds 85 decibels adjusted continuous sound level pressure or 140 decibels peak sound level pressure for impulse or impact noise, regardless of the exposure duration. As a rule of thumb, if normal conversation can be understood at about a 0.6-meter (2-foot) distance, the noise level is probably less than 90 decibels adjusted, which is the point at which prolonged exposure can cause a gradual decay in hearing ability. An example of impulse noise is the sound of firing from a rifle or shotgun. Noise is considered an impulse type when maximum variation in sound level occurs in less than one second.

3-6 **AREA LIGHTING**. Ensure the working area has adequate illumination. Provide temporary lighting where natural or installed artificial illumination is not sufficient. Do not use matches or open flames to provide temporary illumination.

3-6.1 Do not enter spaces containing exposed energized parts, unless illumination is provided. Do not perform tasks near exposed energized parts where lack of illumination or an obstruction precludes observation of the work to be performed. Do not reach blindly into areas that may contain energized parts.

3-6.2 Temporary Lighting:

- All temporary lighting for general illumination must be protected from accidental contact or breakage using approved guards.
    - Guards are not required for flashlights.
- Do not use metal-cased flashlights.
- Do not suspend temporary lights by their electric cords unless cords and lights are designed for this means of suspension.
- Portable electric lighting used in wet and or other conductive locations must be protected by a ground-fault circuit interrupter, or be powered from circuits at 12 V or less.
    - Only explosion-proof lighting/equipment must be used in confined or enclosed spaces until atmospheric tests have proven the space to be non-explosive.

Note: "Mag-lites" and similar handheld flashlights are not listed for use as explosion-proof lighting.

3-7 **MATERIAL SAFETY DATA SHEETS**. Prior to working with hazardous materials, become familiar with their properties and health affects by reviewing the applicable material safety data sheets (MSDS).

3-8 **HAZARDOUS MATERIALS**. Hazardous materials most commonly encountered by electrical workers include asbestos, polychlorinated biphenyls (PCB), sulfur hexafluoride (SF_6), and preservation treatments for wood products, which require special handling. It is beyond the scope of this manual to prescribe procedures to follow in the event of hazardous releases of such materials. Protective apparel and accessories are discussed in section 4.

3-8.1 **Asbestos**. Asbestos is prohibited for new installations, but might be encountered at existing facilities. It was commonly used for insulation, fire protection smoke and flame barriers, and as part of conduit or piping material. Some older circuit breakers may have asbestos-containing arc chutes. Cutting existing asbestos materials can release asbestos fibers to the atmosphere. If fibers are suspended in the air in sufficient quantities, respiratory harm may result. Handling of asbestos-containing materials must be performed only by authorized and trained personnel. Employees who are not qualified to work with asbestos are not to handle or remove materials containing asbestos fibers. Refer to 29 CFR 1915.1001, *Asbestos*, for worker qualifications and requirements for handling asbestos-containing materials.

3-8.2 **Polychlorinated Biphenyl (PCB)**. Used for many years in electrical equipment, PCB provided a suitable liquid insulation for transformers, capacitors, and other equipment. Note that PCBs were distributed by equipment manufacturers under trade names such as Askarel, Inerteen, Pyranol, Chlorextol, Saf-T-Kuhl, No-Flamol, and many others. Capacitors made before 1979 usually contain PCBs. Light ballasts made before 1979 usually also included a capacitor with liquid PCBs. Mineral oil filled transformers often became contaminated with PCBs during maintenance. Electrical

items containing liquid PCBs in concentrations of 50 parts per million or greater are governed by EPA regulations.

3-8.2.1 PCB liquid acts as a “strong solvent” on skin and prolonged contact can result in removing the natural skin oils. Nonabsorbent gloves, face shields, and protective clothing must be worn when handling PCBs. Nonabsorbent footwear may be required when dealing with the cleanup after an outdoor spill. For accidental contact with PCB liquid, wash contacted body parts immediately with soap and water.

3-8.2.2 Workers must make every effort to handle PCBs in closed containers. If PCB exposure might be a possibility, cover all exposed skin with petroleum jelly, olive oil, cold cream, or an approved skin compound. Use of respirators and goggles is also highly recommended.

3-8.3 **Sulfur Hexafluoride (SF_6)**. In its pure state, SF_6 is colorless, odorless, tasteless, nonflammable, nontoxic, and non-corrosive. It is shipped in a liquid state but will transition to a gaseous state if released at atmospheric pressure. The gas is about five times heavier than air and can asphyxiate in an enclosed space. In a liquid state, it can cause tissue freezing similar to frost bite. SF_6 is used as an insulating medium in many types of electrical equipment such as circuit breakers, switches, busway, and cable. Decomposition products from SF_6 can result as electric arcs are created during normal switching operations and during faults. These decomposition products are non-conductive, and do not interfere with the insulating properties of the SF_6 gas; however, the decomposition products can be toxic. SF_6 gas-insulated equipment can rupture and leak gas. Always treat SF_6 as hazardous.

3-8.3.1 **Handling**. Only workers trained to work with SF_6 must analyze, fill, reclaim, or otherwise handle this material. No worker must work alone when handling SF_6. Wear approved insulating gloves, safety glasses, and protective clothing to prevent any skin contact. Deenergize power sources that could cause electrical arcing and turn off any source of heat or open flame. Provide adequate ventilation to prevent the atmosphere from becoming oxygen deficient. Alternatively, use an external air supply (such as a hood with an airline or self-contained breathing apparatus) when entering an oxygen-deficient atmosphere. Chemical cartridge respirators are not suitable in these situations, also provide a safety line and a standby worker having an external air supply as back up for the worker in the hazardous SF_6 atmosphere.

3-8.3.2 **Fire Effects**. Although SF_6 is a non-flammable gas, it can decompose at high temperatures to yield toxic and corrosive by-products. If a fire occurs, use an appropriate fire-extinguishing agent for the type of fire, and ensure all personnel exposed to the fire wear the correct-type of breathing apparatus as discussed in the preceding section.

3-8.4 **Wood Product Preservative Treatments**. Creosote, water-borne, or oil-borne preservatives used for the treatment of wood products must only be applied by certified pesticide applicators. Certification is not required for a copper naphthenate preservative treatment.

3-9 **ELECTROMAGNETIC FIELDS (EMF)**. EMF effects occasionally become a source of concern in regard to potential health hazards of electric and magnetic fields. This manual is intended to cover safety measures appropriate when working around sources of electric and magnetic fields produced by electric power sources for facilities and facility equipment. These power sources (usually operating at a 50- or 60-hertz frequency) emit only an extremely low frequency (ELF) EMF field. To date, no conclusive evidence exists that demonstrates that EMF from ELF sources is harmful.

3-9.1 **Electromagnetic Field**. Electric and magnetic fields are produced whenever electric power is used. Electric fields and magnetic fields can be considered as separate fields only at low frequencies. Electrostatic fields are a form of electromagnetic field that occurs because of a voltage difference. Electrostatic fields can create a flow of current through the air or through a worker if the voltage difference is high enough.

3-9.2 **Electric Field**. The strength of an electric field is a direct function of its system voltage level, and is inversely proportional to its distance from the electric conductor generating the field. Current flow is not required to generate an electric field. An electric field may be present in an appliance, even if the power switch is off, as long as it remains connected to an energized receptacle or power source. Electric fields are measured in units of volts per meter (V/M).

3-9.3 **Magnetic Field**. The strength of a magnetic field depends on the magnitude of electric current and its direction. The strength of the earth's magnetic field will also contribute to other magnetic fields, but is usually insignificant in most practical applications. Magnetic fields increase in strength directly with the magnitude of electric current, and vary with distance as an inverse square factor for an electric line conductor, and as an inverse cube factor for highly localized sources, such as an electric motor or generator. Magnetic fields are measured in units of milligauss (mG).

3-9.4 **Biological Fields**. Living organisms also generate electric fields, voltages, and currents. The human body generates fields that are similar to the electric and magnetic fields induced by 60-hertz electric lines.

3-9.5 **Protection from Electrostatic Fields**. Since electrostatic fields can create an electric current that could pass through the body of the worker, protection is commonly provided when working on systems with very high voltage levels. Electric field shielding is commonly provided for electricians who work on energized lines above 150 kV line-to-line. Conductive shielding, including conductive clothing, screens, and bucket liners, provide an alternate path of current flow around the workers body. A worker may notice a sensation in the body from an induced electric current at approximately one-milliampere. For comparison, the induced current through a worker's body working without shielding at a distance of 2.4-meter (8-feet) from an conductor energized at 138 kV is 0.125-milliamperes, or if energized at 345 kV is 0.395-milliamperes. Working near electric lines at the voltage levels found on most military installations (generally under 138 kV) usually may not require shielding provisions

unless the worker experiences discomfort within the electrostatic field because of work close to the energized lines.

3-10 **ELECTRICAL HAZARDS**. Electrical hazards are particularly dangerous because the human body usually does not sense electrical energy until contact is made and significant injury has already occurred. Workers must always be aware of the location of energized equipment and its voltage level at each job site. Additionally, workers must be aware of the possible sources of electrical feedback from other energized power sources into the work site. These hazards must be determined before starting work. Pre-job planning must include engineering guidance in understanding the system's operation and review of up-to-date single line and schematic as-built drawings. All apparel, tools, and other equipment required for worker safety must be identified and available before beginning the job.

3-10.1 **Electrical Shock Dangers and Effects**. Electric shock results from setting up an electric current path within the human body. The current flows because there is a potential gradient (voltage difference) between an energized object and the grounded worker. Table 3-1 indicates the effects of 60-hertz current on humans.

Table 3-1. Effect of 60-Hertz Current on Humans

Effect	Milliamperes	
	Men	Women
Slight sensation on hand	0.4	0.3
Perception threshold	1.1	0.7
Shock, not painful and muscular control not lost	1.8	1.2
Painful shock, painful but muscular control not lost	9	6
Painful and severe shock, muscular contractions, breathing difficult	23	15
Ventricular fibrillation, threshold	75	75
Ventricular fibrillation, fatal (usually fatal for shock duration of 5 seconds or longer)	235	235
Heart paralysis (no ventricular fibrillation), threshold (usually not fatal; heart often restarts after short shocks)	4,000	4,000
Tissue burning (usually not fatal unless vital organs damaged)	5,000	5,000

3-10.2 **Arc Flash Dangers and Effects**. With respect to electrical safety, the term "arc flash" refers to the unintentional creation of an electric arc that has the potential to cause bodily harm for nearby personnel. Arc flash is also referred to as arc blast and arc fault. This manual addresses arc flash criteria for electrical safety.

3-10.2.1 **Electrical Arc Characteristics**. An arcing fault is different from a bolted fault. A bolted fault occurs with the fault current flowing through a solid connection to ground, whereas an arcing fault has its current flowing through ionized air. A bolted fault releases its energy into the faulted equipment through the path to ground; an arcing fault releases its energy into the ambient environment. The energy released by an arc depends on the current magnitude and duration. Arcs can have the following characteristics:

- High temperatures – arcs can generate temperatures of up to 35,000 degrees Fahrenheit.
- Air blasts – the high arc temperature can cause an air blast.
- Material vaporization – all known materials are vaporized at arc temperatures. The associated air blast can eject molten metal with great force.
- Enclosures – arcs inside enclosures, such as motor control centers and switchgear, tend to magnify the blast effects toward the open side of the enclosure where an electrical worker might be standing.

3-10.2.2 **Electrical Arc Hazards**. It is estimated that 5 to 10 arc flash explosions occur in electric equipment every day in the United States. This estimate only includes events in which the victims' injuries were so severe that special treatment from a burn center was required rather than from an ordinary hospital. Arcs produce the following extreme hazards:

- Heat – fatal burns can occur, even when a worker is several feet from an arc. Serious burns are common even at a distance of 3 meters (10 feet).
- Pressure – arc blast pressure bursts have thrown workers across rooms and knocked them off of ladders.
- Shrapnel and molten metal – vaporized and molten metal can burn and penetrate the body.
- Ignition – clothing can be ignited several feet away from the arc. Depending on the clothing, clothed areas can be burned more severely than exposed skin.
- Noise – the explosive sound of an arc can cause hearing loss.

3-10.2.3 **Industry Standards**. Industry experience with arc flash hazards has led to revisions in several industry codes and standards. The following documents specifically address arc flash hazards:

- **OSHA 29 CFR 1910.269, *Electric Power Generation, Transmission, and Distribution***. This document requires that arc hazards be considered in the training and dress of electrical workers. Section 1910.269(l)(6)(ii) requires the employer to train each employee who is exposed to the hazards of flames or electric arcs in the hazards involved. Section 1910.269(l)(6)(iii) requires the employer to ensure that each employee who is exposed to the hazards of flames or electric arcs does not wear clothing that, when exposed to flames or electric arcs, could increase the extent of injury that would be sustained by the employee. Note: Clothing made from acetate, nylon, polyester, or rayon, either alone or in blends, is prohibited by this paragraph, unless the employer can demonstrate that the fabric has been treated to withstand the conditions that may be encountered or that the clothing is worn in such a manner as to eliminate the hazard involved.

- **NFPA 70, *National Electrical Code (NEC)***. The 2002 edition of the NEC makes one reference to arc flash protection in Article 110.16, *Flash Protection*, and requires that switchboards, panelboards, industrial control panels, and MCCs located in other than dwelling occupancies and likely to require examination, adjustment, servicing, or maintenance while energized shall be field marked to warn personnel of potential arc flash hazards. An associated Fine Print Note (FPN) refers to NFPA 70E for assistance in determining the severity of potential exposure, planning safe work practices, and selecting personal protective equipment (PPE).

- **NFPA 70E, *Electrical Safety in the Workplace***. NFPA 70E establishes stringent requirements related to arc flash safety. It requires that a flash hazard analysis be completed before a person approaches any exposed electrical conductor or circuit part that has not been placed in an electrically safe work condition. It also describes the PPE required as a function of the available incident energy.

- **NFPA 70B, *Electrical Equipment Maintenance***. The 2002 edition of NFPA 70B has strengthened the electrical safety requirements associated with electrical maintenance and refers to NFPA 70E with respect to arc flash safety.

- **IEEE 1584, *Guide for Arc Flash Hazard Analysis***. IEEE 1584 was approved in 2002 and is intended to assist in the calculation of arc flash hazards in electrical equipment. The 2004 edition of NFPA 70E endorses IEEE 1584 as an acceptable method for determining location-specific arc flash hazard requirements.

3-11 **PHASE DIFFERENCES**. When it is necessary to parallel two or more circuits together, the phases must first be checked using a hot-stick phasing tester, potential transformers, or other suitable instruments to determine the correct connections.

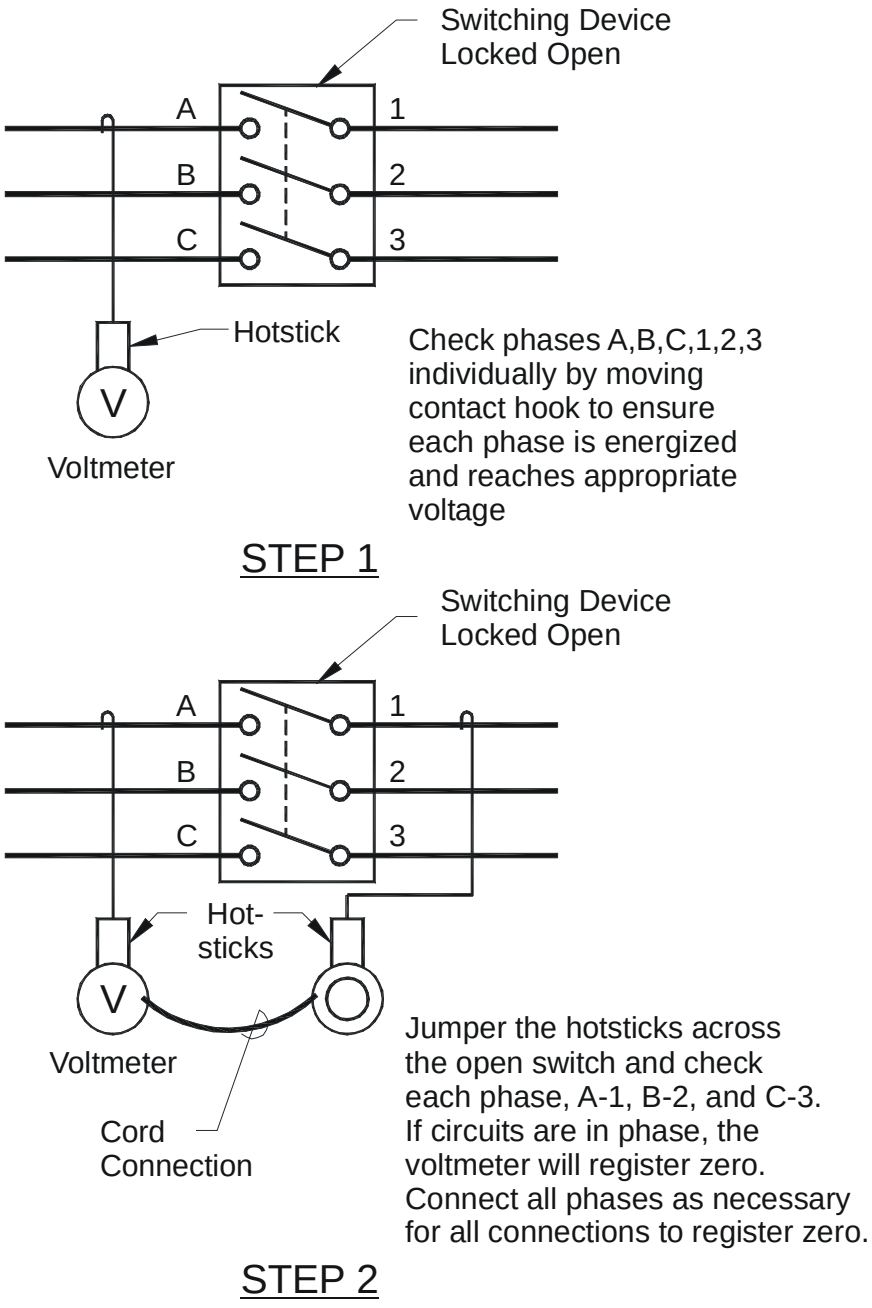
Extremely hazardous high current levels can occur if two circuits are tied to each other out of phase.

3-11.1 **Phasing Out Process**. Prior to paralleling two circuits, determine the correct connection for each conductor by checking the voltage level between that conductor and all other conductors. The voltage across corresponding lines or phases must be zero.

3-11.2 **Hot-Stick Phasing Tester**. A typical phasing tester consists of two high-resistance units on hot sticks connected through a voltmeter. Refer to Figure 3-1 for connections.

3-11.3 **Potential Transformers**. If potential transformers are available, a voltmeter can be used to measure voltages by connecting a voltmeter between the two sides. If the lines are in phase, the voltmeter will register zero.

Figure 3-1. Phasing Check Using Hot-Stick Phasing Testers



3-12 **NUMBER OF WORKERS REQUIRED.** All work must be performed with a sufficient number of workers to provide safe working conditions. The following provides specific requirements:

3-12.1 **Jobs Requiring Two Qualified Electrical Workers**. A hazard exposure involving installation, removal, or repair when working on or near lines or parts energized at more than 600 VAC or 250 VDC requires a minimum of two electrical workers. Examples of the type of work include:

- Working on energized lines or equipment.
- Deenergized lines or equipment with possible energized parts contact.
-
-
- Other work with equal or greater hazard exposure.

3-12.2 **Confined Space Jobs Requiring Additional Workers**. Additional requirements apply to installation, removal, or repair when working in a confined space. Manhole or vault requirements are generally classified as confined spaces. The following summarizes the additional worker requirement:

- An attendant with first-aid and CPR training must be available on the surface in the immediate vicinity.
- If a hazard exists within the space, or a hazard exists or is created because of traffic patterns outside the space, the attendant can not enter the confined space.
- If the restrictions of the second item above do not apply, the attendant can enter the confined space to provide assistance, but only for a brief period (other than in an emergency). For extended periods of assistance, a second worker in addition to the attendant is required.

3-12.3 **Jobs Generally Acceptable for One Qualified Electrical Worker**. The following types of work are generally acceptable for a single electrical worker; however, consult local guidance:

- Work on deenergized systems with nominal system voltages of 600 VAC or 250 VDC, or less.
- Routine electrical measurements on energized systems with nominal system voltages of 600 VAC or 250 VDC, or less.
- Routine operation of metal-enclosed switchgear with nominal system voltages of 600 VAC or 250 VDC, or less.
- Emergency repair work to safeguard the general public, if previously authorized.

CHAPTER 4

PERSONAL PROTECTIVE EQUIPMENT

4-1 **INTRODUCTION**. This chapter addresses the apparel and related protective equipment that support electrical maintenance, and the associated requirements for their inspection and use. Always refer to manufacturer's instruction for specific instructions when available.

4-2 INSPECTION OF APPAREL, TOOLS, AND MATERIALS HANDLING EQUIPMENT.

4-2.1 All apparel, tools, and equipment used on the job must comply with this manual, as well as the applicable service or OSHA requirements. Regular inspections are also necessary to prevent the use of defective items on the job. The authorized individual-in-charge may, regardless of ownership, prohibit the use of any equipment on the job which could be considered unsafe.

4-2.2 An initial inspection of tools brought on the job by a new worker must be made by the authorized individual-in-charge. Use must be permitted only if the tools are in good condition and conform to requirements of this manual.

4-2.3 Inspections of tools and equipment that are owned by an individual worker may be made by the authorized individual-in-charge at any time.

4-2.4 Before a job is started, each worker must inspect protective apparel, tools, ladders, scaffolds, ropes, and other materials handling equipment to be used. All items must be suitable for their intended use and in good material condition.

4-3 PERSONAL PROTECTIVE EQUIPMENT FOR ARC FLASH PROTECTION.

4-3.1 Perform a flash hazard analysis in accordance with NFPA 70E, Section 130.3, to determine the personal protective equipment (PPE) requirements for the intended work location. PPE selection can also be based on NFPA 70E, Table 130.7(C)(9)(a), which establishes the hazard/risk category for different tasks. Refer to NFPA 70E, Table 130.7(C)(10) for the PPE requirements for the specified hazard/risk level.

4-3.2 NFPA 70E, Table 130.7(C)(9)(a), is based on certain maximum levels of short circuit current available and expected protective device clearing times. If the available short circuit current or protective device clearing times are not known for the intended work location, apply a minimum hazard/risk category of 2 for the selection of PPE.

4-3.2 For low-voltage work, NFPA 70E, Table 130.7(C)(9)(a) allows reducing the hazard/risk category by one level if the available short circuit current is less than 10,000 amperes for panelboards and switchboards, or is less than 25,000 amperes for motor control centers. Figures 4-1 and 4-2 show typical levels of short circuit current that can

be expected on the secondary side of facility transformers. These graphs show the short circuit variation as a function of internal transformer impedance for each kVA rating and do not include the effect of secondary-side conductors, which would further reduce the available short circuit current. As shown, smaller facility transformers are unlikely to produce short circuit currents greater than the criteria specified in NFPA 70E, Table 130.7(C)(9)(a).

Figure 4-1. Short Circuit Current Variation with Transformer Impedance – 208 V
(Units of Symmetrical Short Circuit Current in kA)

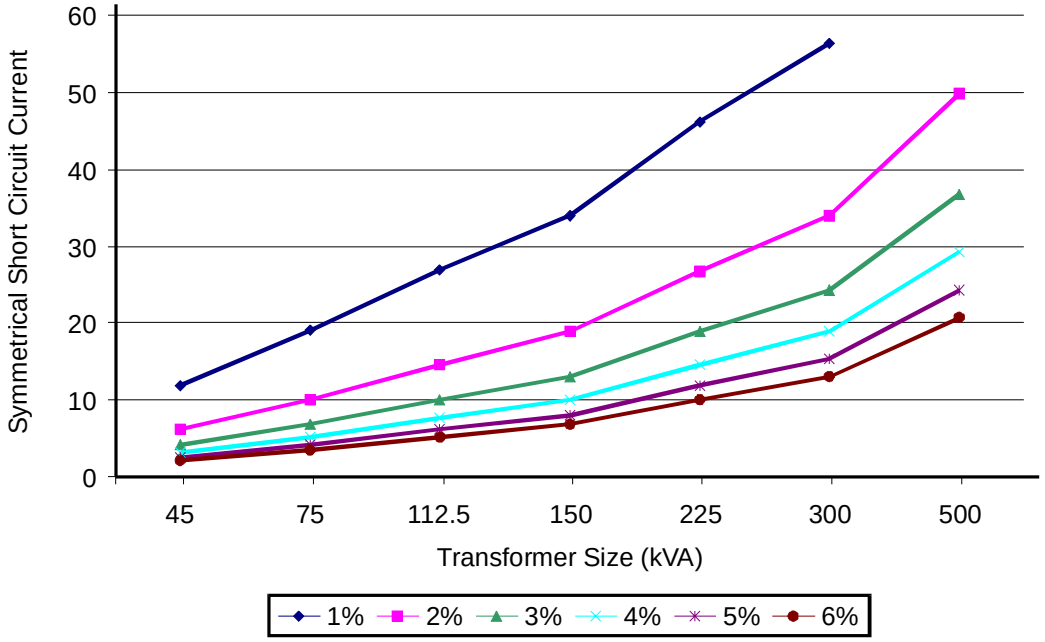
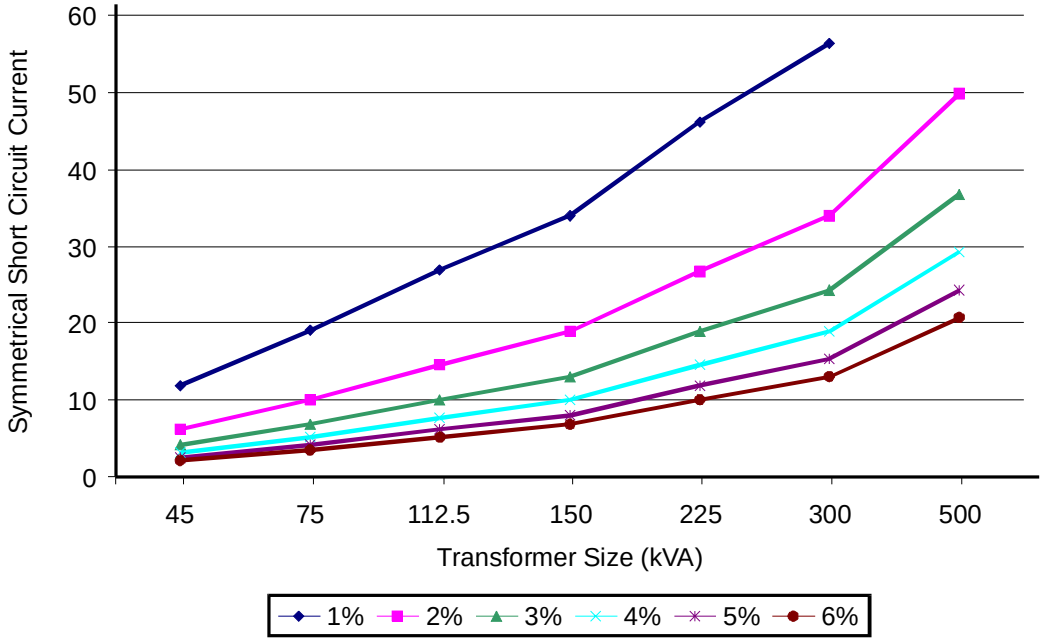


Figure 4-2. Short Circuit Current Variation with Transformer Impedance – 480 V



4-4 PERSONAL PROTECTIVE APPAREL.

4-4.1 **Applicable Documents**. The following documents provide minimum safety, fire prevention, and occupational health requirements for protective clothing and equipment.

- AFOSH Standard 91-10, *Civil Engineering*.
- AFOSH Standard 91-31, *Personal Protective Equipment*.
- AFOSH Standard 91-66, *General Industrial Operations*.
- ANSI C2, *National Electrical Safety Code (NESC)*, American National Standards Institute.
- EM 385-1-1, *US Army Corps of Engineers Safety and Health Requirements Manual*.
- NFPA 70, National Fire Protection Association (NFPA), *National Electrical Code (NEC)*.
- NFPA 70E, *Electrical Safety in the Workplace*.
- Navy Handbook OPNAV P-45-117-6-98, *Electrical Safety Field Guide*.
- OPNAVINST 5100.23 Series, *Navy Occupational Safety and Health (NAVOSH) Program Manual*.
- OSHA 29 CFR 1926, Subpart E, *Personal Protective and Life Saving Equipment*.

4-4.2 **General Clothing Requirements for Electrical Work**.

4-4.2.1 Wear clothing appropriate for the weather conditions and for the job to be accomplished. Coveralls should not be worn half-dressed where the top-half is wrapped around the waist area.

4-4.2.2 Always wear a top shirt or similar garment with long sleeves. because they provide protection from cold and sun. (Loose sleeves must not be worn around moving machinery.)

4-4.2.3 Wear safety shoes or boots in good condition, with non-slip soles and heels, and with safety-toe protection when handling heavy loads such as poles, cross-arms, apparatus, reels, and motors. Workers must consider wearing safety-toe shoes at all times since they often cost little more than any other good work shoe but provide superior protection for the feet.

4-4.2.4 Wear work gloves when handling rough or heated objects, and when performing any other work where gloves could help in prevent injuries. Rubber glove protectors must not be used as work gloves.

4-4.2.5 The appropriate protective clothing required for specific welding operations will vary with the size, nature, and location of the work to be performed. Separate documents provide information on personal protective equipment required for welding operations.

4-4.2.6 Wear safety shoes or boots, and non-conducting hard hats when working on overhead and underground systems, in congested areas, in industrial facilities, in missile silos, and other such areas. Wear hard hats when working below other workers, or near exposed energized lines. Hard hats prevent head injuries caused by fixed obstructions, falling or flying objects, or from direct contact with energized lines. Hard hats must meet ANSI Z89.1 Class E requirements (20,000 V ac tests for 3 minutes).

4-4.2.7 Wear appropriate and approved safety equipment when using a chain saw, including work gloves, work shoes with safety toe, hard hat, protective chaps, goggles with clear lenses, and hearing protection.

4-4.2.8 Wear safety-colored fluorescent clothing when working around vehicular traffic during daytime operations. Light reflective and luminescent materials are particularly effective for reducing mishaps caused by poor visibility or darkness. Personnel exposed to vehicle or aircraft traffic during hours of darkness or periods of reduced visibility must be provided and use reflective accessories or must use organizational clothing with sewn-on reflective tape (red or orange reflective colors provide better contrast in a snow or white environment).

4-4.2.9 Eyeglasses must be fastened with a head or neckband, or otherwise restrained under safety goggles so they cannot fall into energized circuits when goggles are removed.

4-4.2.10 Long hair must be secured to prevent entanglement in moving machinery.

4-4.3 **Additional Clothing Requirements for Work On or Near Energized Equipment**.

4-4.3.1 Select PPE based on the criteria provided in Section 4-3. This section provides additional requirements.

4-4.3.2 Wear arc flash-resistant clothing, minimum 7 cal/cm2, when working on or within 3 meters (10 feet) energized equipment of greater than 50 V. Alternately, arc flash resistant overalls equivalent in to those made of at least 4-ounce weight Nomex™ material may be worn over arc flash resistant clothing. Clothing made from acetate, nylon, polyester, and rayon, either alone or in blends, cannot be worn as undergarments when working on or near energized equipment of greater than 50 V.

4-4.3.3 Long sleeves must be rolled down and buttoned while working on or near live equipment and electric lines of greater than 50 V and have minimum 7 cal/cm2 protective rating. Garments with exposed metallic fasteners must not be worn.

4-4.3.4 Wear arc rated clothing, including face shields that meet the minimum requirements according to your system arc hazard analysis (min 7.3 cal/cm2) equivalent to those made of at least 6-ounce weight Nomex™ material when operating or servicing electrical switchgear of voltage greater than 15 kV. Other persons located in the immediate blast zone must also wear a protective clothing as follows:

- Persons located within 3 meters (10 feet) must wear a blast suit unless protected by a structural building member (wall, floor, ceiling) of substantial construction.

- Persons located at a distance 3 to 6 meters (10 to 20 feet) must wear a blast suit or flash-resistant overalls unless protected by a structural building member (wall, floor, ceiling) of substantial construction.

Note: Sheet metal and gypsum building materials generally must not be considered to be "substantial construction" for the purposes of this section.

4-4.3.5 Wear arc rated face shields that meet the minimum requirements according to the system arc hazard analysis or NFPA 70E (min 7.3 cal/cm2), such as those made of polycarbonate material, to provide eye protection from ultraviolet light when working on or near energized equipment of greater than 50 V. Face shields are worn in addition to required eye protection. Face shields must attach to the hard hat, except for those used in blast suits. Face shields are not required for aerial work.

4-4.4 **Clothing Prohibitions**.

4-4.4.1 Do not wear metal wristbands or watch chains when working on energized electrical equipment.

4-4.4.2 Metal finger rings must not be worn during work activities where personnel are exposed to energized electrical circuits. Any jewelry that presents a potential for catching, snagging, pulling, and tearing must be evaluated and restricted from wear if necessary. Some types of jewelry that must be controlled under these job situations are watches, bracelets, and necklaces. Climbing, ascending, or descending activities where personnel could fall or jump from elevated surfaces account for the majority of injuries caused by the finger ring catching on an object. Some examples include personnel working on elevated surfaces; i.e., ladders, scaffolds, platforms, roofs, or descending from large vehicles such as stake bed trucks. Work activities where personnel are exposed to moving machinery, rotating or revolving parts, or any task that could result in hands being caught in moving parts.

WARNING

Placing tape over rings or wearing gloves on the hand with a ring does not provide protection or eliminate the requirement to remove finger rings.

4-4.4.3 Do not wear clothing that could increase the extent of injuries when exposed to electric arcs or open flames. Clothing made from acetate, nylon, polyester, and rayon, either alone or in blends, cannot be worn as undergarments when working on or near energized equipment of greater than 50 V. Military clothing such as BDU's, field jackets, field jacket liners, gortex jackets and pants, gortex fleece liners, nylon cold weather gloves, nylon upper combat boots, chemical warfare suits, winter parka, winter parka pants, all are polyester blend materials and not allowed to be worn when working on or near energized equipment of greater than 50V.

4-4.4.4 Do not wear anything made of celluloid or other flammable plastic when working near electric arcs or open flames. This may include cap visors, collars, cuff protectors, and rims for eyeglasses or goggles. Glasses must meet Z-87 standard for safety glasses.

4-4.4.5 Do not wear shirts with sleeves rolled up.

4-4.4.6 Do not wear loose clothing, dangling sleeves, or neckties when working around moving machinery.

4-4.4.7 Do not wear gloves while working on moving parts in a machine shop (gloves are more easily caught than your skin).

4-4.4.8 Do not wear garments equipped with metal slides or zipper fasteners, unless the slide or fastener is effectively covered, when working around energized electrical equipment.

4-4.4.9 Do not wear shoes with metal heel or toe plates, or with hobnails.

4-4.5 **Skin Protection**. Provide protection for the worker's skin from toxic and irritant substances where there is a possibility they can occur at the job site. Ensure workers prevent injury by wearing suitable protective clothing. Keep protective ointments, proper cleaners for the skin, and appropriate first aid remedies on hand. Ensure protective ointments are not of a type that can damage rubber protective apparel. Keep emergency water sources on hand for flushing of irritant substances which could spill on the body, such as battery acid when working in a battery room. Keep sun-blocking ointments on hand when working outdoors.

4-4.6 **Responsibility**. Personal protective apparel is worn when it is impossible or impracticable to eliminate a workplace hazard. Authorized individuals must ensure that workers are trained in their proper use and selection, and the reasons why they are needed. Authorized individuals are responsible for ensuring that personal protective apparel is worn. Workers must be provided with the most comfortable apparel feasible. This applies not only to apparel but also to accessories for fall protection and other equipment discussed later in this chapter. Inspection and maintenance of equipment is

the responsibility of both the authorized individual-in-charge and the worker. Workers must be trained in maintenance and inspection requirements. An authorized individual must be responsible for the repair or replacement of unacceptable equipment.

CHAPTER 5

WORK AREA PROTECTIVE EQUIPMENT AND TOOLS

5-1 **INTRODUCTION**. This chapter addresses the work area protective equipment that support electrical maintenance, and the associated requirements for their inspection and use. Always refer to manufacturer's instruction for specific instructions when available.

5-2 **RUBBER PROTECTIVE EQUIPMENT**. Rubber protective equipment consists of gloves, sleeves, blankets, insulator hoods, and line hose. Ensure all items meet or exceed the requirements of the applicable ASTM F 18 series standards.

5-2.1 **Job Requirements**. The authorized individual-in-charge must determine the necessary type and amount of protective equipment required on the job and visually inspect it before use. Rubber goods must be inspected immediately before each use. Destroy any item found to be defective

5-2.1.1 Each line truck and service/trouble truck, which is required to carry protective equipment, must carry enough protective equipment rated at or above the voltages that could be encountered. Transport the protective equipment in waterproof, lightproof, and dustproof compartments or containers.

5-2.1.2 Do not carry rubber protective equipment in compartments with other tools, even if the tools are in tool bags.

5-2.2 **Use of Rubber Protective Equipment**. Rubber or other approved protective equipment must be used on all conductors or energized parts, which could be contacted by a worker climbing to or reaching from a work position. Rubber or other approved protective equipment must be rated for the voltage encountered. Table 5-1 provides the OSHA 29 CFR 1910.137 voltage requirements for rubber insulating equipment.

Table 5-1. Rubber Insulating Equipment Voltage Requirements

Class of Equipment	Maximum Use Voltage (AC – RMS)	Retest Voltage(AC – RMS)	Retest Voltage (DC – Average)
0	1,000	5,000	20,000
1	7,500	10,000	40,000
2	17,000	20,000	50,000
3	26,500	30,000	60,000
4	36,000	40,000	70,000

Note: The maximum use voltage is the AC RMS voltage classification of the protective equipment that designates the maximum nominal design voltage of the energized

system that may be safely worked. The nominal design voltage is the phase-to-phase voltage on multi-phase circuits. The nominal design voltage can be considered the phase-to-ground voltage only if 1) there is no multiphase exposure in a system area and if the voltage exposure is limited to the phase-to-ground potential, or 2) the electrical equipment and devices are insulated or isolated or both so that the multi-phase exposure on a grounded wye circuit is removed.

5-2.2.1 Protective equipment must be positioned to protect workers against unforeseen hazards such as slipping, cutting out, leaning back, or falling.

5-2.2.2 Protective equipment must be placed by working from a level below the wires or insulators on the pole or structure, beginning with those nearest the climbing space, and covering the live parts in the order of their distance away from the climbing space.

5-2.2.3 Cover other points of contact, such as grounded guys, equipment, and secondary wires to provide complete protection.

5-2.2.5 The removal of protective equipment must be done with equal care, working below the level of wires and insulators. The order of removal must be the reverse of the order of placement.

5-2.3 **Use of Rubber Gloves**. Wear rubber gloves with leather protectors suitable for the purpose when climbing or working on installations or structures in the vicinity of live circuits, or in the vicinity of any wire or equipment that may become energized by remote or accidental means. Do not use rubber gloves without leather protector gloves over them. Liners are available for use inside the rubber gloves to absorb perspiration.

5-2.3.1 Use only the gloves assigned, except in case of emergency.

5-2.3.2 Keep sleeves of wearing apparel tucked inside the cuffs of the rubber gloves.

5-2.3.3 Put on rubber gloves before getting within reaching distance of live wires or parts. Reaching distance is within 90 centimeters (3 feet) in any direction of wires or parts at or above 600 V.

5-2.3.4 Do not remove gloves until out of the reaching distance of live wires or parts.

5-2.3.5 Use rubber gloves and protector gloves (leather gauntlets) only for the specific purposes for which they are intended. Rubber gloves must extend beyond the leather protective gloves.

5-2.3.6 Take care to keep hands away from contact points where an arc may form.

5-2.3.7 Wear rubber gloves when possible to contact a live conductor such as when:

- Working on circuits, wiring, or equipment.

- Removing or replacing fuses.
- Changing surge arresters.
- Changing capacitors.
- Applying or removing grounding devices. Apply the OSHA 29 CFR 1926.950 requirements for minimum hot stick distances (provided below in Table 5-2 for the most common military voltage; refer to OSHA 29 CFR 1926.950 for higher voltages).
- Working on equipment or lines which parallel power circuits and which may be subjected to induced voltage or accidental contact with live conductors.
- Working on street lighting, runway lighting, or other series circuits.
- Working on signals and signal wires.
- Assigned as a pulling, tensioning, or reel attendant.
- Assigned as ground worker who may contact conductors being installed on poles and equipment.
- Handling poles or structures that are being erected in or between existing energized lines.

Table 5-1. Minimum Working and Clear Hot Stick Distance

Voltage Range (phase-to-phase, kV)	OSHA 29 CFR 1926.950 Minimum Working and Clear Hot Stick Distance
2.1 to 15	2 ft. 0 in.
15.1 to 35	2 ft. 4 in.
35.1 to 46	2 ft. 6 in.
46.1 to 72.5	3 ft. 0 in.
72.6 to 121	3 ft. 4 in.

5-2.4 **Use of Rubber Sleeves**. Wear rubber sleeves whenever there is a possibility of arms coming within the working distance specified in Table 8-1. Rubber sleeves are normally worn in conjunction with rubber glove work. Wear rubber sleeves when performing live-line pole or bucket work within contact distance of a live line.

5-2.5 **Care and Inspection**. Rubber protective equipment must be inspected daily and stored in its proper compartment or container. Protective equipment must not be stored in a sharply bent position or exposed to the sun's rays, light, or heat.

5-2.5.1 **General Care**. Wipe dry all protective equipment before storing. Protect it from contact with oil, paint, creosote, kerosene, gasoline, acids, and other harmful materials. Rubber protective equipment must be turned in to an experienced testing laboratory for cleaning, inspection, and electrical tests. Shorter inspection periods must be considered where equipment is used frequently.

5-2.5.2 **Care of Rubber Gloves**. When not in use, rubber gloves must be carried in glove bags. When in use, take the following precautions:

5-2.5.2.1 Rubber gloves must be washed when tested at an approved laboratory, and kept free from embedded foreign matter.

5-2.5.2.2 Powder specifically designed for protective rubber gloves can be used after washing rubber gloves to avoid skin irritation and to prevent the rubber from sticking together.

5-2.5.3 **Inspection of Rubber Gloves**. Before putting on rubber gloves, give each glove an air test to detect cuts and weak spots. This is accomplished by rolling up the glove tightly beginning at the gauntlet end. Listen and feel for air escaping through the palm, thumb, or fingers. Gloves that show weak spots or air leakage must be destroyed. It is recommended that one or more fingers of a defective glove be immediately cut off to ensure no other worker inadvertently uses the glove.

5-2.5.4 **Care of Rubber Blankets and Sleeves**. Roll, never fold, rubber blankets and sleeves. When being rolled, their surfaces must be brushed clean to prevent dirt from becoming embedded in the surface of the rubber. Do not wear climbers when standing on rubber blankets.

5-2.5.5 **Inspection of Rubber Blankets and Sleeves**. Inspect rubber blankets and sleeves immediately before each use. Items with cracks, holes, snags, blisters, or other defects must be discarded.

5-2.5.6 **Inspection of Line Hose and Insulator Hoods**. Inspect hose and hoods immediately before use. Examine hose and hoods before each use to ensure that there are no defects, and determine if they are suitable for further use.

5-2.5.7 **Care of Line Hose and Insulator Hoods**. Line hoses and hoods must be air dried. Store hoses and hoods in compartments so that no part is strained or distorted.

5-2.6 **Test Intervals for Rubber Protective Equipment**. Rubber protective equipment must be subjected to periodic electrical tests. Table 5-3 provides the OSHA 29 CFR 1910.137 required test intervals for rubber insulating equipment.

Table 5-3. Rubber Insulating Equipment Test Intervals

Type of Equipment	Test Frequency
Rubber insulating line hose	Upon indication that insulating value is suspect
Rubber insulating covers	Upon indication that insulating value is suspect
Rubber insulating blankets	Before first issue and every 12 months thereafter
Rubber insulating gloves	Before first issue and every 6 months thereafter
Rubber insulating sleeves	Before first issue and every 12 months thereafter

Note: If the insulating equipment has been electrically tested but not issued for service, it may not be placed into service unless it has been electrically tested within the previous 12 months.

5-3 **ELEVATED WORK**. Ensure workers, materials, and equipment are properly supported and adequately fastened in place before starting work in a position elevated above the ground. The use of ladders, scaffolds, and boatswain's chairs as temporary work locations can result in injuries if safe practices are not followed carefully. Chapter 10 addresses the safe support of workers when working on wooden poles, associated structures, and on any portion of a tree.

5-3.1 **Boatswain's Chair**. A boatswain's chair used for elevated work must be constructed to meet the following minimum safety requirements:

5-3.1.1 The chair seat dimensions must be not less than 300 by 600 millimeters (12 by 24 inches) in area and 25 millimeters (1 inch) in thickness. The seat must be reinforced on the underside to prevent the board from splitting.

5-3.1.2 Provide two seat slings of a fiber rope approved for use near electric lines and of at least 19 millimeter (5/8 inch) diameter. Reeve the slings through the four seat holes so they cross each other on the underside of the seat.

5-3.1.3 Seat slings must be made of at least 9.5 millimeter (3/8 inch) diameter wire rope when a worker is performing a heat producing process such as gas or arc welding, or using an open flame.

5-3.1.4 The worker must be protected by a safety harness attached to a lifeline. The lifeline must be securely attached to a substantial member of the structure (not to a scaffold), or to securely rigged lines. The lifeline must safely suspend the worker in case of a fall.

Note: A safety belt is not an acceptable means of fall protection.

5-3.1.5 Tackle must consist of correctly-sized (ball bearings or bushed) blocks, and properly spliced 19 millimeter (5/8 inch) diameter, first-grade, approved rope.

5-3.1.6 Roof irons, hooks, or the object to which the tackle is anchored must be securely installed. Tiebacks, when used, must be installed at right angles to the face of the structure and be securely fastened.

5-4 **RIGGING**. Various types and combinations of fiber rope, wire rope, chains, and rigging hardware are used to lift material and equipment. The safe use of rigging devices requires that the combination of rope and rigging hardware must have adequate lifting capacity ratings and, when applicable, be approved for such use near any energized equipment. Only qualified workers must install, maintain, or repair ropes and chains used as rigging.

5-4.1 **Fiber Rope**. Fiber ropes can be made of synthetic materials or natural vegetable fibers.

5-4.1.1 **Materials**. Synthetic fibers used for rope are nylon, polypropylene, polyester, and polyethylene. Natural fibers used are manila and sisal. Natural fiber ropes must not be used because they have high moisture absorbing factors and low loading strengths. Synthetic rope sizes to strength characteristics are given in Table 5-4. Values are given in inches (in) and pounds (lb) first followed by, in parentheses, millimeters (mm) and kilograms (kg). These values are based on new ropes under static testing without consideration of operating conditions. A safety factor must always be used in determining actual safe lifting capacity.

Table 5-4. Approximate Safe Working Loads of New Three-Strand Fiber Ropes Used in a Straight Pull

Nominal Diameter in (mm)	Polypropylene lb (kg)	Polyester lb (kg)	Nylon lb (kg)	Polyethylene lb (kg)
1/4 (6.4)	250 (113)	300 (136)	300 (136)	250 (113)
3/8 (9.5)	500 (227)	700 (318)	700 (318)	500 (227)
1/2 (12.7)	830 (376)	1,200 (544)	1,250 (567)	800 (363)
5/8 (15.9)	1,300 (590)	1,900 (862)	2,000 (907)	1,050 (476)
3/4 (19.1)	1,700 (771)	2,400 (1,089)	2,800 (1,270)	1,500 (680)
7/8 (22.2)	2,200 (998)	3,400 (1,542)	3,800 (1,724)	2,100 (953)
1 (25.4)	2,900 (1,315)	4,200 (1,905)	4,800 (2,177)	2,500 (1,134)

5-4.1.2 **Construction**. Commonly encountered ropes include twisted, braided, and parallel ropes. Twisted rope is usually made of three or four strands. Each type of rope requires a different method of splicing. Refer to AFMAN 32-1280(I) and the "Lineman's and Cableman's Handbook" for knot and splice data.

5-4.1.3 **Conductivity**. Generally, rope must not be treated as an insulator because ropes contain moisture as part of their fiber makeup. The moisture regain of fibers is given in Table 5-5. Additionally, when rope becomes wet, dirty, or contaminated, its electrical conductivity will increase. Recall, even insulators conduct electricity if not kept clean or dry. Only polypropylene and polyethylene ropes, which are specially treated to resist wetting, are recommended for use near energized conductors. Use only moisture-resistant polypropylene synthetic rope for aerial lines

Table 5-5. Moisture Regain of Fiber Ropes

Type	Moisture Regain (Percent)
Polypropylene	0.0
Polyethylene	0.0
Polyester	0.4
Nylon	4.5

5-4.1.4 **Safety (Design) Factor**. Ropes vary in their characteristics for shock and sustained loading. The minimum recommended safety factor is 6 for polypropylene and polyethylene ropes, and 9 for polyester and nylon ropes

5-4.1.5 **Care of Rope**. Rope must be cared for as follows:

5-4.1.5.1 Never overload a rope or drag it over rough or sharp objects. The safety factor is based on the minimum breaking strength of a rope without damage. In evaluating the safety factor, make allowance for the age and condition of the rope.

5-4.1.5.2 Be careful in making a rope fast. Avoid short acute bends over unyielding or sharp-edged surfaces. Never drag rope over the ground, over sharp objects, or over another rope. If rope is installed on an object with sharp corners, use pads to protect the rope.

5-4.1.5.3 A rope with a kink or hockle (reverse kink) must be removed from service.

5-4.1.5.4 When rope is not in use, store it properly in a cool dry area away from direct sunlight to prevent shrinkage. Be sure it is free from mechanical injury, heat, or excessive dryness. Keep loose coils off the floor and hung on a wooden peg.

5-4.1.5.5 Never use rope around storage batteries due to the danger of damage by battery acid.

5-4.1.5.6 A wet rope can absorb moisture and might not be as strong as a dry rope. Exceptions are polypropylene and polyethylene ropes that do not absorb moisture. Another exception is polyester and nylon ropes that, when they are properly finished with a marine overlay, could actually provide an increase in strength when wet. Never use a wet rope next to an energized electrical line. Never permit a wet rope to freeze, and never use a frozen rope. Discard ropes that have been frozen wet.

5-4.1.5.7 Keep ropes clean. Dirt on the surface or embedded in the rope acts as an abrasive on strands and fibers.

5-4.1.5.8 Always finish (serve) the ends of fiber rope to prevent unraveling.

5-4.1.5.9 The ends of all synthetic fiber ropes must be prevented from fraying by first whipping and serving and then melting.

5-4.1.5.10 Avoid excessive stretching of nylon rope by surging loads to prevent surface abrasion.

5-4.1.6 **Inspection of Ropes**. A rope must be inspected each time it is used.

5-4.1.6.1 Examine carefully for cuts, worn spots, acid stains, and burns. However, be aware the outward appearance of a rope may be deceiving of its internal condition.

5-4.1.6.2 Rope must be free from metal strands and cores, solder, oil, and grime. An approved safety hook is the only metal permitted on a handline.

5-4.1.6.3 A splice in a rope must be free of all metal objects, tapes, or knots. Splicing must be done in accordance with standard industrial practices, be tested, and also be approved by the authorized individual-in-charge before use. Splicing can reduce the safe working load down to 80 or 90 percent of a new rope. A hitch in the rope can reduce the rope strength to 45 percent and must not be permitted. A bowline knot (which may reduce the rope strength to 60 percent) can be used.

5-4.1.6.4 A tackle must always be used with a block or load connected. If a tackle is to be used intermittently, it must be tested before each use, as a safety precaution, with three times the load that it will carry.

5-4.1.6.5 Before using fiber ropes as slings to lift loads, first determine the capacity of the ropes. When different types of ropes, chains, and rigging hardware are used in combination, the overall capacity of the combination is the capacity of the weakest item.

5-4.1.6 **Use of Rope**. Be aware of the following requirements when using rope:

5-4.1.6.1 The elasticity and stretch of synthetic rope can cause a delay in response when lifting or dropping loads. Different fiber compositions will have different elongation curves.

5-4.1.6.2 Use caution when the load is under excessive tension and then suddenly released. The whipping action is very dangerous to personnel and equipment in the area.

5-4.1.6.3 Never use wet rope on or near energized conductors.

5-4.1.6.4 Carry handlines uncoiled and attached to the back of your body belt up poles or structures . Be cautious so handlines do not catch on pole or structure attachments.

5-4.1.6.5 Do not exceed the safe loads for rope indicated in Table 5-1.

5-4.1.6.6 Avoid sudden jerks or strains.

5-4.1.6.7 Reverse rope ends periodically so all sections of the rope receive equal wear.

5-4.1.6.8 For hoisting work, where protection of a worker's life is paramount, use a safety factor three times as great as the safety factors previously given.

5-4.1.6.9 When bent around a rounded surface the radius around which the rope is bent should be eight times the rope diameter (not less than six times the rope diameter).

5-4.1.6.10 Use pulleys while lifting or lowering loads as necessary to prevent chaffing ropes.

5-4.2 **Wire Rope**. Increased fatigue life and resistance to abrasion and abuse are the main reason for the use of wire rope in slings and other hoisting devices. Such rope is usually made of wire strands laid together and twisted over a fiber-saturated and lubricated core. The core cushions and preserves the shape of the rope and lubricates the wires. Use wire rope in accordance with the recommendations of the manufacturer and do not exceed the safe working load required by ANSI B30.9, based on the breaking strengths of ASTM A 603. The safety factor for wire rope can be from 3 to 7 depending upon consideration of load type, acceleration of load, rope speed, sheaves and drums (number, size, and arrangement), and the length of the rope.

5-4.2.1 Wire rope should not be used on the boom sections of line trucks or on bucket trucks because it can conduct electricity. Wire rope may be used on side winches that do not come in contact with live lines.

5-4.2.1 **Care of Wire Rope**.

5-4.2.1.1 Never overload wire rope beyond its safe load.

5-4.2.1.2 Never store wire rope or put any strain on it that may cause a kink.

5-4.2.1.3 Never store wire rope by winding it too tightly.

5-4.2.1.4 Never store wire rope in a wet or damp storage area.

5-4.2.1.5 When wire rope is cut, finish (serve) the cut ends with soft iron wire to keep the wires from unraveling.

5-4.2.1.6 Lubricate wire rope as needed and never remove the rope's internal lubricant. Use a jet of air or steam, or wire brush the rope's exterior prior to applying the manufacturer's approved lubricant.

5-4.2.2 **Inspection of Wire Rope**. Never use a wire rope without wearing gloves for safety. Check wire rope for broken strands by running a cloth over the rope to find the broken strands. Immediately remove wire rope from service and discard upon finding one or more of the following defects:

5-4.2.2.1 Corrosion of the wire rope or attachments caused by acids or bases.

5-4.2.2.2 Rust which has caused pitting or loss of one-third or more of the original diameter of outside individual wires. Rust film that has caused the loss of less than one-third can be removed and the wire can be cleaned, re-lubricated, and reused.

5-4.2.2.3 One or more broken wires in the valley between two adjacent strands, six randomly distributed broken wires in one rope lay, or three broken wires in one strand in one rope lay.

5-4.2.2.4 Wear or scraping of one-third the original diameter of outside individual wires.

5-4.2.2.5 Kinking, crushing, bird caging, or any other damage resulting in distortion of the wire rope structure.

5-4.2.2.6 Evidence of heat damage.

5-4.2.2.7 End attachments that are cracked, deformed, or worn.

5-4.2.3 **Use of Wire Rope**. Handle wire rope in accordance with the following requirements:

5-4.2.3.1 Never use wire rope on or near energized conductors.

5-4.2.3.2 Never apply sudden or abrupt loads on wire rope. When handling extra heavy loads never fasten rope over sharp edges or corners without padding.

5-4.2.3.3 Wire rope must never be coiled or uncoiled like fiber rope. Always wind around sheaves or drums. Avoid rope twist and spreading of coils, and prevent crossings or overlapping when winding on sheaves or drums.

5-4.2.3.4 Use sheaves and drums with grooves slightly larger than the wire rope to avoid pinching and binding the strands, and to permit the rope to adjust itself to the curvature. However, the grooves must not be so large that the rope will flatten.

5-4.3 **Chains**. Chains have an advantage over wire rope in that they are not as easily damaged. Always check that chains are of an approved type for lifting. Use only alloy steel chains for rigging which are so marked, and have been maintained in conformance with the manufacturer's guidelines. Do not use these chains for tying down equipment. Never overload chains beyond the safe loads indicated by the manufacturer's recommendations, and do not exceed the safe working loads of ANSI B30.9 based on the breaking strengths of ASTM A 906. Hooks, rings, links, couplings, or other attachments, when used with steel chains must have a rated capacity at least equal to that of the chain.

5-4.3.1 **Care of Chains**.

5-4.3.1.1 Never store chains in a wet or damp storage area.

5-4.3.1.2 Normalize or anneal chains periodically as recommended by the manufacturer.

5-4.3.1.3 Chains are to be repaired by the manufacturer or in strict accordance with the manufacturer's recommendations.

5-4.3.2 **Inspection of Chains**. Inspect chains used in load carrying service before each use and weekly thereafter for chains in continuous service. Remove chains from service when any of the following defects are evident:

5-4.3.2.1 Nicked or cracked links.

5-4.3.2.2 Lifted link welds.

5-4.3.2.3 More than 10 percent elongation of any link or section.

5-4.3.2.4 When wear of 20 percent of the diameter of any link has occurred.

5-4.3.3 **Use of Chains**.

5-4.3.3.1 Avoid sudden or abrupt application of loads to chains. When handling extra heavy loads do not fasten chains over sharp corners or edges without padding.

5-4.3.3.2 Chains are conductors; they must never be used near live conductors or energized equipment.

5-4.3.3.3 Never shorten or lengthen a chain by use of kinks or bolts.

5-4.3.4 **Slings**. Before using slings, determine the capacity rating of the component fiber rope, wire rope, chains, rigging hardware, or combinations thereof before using the sling to lift loads. Refer to the requirements of ANSI B30.9. For individual items used in combination, the safety factors are not cumulative, and the overall capacity rating of the combination is the capacity of the weakest item. The particular application or other service factors may further reduce the capacity rating. The sling angle affects the capacity of each leg by a factor computed as the sine of the angle to the horizontal. Never provide a sling angle of less than 30 degrees because this reduces the capacity of the sling by 50 percent or more.

5-4.3.4.1 Store slings so they can not be damaged.

5-4.3.4.2 Perform the following to prevent sling-related mishaps:

5-4.3.4.2.1 Protect slings from being damaged by sharp, rough, or square corners. Use chafing protection between rope and edges. Sharp bends (which must be avoided to protect the sling from being damaged) also need chafing protection.

5-4.3.4.2.2 Never use chain slings that do not have permanently affixed durable identification label stating the size, grade, rated capacity, and sling manufacturer.

5-4.3.4.2.3 Do not use knots or other devices to shorten slings.

5-4.3.4.2.4 Keep sling legs free of kinks.

5-4.3.4.2.5 Keep the load within the sling's capacity.

5-4.3.4.2.6 Balance loads supported by basket hitches to prevent slippage.

5-4.3.4.2.7 Securely attach the slings to the load.

5-4.3.4.2.8 Keep suspended loads clear of obstructions.

5-4.3.4.2.9 Keep people clear of suspended loads and loads about to be lifted.

5-4.3.4.2.10 Keep your hands and fingers from between the sling and the load while the sling is being tightened around the load.

5-4.3.4.2.11 Place blocks under the load so slings may be removed without damaging them.

5-4.3.4.2.12 Remove damaged slings from use and destroy them.

5-4.3.5 **Rigging Hardware**. Do not use work site-fabricated rigging hardware unless it has been tested and certified by a rigging engineer. Use forged-alloy or stainless steel hoisting hooks (excluding sling and choker hooks) that are stamped with their safe working load and are equipped with safety keepers, swivels, and headache balls

(minimum tension devices). Use forged-alloy or stainless steel shackles of the locking or secured-pin type for hoisting. Inspect them before use and discard any that are worn in the crown or pin by more than 10 percent of the original diameter. Do not replace shackle pins with bolts.

5-5 **HEAVY LIFTING EQUIPMENT.** Cranes, winches, and derricks are used on vehicles for hoisting heavy equipment. Aerial lifts or buckets are used to elevate personnel to job-sites above ground are discussed later in this chapter.

5-5.1 Equipment and workers must take into account the safe operating requirements for such an operation. When mobile hoists, cranes, or similar lifting devices are used near energized lines or equipment, the lifting device must be properly grounded, or insulated, isolated, or considered as energized.

5-5.2 Unqualified workers must not set up nor operate any piece of equipment where it is possible to bring such equipment or any part thereof within the minimum safe approach distances specified in Table 8-1. This applies to any medium- or high-voltage (600 V and above) line or installation unless the line is deenergized, a safe clearance is secured, and the line or equipment is grounded. To maintain the minimum safe approach distances, the worker may:

5-5.2.1 Install adequate guards or barriers, or

5-5.2.2 Use a full-time signalman to warn the operator when approaching minimum distances.

5-6 **AERIAL LIFTS**. Aerial lifts are electrically isolated buckets, which are often referred to as insulated buckets. Aerial lifts must be constructed to meet ANSI/SIA A92.2.*Vehicle-Mounted Elevating and Rotating Work Platforms*.

5-6.1 **Operation of Aerial Lift Equipment Near Energized Electrical Facilities**. Qualified electrical workers may operate aerial lift equipment between the approach distances and the working distances given in Table 8-1, if all of the following conditions are met:

5-6.1.1 A job safety (JSA)/job hazard analysis (JHA) has been completed.

5-6.1.2 The activity is being performed under the direct supervision of a designated person who is trained and competent in this type of work.

5-6.1.3 The distances between energized parts and the aerial lift equipment is monitored while the aerial lift equipment is being moved and or repositioned.

5-6.1.4 The aerial lift equipment is grounded.

5-6.1.5 No one, other than necessary workers, is within 3 meters (10 feet) of the equipment during its operation. Workers are to perform their work while on the equipment, not from a position on the ground.

5-6.2 **Types of Aerial Lifts**. Aerial lifts include the following types of vehicle-mounted aerial devices used to elevate personnel to job-sites aboveground.

- Extensible boom platforms.
- Aerial ladders.
- Articulating boom platforms.
- Vertical towers.
- A combination of any of the above.

5-6.3 **Manufacture**. Aerial equipment can be made of metal, wood, fiberglass-reinforced plastic (FPR), or other materials. They can be powered or manually operated. The device is considered to be an aerial lift whether or not it is capable of rotating about a substantially vertical axis. Aerial lifts must not be “field modified” unless such modification is certified acceptable by the manufacturer.

5-6.4 **OSHA Aerial Lift Rules**. OSHA mandates the following rules:

5-6.4.1 Secure aerial ladders in the lower traveling positions by the locking device on top of the truck cab and the manually operated device at the base of the ladder, before the truck is moved for highway travel.

5-6.4.2 Lift controls must be tested each day prior to use if the lift is to be used that day, to determine if the controls are in safe working condition. Lift controls must be tested on a monthly basis when not in use.

5-6.4.3 Only authorized persons may operate an aerial lift.

5-6.4.4 Do not belt off to an adjacent pole, structure, or equipment while working from an aerial lift.

5-6.4.5 Stand firmly on the floor of the bucket and do not sit or climb on the edge of the bucket or use planks, ladders, or other devices for a work position.

5-6.4.6 Wear a body harness and a lanyard attached to the boom or bucket while working from an aerial lift.

5-6.4.7 Do not exceed the manufacturers boom and bucket load limits.

5-6.4.8 Set the brakes and position outriggers on pads or a solid surface. Install wheel chocks before using an aerial lift on an incline.

5-6.4.9 Do not move an aerial lift truck when the boom is elevated in a working position with workers in the bucket.

5-6.4.10 Articulating boom and extensible boom platforms, primarily designed as personnel carriers, usually have both platform (upper) and lower controls. Upper controls must be in or beside the platform within easy reach of the operator. Lower controls must provide for overriding the upper controls. Controls must be plainly marked as to their function. Lower level controls must not be operated unless permission has been obtained from the worker in the lift, except in case of emergency.

5-6.4.11 Do not wear climbers while performing work from an aerial lift.

5-6.4.12 The insulated portion of an aerial lift must not be altered in any manner that might reduce its insulating value.

5-6.4.13 Inspect the boom before moving an aerial lift for travel. See that equipment is properly cradled and outriggers are in the stowed position.

5-6.5 **Insulated Buckets**. An insulated bucket of an aerial lift is provided with a conductive bucket liner.

5-6.5.1 The liner, usually a metallic screen, must completely surround the bucket interior walls and floor to provide electrostatic shielding for the occupant. Tools and other equipment carried in the bucket must be stowed carefully to avoid damaging the liner.

5-6.5.2 Insulated buckets must be subjected to an arm current (dielectric) test. This test consists of placing the insulated bucket in contact with an energized source equal to the voltage to be worked upon for a minimum 3-minute period. The leakage current must not exceed one microampere per kilovolt of nominal line-to-line voltage. Arm current tests must be accomplished annually or when changed conditions indicate a need for additional tests, such as mechanical alteration of the vehicle through maintenance procedures. Keep a record of all tests. Work operations must be suspended immediately upon any indication of a malfunction in the equipment.

5-6.6 **Maintenance**. Perform periodic maintenance in accordance with the manufacturer's operations and maintenance manual. Perform electrical tests on insulation no less than every 6 months in accordance with ANSI/SIA A92.2, *Vehicle-Mounted Elevating and Rotating Aerial Devices*.

5-7 **LIVE-LINE TOOLS, ELECTRICAL SAFETY TOOLS, AND SPECIALTY ELECTRICAL TOOLS**. These are tools manufactured for use by electrical workers to provide protection (and thus safety) when working on energized (live-line) equipment

such as lines and bus bars, on deenergized and grounded lines, or for other maintenance activities.

5-7.1 **Live-Line Tools**. Live-line or hot-line tools insulate the worker from the energized line. They are also known as hot sticks since they are in the form of an insulated stick or pole. If there is a loss of insulation the worker's safety is compromised. Live-line tools are not only used to work on energized lines; they are also used to safely deenergize and ground lines for deenergized line working. This paragraph discusses their terminology and use.

5-7.1.1 **Terminology**. ANSI/IEEE 935 is the guide to be used for tool terminology. It does not give detailed definitions but does provide pictorial descriptions of the various components used. Another useful tool reference is "Hot Sticks - a Manual on High-Voltage Line Maintenance."

5-7.1.1.1 **Tool Material**. Tools are constructed of insulating material and or conductive material. Metal conductive material is used primarily for mechanical strength. The conductive material may be coated or covered with insulating material to protect the worker from electrical contact and to avoid flashover.

5-7.1.1.2 **Insulated Versus Insulating Tools**. An insulated tool is made of conductive material and then fully or partly covered by insulating material, while an insulating tool is essentially made entirely of insulating material.

5-7.1.2 **General Hot-Line Tool Types**. ANSI/IEEE 935 covers 10 different types of equipment used in live-line working. These are:

5-7.1.2.1 **Insulating Sticks**. Insulating sticks consist of hand sticks used only to operate on a line or equipment by a worker. They may be fitted with splines at their ends to permit other tool attachments. Support sticks are used to hold or move conductors.

5-7.1.2.2 **Universal Tool Fittings**. These tool fittings are splined-end tools such as pliers, wrenches, hammers, and some 35 others, and some 6 clevis and tongue tools to fit on the end of insulating sticks.

5-7.1.2.3 **Insulating Covers and Similar Assemblies**. These are of various types to provide insulation from conductors, conductive hardware, insulators, and as barriers to limit work zones. See rubber protective equipment covered in this chapter.

5-7.1.2.4 **Bypassing Equipment**. This equipment is used to provide an electrical shunting device around equipment, to connect or disconnect a circuit under load, to bypass a fuse or other device, or to pickup an electrical load.

5-7.1.2.5 **Small Individual Hand Tools**. These are insulating or insulated hand tools for use with rubber gloves.

5-7.1.2.6 **Personal Equipment**. Personal equipment includes mechanical protection such as gloves, boots, helmets, and shoes, and electrical protection such as conductive or insulating apparel, and eye protection.

5-7.1.2.7 **Positioning Equipment**. Positioning equipment includes bucket trucks, ladders, suspension attachments, platforms, and seats.

5-7.1.2.8 **Handling and Anchoring Equipment**. Includes ropes, slings, rope block yokes, gin poles, saddles, and various accessory devices.

5-7.1.2.9 **Measuring and Testing Equipment**. Includes dynamometers, gap and wire gages, measuring sticks, phasing testers, and voltage detectors.

5-7.1.2.10 **Hydraulic and Miscellaneous Equipment**. Includes hydraulic compression heads, cutter hoses, pumps, and various hot-line devices.

5-7.2 **Safety Tools**. Safety tools may be used in conjunction with hot-line tools to deenergize a line, or after deenergization, to maintain ground continuity. Grounding jumpers, elbow connectors, fuse pullers, grounding clusters, and underground cable grounding spike clamps are readily available devices. They must meet ASTM F 855 and IEEE 1048 requirements for protective grounding of power lines.

5-7.3 **Specialty Tools**. Specialty tools are used in electrical maintenance activities, such as jennies, cant hooks, pike poles, and bumpboards which are used for setting poles by the pike pole method. Specialty tools not covered in this chapter include fall protection climbing devices and hand lines.

5-8 **CARE AND INSPECTION OF LIVE-LINE (HOT-LINE) TOOLS**. Live-line 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.

5-8.1 **Manufacture**. Tools must be manufactured to meet ASTM F 18 series specifications as appropriate to the device and material. The insulating tool portion can be made of fiberglass-reinforced plastic (FRP) or wood. FRP must be used, if possible, as it does not absorb moisture, is impervious to oil-borne materials and solvents, is stronger, and is a better insulator than wood. Like any insulator, FRP must be kept clean and dry to maintain its insulating ability. Use only live-line tools that have a manufacturer's certification as having been tested to meet the following minimum acceptance requirements:

5-8.1.1 **FRP**. A FRP tool must have withstood 100,000 V ac per foot (305 millimeters) of length for 5 minutes.

5-8.1.2 **Wood**. A wooden tool must have withstood 75,000 V ac per foot (305 millimeters) of length for 3 minutes.

5-8.2 **Authorized Types of Tools**. All new tools must be FRP tools. Replace existing wooden tools with new FRP tools.

5-8.3 **Records**. Records must be maintained for all live-line tools to demonstrate satisfactory accomplishment of laboratory and shop testing.

5-8.4 **Tool Cleaning Before Use**. A live-line tool must be wiped clean before each day's use and visually inspected for cleanliness and a glossy surface. Clean live-line tools with a clean absorbent paper towel or cloth and then wipe with a clean, dry cloth (a silicone-treated cloth is also permitted). Never use cloths that have been washed in harsh solvents, soap or detergents. Residues could be left on the tool that may be conductive. Abrasives could damage the surface gloss of the tool (thus permitting water to "wet-out" or "sheet" on the surface of the tool if later exposed to rain or heavy fog). If the surface of the tool is not glossy, or any contamination is present after wiping that could adversely affect the insulating qualities of the tool, the tool must be removed from service and tested before being returned to service.

5-8.5 **Tool Inspection After Cleaning and Before Use**. After each cleaning and before use, a live-line tool must be visually inspected for defects. If any defect is present that could adversely affect the insulating qualities of the tool, the tool must be removed from service and tested before being returned to service. The following field observations warrant removing a tool from service

5-8.5.1 Evidence of an electrically overstressed tool, such as: electrical tracking; burn marks; or blisters caused from heat.

5-8.5.2 Evidence of a mechanically overstressed tool, such as: damaged, bent, warped, worn or cracked components; deep cuts, scratches, nicks, gouges, dents or delamination in the tool surface; or deterioration of the tool's glossy surface.

5-8.6 **Other Conditions for Removal from Service**. A live-line tool must be removed from service if one or more of the following conditions are detected:

5-8.6.1 It fails to pass an electrical dry or wet test during laboratory, shop, or field-testing.

5-8.6.2 If a tingling or fuzzy sensation is felt when the tool is in contact with energized conductors or hardware.

5-8.6.3 If a tool has been dropped from a significant height (such as from an overhead line or a structure) or subjected to impact such that internal structural damage is suspected.

5-8.7 **Returning a Tool to Service**. A tool may not be returned to service until the tool has been examined, cleaned, and repaired (if necessary), and electrically tested.

5-8.8 **Waxing**. 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. All live-line tools must be electrically tested under wet conditions before being returned to service after any waxing.

5-8.9 **Repairs and Refinishing**. Only competent personnel must make repairs, including any necessary refinishing. Generally, if there is no roughness on the surface and the live-line tool meets electrical tests, there is no need for repair. Small surface ruptures and small voids beneath the surface may need repair and refinishing. Refinishing of FRP tools typically includes abrasive smoothing of the surface and application of a clear epoxy coat. All live-line tools must be electrically dry tested before returning to service after repair or refinishing. FRP tools must also be electrically wet tested before returning to service after repair or refinishing.

5-8.10 **Dry Electrical Testing**. All live-line tools must be submitted to a dry electrical test at intervals of not more than 6 months for tools in frequent use and not more than one year for tools stored for long periods of time (such as for mobility purposes). This test must also be performed on all live-line tools after cleaning (except the daily cleaning before use), waxing, repair, or refinishing. This test must be performed over the entire working length of the tool. Use of either of two procedures is acceptable to complete these tests:

5-8.10.1 Laboratory testing (dry) in accordance with IEEE 978. FRP tools require an application of 75,000 V per foot (305 millimeter) for one minute. Wooden tools require an application of 50,000 V (ac) per foot (305 millimeter) for one minute.

5-8.10.2 Shop or field testing (dry) using the trade name device “Chance Co., Hubbell Power Systems, LS-80 Hot Stick Tester”, or other devices if approved.

5-8.11 **Wet Electrical Testing**. In addition to the dry electrical testing, FRP tools must be submitted to a wet electrical test at not more than 2-year intervals, and after any repair or refinishing. (Wooden tools must never be tested wet). This test must be performed over the entire working length of the tool. Use of either of two procedures is acceptable to complete these tests:

5-8.11.1 Laboratory testing (wet) in accordance with IEEE 978. FRP tools require an application of 75,000 V (ac) per foot (305 millimeter) for one minute.

5-8.11.2 Shop or field testing (wet) using the trade name device “Chance Co., Hubbell Power Systems, LS-80 Hot Stick Tester”, or other devices if approved.

5-8.12 **Precautions for Shop or Field Testing**. Follow the manufacturer’s instructions when using the trade name device “Chance Co., Hubbell Power Systems, LS-80 Hot Stick Tester” and other devices if approved. Additionally, when performing the wet test using the trade name device “Chance Co., Hubbell Power Systems, LS-80 Hot Stick Tester”, comply with the following precautions:

5-8.12.1 Use demineralized water (such as sold in local grocery stores), if available. Otherwise use clean water of conductivity of 3.0 micromho-centimeters or less at room temperature.

5-8.12.2 Support the tool in a horizontal position during the test.

5-8.12.3 Avoid over-wetting. Use a mist applicator (such as a laundry-type spray bottle) and spray the test section until drops just start to run down the surface. If too much water is sprayed on the tool, water can collect in a line of drops at the undersurface, producing a false rejection because of flashover or high leakage current.

5-8.12.4 Take overlapping readings from one end of the tool to the other but do not slide the tester on the tool. Lift up the tester before moving it. This can prevent streaks that can cause a false rejection.

5-8.12.5 Rotate the tool 90 degrees and again test the tool from end to end. Continue in this manner until four different positions around the tool circumference have been tested.

5-8.13 **Transportation**. Live-line tools must transported with care and protected from mechanical damage. Exposure to inclement weather must be avoided. Containers must prevent damage to insulating surfaces from abrasive surfaces and bumping motions, and to minimize contamination buildup. In house fabricated containers made from PVC pipe and fittings provide excellent protection for live line tools. Special PVC fittings are also available from vendors for this purpose.

5-8.14 **Storage**. All live-line tools not being regularly transported must be stored in a dry location and must not be tampered with or handled by unauthorized personnel. If possible avoid locations subject to temperature changes because this can permit the formation of condensation and because wood tools can warp. Store tools in bins and racks, constructed to prevent damage to insulating surfaces, away from dirt, moisture and sunlight (and other sources of ultraviolet light). In house fabricated containers made from PVC pipe and fittings provide excellent protection for live line tools. Special PVC fittings are also available from vendors for this purpose.

5-8.15 **Use of Live-Line Tools**. When using live-line tools, workers must not place their hands closer than is absolutely necessary to energized conductors or equipment or to the metal parts of the tool, and in no case closer than the minimum working distances specified in Table 8-1. Additional requirements on the use of live-line tools include:

5-8.15.1 If tools used have quick-change heads, they must not be used without a “quick change safety clip”.

5-8.15.2 Approved blocks, ropes, slings and other tackle used in live-line tool work must not be used for any other purpose and must be kept clean, dry and free from contamination.

5-8.15.3 Live-line tools being used to spread or raise conductors must be securely fastened and must not be held by workers except as necessary to secure or release them.

5-8.15.4 Live-line tools must be hung on a hand line or approved tool hanger, if possible. Do not hang a tool on a conductor or bond wire.

5-8.15.5 Never lay live-line tools on the ground. When brought to the worksite, place tools on portable racks or lay them on clean, dry tarpaulins or plastic sheeting.

5-8.15.6 Do not use live-line tools in rain or heavy fog except in an emergency as directed by the authorized individual-in-charge. In no case must they be used when conditions permit formation of rivulets of water along the tool. After completing the job, make sure the tools are wiped dry before returning them to storage.

5-9 **ELECTRICAL TESTING DEVICES**. Electrical testing devices are necessary to ensure maintenance of electric lines can be accomplished safely. For a more complete discussion of test devices, *Electrical Equipment Testing and Maintenance* is recommended as a reference. This section covers testers that are considered necessary for normal safety considerations. Always use testing devices in accordance with the manufacturer's recommendations, and with the appropriate personal protection. Live-line tools may also be needed.

WARNING

Proximity voltage detectors are not to be used solely to verify de-energized conditions. Direct contact voltage meters shall be used

5-9.1 **Voltage Detectors**. Voltage detectors are used to determine whether the line or device is energized. Low-voltage detectors often use neon glow lamps or solenoid plunger testers. Medium- and high-voltage detectors are proximity and direct-contact types. The user must understand where and how the detectors can be used. Some detectors cannot be used to detect or measure voltages on cables with metallic sheaths or semiconductor coatings. Some detectors cannot be used on ungrounded circuits or to detect lower voltages.

5-9.2 **Phasing Testers**. Use phasing testers to determine the phase relationships and approximate voltages on energized lines.

5-9.3 **Line Fault Locators**. Use line fault locators on underground lines up to 34.5 kilovolts to determine the location of line faults.

5-9.4 **Insulator Testers**. Use insulator testers to measure the potential across each insulator in a suspect string of cap and pin insulators. They can be used without interrupting service.

5-9.5 **Leakage-Current Monitors**. The leakage current that can occur from overcurrent conditions on insulated ladder and truck booms must be monitored for worker safety.

5-9.6 **Combustible Gas/Oxygen Detectors**. Portable monitors provide visual and audible warnings of explosive atmospheres, and of low oxygen levels. Usually, the detector will provide a continuous reading of the combustible gas concentration ranging from 0 to 100 percent of the lower explosive level (LEL) and from 0 to 25 percent of the oxygen level.

5-10 **INSULATING OIL HANDLING OPERATIONS**. Deenergize oil-insulated equipment, if possible. Observe the following additional precautions during oil filtering, oil reclaiming, and other oil-handling operations:

5-10.1 Always deenergize potential and current transformers before taking oil samples.

5-10.2 Have appropriate types and sizes of fire extinguishers readily available.

5-10.3 When necessary to process oil in an energized power transformer, first conduct a job hazard Operational Risk Analysis (ORM), and prepare a written work procedure.

CHAPTER 6

DEENERGIZED LINE CLEARANCE

6-1 **SAFE CLEARANCE AND LOCKOUT/TAGOUT PROCEDURES**. The basic safety rule governing safe clearance and lockout/tagout procedures is that all conductors and equipment are considered energized until all sources of electrical energy have been disconnected or otherwise prevented from energizing the equipment or circuits being worked on. Even with safe clearance and lockout/tagout procedures applied, all lines and apparatus must be grounded with approved grounding methods and tested for no voltage. This will reduce the voltage across the worker to the lowest practical value possible, in case the line or equipment being worked on is accidentally energized. Table 6-1 summarizes the sequence of events associated with lockout and tagout. As part of safe working practices, the lockout/tagout process requires a circuit be deenergized, tested dead, isolated, tested dead, locked out, tagged, and grounded.

Table 6-1. Lockout/Tagout Sequence

	Steps to Deenergize a Circuit
1	Notify all affected workers of hazards, their control, and any possible stored energy.
2	Prior to shutdown, check voltage to insure test meters are working properly and that phase rotation will be right once it is re-energized.
3	Shut down the system by isolation of energy sources. System is made inoperative.
4	Secure all energy source shutdown methods by lockout/tagout/tryout of controls. Tryout refers to verification of successful lockout/tagout.
5	Release any stored energy and verify such release.
6	Verify by testing that the system is deenergized (no voltage).
7	Provide temporary grounding.
	Steps to Reenergize a Circuit
1	Inspect the work area for an operationally intact system and remove nonessential items.
2	Notify all affected workers that system will be reenergized and warn them to stand clear.
3	Remove temporary grounding.
4	Remove lockout/tagout/tryout devices.
5	Visually determine that all affected workers are clear of the circuit.
6	Check voltage and phasing before re-energizing system.
7	Proceed with restoring service.

6-1.1 **Development of Procedures**. Establish safe clearance and lockout/tagout procedures at each base or facility. Each service has documents controlling this process; refer to Appendix A for a list of documents.

6-1.2 **Lockout**. A lockout is the placing of a valve, switch, or other line opening device for a prime mover in the open or closed position, as appropriate, and ensuring by some means (usually mechanically) that the position of the valve, switch, or line opening device can not be inadvertently changed. Examples of mechanical means include removal of an isolating circuit element, blocking of a controlling switch, opening of an extra disconnecting device, or the removal of a valve handle. If a device is listed on the Safe Clearance and is capable of being locked out, then lockout must be utilized. Use of only tagout and not lockout must be justified on the Safe Clearance. This might occur when the device is not physically configured to accept and cannot be adapted for a lockout device. In these cases, the Safe Clearance must include provisions for other means to provide a level of safety equivalent to that obtained by a lockout

6-1.3 **Tagouts**. Apply Danger (red) tags to prohibit changing the position of devices by unauthorized persons. All energy-isolating devices must be provided with a Danger tag, even those locked out. Use a Danger tagout for each Safe Clearance. Use Caution (yellow) tags in connection with a Safe Clearance to provide precautions necessary before operation of a switch or other device. Out-of-Order tags are not used as part of a Safe Clearance. If used, green tags indicate placement of a ground on a circuit or equipment. Tags and tag ties must meet the OSHA's 50-pound pull test requirement.

6-1.4 **Preparation of the Safe Clearance Form**. The details and the person preparing the Safe Clearance must include:

- Details of blocking, switching, tags, and locks. A second worker who is at least classified as an electrical journeyman must check this information. This check must be done before beginning any switching. Enter details in their proper sequence, reading down the form. Include any switch operations (such as opening or shutting) necessary to transfer load or put other equipment into operation.

- Supplemental direction, if necessary, to be provided to the crew involved in the work to ensure their understanding of boundaries of coverage of the Safe Clearance.

6-1.5 **Issue (Approval) of the Safe Clearance Form**. Only designated persons must be authorized to issue (approve) Safe Clearances for work by qualified personnel. These persons must be designated in writing in accordance with local procedures. The designated person in issuing (approving) a Safe Clearance must ensure that the following objectives have been met:

- Inclusion of the correct switching and equipment operations sequence.

- Provisions are included to discharge and ground capacitors and other sources of stored electrical energy that might endanger personnel.

- Provisions are included to discharge or block the release of stored non-electric energy (such as springs) in any device that could cause electric circuits to re-energize.

- Selection of a qualified worker who is authorized to receive the approved Safe Clearance and then perform the required switching and operations. The qualified worker must have previously been approved in writing as one authorized to receive a Safe Clearance.

- Arrangements have been made for any necessary interruption of service, such as notifying users and notifying the utility company supplying power to the facility. Notifications to the utility company must be given to the person designated by the utility company to receive such information. In the event this individual cannot be reached, the nearest system operating or load dispatching office of the company must be informed.

6-1.6 **Safe Clearance Form Description**. Detailed information follows section by section, for completing the Safe Clearance form.

6-1.6.1 **Record Number**. A consecutive number must be assigned from records maintained in the appropriate (locally designated) office.

6-1.6.2 **Other Clearance Numbers**. If more than one Safe Clearance is to be issued on the same line or equipment, show the numbers of the other clearances in the upper right-hand box. When feasible, only one Safe Clearance should be issued. If more than one crew is assigned to the work, one authorized individual-in-charge must be responsible for all the crews. When because of the distance separating the various crews or the extent of the work, additional Safe Clearances may be issued. In such a case, one authorized individual-in-charge must supervise the receipt of all the Safe Clearances and the removal of lockouts and tagouts.

6-1.6.3 **Issued By, Time, and Date**. Provide the name and signature of the person issuing the Safe Clearance and time and date of issuance. This person is often the electrical supervisor.

6-1.6.4 **Issued To**. Fill in the name of the person receiving the Safe Clearance. Safe Clearances must be issued only to workers authorized to receive them. A list of all such workers must be kept in the office that contains Safe Clearance records. The worker receiving a Safe Clearance is responsible for checking all lockouts and tagouts, especially being assured that all points of possible feed, including stored-energy devices, are open, locked out, and provided with correct tagouts.

6-1.6.5 **Line/Equipment Involved**. Give a brief description of the lines or equipment on which work is to be performed. This information is prepared prior to issuance of the Safe Clearance.

6-1.6.6 **Details of Blocking and Tagging**. Step-by-step instructions and supplemental information are provided relative to hanging tags and installing lockouts. This information is prepared prior to issuance of the Safe Clearance.

6-1.6.7 **Time Applied**. Progressing downward in proper sequence of the form, fill in the actual time each step of the details is performed.

6-1.6.8 **Released By, Time Released, and Date Released**. Provide the name and signature of the person releasing the Safe Clearance. This is usually the authorized individual-in-charge for the job. The person releasing a Safe Clearance is responsible for making sure that all workers and temporary grounds are clear and that the line or equipment is ready to return to service.

Note: Switching operations, and removal of lockouts and tagouts are not yet approved or accomplished at this point.

6-1.6.9 **Accepted By**. Provide the name and signature of the person accepting the release of the Safe Clearance. This is often the same person that issued the Safe Clearance. If more than one Safe Clearance is issued for the same equipment or location, this person is also responsible for ensuring all Safe Clearances are released before any change is made in lockouts or tagouts. Once accepted, removal of lockouts and tagouts may be authorized, and switching operations may be performed to restore the line or equipment to service.

6-1.6.10 **Time Removed**. Beginning with the last detail of switching, lockout, and tagout on the Safe Clearance, perform the reverse operation, progressing upward on the form, and enter the time each operation is performed. For instance, if a detail of switching, lockout, and tagout reads “Switch ‘A’ open and hang danger tag” the opposite operation is “remove danger tag and switch ‘A’ shut.” Do not operate the equipment or perform any switching operation after removing your danger tag if it is still tagged with another danger tag.

Note: If lockouts and tagouts have been installed for more than one Safe Clearance on the same equipment or line, perform no switching operations until releases have been accepted for <u>all</u> Safe Clearances.

6-1.6.11 **Notification**. Return the completed Safe Clearance form to the office that retains Safe Clearance records.

6-1.7 **Lockout and Tagout Precautions**.

6-1.7.1 A single blade, stick-operated disconnect switch cannot be mechanically blocked open and ordinarily is not capable of being locked out. In this case, a danger tag hung on each phase would normally be considered an acceptable provision for electrical safety. Suitable tag holders, made of insulating material and designed for installation with a hot stick, must be used on single blade stick-operated disconnect switches, fused cutouts, open jumpers, and similar visible line breaks.

6-1.7.2 Gang-operated switches are normally designed to be locked open and a single danger tag must be tied on the locked switch. Tag must be secured with minimum 50-pound pull-rated tie.

6-1.7.3 A turbine throttle valve can usually be locked in the closed position. A danger tag must also be provided.

6-1.7.4 On overhead lines, a visible line break must be provided at all points of possible feed. An opened circuit breaker is not normally acceptable in lieu of a visible line break on overhead systems, and must be used only when it is not feasible to remove the line side leads from the circuit breaker bushings and it is not possible to provide a visible line break near the circuit breaker. If a circuit breaker is used for electrical isolation, the circuit breaker must be mechanically blocked or locked open, and a danger tag tied on the circuit breaker. Additionally, the authorized individual-in-charge must ensure workers are particularly careful in determining that the line is actually deenergized. Also, temporary grounds must be installed on overhead systems as close as practical to the circuit protective device. Tag must be secured with minimum 50-pound pull-rated tie.

6-1.7.5 On underground systems, it is often not feasible to provide a visible line break. For these systems, use of a circuit breaker or subway disconnect switch locked or blocked mechanically in the open position and provided with a danger tag is acceptable. The authorized individual-in-charge must ensure workers are particularly careful in determining that the line is actually deenergized. Also, temporary grounds must be installed on underground system as close as practical to the circuit protective device

6-1.7.6 Fuse cutouts must be blocked or locked in the open position, the fuse block removed, and the clamp provided with a Danger tag.

6-1.7.7 A Caution tag must be hung on a normally open switch if it has been closed to tie two lines together prior to taking a section of one of the lines out of service. The position of the switch with the Caution tag must not be changed without prior approval of the authorized individual-in-charge. Additionally, if the position of the switch with the Caution tag is to remain in the changed position, the Safe Clearance must be updated with the new position and the date and time the change was effected. Tag must be secured with minimum 50-pound pull-rated tie.

6-2 **DEENERGIZED LINE WORK RULES.** These rules apply to both low and medium-voltage levels.

6-2.1 **Low-Voltage Levels (600 Volts and Below)**. Safe Clearance procedures do apply to low-voltage levels. Lines and equipment must be positively proven to be deenergized before work is begun. A locally approved voltage detector may be used for

this test in conjunction with a direct contact voltmeter. The detector must be checked on a conductor known to be energized both before and after checking the deenergized line or equipment. All energized conductors or equipment within reach of workers must be covered with insulating material or approved rubber protective equipment. Temporary grounding must be installed on lines and equipment to be worked on, unless the authorized individual-in-charge determines that temporary grounding is not practical. The authorized individual-in-charge must explain to the work crew the reasons for not installing temporary grounding. When pulling in new conductors near energized conductors, the new conductors must be provided with temporary grounds, and treated as if energized until the work is complete. Always treat bare wire communication conductors on power poles as energized lines and use appropriate personal protective equipment.

6-2.2 **Medium-Voltage Levels (>600 Volts to 69,000 Volts)**.

Note: Voltage levels in the medium-voltage range are commonly called "high voltage" by facility workers. This terminology is also used by the National Electrical Code. Transmission and distribution line industry standards define high voltage circuits as ones with voltage levels from 115 to 230 kilovolts.

6-2.2.1 Maintain the minimum approach and working distances given in Table 8-1 until the lines and equipment are positively proven to be deenergized and wear appropriate personal protective equipment.. Use a locally approved voltage detector for this purpose. Check the detector on a conductor known to be energized both before and after checking the deenergized line or equipment. If an energized conductor is not available for the check, the detector may be checked on a spark plug of a running gasoline-powered engine. Commercially available spark testing devices can also be used

6-2.2.2 After the lines or equipment have been proven deenergized, install temporary grounds at the first power pole or at other appropriate conductor locations on each side of the work. When installing temporary grounds, make the earth connection first, pole band brackets, and then connect to the conductor or equipment. Use a hot stick when making the connection to the conductor due to the hazard of static discharge. When removing temporary grounds, disconnect the earth connection last.

6-2.2.3 All electric lines and equipment (energized at 600 V to 7,500 V between conductors) within reach of workers, or which must be climbed through or worked next to, must be covered with rubber line hose, insulator hoods, or blankets, or isolated with suitable barriers. A worker who changes position must, before starting the new work, cover or barricade any energized or grounded conductor or equipment coming within reach.

6-2.2.4 Before working near energized equipment at any substation, install suitable barriers and warning signs.

6-2.2.5 All cable to be cut should be positively identified, using approved methods or equipment, and de-energized before each cut. Determine whether special precautions must be taken for asbestos. If located in a manhole, check the duct location using an as-built drawing or by other means, such as cable identification tags. Insure the line is grounded at the first possible grounding point on each side of the work location before any cuts are made. . After the cable has been positively identified and grounded, remove about a 75-millimeter (3-inch) strip of fireproofing, covering or jacketing from around the cable. Test the cable with two voltage detectors, one at a time, at two or more points near the center of the exposed insulation. Permit no workers to remain in the space during the cutting.

6-2.2.6 Confirm that reactors and connected equipment are deenergized and grounded before touching or approaching within the minimum working distances

6-2.2.7 Discharge surge arresters and stored energy devices in accordance with manufacturer's recommendations or local instructions.

CHAPTER 7

DEENERGIZED LINE GROUNDING

7-1 **TEMPORARY GROUNDING**. Temporary grounding is provided to protect workers engaged in deenergized electric line maintenance. In addition, lines and equipment are protected. Unsafe potentials can occur on the line from static charge buildup, induced voltages through magnetic and capacitive coupling from nearby energized lines, and accidental energizing of the line. The temporary grounding will cause an inadvertently energized line to become deenergized through the action of ground fault relays, and will drain off induced currents. Further information on temporary grounding may be found in IEEE Standard 1048, *Guide for Protective Grounding of Power Lines*.

7-1.1 **Testing**. Test the line to be sure it is deenergized before installing protective grounds.

WARNING
Protective grounds should be placed on the disconnected lines or equipment to be worked on in accordance with 29 CFR 1910.269(n), *Grounding for Protection of Employees*. All lines/equipment that are not effectively isolated, tested as de-energized and grounded will be worked as if they are operating at their full potential.

7-1.2 **Installation Criteria**. A good temporary ground provides adequate current-carrying capacity and a low-resistance path to the reference ground, and is connected at the proper points with clean tight joints. If the temporary ground is not installed correctly, a worker might feel secure but not actually be protected. When connecting grounds to conductors, maintain the proper clearances from energized lines, using hot-line tools as required. To avoid hazardous touch and step potentials, persons on the ground within the work area must stay at least 3 meters (10 feet) from any protective grounds or devices, and from vehicles bonded to them. If this is not feasible, workers must wear insulated footwear or use other protective measures to minimize the hazard.

7-1.3 **Specifying, Maintaining, and Storing**. Cables, clamps, ferrules, and jumpers must comply with the specification requirements of ASTM F 855 and be maintained in good condition. Store in accordance with the requirements for electrical tools and rubber protective equipment. Grounding sets and jumpers should be workbench assembled and tested annually using an instrument specifically designed to test grounding equipment.

7-1.4 **Cables**. Do not use aluminum cables for testing. Be aware that the use of sharp bends and continuous flexing of cable can break conductor strands. Excessive cable lengths must be avoided as this increases resistance, and twists and coils also reduce their current-carrying capacity. As a general rule, limit the length of grounding cables to 9 meters (30 feet) for line use and 12 meters (40 feet) for substation use.

Cables must be a minimum #1/0 AWG copper and be able to withstand the available fault currents for 15 cycles for substation use and for 30 cycles for line use.

7-1.5 **Equipotential Zone**. All metal within reach must be at the same (zero or minimum) potential with reference to ground in order to safely protect the workers. Install and connect grounding and bonding conductors in a proper manner to provide an equipotential zone of protection for workers.

7-1.6 **Ground Connection and Electrodes**. Temporary grounds must be connected to the permanent ground of the structure or pole, to another grounding electrode or grounded conductor. This may be the neutral conductor, or an overhead ground wire, or the station ground, or one or more temporarily driven ground rods, driven so at least 1.8 meters (6 feet) of the ground rod is in contact with moist soil. Grounding system resistance shall be 25 ohms or less. Additionally, any metallic object that is a good conductor, such as an anchor rod or permanent ground rod, which extends several feet into the ground, may be used for the connection if sufficiently low ground resistance is determined. When connecting to a metal pole or structure, always verify it has an unbroken connection to its permanent ground rod. Temporarily driven ground rods are required as temporary ground connections for work on wood poles. In areas accessible to unauthorized personnel, provide a barricade for the ground rod as a physical and visual barrier to prevent anyone from approaching within the minimum approach distances specified in Table 8-1.

7-1.7 **Vehicle Grounding**. Ground and bond each vehicle being used at the job site when any parts of it will come within the clearance distances of Table 8-1. When in transit or when parked with no load and all booms lowered, the vehicle may be ungrounded if it is located outside the minimum distances. Ensure the workers and the vehicle operator are aware of step potential hazards near vehicles as well as near permanent and temporary ground rods and electrodes.

7-1.7.1 **Aerial Lift Truck**. Provide an equipotential zone for work done from an aerial lift truck by bonding the truck, as applicable.

7-1.7.2 **Other Work Vehicles**. Diggers, cranes, and other work vehicles must be bonded, if practical, to the common temporary or permanent ground electrode provided when performing work on deenergized circuits.

7-2 **SUMMARY OF GROUNDING RULES FOR AERIAL LINES**. The following rules apply for the grounding of deenergized aerial lines.

7-2.1 All lines and apparatus, regardless of voltage, must be considered as energized unless shorted to ground using approved grounding devices.

7-2.2 The grounding connector must consist of a screwed clamp and must be attached to a conductor only by means of an insulating stick not less than 1.5 meters (5 feet) in length. The lead from this conductor clamp to the ground connection must be a rubber-insulated copper grounding cable not smaller than No. 1/0 AWG, and preferably

of the extra flexible welding type meeting ASTM F 855. A screwed clamp must be provided at the ground connection similar to the conductor connection. Group or individual grounding may be used, but either method must both ground and short circuit each phase of the lines or equipment.

7-2.3 Where ground switches are installed, they must be approved for use as a grounding switch by a nationally recognized testing laboratory.

7-2.4 When applying a temporary ground, the ground connection must always be made first, before making the line connection. In removing a temporary ground, the ground connection is removed last, after breaking the line connection. Never remove the ground connection until all line conductors have been cleared. Ground clamps must be installed only with an approved insulated handle or hot tap stick.

7-2.5 When it is necessary to ground lines above energized circuits, take the following additional steps according to the voltage of the energized circuit:

- Energized circuits less than 7.5 kV must be covered with suitable rubber protective devices.
- Energized circuits between 7.5 kV and 15 kV either must be moved out to a safe distance with live-line tools, or be covered with suitable rubber protective devices.
- Energized circuits over 15 kV must be deenergized. These circuits are not permitted to be moved with live-line tools.

7-3 **GROUNDING METHODS FOR AERIAL LINES**. Personnel can proceed with the installation of grounding equipment when they have taken the necessary precautions as outlined above.

7-3.1 The following provides guidance regarding the number of sets of grounding devices and their locations.

7-3.1.1 If possible, establish an equipotential zone in the work area by bonding all conductors together and to earth. Refer to OSHA 29 CFR 1910.269, Appendix C, for additional information regarding the importance of equipotential grounding and establishing an equipotential work zone.

7-3.1.2 Otherwise, use one or more grounding devices based on the following:

- On single-feed lines with no energized circuits paralleling or crossing them, install a grounding device between the work and the source of power. Preferably, the work must be done no farther than 1.6 kilometers (one mile) from the grounding device.

- On single-feed lines with energized circuits crossing them, install a grounding device between the work and the location of the crossing. In no case will the work be done farther than 1.6 kilometers (one mile) from the grounding device.

- On single-feed lines with energized circuits paralleling them, install a grounding device between the work and the location of the source of power. In no case will the work be done farther than 1.6 kilometers (one mile) from the grounding device.

- On double-feed lines with no energized circuits paralleling or crossing them, only one grounding device on either side of the work is required if the work is to be done at no more than 0.8 kilometers (0.5 miles) from the grounding device. Otherwise install a grounding device on each side of the work. When two sets of grounding devices are used, preferably they must be located not more than 3.2 kilometers (2 miles) apart.

- On double-feed lines with energized circuits crossing them, install grounding devices between the work and the location of the crossings. Only one grounding device on either side of the work is required, if the work is to be done at no more than 0.8 kilometers (0.5 miles) from the grounding device. Otherwise install a grounding device on each side of the work. When two sets of grounding devices are used, they must not be located more than 3.2 kilometers (2 miles) apart.

- On double-feed lines with energized circuits paralleling them, install grounding devices between the work and the location of the source of power. Only one grounding device on either side of the work is required, if the work is to be done at no more than 0.8 kilometers (0.5 miles) from the grounding device. Otherwise install a grounding device on each side of the work. When two sets of grounding devices are used, they will not be located more than 3.2 kilometers (2 miles) apart.

7-3.2 When work is to be done on deenergized lines equipped with pole gaps in the ground wires, bridge such gaps with ground clamps or suitable gap bridging devices before climbing to positions above them.

7-3.3 When installing grounding equipment on deenergized lines attached to a wooden pole, first sink a ground rod at least 1.8 meters (6 feet) into damp earth (as damp as can be found) near the location where the grounding device is to be attached. Attach the ground device, including pole band bracket, securely to this rod and then to the conductor, keeping all portions of your body as far below the line conductor as possible. Be sure that your body does not come in contact with the ground wire or any line conductor. Start at the lowest line conductor and ground each line conductor, working upwards. Be sure to use the same ground rod for all line conductors.

7-3.4 When installing grounding equipment at substations, first securely attach the grounding device to the station grounding system and then to each line conductor keeping all portions of your body as far away as possible and below the line conductors. Be sure that your body does not come in contact with the ground wire or line conductor.

7-3.5 Use the following method to remove the protective ground. First, remove the grounding device from each line conductor, keeping as far away as possible and being sure your body does not come in contact with the ground wire or line conductor. Then remove the grounding device from the station grounding system.

CHAPTER 8

ENERGIZED LINE WORK

8-1 **WORK ON ENERGIZED CIRCUITS**. Do not work on energized electrical circuits except when required to support a critical mission, prevent human injury, or protect property. In all instances of work on energized electrical circuits, workers must be qualified for hot line work and all required protective equipment and special tools must be available at the work site. OSHA 29 CFR 1910.333 limits work on live energized electrical equipment as follows: "Live parts to which an employee may be exposed shall be deenergized before the employee works on or near them, unless the employer can demonstrate that deenergizing introduces additional or increased hazards or is not feasible due to equipment design or operational limitations." For the Navy, all energized line work will require written, job specific procedures approved, in writing, by the Commanding Officer/Executive Officer and considered necessary to support a critical mission, prevent human injury, or protect property.

WARNING

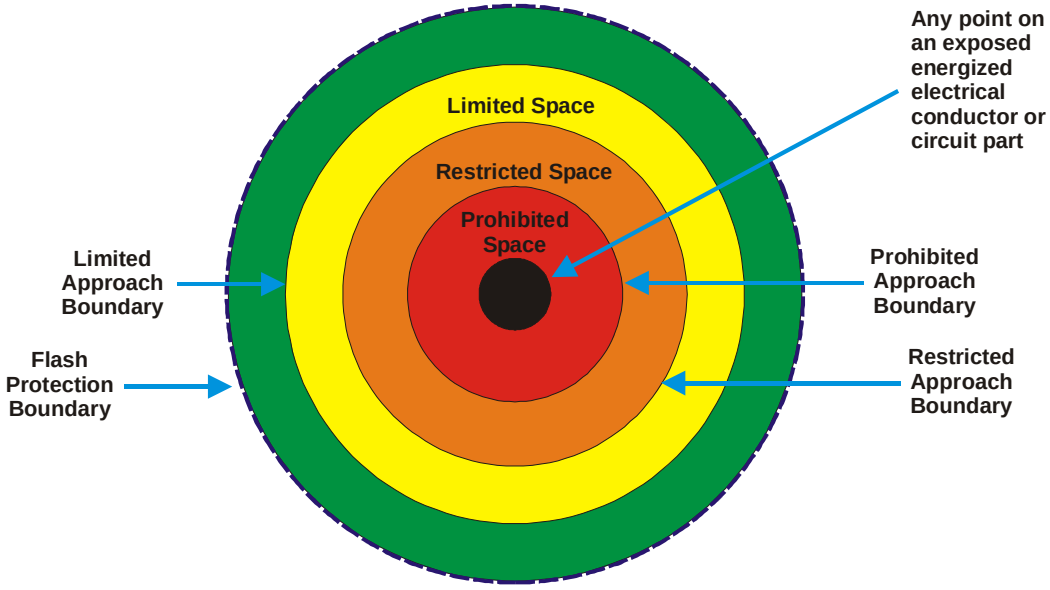
Only workers qualified by electrical training can work in areas on or with unguarded, uninsulated energized lines or parts of equipment operating at 50 V or more. All electric lines and equipment will be treated as energized unless deenergized and grounded. Maintain the specified minimum clearances based on the voltage range. The flash protection boundary distance requires the wearing of arc rated clothing. No energized line work can be performed during adverse weather conditions (ice storms, high winds, electric storms) unless there is an emergency and the work has been approved by the designated authority.

8-1.1 **Exceptions**. An exception to the general rule permits low-voltage control circuits (50 V or less) to be worked on while energized. Also, low-voltage power and control circuits (277 V or less to ground) can be tested or checked while energized using voltmeters, voltage detectors, ammeters, or other appropriate test equipment. Testing must be performed only while complying with all safety precautions.

8-1.2 **Working Near Energized Circuits**. Perform electrical maintenance near energized circuits with rubber blankets or other suitable guards as a safety measure. Minor work (such as cutting weeds, taking oil samples, or securing nameplate data) when done near energized apparatus or conductors located on or near the ground may be performed when workers maintain at least the qualified worker minimum working distances or the unqualified worker minimum approach distances, as appropriate.

8-1.2.1 **Minimum Approach Distances**. Figure 8-1 shows a general layout of the various approach limits. Each boundary is defined following Figure 8-1.

Figure 8-1. Approach Limits



8-1.2.1.1 **Flash Protection Boundary**. The distance from an arc source (energized exposed equipment) at which the potential incident heat energy from an arcing fault on the surface of the skin is 1.2 calories/cm2. Within this boundary, workers are required to wear protective clothing, such as flame resistant shirts and pants and other PPE.

8-1.2.1.2 **Limited Approach Boundary**. A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which is not to be crossed by unqualified persons unless escorted by a qualified person.

8-1.2.1.3 **Prohibited Approach Boundary**. A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which, when crossed by a body part or object, requires the same protection as if direct contact is made with a live part.

8-1.2.1.4 **Restricted Approach Boundary**. A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which, due to its proximity to a shock hazard, requires the use of shock protection techniques and equipment when crossed.

8-1.2.2 **Minimum Approach Distance for Unqualified Workers**. The minimum approach distance for an unqualified worker is 10 ft (3 m) for any line to ground voltage below 50 kV. The minimum approach distance refers to the shortest possible distance between energized electrical lines or apparatus and any part of a worker's body and tools or material being handled.

8-1.2.3 **Minimum Working Distances**. Table 8-1 lists the minimum working distances from exposed energized parts within which a qualified worker may not approach or place any conductive object without an approved insulating handle, unless

certain other live-line work techniques are used (such as isolation, insulation, or guarding) in accordance with accepted industry practice. Refer to OSHA 29 CFR 1910.269 for voltages higher than 46 kV.

Table 8-1. Qualified Worker Minimum Working Distances

Nominal System Voltage Range	Flash Protection Boundary (1)	Limited Approach Boundary		Minimum Working Distance (2) (3)		Prohibited Approach Boundary
	From Phase to Phase Voltage	Exposed Movable Conductor	Exposed Fixed Circuit Part	Includes Standard Inadvertent Movement Adder		Includes Reduced Inadvertent Movement Adder
				Phase to Phase (4)	Phase to Ground (5)	
50 V to 300 V	3ft 0in	10ft 0in	3ft 6in	Avoid contact		Avoid contact
>300 V to 750 V	3ft 0in	10ft 0in	3ft 6in	1ft 0in	1ft 0in	0ft 1in
>750 V to 2 kV	4ft 0in	10ft 0in	4ft 0in	2ft 3in	2ft 2in	0ft 3in
>2kV to 15 kV	16ft 0in	10ft 0in	5ft 0in	2ft 3in	2ft 2in	0ft 7in
>15 kV to 36 kV	19ft 0in	10ft 0in	6ft 0in	2ft 10in	2ft 7in	0ft 10in
>36 kV to 46 kV	21ft 0in	10ft 0in	8ft 0in	2ft 10in	2ft 10in	1ft 5in

Notes for Table 8-1:

1. *A flash protection boundary larger than the minimum approach boundary indicates a need for personal protective equipment (PPE).*

2. *The minimum working distance is defined as the distance between energized parts and grounded objects without insulation, isolation, or guards.*

3. *The minimum working distance applied to hot sticks is the distance between a worker's hand and the working end of the stick.*

4. *Applies to work on three-phase delta systems, and on more than one phase of three-phase wye systems.*

5. *Applies to work on single-phase systems, and on one phase only of three-phase wye systems.*

8-1.2.3 **Altitude Correction for Minimum Working Distances**. Refer to Table 8-2 for altitude correction factors for work performed at elevations greater than 3000 ft (900 m); the minimum approach distance is determined by multiplying the distances in Table 8-1 by the appropriate correction factor from Table 8-2.

Table 8-2. Altitude Correction Factor

Altitude		Correction Factor	Altitude		Correction Factor
Meters	Feet		Meters	Feet	
900	3000	1.00	3000	10000	1.20
1200	4000	1.02	3600	12000	1.25
1500	5000	1.05	4200	14000	1.30
1800	6000	1.08	4800	16000	1.35
2100	7000	1.11	5400	18000	1.39
2400	8000	1.14	6000	20000	1.44
2700	9000	1.17			

8-1.3 **Categories of Work**. The approved work procedures to be used for work on energized circuits depend on the potentials at which the worker operates. These include:

8-1.3.1 **Workers at Ground Potential**. Workers are located on the structure supporting the conductor or on other work platforms and remain essentially at ground potential using insulating tools and equipment.

8-1.3.2 **Workers at Intermediate Potential**. Workers are isolated from grounded objects by insulating means, such as an aerial lift or an insulating ladder or platform, and they work with insulating tools and equipment.

8-1.3.3 **Workers at Line Potential**. Workers are bonded to the energized device on which work is to be performed and are insulated from grounded objects and other energized devices that are at a different potential. This is commonly known as the bare hand technique and is prohibited.

8-2 **ENERGIZED LINE WORK RULES**. With the use of various types of aerial equipment and hot-line tools, it is possible to perform many operations in the maintenance of overhead distribution lines while these lines are energized. Exact compliance with safety precautions is particularly important for energized line work, and personnel engaged in this type of work must be thoroughly trained in the procedures and the use of tools and equipment. Trained personnel must be familiar with ANSI/IEEE 516, *Guide for Maintenance Methods on Energized Power-lines*, and ANSI/IEEE 935, *Guide on Terminology for Tools and Equipment to Be Used in Live Line Working*. The “Lineman’s and Cableman’s Handbook” also provides pictorial data on many of the tools, equipment, and techniques used for live-line operations.

8-2.1 **Permitted Work**. Energized line work must not be performed at any facility without authorization.

8-2.2 **Personal Protective Equipment**. Before working on live energized equipment or lines, perform a flash hazard analysis in accordance with Section 4-4.3 and determine the protective clothing that will be required before entering the flash protection boundary.

WARNING
Depending on the system configuration, arc flash safety might be necessary even for the process of deenergizing the circuit.

8-2.3 **Statement of Qualifications**. Each worker authorized to perform work on energized lines or equipment must be qualified and covered by a written statement that indicates the highest voltage on which the individual is authorized to work. Local policy must establish who can issue the statement of qualification. Electricians in upgrade training shall work under the direct supervision of a qualified person.

8-2.4 **Insulated Buckets**. Personnel working in insulated buckets will be instructed on procedures applying to the use, care, and inspection of insulated buckets as well as precautions to be observed during their use. Work on energized lines must be suspended when an electrical storm occurs in the work area or when the supervisor determines it is too hazardous to work, such as during inclement weather or at night.

8-2.5 **Work Methods for Voltage Levels**. Energized line work methods and the minimum working distances must be in accordance with this manual. All rubber equipment must be properly rated for the maximum possible expected working voltage.

8-2.6 **Required Checks**. The following items must be checked before work starts on energized lines.

- Voltage rating of the circuits to be worked on.
- Clear distance to the earth of lines and other energized equipment.
- Voltage limitations of the bucket equipment, if used.
- Proper operating condition of conductive shoes, clips, and other devices used to connect the bucket liner to the worker.
- Automatic reclosing devices made inoperative while work is being performed.

8-2.7 **Energized Line Precautions**. The following precautions apply to all energized line work.

- The condition of conductors, tie wires, and insulators must be checked and special care exercised if there are any signs of burns or other defects.
- Rubber gloves must be worn when entering a glove-required area and removed only after leaving that area. Gloves and other items of a lower voltage-class than

required at the work site must not be located at that site unless they are collected and stored in such a manner as to make them unavailable for use at the site.

- Energized and neutral conductors, ground wires, messengers, and guy wires in the proximity of the work site must be covered with approved protective equipment. The covering must be applied to the nearest and lowest item first, and removed in reverse order.

- Exercise special care when working in the proximity of fuses, surge arresters, and similar equipment.

8-3 **FEEDBACK PRECAUTIONS.** There is always the possibility of feedback of electrical power when working on apparatus. Feedback typically occurs because of improper or incomplete lockout/tagout procedures, from accidental connections, or because of electrical surges, such as might be caused by a nearby lightning strike. Safety can only be assured through a thorough understanding of the particular circuitry along with proper lockout/tagout and grounding provisions.

CHAPTER 9

SUBSTATIONS AND SWITCHGEAR

9-1 SUBSTATION WORK.

9-1.1 **Purpose of Substation**. A substation provides a protected area for switching power circuits and may include transforming power from one voltage to another. A substation presents an inherent safety hazard because usually only some portions of the substation apparatus can be deenergized for maintenance. For safe operation and maintenance, a thorough knowledge of the substation, including aerial and underground line connections, is necessary. Systems are designed to be safe to operate if maintained properly. Operating safely requires maintenance to be done in a manner that eliminates risks and requires knowledge of the work area, its hazards, and its design basis.

9-1.2 **Diagrams and Schematics**. Electrical diagrams and schematics of the substations must be available and up-to-date. Diagrams and schematics must be studied to understand the operation of the systems and the location and connections of all circuits. Protective devices, alarms, and interlocking circuits all are intended to protect the system. The electrical worker must understand where, why, how, and when blocking protective devices can maintain safe working conditions.

9-1.3 **Engineering Guidance**. Diagrams and schematics must be kept up to date under the supervision of the facility's engineering staff. Engineering staff guidance must be sought when performing maintenance on complex systems. Engineering input is mandatory if the maintenance work involves additions or changes to the power and control systems involved.

9-1.4 **System Operation**. System single line diagrams must be permanently mounted at each substation. When Safe Clearance switching operations are performed, mimic buses on switchgear can be helpful as a visual indication of the lines or equipment being operated.

9-1.4.1 **Protective Devices**. Protective devices within the system, such as relays and fuses, must retain, respectively, their correct coordination settings or be of the proper size and type. Always record previous data so that unintended changes in system coordination are not made.

9-1.4.2 **Alarms**. System alarms, if blocked during maintenance, must be returned to their correct operating condition at the completion of the maintenance.

9-1.4.3 **Interlocking**. Interlocking is used to maintain proper electrical operation in the case of a circuit loss or switching change. Interlocking provisions must be fully understood so to eliminate the danger of electrical feedback from another source, possible paralleling of two unsynchronized sources, or other unsafe operations.

9-1.5 **Abnormal Conditions**. Maintenance accomplished after the occurrence of fault conditions that interrupted normal service imposes higher than usual maintenance risks. Faulty energized equipment and lines must always be deenergized before any work is done. All abnormal operating equipment and electrical components must be deenergized and tagged.

9-1.6 **Defective Equipment**. Electrical apparatus found to be in a dangerous condition or not working properly must be removed from service immediately and tagged. Subsequently, a complete report on the defective equipment must be provided by the worker to the authorized individual-in-charge, the same day if feasible.

9-1.6.1 Defective equipment removed from service, such as: distribution, potential, and current transformers; capacitors; and surge (lightning) arresters must positively be identified by an authorized individual before they are put in storage. Existing defective equipment in storage or at any other location must also be clearly identifiable.

9-1.6.2 Identify defective equipment by painting a large red “X” on the body (not on the top) of the equipment. The red X must remain on such equipment until it has been repaired or until it has been properly disposed of. Local policy may dictate use of their preferred defective equipment identification marking.

9-1.6.3 It must be considered a serious neglect of duty, and willful disobedience of instructions for a worker to deface in any way the identification marking on defective equipment or to place such equipment in service while so identified. The worker in charge of repairing any piece of defective equipment must be the only person authorized to remove the defective markings, and then only after all repairs have been made and the equipment has passed all required testing.

9-2 **WORK AREA CONTROL.** Control of the work area is essential in mishap prevention. Procedures for specific maintenance will vary, but certain rules are common to all electrical work.

9-2.1 **Pre-Visit Briefing**. A pre-visit briefing must be carried out to familiarize workers with the work area. The briefing must include the status of the equipment, parts remaining energized, location of grounds, limits of the working space, open switches which disconnect the equipment from all power sources, and other system operating features. If for any reason there is an interruption in the work, or conditions change, another conference briefing will be conducted to familiarize all assigned workers with the new conditions.

9-2.2 **Clearance Access**. When entering an attended substation, workers not regularly employed in the substation must report immediately to the operator in charge, stating their names, offices, purpose of the visit, and their planned activities. For unattended substations, electrical workers must be receive prior authorization for entry. Unattended substations must always be kept closed and locked. An authorized person must keep the substation access key.

9-2.3 **Deenergizing Work Areas**. When it is necessary to work on or near any electrical circuits or apparatus in the substation, the Safe Clearance procedures prescribed in Chapter 3, as well as pertinent rules given in this chapter, must be carefully followed. If work must be performed on energized lines, it is mandatory that the energized line work rules given in Chapter 3 are followed.

9-2.3.1 **Switching**. Station operators must notify maintenance workers before doing any switching that affects their work.

9-2.3.2 **Lockout and Tagout**. Lockout and tagout all power sources and circuits to and from the equipment and circuits in the work area. All controls must be made non-operative and all feedback circuits, such as from potential transformers or other sources, must be cleared.

9-2.3.3 **Barriers and Barricade Tape**. Place approved temporary barriers between the space occupied by workers and the nearest energized equipment, both for physical protection and as a reminder of the limits of the safe working space. The individual holding the Safe Clearance is responsible for barricade locations, and barricades may be moved only under that person's direction. After the work is finished, the individual holding the Safe Clearance must remove the barriers prior to release of the Safe Clearance.

9-2.3.3.1 Solid red barricade tape is recommended to enclose work areas, and a white-with-a-red-stripe barricade tape is recommended to isolate temporary hazard areas. Only assigned electrical workers can enter the solid red taped area until the hazard has been corrected. An example of a temporary hazard could be a faulty, but energized line.

9-2.3.3.2 Tape must completely enclose the work area, be visible from all approach areas, and be at an effective barrier level. The area enclosed must be large enough to provide worker safety and arranged so any test equipment can be operated outside the taped area.

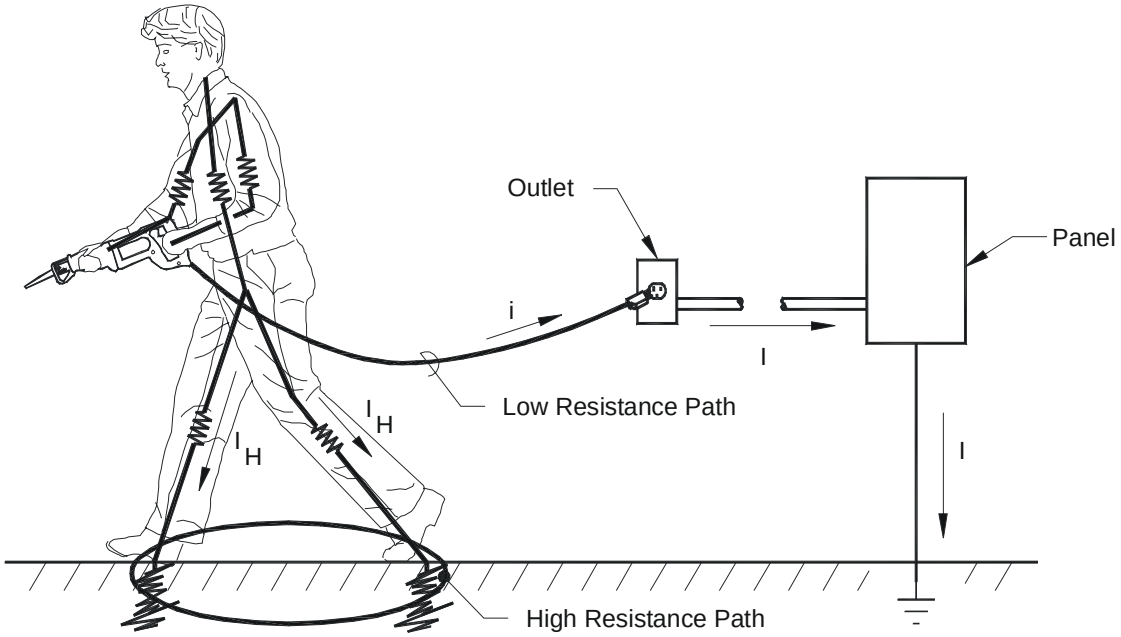
9-2.3.3.3 Temporary barriers and barricade tape must not be used as a substitute for guard railings, for work platforms, or for protection from holes in the floor.

9-2.3.3.4 Information tags or other warning devices must be provided to identify a hazard that is not obvious.

9-2.3.4 **Deenergized Proof Testing**. All lines and equipment on which deenergized work is to be performed must be tested to be sure they are deenergized before protective grounds are applied.

9-2.3.5 **Grounding**. After indication that all circuitry in the work area is deenergized, provide protective grounds as described in Chapter 8. Place grounds so that each ground is readily visible to at least one member of the crew. Stay clear of cables and connecting devices while grounds are being applied. Refer to Figure 9-1.

Figure 9-1. Grounding Path



9-2.3.6 **Adjacent Energized Equipment**. When work is to be done on or near energized lines, all energized and grounded conductors or guy wires within reach of any part of the worker's body must be covered with rubber protective equipment. Bare communications conductors will be treated as energized lines and must be protected accordingly.

9-2.3.6.1 Flexible blankets must not be used at grade level without protecting them from physical damage and moisture by means of a tarpaulin, canvas, or protective mat.

9-2.3.6.2 To avoid corona and ozone damage, rubber protective equipment must not be allowed to remain in place on energized lines or apparatus overnight or for more than one 8-hour period, unless approved by the authorized individual-in-charge.

9-2.3.7 **Worker Protection**. Personal protective apparel must be worn as deemed necessary by the authorized individual-in-charge, as recommended by the manufacturer for the tool being used, or as otherwise directed in this manual. Protective tools will be used as appropriate for the work being done.

9-2.4 **Working Area Housekeeping Checks**. Check the working area to ensure safe conditions and to eliminate or protect against hazards including the following:

- Equipment hazards such as lack of guards or safety devices.
- Material hazards such as sharp, worn, slippery, corroded, or rough items or areas.

- Work station weather hazards such as wind, rain, ice, or dust.
- Arrangement hazards such as congestion, unsafe storage in place, or improper workers' tool provisions and storage.
- Lack of fire prevention and first aid equipment, and inadequate working equipment and tools.
- Insufficient testing equipment, protective apparel and equipment, or safety forms and tags.

9-2.5 **Installation Precautions**. Mark all apparatus and lines for identification, and to match diagrams and schematics before any work is done. Markings must not be placed on removable parts. Where permanent markings are not provided, temporary markings may be utilized; however, permanent markings must be later installed for all devices and circuits operating at voltage levels above those used for control circuitry.

9-3 **SAFETY REQUIREMENTS SUMMARY**. The following minimum requirements are mandatory to assure worker or equipment safety.

WARNING
The following minimum requirements are mandatory to ensure worker or equipment safety.

9-3.1 **Communication Channel Availability**. Provide some method of communication to summon emergency personnel or medical assistance. A method of communication must be functional throughout the period during which work is performed.

9-3.2 **Lighting Level**. The lighting level will be sufficient for safe work. Temporary self-contained lighting systems must be provided where natural or installed lighting is not available or sufficient.

9-3.3 **Working Period**. Normally no worker must work more than a standard 8-hour period with suitable breaks. Under emergency conditions extended duration work periods may become necessary, but the work period must be preceded and followed by a minimum of 8 hours off duty. Extended work periods must not exceed a maximum of 12 hours.

9-3.4 **Technical Direction**. Suitable technical direction is required for all cases of unusual, unfamiliar, or complex and specialized work tasks.

9-3.5 **Coworker Requirement**. No one must work alone within a substation. Jobs generally acceptable for one electrical worker are listed in Chapter 3.

9-3.6 **Worker Qualification**. Workers must be qualified to do the work in question, must be fully cognizant of all safety procedures and equipment conditions, and must be alert and in good health.

9-3.7 **Equipment Preparation**.

9-3.7.1 All control power must be deenergized and all stored-energy mechanisms must have been discharged.

9-3.7.2 All stationary (bolted or plug-in) non-drawout type circuit breakers must be deenergized.

9-3.7.3 All drawout circuit breakers must be checked to be sure that interlocks have not been defeated or bypassed, and the circuit breaker cannot be withdrawn in the closed position.

9-4 **REQUIREMENTS FOR TESTING.** Take the following precautions when performing electrical tests.

9-4.1 Check all test devices for normal operation and proper calibration before starting testing.

9-4.2 When testing live circuits or equipment, all temporary leads used in testing must be securely supported to prevent interference with other workers or injury to the tester.

9-4.3 Protect testing personnel and others, particularly their eyes, from flashover hazards using personnel protective equipment as specified in Chapter 5.

9-4.4 When performing mechanical tests, use barricades to keep personnel at a safe distance in case of failure of the equipment under test.

9-4.5 Use an approved voltage detector when testing for blown fuses on low-voltage circuits. Do not use fingers to test for blown fuses.

9-4.6 Testing for absence of voltage on a transformer or regulator will be accomplished by measurements on both the primary and secondary terminals. Absence of voltage on the secondary side of a transformer or regulator is not sufficient demonstration of the absence of voltage on the primary side.

9-4.7 To test transformers and other equipment for short circuits, open circuits, or grounds using a step-up test transformer, the following procedure must be used:

9-4.7.1 In the low-voltage circuit of the step-up transformer, use fuses rated not larger than 10 amperes unless large equipment is being tested. Control the circuit with a double-pole switch, so that all wires feeding the step-up transformer will be deenergized when the switch is open. The medium-voltage leads from the test transformer to the

apparatus being tested must be kept insulated from the surface on which test personnel are standing. The medium-voltage wire to be handled during the test must be attached to the end of a live-line safety tool, and personnel handling the tool must hold it near the opposite end.

9-4.7.2 In testing large transformers, use a testing transformer and fuses large enough to handle the charging current of the transformer being tested.

9-4.7.3 Workers must not handle live medium-voltage wires with their hands. The step-up transformer circuit must be deenergized each time it is necessary to make connections for the test, unless using a live-line safety tool.

9-5 **REQUIREMENTS FOR SWITCHING**. Opening or shutting a power switch can expose the electrical worker to some degree of hazard. A mishap might occur if a switch is closed when a fault is still present on the line. To prevent a mishap, the authorized individual must prepare a switching sequence and identify all load isolation requirements. All switches operated in the switching sequence must be correctly identified. The electrical worker will review the manufacturer's operation manual for any switch that is unfamiliar, and all safety steps listed in the operation manual will be accomplished before opening or closing the switch.

WARNING
Switches can fail during switching operations, creating arc flash hazards. Wear arc rated clothing and/or switching suits during these operations in accordance with Section 4 distances.

9-5.1 **Air Switches**. The most common switches in present use are air switches. Many air switches cannot be opened if there is a load on the line, a large magnetizing current from a transformer, or a heavy charging current from an unloaded transmission line. Be sure to know the interrupting capabilities of each switch being operated.

9-5.1.1 **Disconnect Switches**. Disconnect switches of the non-load break-type must not be used to interrupt loads and magnetizing currents, unless an engineering review has determined the disconnect switch can safely interrupt the actual current. Switch sticks will be used when necessary to provide the minimum working and clear hot stick distances. Assume disconnect switches are of the non-load break-type unless you have positive proof otherwise. Operate non-load break-type switches on the following basis:

9-5.1.1.1 Disconnect switches can be used to open a live line when not under load.

9-5.1.1.2 Disconnect switches can be used to open sections of deenergized lines where these lines parallel other medium- or high-voltage lines. Use caution because induced voltages can build up in the deenergized line and create dangerous switching conditions.

9-5.1.1.3 Evaluate the hazard before using disconnect switches to open a tie line or to break two parallel medium- or high-voltage lines.

9-5.1.2 **Airbreak Switches**. Gang-operated airbreak switches equipped with arcing horns may be rated for load-break operation, or they may only be rated for interrupting the magnetizing current of transformers or the charging current of lines, or to make and break line parallels. The handle of an airbreak switch must be of the permanently insulated-type, and be effectively grounded when operated. Ground mats must be provided for the operator to stand on and be large enough for both feet. Either fixed or portable small iron-mesh mats must be used. The mats must be electrically connected to the operating rod and the substation ground grid to equalize the ground gradient and prevent any potential differences in case of insulation failure or flashover. The electrical worker must wear rubber gloves.

9-5.1.2.1 The hinges of airbreak switches must be sufficiently stiff (and kept in this condition) so that after the blades have been turned into the open position they will not accidentally fall back on their line-side energized clips.

9-5.1.2.2 The switch must be inspected after it has been opened to see that all blades have opened the proper distance. Single-throw airbreak switches must be opened to the maximum amount. Double-throw airbreak switches must be opened so that the blades clear both sides of the switch by the same amount.

9-5.1.2.3 Locks will be provided for all airbreak switch-operating mechanisms. Airbreak switches will be kept locked except when opening or shutting the switch.

9-5.1.3 **Interrupter Switches**. Interrupter switches are designed to be opened under load. Metal-enclosed interrupter switches have sometimes been used in place of circuit breakers as a more economical switching method.

9-5.1.4 **Inching**. The method of opening manually operated non-load break-type disconnects in a gradual manner is called inching, when the operator believes there is no load current. If a small arc occurs from the charging current, it has been assumed that a cautious opening would allow the arc to be broken; however, inching is dangerous and is prohibited.

9-5.2 **Oil Switches**. The consequences of operating a faulty oil switch, or closing into a faulted circuit with an oil switch are likely to be catastrophic and, often fatal. Switching procedures will be used to make sure that no energized oil switch is operated while workers are in the vicinity. Unless the switch has been equipped for remote operation (at least 6 meters (20 feet)) away, the switch must be completely deenergized before switching. Switch position and grounding conditions must be verified before operation. In addition, no medium-voltage oil switch must be operated unless routine maintenance has been performed within the past year. Oil switches must incorporate a mechanical stop to prevent inadvertent operation to ground. Any abnormalities or defects discovered in any oil switch must be reported to an authorized individual.

9-5.3 **Separation Barriers**. When switch bays, cells, or compartments are similar to adjacent sections, the separation barrier between sections must be painted an appropriate color to prevent the possibility of pulling the wrong blade.

9-6 **FUSES**.

WARNING
Fuses might fail during handling if energized, creating arc flash hazards. Wear arc rated clothing or switching suits when changing energized fuses in accordance with Section 4 distances.

9-6.1 **Characteristics**. A fuse is a single-phase device. Fuses can be subject to partial melting or damage by currents that might not have been of sufficient magnitude to blow the fuse.

9-6.2 **Fuse Handling**. Fuses must normally not be handled, except when they need to be replaced. Pull them briskly, and remove completely. Use safety glasses when replacing fuses in primary fuse cutouts, do not use your free arm in an attempt to shield your eyes from possible flashes. The worker changing the fuses must stand firmly on a level surface. Where operating in an elevated position, the worker will be secured with a safety belt to prevent a slip and fall if there is a flash. Fuse sticks must be used in all instances. Whenever possible, deenergize the circuit before removing a fuse.

9-6.3 **Operation of Energized Fuses**. Open all lines protected with energized fuses in the same manner as for air switches. Deenergize non-load-break type installations. For load-break installations, wait for a short time after fuse replacement in order to allow the fuse to interrupt any fault condition that might remain prior to the fuse replacement.

9-6.4 **Open Fuse Holder**. Do not leave outdoor fuse holders open for an extended period of time. Water damage or warping could make closing them dangerous, or degrade their protective ability.

9-6.5 **Closed-Position Fuse Locking**. Follow the fuse or switch manufacturer's instructions, as appropriate, to be sure that the fuse is securely locked, latched, and held fast in a closed position.

9-6.6 **Bypassing**. Do not bridge fuses or fuse cutouts internally. Where it is necessary to bypass fused conductors, use plainly visible external jumpers and remove them as soon as possible.

9-7 ENERGY STORING PROTECTIVE DEVICES.

9-7.1 Electrical Charge.

WARNING
Protective devices such as surge arresters, choke coils, and capacitors store electrical charges as a byproduct of their protective mechanism. This stored charge must be discharged to ground before such devices can be considered deenergized. Always wear eye protection when deenergizing or energizing these devices.

9-7.2 **Surge Arresters**. A surge arrester limits overvoltages and bypasses the related current surge to a ground system that absorbs most of the energy. An overvoltage condition can be caused by a fault in the electrical system, a lightning strike, or a surge voltage related to load switching. All surge arrester equipment must be considered as loaded to full circuit potential, unless it is positively disconnected from the circuit. Be sure the permanent ground conductor is intact before any work is performed.

9-7.2.1 High-voltage substation and at-grade surge arresters must always be provided with screens or fences to prevent possible contact while parts of the surge arresters may be live. The screen or fence must have a gate large enough to permit the removal of individual units. The gate must be provided with a lock, and an authorized person must keep the key.

9-7.2.2 Surge arresters must never be touched or approached, unless they are completely disconnected from all live lines and live equipment, and all parts have been discharged to ground and effectively grounded.

9-7.2.3 Horn gap switches must be fully opened and completely separated from all live lines and equipment whenever it is necessary to work near a surge arrester.

9-7.2.4 If the first attempt to disconnect a surge arrester is unsuccessful, wait 2 or 3 minutes before making another attempt so not to cause an internal fault.

9-7.3 **Choke Coils**. Choke coils are inductors that operate in a manner similar to surge arresters, except that they operate on over-frequency rather than over-voltage.

9-7.4 **Capacitors**. Capacitors consist of an electrical condenser housed in a suitable container. Power capacitors are used to provide power factor correction. Coupling capacitors are used for coupling communication circuits to metering circuits. Because capacitors can hold their charge, they are not electrically deenergized immediately after being disconnected from an energized line. Capacitors on electric lines must be provided with discharge devices to discharge the voltage to 50 V or less, within 5 minutes after the capacitors have been completely disconnected from the circuit.

9-7.4.1 Discharge circuits are intended to discharge capacitors after the circuit is deenergized. Since there could be no indication that the circuit is burned out or otherwise not functioning, always assume capacitors are fully charged until tested.

9-7.4.2 Line capacitors removed from service for any purpose must be considered at full or higher voltage, until the terminals have been shorted together and discharged by an approved method. Do not short terminals until capacitors have been deenergized for at least 5 minutes to allow time for the voltage level to reduce.

9-7.4.3 It is not safe to use fuses or disconnect switches to disconnect large capacitor banks (above 60 kilovolt-reactive single-phase, or 180 kilovolt-reactive three-phase). Circuit breakers or switches designed specifically for this purpose must be used.

9-7.4.4 After disconnecting all capacitor banks, wait 5 minutes. Short together and ground all terminals; ensure the neutral is grounded. All operations must be performed using rubber gloves or a hot stick.

9-7.4.5 Grounds and terminal shorts on capacitors must be left on until the work is completed.

9-7.4.6 Barricade the work area as a safety measure for other workers, when working on or testing capacitors in the shop.

9-7.4.7 Capacitors made before 1979 usually contained PCBs. Refer to the precautions listed in Chapter 3 for hazardous materials if the case is ruptured or any liquid is visible on the outside of the case.

9-7.5 **Coupling Capacitors**. These capacitors have a high impedance, which results in a long discharge period. This characteristic of coupling capacitors is typically overlooked, which makes them particularly hazardous to personnel if not properly grounded. To minimize shock hazard follow the precautions below:

9-7.5.1 A coupling capacitor must always have a shorting wire installed.

9-7.5.2 During maintenance, a grounding wire must be connected to each exposed metal terminal that a worker could contact. Grounding wires must be left in place for the entire duration of maintenance.

9-8 INSTRUMENT TRANSFORMER SAFETY.

9-8.1 **Instrument Transformer Purpose**. Instrument transformers reduce a primary circuit voltage or current to a low-voltage voltage or current for use in metering or relaying of the primary circuit.

9-8.2 **Potential (Voltage) Transformers (PT).**

9-8.2.1 PTs provide a means of obtaining a low voltage from a higher voltage circuit. They are designed and selected to operate within certain accuracy limits and burdens.

9-8.2.2 Replacement transformers must have characteristics identical with the original units.

9-8.2.3 The case and one of the windings of the low-voltage side of voltage transformers must always be grounded before energizing the transformer.

9-8.2.4 Be aware of the following hazards inherent in the maintenance and removal of these units.

9-8.2.4.1 If the secondary windings are inadvertently shorted together when the primary windings are energized, a very high current will flow causing the windings to quickly overheat.

9-8.2.4.2 On most modern switchgear, a drawout arrangement automatically disconnects and grounds the transformers when access to the fuses is necessary.

9-8.2.4.3 On older obsolete switchgear, fuse replacement is potentially dangerous when the primary circuit to the transformer remains energized. Follow these additional safety precautions.

9-8.2.4.3.1 The authorized individual-in-charge will give specific instructions for replacing a blown primary winding fuse on a potential transformer located within switchgear and whenever it is not possible to use a standard 1.8-meter (6-foot) fuse puller.

9-8.2.4.3.2 If a circuit breaker or sectionalizing switch is not installed to isolate a potential transformer, the worker must report the situation to the authorized individual-in-charge before replacing the fuse. The authorized individual-in-charge will arrange for deenergizing the primary circuit. Replacing a primary fuse when the potential transformer is not isolated is particularly hazardous, and requires specific approval.

9-8.2.4.3.3 When disconnecting the primary service to the transformer, verify the absence of voltage using a suitably rated voltmeter (a handheld test meter with a high-voltage probe is not acceptable). Lamps can be used in addition; however, note that a non-illuminated lamp, connected on the low-voltage side of a voltage transformer, is not an adequate indication that the primary side of the transformer is deenergized.

9-8.2.4.3.4 The secondary fuses must also be removed before replacing the primary fuse, and then reinstalled before the transformer is reenergized.

9-8.2.4.3.5 While the transformer is deenergized, the worker must visually inspect for obvious symptoms of trouble such as a smoked or burned case, a damaged bushing, or a damaged fuse holder.

9-8.3 **Current Transformers (CT)**.

9-8.3.1 CTs provide a method of obtaining a low amperage current at a low voltage from a higher amperage current at a higher voltage.

WARNING
The most serious hazard associated with the maintenance of CTs occurs when the secondary side is opened while the primary side is energized. This causes a very high voltage to develop in the secondary winding, which both stresses the insulation and presents an extreme personnel hazard. The secondary circuit of a current transformer must never be opened while the primary side is energized; however, the secondary leads can be shorted together without damage to the transformer.

9-8.3.2 Before opening the secondary circuits of any energized current transformer, the secondary leads must be shorted together and grounded. The location of the short and ground is preferably located at the transformer secondary terminals, but can be at any point between the current transformer and the location at which the secondary circuit is to be opened.

9-8.3.3 Current transformer cases and secondary circuits must be grounded before energizing any current transformer.

9-9 **POWER TRANSFORMERS AND REGULATORS**.

9-9.1 **Purpose**. Power transformers are designed to change voltage levels usually from a high transmission or distribution level to a much lower distribution or utilization level. Voltage regulators are somewhat similar in internal design, but are intended to control variations in line voltage for loads where voltage variation can exceed acceptable limits. Their protective and circuit disconnecting means are not necessarily similar. Both require regular servicing.

9-9.2 **Transformers**.

9-9.2.1 Consider all transformers energized and at full voltage, unless they are disconnected from primary and secondary wires or disconnected from the primary wires and all phases shorted together and grounded. The secondary neutral normally is sufficient as a ground, provided that there is a grounding conductor interconnected with the common neutral, the transformer case, and a ground electrode. Always check continuity of the ground connection.

WARNING
Under no conditions should transformer covers or handhole plates be removed, nor should any work be done on the inside of transformers until the following instructions have been completed.

9-9.2.2 When transformers are installed or replaced, the secondary terminals will be checked for correct voltage and for phase rotation (if applicable).

9-9.2.3 When transformers are installed, and before they are energized, the ground connection must first be made to the case and to the neutral, when applicable.

9-9.2.4 When removing transformers, case and neutral grounds must be disconnected last.

9-9.2.5 When working on or near an energized three-phase, wye-connected transformer or transformer bank, verify the transformer neutral is properly grounded.

9-9.2.6 Never operate no-load (or manual) tap changers when the transformer is energized. Only load-tap-changing (LTC) type tap changers can be operated when the transformer is energized. When reenergizing a transformer after changing the position of manual tap changers, maintain a distance of at least 6 meters (20 feet) until it is determined the internal switching was successful.

9-9.2.7 If necessary to relieve pressure on a transformer, the pipe plug, pressure relief device, or inspection cover plate must be loosened slowly so the internal pressure of the transformer can dissipate gradually.

9-9.2.8 Pressure relief valves must never be opened when there is precipitation or high humidity, except on failed transformers and when re-fusing.

9-9.2.9 Never draw an oil sample, open a pressure relief valve, or otherwise open a transformer when there is an internal vacuum on an energized transformer. Doing so can cause an explosion.

9-9.2.10 Transformers or tanks must not be entered unless forced ventilation or an air supply is used to maintain a minimum oxygen level of 19.5 percent by volume in the work area.

9-9.2.11 Energized pad-mounted transformers and associated equipment must be locked or otherwise secured when unattended.

9-9.3 **Voltage Regulators**.

9-9.3.1 Voltage regulators are normally installed with bypass and disconnect switches.

WARNING
Never open or close a regulator bypass switch, unless the regulator is set on its neutral position and the control switch is open, or the automatic control feature is inactivated in accordance with the manufacturer's recommendations.

9-9.3.2 When regulators are maintained as spares in substations, their bushings must be short-circuited and grounded.

9-10 **METALCLAD SWITCHGEAR**.

9-10.1 Metalclad switchgear shall be operated and maintained according to manufacturer's instructions and the guidance provided in this section are follows.

9-10.2 Perform the following prior to drawout (rack out) of a circuit breaker operating mechanism. Always rack out switchgear/breaker whenever there is work on the circuit originating from that switch/breaker.

9-10.2.1 Deenergize the switchgear (including control power) and ground as much of the switchgear as permitted by operating conditions.

9-10.2.2 Open the circuit breaker.

9-10.2.3 Discharge the stored-energy mechanism, if provided.

9-10.2.4 Check that protective interlocks are functioning to protect against closed-position circuit breaker rack out.

9-10.2.5 Ensure that all workers in the vicinity know the circuit breaker is being racked out.

9-10.3 Access to switchgear terminals through portholes for maintenance in circuit breaker cells is limited to the following.

- When both sets of terminals in a cell are deenergized (i.e., line and load, or bus to bus).

- After both sets of terminals are deenergized, access to switchgear terminals through the portholes is permitted for cleaning, inspecting, and routine maintenance of terminals and bushings.

9-10.4 A manufacturer-approved ground and test device can be used for access to terminals for procedures such as the application of protective grounds, phase identification on deenergized circuits, or phasing tests on live circuits. Use of this device avoids the hazardous operation of opening and shutting the shutters of a

medium-voltage switchgear cell. It can be an extremely hazardous device if not used according to manufacturer's instructions.

9-10.4.1 Do not install the device with ground cables already connected. Connect ground cables after installing the device.

9-10.4.2 Shut all access doors on the device while installing and removing the device. Use padlocks on any door where studs are intended to remain energized and access is not needed for testing.

9-10.4.3 After installing the device, verify by using a voltage detector that exposed studs are deenergized.

9-10.4.4 Install the ground cables, with the device end of the ground cables connected last (and disconnected first upon removal of the ground cables). For a stud-type device, the ground cables must be connected with the device in the "disconnect" position. For a bale-type device, the ground cables can be connected with the device in either the "disconnect" or the "engage" position.

9-11 **STATIONARY STORAGE BATTERIES**.

9-11.1 **Basis for Safety Requirements**.

9-11.1.1 Batteries and DC system components are different from AC electrical system equipment. Batteries contain acid, which is harmful to skin and eyes, and the electrical shock hazards associated with DC power can be more severe than those associated with AC power for equivalent voltages and currents.

9-11.1.2 Only authorized personnel who have been familiarized and trained on battery fundamentals and maintenance procedures are allowed to perform maintenance-related activities on a battery.

9-11.1.3 The following industry standards provide the most complete safety standards for stationary batteries and DC systems. Refer to the appropriate document for the type of battery used in a particular application.

- ANSI/IEEE 450, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications*.
- ANSI/IEEE 484, *IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications*.
- ANSI/IEEE 1106, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications*.

- IEEE 1187, *IEEE Recommended Practice for Installation Design and Installation of Valve Regulated Lead-Acid Batteries for Stationary Applications*.

- IEEE 1188, *IEEE Recommended Practice for Maintenance, Testing and Replacement of Valve Regulated Lead-Acid Batteries for Stationary Applications*.

9-11.1.4 In addition to substation applications, the requirements of this section apply to all stationary battery applications, including engine starting, UPS, and other backup power applications.

9-11.1.5 No smoking shall be permitted in battery rooms or near storage batteries.

9-11.2 **Protective Equipment**. The following equipment must be available for the safe handling of the battery and protection of personnel:

- Safety glasses with side shields, goggles, and/or face shields

- Acid-resistance gloves

- Protective aprons and safety shoes

- Portable or stationary water facilities for rinsing eyes and skin in case of contact with acid electrolyte

- Class C fire extinguisher

- For lead acid batteries, bicarbonate of soda to neutralize any acid spillage (0.1 kg/L or 1 lb/gal of water)

- Adequately insulated tools

- Lifting devices of adequate capacity, when required

9-11.3 **Safety Precautions**.

WARNING
Stationary batteries generate a direct current (DC) voltage, which is particularly dangerous with respect to electrical safety. Exercise extreme caution whenever working on battery systems.

9-11.3.1 Wear proper safety clothing to prevent contact with acid or live electrical connections. Whenever working around batteries, wear a rubber apron and rubber gloves. Ensure goggles and face shields are available for personnel.

9-11.3.2 Use only insulated tools in the battery area to prevent accidental shorting across battery connections. Never lay tools or other metal objects on cells; shorting, explosion, or personal injury could result. As a general rule, the length of the exposed metal for any tool should be less than the distance between the positive and negative posts of each cell.

9-11.3.3 Wear only nonconductive hard hats near batteries. Metal hard hats can fall across the battery terminals or connections and create short circuits.

9-11.3.4 Remove all jewelry, wristwatches, or clothing with metal parts that could come into contact with the battery terminals.

9-11.3.5 Do not make or break series connections within an operating group of cells. Before proceeding, open the battery system circuit breaker to minimize the possibility of arcing.

9-11.3.6 Because batteries can generate hydrogen gas that, in sufficient concentrations, can be explosive if ignited, never bring burning materials such as lighted matches, cigarettes, or sparks of any kind near the battery. Avoid the use of spark-producing equipment near batteries. Residual gases can remain within cells during storage and shipment. Take these precautions at all times while handling batteries.

9-11.3.7 Ensure that the exit from the battery area is unobstructed.

9-11.3.8 Minimize access to the battery by personnel unaware of battery safety precautions.

9-11.3.9 Ensure that the battery area is suitably illuminated.

9-11.3.10 Keep the battery and adjacent area clear of all tools and other foreign objects.

9-11.3.11 Avoid static buildup by having personnel contact ground periodically while working on batteries.

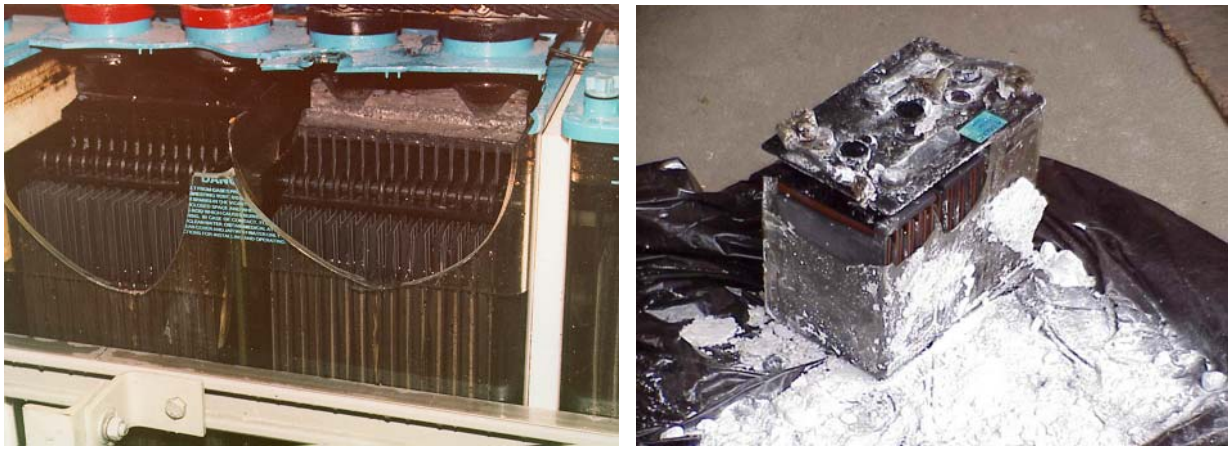
9-11.4 **Battery Explosion Hazards**.

9-11.4.1 Hydrogen and oxygen gases can be released from a battery during operation. Oxygen is generated at the positive plate and hydrogen is generated at the negative plate. Gases are created primarily during battery charging; the rate of gas evolution depends on the charge voltage and the charge current that is not absorbed by the battery. The excess charge current causes electrolysis of the water in the electrolyte into hydrogen and oxygen. This gas evolution can occur with both lead acid and nickel cadmium batteries, including valve-regulated lead acid (VRLA) batteries.

9-11.4.2 Cells are equipped with flame arresters designed to allow gases to escape the battery while preventing external sparks from igniting any gases inside the battery. A 4 percent hydrogen concentration is flammable. The ventilation system in a battery

area must be designed to keep hydrogen concentration under 2 percent. Figure 9-2 shows examples of explosions caused by igniting hydrogen within a cell.

Figure 9-2. Battery Cell Explosions



CHAPTER 10

AERIAL LINES

10-1 **AERIAL LINE WORK.** This chapter includes specific requirements for poles and structures, pole-mounted equipment, and aerial lines. Requirements addressed include pole handling and erection, climbing and working on poles, stringing of lines, working around pole-mounted lighting and other equipment, tool handling, and tree and brush trimming adjacent to an aerial line right-of-way.

10-1.1 **Working in Elevated Positions**. Additional safety requirements are needed for aerial line work since climbing poles is often necessary. Not all work can be accomplished from aerial lifts. Electrical workers must both recognize electrical hazards, and be trained how to prevent falls. This includes training in safe climbing procedures when the structure design cannot accommodate optimum fall protection load requirements.

10-1.2 **Qualified Climber**. Only workers who meet “Qualified Climber” requirements must be permitted to do work which requires climbing poles or trees. Each facility must establish these requirements for both facility personnel and contract personnel. They must apply to all persons whose work involves climbing.

10-1.3 **Navy Criteria for Qualified Climbers**. Comply with the requirements of OSHA 29 CFR 1926(q) “Overhead Lines.” The majority of the work will be done in an elevated position above ground level. Climbing aerial line structures such as poles may be required. Situations with limited structure access can prevent use of an aerial lift bucket truck. The structure design may not accommodate positive fall protection load requirements. Only workers who meet "Qualified Climber" requirements should be permitted to do work which requires climbing poles or trees. Each facility should establish “qualified climber” requirements both for facility personnel and for contract personnel, including the following:

- Physical fitness required for climbing should be documented not only by an annual physical, but also be validated by supervisory observation.
- Climbing duties should be a part of routine job activities, not an occasional occurrence.
- A minimum of 2 years of documented climbing training should be completed. Experience should include hazard recognition and hands-on-training incorporating appropriate safe climbing practices and rescue training.
- Demonstrated proficiency is required on structure types similar to those that are to be climbed and should show that these structures have been climbed on a routine basis within the last 5 years.

- A worker in training may function as qualified only when working under the direct supervision and observation of a "Qualified Climber."

10-2 **POLE HANDLING OPERATIONS.** Precautions are necessary in handling poles safely. Poles are long, heavy, and treated with potentially hazardous pesticides and preservatives. They pose hazards to the workers involved in installation and dismantling operations. Additionally, mistreatment of poles during installation may degrade their ability to meet service requirements, and could endanger those workers who climb them.

10-2.1 **General**. The authorized individual-in-charge must either do it themselves or assign a crew member to direct the handling of poles and give all signals when poles are being lifted or handled. Poles must, whenever possible, be handled starting from the top and the end of the stack. Workers must roll poles away from them using cant hooks or bars. Poles must not be caught with cant hooks while in motion. Whenever possible, carrying hooks must be used when carrying poles.

10-2.2 **Pole Contact Precautions**.

WARNING
Creosote, which is applied to poles as a preservative, can cause skin burns on contact. The following precautions must be taken to avoid burns:

10-2.2.1 Keep arms covered with long sleeved shirts when handling poles.

10-2.2.2 Always wear gloves.

10-2.2.3 Keep neck well covered with a collar or a handkerchief.

10-2.2.4 Keep trousers as long as practical to protect ankles.

10-2.2.5 Never rub eyes or wipe perspiration from face using hands or shirtsleeves after they have been exposed to creosote.

10-2.2.6 Protect hands, arms, and face with a preparation made up of one part gum acacia or gum tragacanth, and three parts lanolin where direct contact with creosote is likely to occur. If this preparation cannot be obtained, acceptable protection can be provided by petroleum jelly (such as Vaseline™). First aid treatment must be obtained immediately when bare skin or eyes come in contact with creosote.

10-2.3 **Receiving Pole Shipment**. Poles are usually shipped to a facility's pole storage yard using flatbed railway cars, on which they are secured with skids, stakes, slings, and binding. Removal is safe if done properly. The principal objectives are to unload poles so that none are broken, and so that the poles do not roll onto any worker.

10-2.3.1 Skids, rope lines, and slings must preferably be 12.5 to 16 millimeter (1/2-inch or 5/8-inch) wire rope. These must be inspected to ensure they are in satisfactory condition for the operation.

10-2.3.2 All binding wire, stakes, and other fastenings must be inspected for weak or broken areas before unloading.

10-2.3.3 Always preposition lines as necessary to restrain loads when stakes and binding wires are cut.

10-2.3.4 The authorized individual-in-charge must determine that all workers are safely in the clear before permitting binders or stakes to be cut.

10-2.3.5 Binding wires must be cut with long-handled wire cutters. Never cut binders from the top of the load.

10-2.3.6 Only one person must be permitted on top of a loaded car at a time. No one must be allowed on top of a carload of poles to cut wires, or if any wires or braces have been cut or removed.

10-2.4 **Ground Handling**. Once on the ground the poles can be positioned by the use of cant hooks. Special precautions must be taken while using these hooks:

10-2.4.1 Hooks must be kept sharp, and must be protected when not in use.

10-2.4.2 The hook bolt must be inspected periodically for wear. If a worn hook bolt breaks in use, sudden and possibly severe injuries could result.

10-2.4.3 Injuries most often occur when a pole handle breaks or the hook comes out. Be sure the hook is firmly set in the pole.

10-2.4.4 The cant hook is a one-worker tool. It is likely to break if two workers double up. If a job requires two workers, two cant hooks must be used.

10-2.4.5 Before moving the pole, make sure that there are no tripping hazards near the workers.

10-2.4.6 Stand so the pole is rolled away. Pulling the pole allows the pole to roll on a foot or crush a leg.

10-2.4.7 Be particularly careful if the pole is rolled over a hump, since the pole could roll back when the grip and position of the hook is changed.

10-2.4.8 When moving a pole by hand, with a pole cart, or with the truck derrick, warn anyone nearby who could possibly be struck. Station a worker with a red flag to warn or stop traffic, if necessary.

10-2.5 **Long Term Pole Storage**.

10-2.5.1 Poles that are stored for considerable periods must be stacked above the ground on racks. The racks must provide ventilation, and properly block the poles to keep them from shifting or rolling.

10-2.5.2 Never store poles with cross-arms, braces, steps, or hardware attached.

10-2.5.3 Poles must be stored according to size, and to make them as accessible as possible.

10-2.5.4 Maintain an area around stored poles of at least 3 meters (10 feet) free of grass and weeds. Provide sufficient space under poles to permit removal of leaves and debris.

10-2.6 **Temporary Pole Storage**.

10-2.6.1 Poles stored temporarily on or near roadways, before erection or removal, must be placed as close as possible to the curb or edge of roadway as is safe; however; never store poles at points along the road where there are sharp turns. Do not place the poles where they interfere with traffic, driveways, or walkways.

10-2.6.2 Place each pole so that its top points in the direction of traffic. Poles temporarily stored along side highways must not have crossarms attached.

10-2.6.3 When laid on an incline, poles must not be placed where they can interfere with drainage.

10-2.6.4 The authorized individual-in-charge must decide whether danger signs (by day) or red lights (at night) are required.

10-2.7 **Hauling Poles**. Pole hauling must be done in a manner to not endanger workers or the public.

10-2.7.1 After being loaded on a vehicle, poles must be secured in at least two places, and in such a manner to ensure poles will not be released when traveling over rough terrain. Never use a chain smaller than 9.5 millimeters (3/8 inch) diameter.

10-2.7.2 A minimum of at least two workers (a driver and a helper) must be assigned to haul a load of poles. The helper must assist the driver by watching traffic from both the sides and the rear. The helper must also check that there is ample clearance when turning corners, entering highways, or crossing intersections. When necessary, the helper must act as a flagman to warn and direct traffic.

10-2.7.3 Poles extending more than 1.2 meters (4 feet) beyond the back of a truck or trailer will have warning devices attached. Attach a red flag by day and a red light by

night to the rear end of the poles being hauled. The red flag or light must be visible from the sides and rear. Observe all local and state highway regulations when poles are transported over off-base highways.

10-3 **POLE INSTALLATION, REPLACEMENT, AND REMOVAL.** Poles for new aerial lines are often installed by contract workers, however, facility workers might need to install poles to replace storm-damaged, insect-damaged, or decayed poles. Remember that poles and guys must be properly located relative to the local facility property line or utility right-of-way.

10-3.1 **Pole Holes**. If new poles are to be set adjacent to existing poles to be dismantled, new holes must be dug. Power tools are available for digging, such as power borers or augers, and only qualified personnel must use these tools. Rock cutting drills are generally a safer alternative than the use of explosives, where rock is encountered. Many pole holes can be dug by hand if power diggers are unavailable or cannot be used.

10-3.2 **Digging Holes**. Digging a pole hole does not normally involve significant hazards, but can cause many minor injuries. These include eye injuries from flying dirt and rocks, blisters on the hands from the use of hand tools, and foot and leg injuries resulting from falling over tools, particularly shovels that have been left turned up.

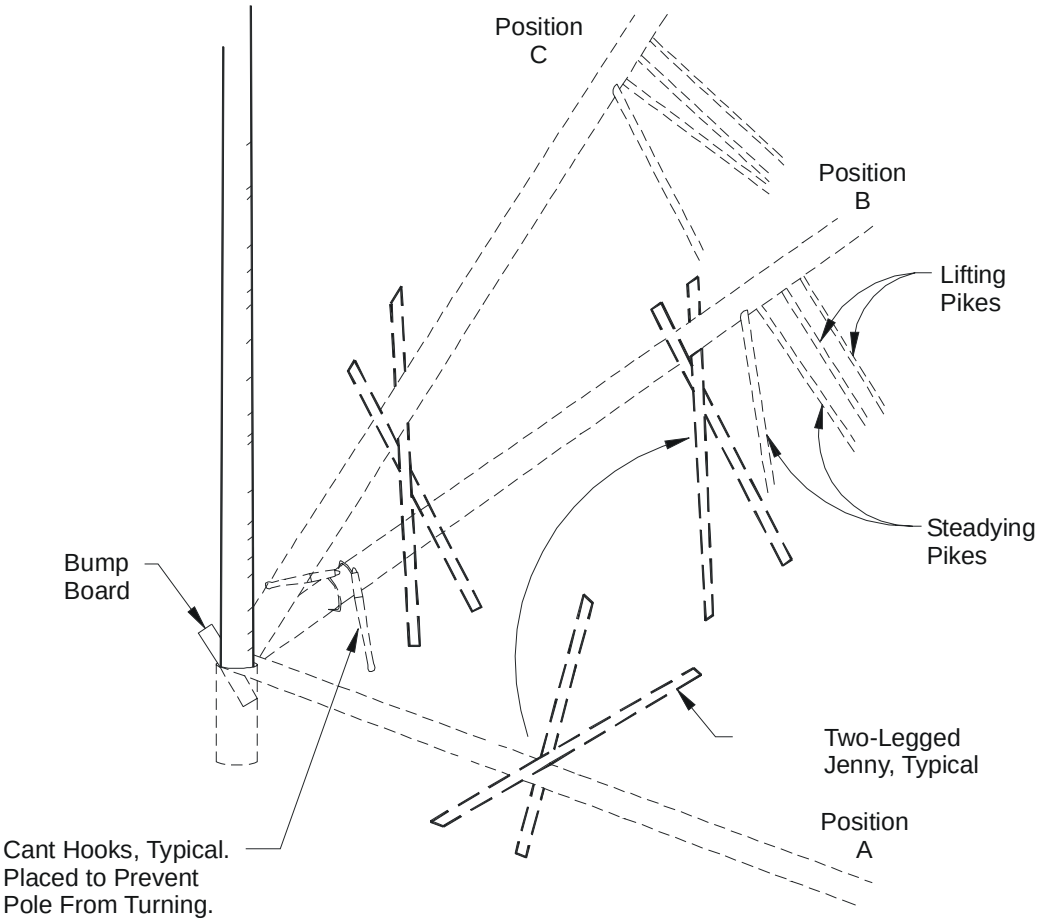
10-3.3 **Covering a Hole**. Cover all open pole holes as soon as they are dug when other related work must continue near the hole, except when the pole is to be immediately set into the hole after digging. Covers must be at least 750 millimeters (30 inches) in diameter, and must be strong enough to support two men. Place four or five shovelfuls of soil on the cover after it is placed over the hole. If necessary, also set up cones to secure the area.

10-3.4 **Hole Casings**. Casings may be required in sandy or swampy soil to prevent the sides of a hole from caving in. Casing covers are required if the pole setting is not done immediately.

10-3.5 **Setting Poles**. Pole setting is a hazardous job even with experienced personnel using the best equipment. The methods authorized for manually setting poles are the pike pole method, the winch line method, and the gin pole method. The use of a line truck is the preferred method whenever possible.

10-3.5.1 **Pike Pole Method**. Figure 10-1 illustrates the pike pole method. This is the earliest method of raising poles and might be used when a truck cannot be brought in. A jenny initially supports the pole, and a cant hook keeps the pole from rolling. The bumpboard protects the wall of the hole from being caved in by the pole butt. Pikers lift the line pole, by punching into the pole the steel spikes of the pike poles. The number of pikers required increases with the pole length as shown in Table 10-1.

Figure 10-1. Pike Pole Method



Position A:

Place jenny near top of pole at approximately right angles to pole. Footing of jenny should be at a point where it will not slip when the pole is lifted and supported by the jenny. Lift pole and jenny to Position B.

Position B:

Place two cant hooks, one to pull against, the other to prevent pole from turning. Place hooks about two feet above the probable ground line. Station a crew member to hold the hooks as the pole is being raised.

Position C:

As pole is being raised by pikers, jenny is moved down the pole until pole weight is supported by jenny (always keep fork of jenny in contact with pole). Repeat operation until pole slides into hole.

Table 10-1. Average Crew Size Required to Raise Poles by Piking

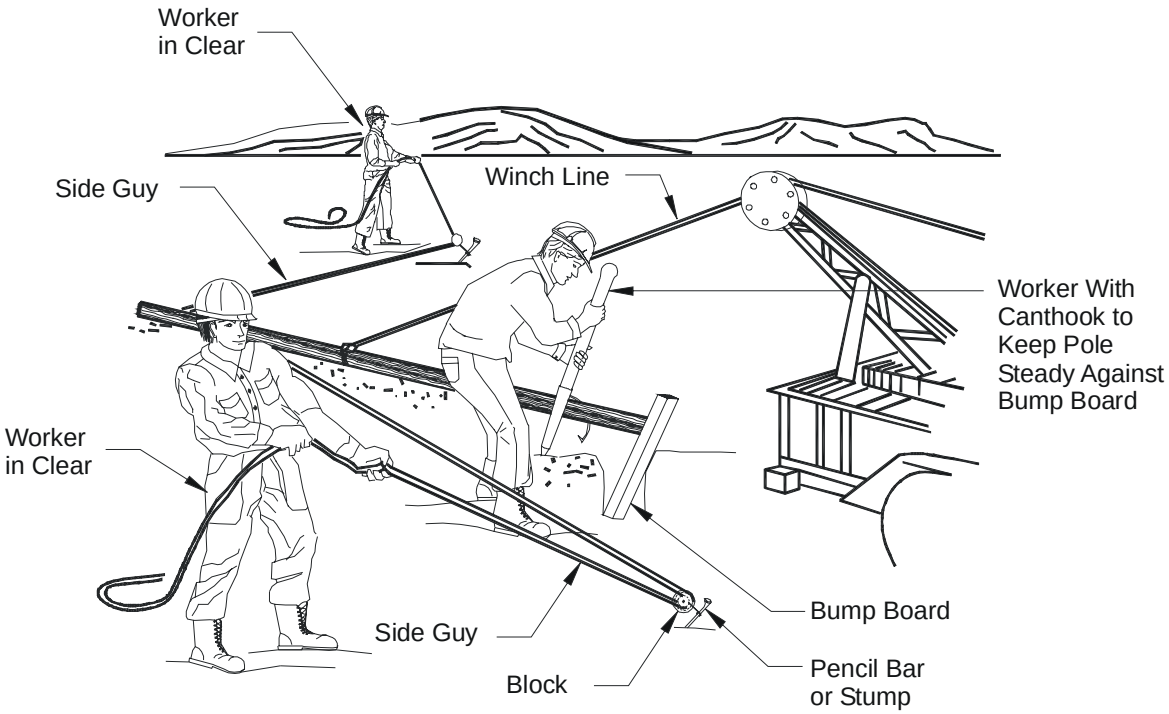
Pole Length		Size of crew	Number of Pikers	Number of Jennymen	Number of Personnel at Butt
Meters	Feet				
7.5	25	5	3	1	1
9	30	6	4	1	1
10.5	35	7	5	1	1
12	40	8	6	1	1
13.5	45	9	7	1	1
15	50	10	8	1	1

10-3.5.1.1 Before setting a pole, the authorized individual-in-charge must ensure there is a clear working space and that all movable obstacles are removed from the area. Personnel must not wear safety harnesses, climbing belts, or climbers when setting poles. Tools or other items must not be substituted for bumpboards. Always use a jenny to support the pole until it is high enough to use pikes. Only experienced workers must use the jenny. The angle of contact between the pole and jenny must be maintained as close to 90 degrees as possible.

10-3.5.1.2 At least three experienced workers must be used in addition to the authorized individual-in-charge. One person must handle the butt of the pole, and a minimum of two side pikers are needed. Inexperienced workers used in this work must be thoroughly instructed on the hazards involved. A two-legged jenny must be used. It is the responsibility of the authorized individual-in-charge to verify that all pole-lifting tools are in acceptable condition prior to the lift.

10-3.5.2 **Winch Line Method**. Figure 10-2 illustrates the winch line method.

Figure 10-2. Winch Line Method



10-3.5.2.1 When erecting poles by truck winch and winch line, ensure all workers are in the clear. Depending on the pole size and class, up to three experienced workers may be needed in addition to the authorized individual-in-charge. For a safe lift, the gins (or maneuverable rigging assembly) must have enough teeth to handle the pole. Pikes must not be used in combination with a winch.

10-3.5.2.2 Side guys used in setting poles or structures must be attached to pencil bars driven into the ground. Tie lines or other guy lines must never be wrapped around any worker's body.

10-3.5.3 **Gin Pole Method**. In setting extra-heavy poles or those of 13.5 meters (45 feet) or longer, it is best to use a tackle block attached to another pole rather than the pike pole method. The other pole is called the gin pole (or maneuverable rigging point), and is either existing or is especially installed for the purpose of raising the new pole. The gin pole must be guyed sufficiently with not less than 16-millimeter (5/8-inch) diameter rope to hold it erect under the strain of the load. When the new pole is raised using power from a vehicle, the temporary guy must be run from a snatch block at the bottom of the gin pole to a substantial anchor. This prevents the gin pole from slipping at the ground line. Otherwise, the gin pole must be set in a hole of depth 0.3 to 0.6 meters (1 to 2 feet).

10-3.6 **Pole Setting Trucks**. Pole setting trucks must be parked, where feasible, so that the boom will never be closer than 3 meters (10 feet) to energized overhead conductors. When the work is to be done around energized conductors and it is impossible to lower the boom sufficiently to be in the clear, the conductors must be

deenergized and grounded before work is begun. When it is not possible to deenergize the conductors, and work must be done with the boom close to energized conductors, all personnel must keep away from the frame of the truck and must not touch the pole. Never touch with bare hands a pole that is being set in an energized line. Instead, an insulated cant hook or dry rope around the butt of the pole may be used to guide it into the hole.

10-3.7 **Setting Poles in Energized Lines**. Only an electrical worker qualified as a Journeyman or Craftsman must be permitted to guide poles through energized conductors.

10-3.7.1 When a pole of any type is being set or removed between or near conductors energized at more than 600 V, the pole, winch cable, and truck frame must be effectively grounded with protective grounds. Lines must be covered with rubber protective equipment to prevent poles from touching energized parts, and workers must use rubber gloves. Attach a protective ground to the frame of all winches. If the pole is to be erected by hand (pikes), the protective ground must be attached to the pole (using an approved grounding band) approximately 4.5 meters (15 feet) from the butt end. Consider installing and using pole guards. In all cases, exercise extreme care to keep the pole from contacting conductors.

10-3.7.2 Wood poles must not be considered as providing adequate insulation from energized lines.

10-3.8 **Backfilling the Hole**. Backfill the hole after the pole has been placed. Use pikes to align the pole while backfilling. Pikes must not be removed until sufficient tamping has been done to prevent the pole from falling.

10-3.9 **Dismantling Poles**. Pole dismantling from a live line is a particularly hazardous operation. Exercise extraordinary care.

10-3.9.1 Each pole must be restrained in at least three different directions by ropes before any work proceeds on the pole. This may be done by the following procedure:

10-3.9.1.1 Make two turns around the pole with a sling and tie securely.

10-3.9.1.2 Tie three lines around the sling at the proper angles.

10-3.9.1.3 Insert pike poles under two sides of the sling well up the pole.

10-3.9.1.4 Snub off securely by pencil bars driven into solid ground or by any other substantial snub.

10-3.9.2 Always check the pole to see if additional support may be necessary because of pole conditions or strains.

10-3.9.2.1 Determine the condition of the pole butt before removing guys or wires, and support the pole with additional pike poles or temporary guys if necessary.

10-3.9.2.2 When an old or reinforced pole is to be dismantled, guy it sufficiently to withstand any altered strain on it. Be sure to include the weight of personnel who are to work on the pole while dismantling.

10-3.9.2.3 When changing the strain on a pole, the authorized individual-in-charge must ensure it is sufficiently guyed to stand the altered strain and prevent the pole from falling. Workers must not climb a pole that is under an abnormal strain.

10-3.9.2.4 A truck equipped with an “A” frame and backed up to the pole can be used to restrain the pole. The top of the “A” frame can be tied by the winch line to the pole. The pole at the groundline level can be securely tied off to the truck.

10-3.10 In locations where poles cannot be lowered with a rope or derrick, a guideline must be attached so that the pole moves in the desired direction.

10-3.11 All members of a crew who are not actively engaged in pole removal must stand well clear in case the pole must fall. Where appropriate, stop all pedestrians and traffic during pole removal.

10-3.12 When a pole is being removed, dismantle the pole before beginning the excavation around the butt.

10-4 **CLIMBING AND WORKING ON POLES.** Workers must be familiar with the general rules for climbing poles and approaching the overhead work area, the differences of climbing wood poles as opposed to steel towers, and the dangers inherent in crossing overhead structures from one side to another.

10-4.1 **General Rules**.

10-4.1.1 Do not work at the base of a structure or a pole while others are working above.

10-4.1.2 Before climbing a pole the worker must first determine:

- What circuits are energized and their voltage, and any unusual conditions which might pose a hazard.
- The types and locations of circuits, and the direction of feeds.
- The best climbing space to avoid all live wires, grounded wires, and signal circuits.

10-4.1.3 Ensure there is an ample supply of rubber protective equipment on hand to completely protect the worker on the pole from all live wires, grounded wires, and signal circuits.

10-4.1.4 Only one worker is permitted to ascend or descend a pole at any one time. Other workers must be in place on the pole or on the ground before the worker ascends or descends the pole.

10-4.1.5 Extraordinary care is required of the workers when it becomes necessary for one worker to work above the other.

10-4.1.6 Before climbing poles, ladders, scaffolds, or other elevated structures; riding span wires, messengers or cables; or entering cable cars, boatswain chairs or similar equipment; each worker must first ensure the structure or device is strong enough to sustain the worker's weight.

10-4.2 **Pole Inspection Before Climbing**. The type of pole to be climbed affects the precautions that the worker must take in regards to climbing equipment and procedures. All types of poles must be safe to climb in terms of being strong enough to bear the weight of the climbers and their tools, and in having adequate climbing space. Before allowing anyone to climb on a pole, the authorized individual-in-charge must ensure the pole is inspected, i.e. hammer tested and pike pole rocking test, and that it can be safely climbed based on the following:

10-4.2.1 Determine age, physical condition, and treatment of the pole.

10-4.2.2 Determine if the configuration of conductors and equipment on the pole will provide adequate climbing space.

10-4.2.3 Determine if the removal of supporting conductors or guys may affect the safety of workers.

10-4.2.4 Determine if the poles to be climbed can be supported in such a way as to safely support workers on the poles. Pikes are not acceptable as a support method while personnel are working on poles.

10-5 POLE CLIMBING EQUIPMENT.

10-5.1 General Rules.

10-5.1.1 Make sure each worker who is authorized to climb has a full set of climbing equipment. Never loan or borrow a set of climbing equipment.

10-5.1.2 Carefully inspect climbing equipment before each day's climbing activities. Examine leather for cuts, cracks, and enlarged buckle tongue holes. Examine metal parts for cracks, wear, or loose attachments. Examine climbers (gaffs) for proper cutting edges, length, and shape.

10-5.1.3 The authorized individual-in-charge, or a designated worker, must inspect all tools, safety devices, and other equipment in use on a weekly basis. Any item that is not considered safe must be condemned, regardless of ownership, and must not be used.

10-5.1.4 Ensure that employees understand that fabricated or purchased fall protection must meet or exceed the requirements outlined in ANSI Z359. Body harnesses, meeting the requirements of ANSI Z359, *Safety Requirements for Personal Fall Arrest Systems, Subsystems, and Components*, with straps or lanyards, must be worn to protect personnel working at elevated locations on bucket trucks, towers, platforms, and other structures. Body harnesses may be worn but are not required on poles (however a body belt and pole strap must be used while on the pole). Inspect body harnesses and straps before use each day to determine they are in safe working condition.

10-5.1.5 Use body harnesses instead body belts for fall protection.

10-5.2 **Wooden Pole Climbing Equipment**. Equipment sets each consist of a body belt (or body harness), a pole strap, and climbers (an assembly of gaffs, leg straps, and pads). The Edison Electric Institute provides an excellent document entitled “Use and Care of Pole Climbing Equipment” which is appropriate for use in training for pole climbing certification.

10-5.2.1 Climbers must meet the following requirements:

- Leg iron (shank) to be made of spring steel.
- Gaff (spur) to be forged from tool steel.
- Leg iron length must be in the range from 380 to 460 millimeters (15 to 18 inches) from the instep to end of the shank.
- Two leather straps must be provided, each at least 26 millimeters (1-1/4 inches) wide and 560 millimeters (22 inches) long.
- Pads must adequately protect the calves.

10-5.2.2 Climbers, pole straps, and other leather items that have any of the following defects must not be used until repaired:

- Cracked, dry, or rotten leather.
- Leather which is worn thin.
- Cuts or worn places which are of sufficient depth to weaken the leather.
- Broken stitches or loose rivets at buckles, D-rings, or snaps.

- Snaps which have weak springs behind the tongue or loose rivets which hold the tongue.
- Loose tongues in buckles.
- Buckles, D-rings, or snaps that show considerable wear or which have been cracked or bent.

10-5.2.3 Leather equipment in regular use must be cleaned and dressed at least every three months, and more frequently when the equipment is wet from rain or perspiration, or is soiled with dirt or mud. Leather equipment not in regular use must be cleaned and dressed at least every six months.

10-5.2.3.1 Wipe off all surface dirt and mud with a sponge dampened (not wet) with water. Never use gasoline or other cleaning fluids, as they tend to dry out and harden the leather.

10-5.2.3.2 Wash leather with a clean sponge in clear lukewarm water and a neutral soap (free from alkali), preferably Castile soap. Thoroughly wash the entire length of the leather and work the lather well into all parts. Place in a cool area to dry.

10-5.2.3.3 Leather must be dressed with oil after each cleaning. Use a small quantity (about 20 milliliters (4 teaspoons)) of pure neatsfoot oil per set of equipment and apply it gradually with the hands, using long light strokes while the leather is still damp from washing. Leave in a cool place to dry for about 24 hours, and then rub the leather vigorously with a soft cloth to remove all excess oil.

10-5.2.3.4 When safety harnesses/belts and straps are not in use, they must be stored in designated compartments on the service truck or other suitable location to protect them from damage. When stored, climbers must be wrapped in pairs and fastened with their straps.

10-5.2.4 Keep climbers, straps, and pads in good conditions at all times. Inspect climbers before each use to detect nicked or dulled cutting edges on the gaff. Check them as soon as possible after striking them against hard objects such as pole hardware or nails. The worker must inspect climbers in regular use at least weekly. If any of the following conditions are found, repair or replace the climbers before using:

- Loose gaff.
- Nicks and depressions in the gaff.
- Ridge of gaff not in alignment.
- Dull gaffs.

- Broken or distorted gaff points.
- Broken, loose leg or foot strap loop.
- Excessively worn, cracked, or torn straps and pads.
- Enlarged buckle holes in the straps.
- Broken or damaged strap buckles.
- Fractured or cracked leg irons and stirrups.
- Excessively worn stirrups.
- Fractured leg iron sleeves.
- Broken or loose rivets or screws on sleeves and straps.
- Defective strap rings.
- Broken or damaged loop clip-on straps.
- Gaff guards not in good condition.
- Improper length of gaffs.

10-5.2.5 Gaffs must be at least 26 millimeters (1-1/4 inches) long, measured from the point of the gaff to the point of contact with the stirrup on the under side.

10-5.2.6 Sharpen climbers using a gaff-shaping bit as follows:

10-5.2.6.1 Place the climber between wood in a vise with the leg iron horizontal and the gaff on the topside.

10-5.2.6.2 Use a smooth cut file and finish with a sharpening stone. Never grind with an emery wheel, as this takes the temper out of the metal.

10-5.2.6.3 The outer ridge of the gaff must never be filed. To obtain the proper width, a file may be used on the rounded portion. Apply strokes that follow the contour of the gaff.

10-5.2.6.4 To sharpen the gaff to proper thickness, file the metal from the flat inner side of the gaff. Care must be taken to prevent notching the leg irons or stirrup. Use forward motions toward the point and down to edges of the underside of the gaff. Do not allow rocking motions of the file because this can round the edges of the gaff. After the proper thickness has been reached, the underside of the gaff must be straight to within 1.5 millimeters (one-sixteenth inch) of the point, then rounded slightly toward the ridge

of the gaff on a radius of 6 millimeters (one-fourth inch). Additional sharpness may be obtained following filing by dressing the underside and rounded portion of the tip with the honing stone. Burrs along the edges must also be removed with the stone.

10-5.2.6.5 Never use a climber with a gaff shorter than 26 millimeters (1-1/4 inches), as measured on the flat side.

10-5.2.7 Restore damaged or dull gaffs to original shape (see Figure 10-3) by filing and honing (see Figure 10-4). If gaffs cannot be restored, replace them.

Figure 10-3. Comparison of Correct and Incorrect Gaff Shapes

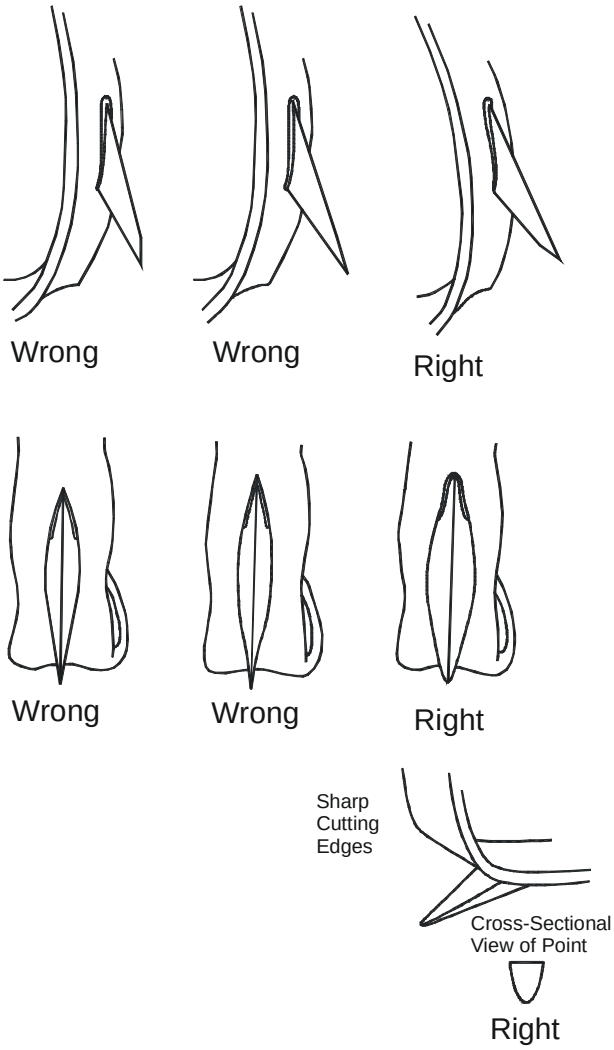
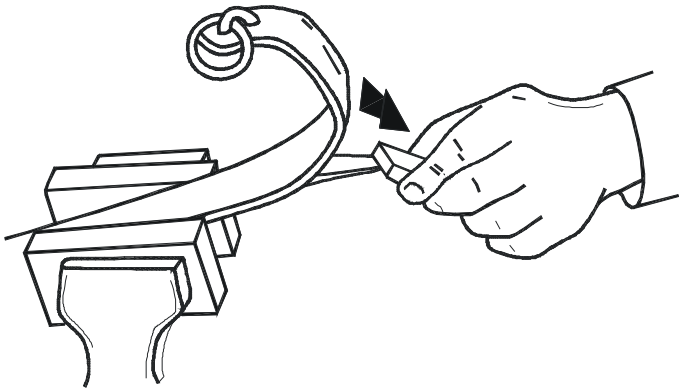


Figure 10-4. Honing a Gaff

Hone Lengthwise - Not Crosswise



10-5.2.8 Three methods are normally used to determine if gaffs are properly sharpened.

10-5.2.8.1 **Gaging Method**. The gaging method is used to determine the length, width, and thickness of the gaff and profile of the point. Reference lines are scored on the gage with slots provided to determine if the gaff length is satisfactory. Most gages also provide a contour test to determine if the point is properly curved. Openings are provided for determining if the point is too keen. Each manufacturer makes a gaff gage to be used with their own climbers. Thus, gaff gages are not usually interchangeable. Manufacturer's instructions must always be used if available. The "thickness" slot in the gage is used to measure the thickness of the gaff at 12.5 millimeters (1/2-inch) from the point. These measurements are made with the outer ridge of the gaff resting flat against the part of the gage containing the scored lines. If the point of the gaff extends beyond the farthest line, the gaff is too thin. If it does not reach the nearest line, then it is too thick. The "width" slot on the gage is used to measure the width 12.5 to 25 millimeters (1/2 to 1 inches) from the point. The same methods and reference line are used in measuring for thickness. A minimum length reference line is provided, intersecting the thickness measurements, to determine if the gaff meets minimum lengths.

10-5.2.8.2 **Plane Test Method**. The plane test method may be used with the gage, or independently if the gaffs are sharpened by machine process. The test is made by using a soft board to determine if proper sharpness has been reached. Place the climber with the gaff side down and parallel to the board without applying downward pressure above the gaff. Push the climber along the board. If the gaff is properly contoured and sharpened, it can dig into the wood and hold within approximately 25 millimeters (1 inch). If the climber continues to glide along the board for more than 25 millimeters (1 inch), additional honing is required. After the "plane test" has been made, it can be supplemented by applying a cutout test. Jab the gaff into the board at about a 30-degree angle for approximately 6 millimeters (one-fourth inch). Bring the leg iron down against the wood while applying forward pressure--one hand holds the leg iron

and the other holds the stirrup. If the gaff cuts out within 75 millimeters (3 inches), it is improperly sharpened.

10-5.2.8.3 **Pole Cutout Method**. The pole cutout method is used after climbers have been machine sharpened or gauged (and as often as required thereafter).

10-5.2.9 To protect the gaffs, use gaff guards when climbers are not being used. They must also be used when other tools and materials are stored or transported along with the climbers.

Note: Climbers must never be stored or transported without appropriate gaff guards.

10-5.2.10 Do not wear climbers when:

- Working on the ground.
- Traveling to and from a job.
- Piking poles
- Walking through underbrush or rough terrain
- Riding in motor vehicles.

10-5.3 **Concrete and Steel Pole Climbing**.

10-5.3.1 OSHA standards (29 CFR 1910 and 1926) require fall protection for certain working heights. Acceptable fall protection includes the use of standard railings and toeboards, floor opening covers, or a personal fall arrest system. A body belt is no longer acceptable as part of a personal fall arrest system.

10-5.3.1.1 Fall protection is required for operations and maintenance activities when personnel are required to work at a height of 1.2 meters (4 feet) or more above ground or the next lower level. For construction activities workers must be protected from falls when working at a height of 1.8 meters (6 feet) or more. An approved positioning device that limits a fall to less than 0.6 meters (2 feet) must be used when a worker needs to be supported on an elevated vertical surface such as a wall or utility pole, and work with both hands free while leaning.

10-5.3.1.2 A proper anchor point must be identified and evaluated by qualified personnel before an appropriate system can be selected. OSHA regulations accept pad eyes, bolt holes, and other sturdy structures capable of supporting 2,200 kilograms (5,000 pounds) per attached worker.

10-5.3.1.3 Positive systems have an anchor point independent of the support method, a harness to hold the worker, and a connecting device between the anchor point and the harness.

10-5.3.1.4 Harnesses must only be used for the personal protective purpose for which they are designed. In addition to fall-arrest harnesses, there are fall-arrest/positioning, fall-arrest/suspension, fall-arrest/retrieval, and retrieval/positioning harnesses.

10-5.3.1.5 Manufacturer's instructions in regard to height and weight must be followed for sizing of the harnesses and their connecting devices, and for inspection and maintenance of the complete systems. All equipment must be taken out of service and inspected for damage after being subjected to a fall impact.

10-5.3.2 Workers authorized to climb must have a complete set of approved tools. The number of tools carried in tool belts must be kept to a minimum. Tools must not be carried in safety harnesses.

10-6 **POLE CLIMBING AND WORK PRECAUTIONS.** Only after a determination of the pole's safety, the collection of necessary climbing equipment and work tools, and obtaining assurance that the line is deenergized and grounded, or that hot-line work is authorized to be carried out, can the worker start climbing. Protect hands and arms by wearing gloves and long sleeve shirts.

10-6.1 **General Pole Climbing Precautions**.

10-6.1.1 Arrange tools and equipment to allow both hands to be free for climbing.

10-6.1.2 Do not stand on mailboxes, signs, fire alarm boxes, or similar equipment that may be attached to the pole or located near it.

10-6.1.3 Do not race up and coast down poles.

10-6.1.4 Do not use safety straps while climbing, except when climbing over slippery or ice-coated crossarms or timbers. Whenever the hands are apt to slip off, a safety strap must be used. The use of rope safeties is prohibited.

10-6.1.5 Remove all signs from a pole before any worker climbs or does any work above them on a pole. It is not desirable to have signs on poles, but some signs, such as street signs, may be necessary. If street signs are removed, they must be replaced as soon as possible after work is completed.

10-6.1.6 Climb on the high side of a raked or leaning pole, if possible, but do not climb on the side where the ground wire is attached. Avoid grasping pins, brackets, crossarms, braces, or other attachments that might pull lose and cause a fall.

10-6.1.7 Never slide down any type of pole or any guy wire. If it is impossible to use climbers for ascending and descending such places, ladders or other means must be used.

10-6.1.8 Do not ride overhead guys or cables. (This is not intended to apply to cables installed for river crossings or otherwise designed to support workers in suitable conveyances.)

10-6.1.9 If more than one worker needs to work on the pole at the same time, the first worker must reach working position before the next worker leaves the ground. Ordinarily, no worker must work directly under another worker on the same pole. When this is necessary, take extreme care to prevent tools or other objects from being dropped on the worker below.

10-6.1.10 Minimize the number of tools carried in tool belts. Keep all other tools on the ground until they are required. Needed tools must be raised and lowered by means of a canvas bucket attached to a handline.

10-6.1.11 When carrying a handline up a pole, leave the handline uncoiled with one end attached to the rear of the body belt or harness. When climbing with a handline, take care to prevent the handline from fouling on any pole attachments.

10-6.2 **Wooden Pole Climbing Precautions**.

10-6.2.1 Seat gaffs securely. Be especially vigilant when the pole is ice or sleet covered.

10-6.2.2 Use pole steps whenever they are available, but only after checking that they can be used safely.

10-6.2.3 Use climbers carefully on the pole to avoid injury to another worker on the pole.

10-6.2.4 Be careful to avoid weather cracks, checks, knots, shakes, rots, and hard places, which might cause gaffs to cut out. Remove any tacks or nails which may impede safe climbing.

10-6.3 **Concrete and Steel Pole and Tower Climbing Precautions**.

10-6.3.1 Always make sure that gloves and shoe soles are in good condition and free from grease or other lubricants. Many falls are caused by slick work gloves or slick shoes. Rough cord sole shoe or boots are recommended. Be particularly careful in wet or icy weather conditions.

10-6.3.2 Carefully wear and regularly inspect the safety harness since steel and concrete surfaces can easily damage or cut the harness.

10-6.4 **Working on Poles**. Never change the amount of strain on a pole by adding or removing wires until you are sure that the pole can stand the altered strain. If in doubt, consult your authorized individual in charge.

10-6.5 **Safety Straps**. Wear safety straps at all times when handling wires or apparatus while on a pole or structure. The following precautions must be taken:

10-6.5.1 Be careful in attaching snaps to D-rings. Visually ensure that the snap keeper is fully closed in the correct ring before any weight is applied to the safety strap.

10-6.5.2 Always be sure that safety straps are connected and not twisted while in use.

10-6.5.3 Never depend on a crossarm or crossarm pins and braces for support.

10-6.5.4 Never attach safety straps above the crossarm in the top gain or around insulator pins, crossarm braces, transformer hangers, pole steps, or guy wires. If there is no crossarm in the top gain, the strap must not be placed closer than 0.6 meters (2 feet) to the top of the pole. In this case take precautions to assure that the strap does not slip off. Ideally the strap must be below the top pole attachment, except where that attachment is above eye level.

10-6.5.5 Never fasten both safety harness snaps in the same D-ring in order to reach out farther on the pole. An extension safety strap must be used or the safety harness let out so that work can be performed with the safety harness snaps fastened one in each D-ring.

10-6.5.6 Do not attach metal hooks or other metal devices to body harnesses. Metal chains and keepers must not be used. Instead, use leather straps or rawhide thongs with hard wood or fiber keepers. Care must be taken to prevent the snaps on the safety harnesses/belts from coming in contact with anything that may open a snap. The tongue of the snap on the safety harness/belt must face away from the body.

10-6.6 **Hoisting or Lowering Materials**. Take the following precautions when hoisting or lowering materials:

10-6.6.1 Drop material that cannot be lowered safely only if there is no danger to workers or the public.

10-6.6.2 Position workers engaged in hoisting tools and materials so that they can not be injured by a falling item.

10-6.6.3 Do not leave materials and tools overhead in an insecure position. Large objects must be securely lashed.

10-7 **CROSSING STRUCTURES**.

10-7.1 To get from one side of a double-pole supported structure to the other, the worker must descend to the ground and go up the other pole unless there are adequate handholds and adequate clearances from live parts to allow safe crossing along the structure.

10-7.2 When it is necessary to climb half-way across a crossarm to inspect middle phase insulators, the worker may climb the rest of the way across, provided that, a safety harness/belt can be kept strapped around a timber as a safeguard.

10-7.3 Never cross through an open-air switch unless both sides are deenergized.

10-7.4 Do not use air switch arcing horns for support in walking timbers since these horns break easily and a fall could result.

10-7.5 Never walk along an H-frame cross-arm with the line energized.

10-8 **STRINGING OR REMOVING DEENERGIZED CONDUCTORS AND OVERHEAD GROUND WIRES**.

10-8.1 **Pre-Work Meeting**. Discuss the plan of operation, type of equipment to be used, adjacent energized lines, necessary grounding devices and procedures, crossover methods, and Safe Clearance requirements before stringing or removing deenergized conductors or overhead ground wires.

10-8.2 **Work Adjacent to Energized Lines**.

10-8.2.1 The worker attending the payout reel must wear rubber gloves when pulling wire over or near energized conductors, and be positioned on an insulated stand of a size equivalent to or larger than a standard rubber blanket.

10-8.2.2 Ground the payout reel. The authorized individual-in-charge must approve any deviation in grounding the payout reels.

10-8.2.3 A bull line, which must be of dry polypropylene rope not smaller than 13 millimeters (1/2-inch) diameter, must be placed in position to pull the wire before attempting to string it. The bull line must be of sufficient length to reach the distance the wire is to be pulled. Fasten the wire to the end of the bull line and pull it into position.

10-8.2.4 A vehicle used to pull the wire must be positioned so that the driver can see the signals of the reel operator. Both in pulling in the wire and in sagging it, the pulling must be slow and steady to prevent swinging the wires into the energized conductors. The wire must be watched carefully to prevent its hanging up on tree limbs, weeds, and other obstructions.

10-8.2.5 Do not touch any conductors or wires on the ground without rubber gloves.

10-8.2.6 Wear rubber gloves and use other protective devices, as appropriate when wires are strung and sagged over, under, or across conductors carrying a voltage of 5,000 V or less. Positively and constantly ground conductors carrying more than 5,000 V during the stringing operation. Ground the wire with standard grounding devices as soon as it is ready to be dead-ended.

10-8.2.7 Discontinue operations and seek appropriate shelter when notified that a lightning warning is in effect. Electrical charges can appear on the line from a lightning strike or from induced static charges from a very dry atmosphere. Be in contact with the Base Weather Service and cease outside activities when notified of a lightning warning. Waiting for an indication of lightning can expose a work crew to adverse weather conditions.

10-8.2.8 Keep wires being strung along or across streets or highways higher than any expected car or truck traffic. Traffic must be blocked when this line elevation is not possible.

10-8.3 **Grounding**. Requirements for grounding of deenergized lines are covered in Chapter 7. Other grounding requirements are as follows:

10-8.3.1 Permanent ground wires are installed to protect workers. All permanent grounds must be installed in accordance with the requirements of the NEC or the NESC, as applicable. If the permanent grounds are not installed, the metallic case, covering, or mounting support of any energized piece of electrical equipment must be treated as if it is energized at full voltage.

10-8.3.2 Install ground wires clear of all metallic line equipment (except that which is normally grounded), hardware, and street lighting fixtures.

10-8.3.3 Install ground wires on distribution wood poles with protective molding for the entire working length of the pole to protect them from damage. The entire working length of the pole is the distance from the point where ground wire terminates near the top of the pole to 1.5 meters (5 feet) below the lowest crossarm or bracket, and from the ground line to 2.5 meters (8 feet) above the ground line.

10-8.3.4 Never cut an overhead ground wire or neutral wires without the specific approval of the authorized individual-in-charge. Always avoid opening a joint in such a wire without first bridging the joint with wire of equal or larger size.

10-8.4 **Handling and Stringing**. ANSI/IEEE 524 provide general recommendations on the methods, equipment, and tools used for the stringing of overhead line conductors and ground wires. Safety precautions include:

10-8.4.1 **Reels**. Use adequate braking to stop all payout reels. Do not touch or attempt to hand stop a revolving reel.

10-8.4.2 **Conductors**. Securely fasten the inside end of the coil wire to the reel to prevent the wire from getting loose when the wire has been extended out. If the inside end of the coil cannot be secured, a tail rope must be fastened securely to the wire before the end is reached to prevent its getting loose.

10-8.4.3 **Grounding**. Bond and ground all stringing equipment, such as reel stands, trailers, pullers, or tensioners.

10-8.5 **Primary Line Installation**. String the lines to clear the ground by an amount not less than that specified in the NESC. These minimums depend upon whether the line is above a street (consider its traffic classification), above a pedestrian way, or over or near other structures. Wire and guys that are being strung must be kept clear of any possible interference with public traffic of any type. Where it is necessary to block traffic temporarily while wires and guys are being installed, one or more members of the crew must be assigned to direct traffic.

10-8.5.1 **Stringing Wire**. Stringing by facility personnel must normally be done by the tension method, since this keeps the conductor clear of energized conductors and clear of obstacles that might cause surface damage to the wire. Slack stringing may be appropriate for new short line extensions. Sag the lines to meet the requirements of the NESC.

10-8.5.1.1 Take care not to put kinks into any part of the line when stringing wires. Kinks reduce the strength of the wire and may result in fallen wires later.

10-8.5.1.2 Before changing the strains on a pole by adding wires, an engineering evaluation must be completed to ensure that the pole can safely stand the new strain.

10-8.5.2 **Clipping-In or Tying Wires**. This involves the transferring of sagged conductors from their stringing travelers to their permanent insulator positions where they may either be clamped or tied to insulators.

10-8.5.2.1 Securely tie wires at each tie-in-type insulator to prevent the wires becoming loose and falling to the ground. Where double arms are provided, line wires must be well tied-in to insulators on each arm. This applies to both pin- and post-type tie-top insulator work. Clamp-type insulators must have the clamps tightened as specified by the manufacturer.

10-8.5.2.2 Test the phase wires with a potential transformer or other means, to make sure that the phase wires of one circuit are being connected to the corresponding phase wires of the other circuit when it is necessary to connect circuits at any point on the line.

10-8.5.2.3 Be sure that the phase wires are not crossed when turning the vertical angle on three-phase lines; that is, phase wires must take the same position leaving an angle as coming into it.

10-8.6 **Secondary Line Installation**. Install secondary lines to meet line clearance requirements of the NESC. Lines can be single or triplex wires. Workers must be particularly careful in stringing secondary services to avoid the hazards of working in close proximity to primary lines.

10-8.6.1 Deenergize and ground nearby or adjacent energized lines before stringing secondary wires. As an exception, service wires can be installed near overhead energized lines provided the following operations are carried out in the following order:

connect service wires to the building; attach a handline to the other end of each wire and carefully raise the wire to its position on the pole; and then attach service wires to the bracket or crossarm. Wear rubber gloves while these operations are being performed, and use insulation to prevent shock from unintentional contact between the service wires and the primary lines. Do not attempt to install meters or other secondary connections on the ground while these operations are being performed.

10-8.6.2 Take care not to injure the weatherproof covering when handling and stringing of weatherproof-covered wires.

10-8.7 **Removing Lines**. Use the same general precautions as stringing wires when removing or salvaging wires. Where practical, the wire to be removed must be pulled out and laid flat on the ground before any attempt is made to coil the wire by hand or on a non-power-driven reel.

10-8.7.1 Never change the strains on a pole by removing wires until certain that the pole can safely stand the altered strain. Where a pole will be weakened by the removal of the wires, it must be guyed before these wires are removed. All wires must be lowered with a handline. Use care before cutting a wire aloft to avoid contact with other wires.

10-8.7.2 Do not allow lines which are being cut or rearranged to sag on, or be blown against other electric power lines, signal lines, signal equipment, metal sheaths of cables, metal pipes, ground wires, metal fixtures on poles, guy wires, or span wires.

10-8.7.3 Do not allow wires which have been cut, or which are being arranged, to fall near or on a roadway where they might endanger traffic. Notify all persons working on lower levels of poles and all personnel on the ground well in advance of the cutting so that they may stand clear.

10-8.8 **Guying**. No installation or removal of guys must ever be attempted without engineering guidance.

10-8.8.1 **Installation**. Install guys to meet the following requirements:

10-8.8.1.1 When insulators are used they must be connected into the guy wire line before the guy wire is set in place. In new work, guys must generally be installed before line wires are strung. In reconstruction work, guys must be installed before any changes are made in the line wires and care must be taken not to place excessive pull on the pole and wires already in position.

10-8.8.1.2 Install guys so that there is minimal interference with the climbing space, and to clear all energized wires.

10-8.8.1.3 Provide guy strain insulators to obtain necessary insulation when required by building or safety codes.

10-8.8.1.4 Install guys to the correct tension. Where necessary, a guy hook may be used to prevent the guy from slipping down the pole. Locate these hooks so they do not interfere with climbing, and place them so they are not convenient for use as a step. Where guys are liable to cut into the surface of a pole, the pole must be protected by a guy plate at the point where the guy is attached. The plate must be well secured to the pole to prevent the possibility of injury to a worker climbing up or down the pole.

10-8.8.1.5 Install guys so that they do not interfere with street or highway traffic. Equip guys located near streets, or highways, with traffic guards. Traffic guards are sometimes called “anchor shields”. Guy guards (traffic shields or anchor shields) must be yellow.

10-8.8.1.6 Install guy wires so that they do not rub against messenger or signal cables.

10-8.8.1.7 Do not use guy wire containing snarls or kinks for line work. Use guy wires of the correct length to avoid splices.

10-8.8.2 **Removal of Guys**. Determine the condition of the pole before removing guys. Brace the pole securely if it is weak before any changes in pole strains are made.

10-8.8.2.1 Brace the pole temporarily if the removal of guys from a pole can change the strain and present a dangerous condition.

10-8.8.2.2 Where it is not possible to install side guys, poles may need to be braced to be self-supporting. Install pole bracing so that it does not interfere with climbing or with street or highway traffic. Pole braced guys must not be used on poles which must be climbed.

10-8.9 **Insulators**. Pick up insulators by their tops to avoid cutting gloves or hands on the insulator petticoats. Do not screw down insulators too tightly because their tops might break off, cutting gloves or hands.

10-9 **ENERGIZED LINE WORK.** General energized line work requirements are discussed in Chapter 8. This paragraph amplifies those requirements for work unique to aerial lines. The inherent variability in local conditions makes it difficult to devise specific rules applicable to all situations. The authorized individual-in-charge must consider implementing additional work requirements applicable to the particular job.

10-9.1 Overhead lines must be worked deenergized whenever this can be done. However, live-line maintenance, carefully done by industry-approved standards, has proven to be an effective method for work on electric power circuits. Recognize that energized line work demands maximum attention to safety rules by all personnel.

10-9.2 The authorized individual-in-charge must supervise the workers closely, and advise them as appropriate.

10-9.3 A careful check must be made to determine the condition of the structure and lines at the point of the work so that the job may be performed safely. In addition, the adjacent spans and structures must be carefully checked for defects in conductors, tie wires, insulators, and other equipment.

10-9.4 Maintain safe working distance from all energized wires at all times. In congested locations where this is impossible, first obtain a Safe Clearance.

10-9.5 Use gloving or live-line tools to work on energized lines carrying more than 600 V between conductors. The safety of the work depends on the integrity of the tools and protective rubber equipment. Continual inspection, maintenance of in-service equipment, and completion of required testing are critical for maintaining worker safety.

10-9.6 Obtain close cooperation from every worker on the job.

10-9.7 Avoid unnecessary conversation that could distract attention and create a hazard.

10-9.8 Do not be permit haste inconsistent with safety.

10-9.9 Do not perform live-line maintenance work at night or in wet weather.

10-9.10 Do not depend on another worker to hold a live conductor clear.

10-9.11 Use wire tongs, blocks, and clamps or boom mounted auxiliary arms when moving heavy conductors so that these lines can be moved slowly and carefully.

10-9.12 Do not perform other work of any nature on the same pole or structure while live-line work is in progress.

10-9.13 For circuits on wood poles or attached to wooden structures, all wood members must be considered to be at ground potential.

10-9.14 Place all protective devices and do all work from a position below live conductors or apparatus whenever possible.

10-9.15 Climb down below energized unprotected conductors and apparatus to a position below live conductors and apparatus when it is necessary to change position on a pole, and then climb up to the new position. If two workers are on the pole, no work may be done on energized conductors until the worker changing position has reached the new location.

10-9.16 Carry a handline up the pole and securely fasten it before work is started when the handling of energized lines and equipment is being done on a pole or structure.

10-9.17 When the minimum working distance is approached because the nature of the work requires close access calibrated insulated measuring sticks or equivalent can be used to verify the distance. Telescoping fiberglass measuring sticks, alternately yellow and red striped are recommended for monitoring minimum distances. It is also recommended to mark live-line sticks to identify the minimum phase-to-ground safe working distance for the circuit being worked. Equivalently, each live-line stick must be equipped with a flexible rubber hand guard to indicate where a worker can safely hold the stick.

10-9.18 Personnel performing structure-type live-line maintenance must not carry hand tools in their belts, particularly when working from ladders. Hand tools must be raised to a worker on a structure in a canvas tool bag. Hand tools must be returned to their canvas tool bags after each use.

10-9.19 Use tested fiberglass-reinforced plastic (FRP) hotsticks, if possible. Wooden hotsticks must be replaced by FRP hotsticks.

10-9.20 Use only hook ladders made of FRP in live-line maintenance. FRP hook ladders must be equipped with nonconductive safety ropes along both outside rails. Personnel on a ladder must keep their safety straps wrapped around the ladder except when mounting or discounting, and must have the ladder snap on their safety strap snapped to a rung of the ladder when they are in a working position and when the ladder is being moved.

10-9.21 Link stick lines must be handled as follows:

10-9.21.1 Take hold of the link stick rope and pull the link stick in before grasping the stick when removing link stick (fuzz lines) from energized conductors.

10-9.21.2 Cut the tie wires off short or roll them up in a ball so they will not contact pins, crossarms, poles, ground wires, or any other conductor when untying conductors.

10-9.21.3 One worker at a time must work and the other must steady the conductor with a tie stick when untying or tying conductors on pin type insulators. The authorized individual-in-charge must check the condition of tie wires and pins on poles adjacent to the one being worked on to make sure they are safe. Before moving the conductor, the authorized individual must verify that adequate clearance exists between the conductor and any object or wires crossing under the line in adjacent spans.

10-9.21.4 Tie off link stick lines to a suitable anchorage on all regular live-line setups. Do not tie them to a vehicle unless the motor is stopped, the ignition key removed, and the brakes set.

10-9.21.5 If the work to be done is on an angle, the authorized individual in charge must arrange to take care of strains by providing sufficient tackle. In addition to anchoring the link stick lines, blocks must be used on the ends of the link stick ropes so the conductor can be moved slowly and carefully.

10-9.21.6 Do not allow rope to lie across energized conductors.

10-9.22 Do not permit live-line, bare-hand work.

10-9.23 Require minimum water resistance, stay outside the minimum working distance, and use the minimum nozzle pressure when washing energized insulators. Consider using the minimum requirements of the local utility company. See IEEE/ANSI 957 on cleaning energized insulators. Minimum values are given in IEEE/ANSI 957, but these are only guides because of the great variety in conditions, practices, contamination possibilities, and electrical system designs in use.

10-10 STREET LIGHTING.

10-10.1 **Voltage Level**. Street lighting circuits might be either low-voltage multiple circuits or medium-voltage series circuits. It is important that the type of circuit be identified and de-energized before starting work because of the different voltage levels involved. Workers must wear rubber gloves, hard hats, face shields, and other personal protective equipment as required by this safety manual0 when working on street lighting circuits.

10-10.2 **Clearance Requirements**. Street lighting lines, fixtures, and wires must be considered energized, which requires wearing personnel protective equipment, unless a Safe Clearance permit is obtained and the line grounded. The voltage of street lighting circuit must be treated as that of the highest voltage occupying any of the poles on which the street lighting circuit is run.

10-10.3 **Multiple Street Lighting Circuits**. Multiple street lighting circuits must be treated with the same precautions as the circuits to which they are connected, unless the circuit is located on a structure with a higher voltage wire, in which case it must be considered to be at the higher voltage level.

10-10.4 **Series Street Lighting Circuits**. Before a series street lighting circuit is opened and work is performed, the following procedures must be followed:

10-10.4.1 Disconnect the circuit from the source of supply by opening disconnecting switches or other cutouts in accordance with a Safe Clearance permit and lockout-tagout equipment. Do not depend on time switches or other automatic devices.

10-10.4.2 Jumper the circuit to avoid an open-circuit condition.

10-10.4.3 In replacing street light bulbs and lamp globes in street lighting brackets, there is danger of an arc developing and causing serious damage and injury if the spring clips in the receptacle do not make contact. These springs might have been heated to the extent that they have lost their temper, or for some other reason do not close the circuit when the lamp socket is pulled out. Use approved changers with at least 1.8-meter (6-foot) handles for replacing lamps on series street lighting circuits.

Workers must wear rubber gloves and face shields when removing or installing lamps where lamp changers cannot be used.

10-10.5 **Climbing Space**. Maintain safe access by hanging street lighting fixtures clear of the climbing space. All bolts, lag screws, and other hardware used in securing the fixtures must be cut, filed, or coated to eliminated sharp or protruding edges or points.

10-10.6 **Time Switches**. When winding time switches and working on automatic time switches, workers must not trip the switch "on" without first pulling the transformer disconnects or first making sure that street lighting circuits can not be energized. On time clocks with medium-voltage connections, workers must always wear rubber gloves in winding, resetting, or otherwise maintaining the clock.

10-11 **WORKING ON OR AROUND POLE-MOUNTED EQUIPMENT.** This paragraph provides precautions applicable to equipment that is mounted above grade. Be aware that some local and state safety regulations do not permit grounding of enclosure cases on wood poles when there is a possibility that an accidental contact with bare aerial lines could occur. The equipment on the facility might have been installed in accordance with these regulations. Transformers connected to an energized circuit must be considered as being energized at the full primary voltage unless positive verification is made that they are adequately grounded.

10-11.1 **Surge Arresters**. Check that the permanent ground connection is intact before any work is done. Do not climb on or strap off to surge arresters. Wear eye protection when connecting, disconnecting, or discharging surge arresters.

10-11.2 **Switches and Fuses**. The maintenance of switches and fuses might require temporary line modifications to permit repairs while maintaining service continuity. Engineering guidance must likely be required in preparing a step-by-step modification procedure. Both sides of fuses must be deenergized in order for repair work to proceed.

10-11.3 **Capacitors**. Chapter 9 discusses discharging capacitors. Individual capacitor banks must be grounded if insulated capacitor mounting racks are not used. Provide grounding in accordance with the manufacturer's instructions.

10-11.4 **Power Transformers and Voltage Regulators**.

10-11.4.1 Work on energized pole-mounted transformers and lines is prohibited except for testing, replacement of fuses, and switching.

10-11.4.2 Observe the following precautions during installation:

10-11.4.2.1 Carefully inspect all frames and tackles used in erecting pole-type transformers before each use. Repair defects before the frames and tackles are used.

10-11.4.2.2 Wherever possible, junction poles, subsidiary poles, and street lighting poles must not be used as transformer poles. When it is necessary to install transformers on junction, subsidiary, or street lighting poles, be careful to maintain proper climbing space and to avoid crowding of wires and equipment.

10-11.4.2.3 Install transformers only on poles strong enough to carry their weight. Transformer poles must be straight and, where necessary, guyed to prevent leaning or raking of the pole after the transformer is hung.

10-11.4.2.4 All crew members must stand clear and detour traffic when transformers are raised or lowered. In congested traffic locations, the pole space must be roped off. Personnel on the pole must place themselves on the opposite side from that on which the transformer is being raised or lowered. Pole steps and other obstructions in the path of ascent/descent of large transformers must be removed.

10-11.4.2.5 When transformers are installed, the pole climbing space must be protected so that climbing workers do not come too close to transformer cases.

10-11.4.3 Pole-type transformers must not be installed until they are supplied with a sufficient amount of the appropriate oil or fluid.

10-11.4.3.1 Phase rotation should be determined before the old bank is removed, and before the new three-phase bank of pole-type transformers is installed, check voltage and phase rotation as well as the nomenclature plate.
10-11.4.3.2 Use rubber gloves and or hot sticks when making live primary connections to a pole-type transformer. First, connect the primary leads from the transformer to the primary cutouts; second, make sure that secondary leads from the transformer are in the clear; third, make connections from cutouts to primary line; fourth, close primary cutouts; and fifth, double check for correct terminals on secondaries and then connect permanently. When removing transformers, open cutouts and disconnect secondaries to prevent the danger of “backfeed”.

10-11.4.4 Only qualified climbers must be allowed to climb poles to inspect and test pole-type transformers. Never stand on or otherwise contact transformer cases, while working on or near energized circuits.

10-11.4.4.1 Disconnect all energized connections to transformers and provide a Safe Clearance from all live circuits before changing or replenishing transformer oil

10-11.4.4.2 Do not use lighted matches or open flames of any kind when opening transformers.

10-11.4.5 When installing fuses, workers must be careful to avoid contact with any live lines and with other metal surfaces even if they are supposed to be grounded (i.e., grounded lines, the casings of grounded transformers, street lighting fixtures, signal lines, signal equipment, the metal sheathing of cables, metal conduits, span wires, or guy wires).

10-11.4.5.1 Before installing fuses in new cutouts, replacing fuses, or opening disconnects, workers must wear and use the appropriate personal protective equipment in accordance with NFPA 70E, Table 130.7(C)(11). Flash shields on hard hats are required.

10-11.4.5.2 When fuses are taken out of the circuit, they must be removed entirely from the fuse enclosures or cutouts.

10-11.4.5.3 Use small size fuses in final connection checking a transformer, especially if the condition of the windings or load is suspect due to a previous fault or surge on the load.

10-11.4.6 Service wires must not be installed on transformer poles, unless minimum separation requirements can be maintained between the service wires and the energized primary conductors or apparatus.

10-11.4.6.1 Use at least two qualified workers when installing services from a transformer pole when primary conductors energized at 4,000 V or more are within contact distance of the secondary wires.

10-11.4.6.2 The neutral wire must be connected first when making connections to secondary buses followed by the phase conductors. Reverse the procedure when disconnecting services.

10-11.4.7 Qualified personnel must perform testing of transformers, autotransformers, and similar equipment. All temporary leads used in testing, such as secondary leads of potential transformers, thermometer leads, and recording voltmeter leads, must be securely supported on the pole and must clear all vehicular traffic. The positions of these leads must not interfere with the climbing space or with other maintenance work which may be required while the testing is in progress.

10-12 **AERIAL ROPE.** Workers working on aerial lines use ropes. Rope qualities and use in rigging for general lifting are covered in Chapter 5.

10-12.1 **Conductivity**. Properly maintained polypropylene synthetic rope (not natural-fiber rope) which meets ANSI/IEEE 516 requirements must be used for aerial lines, handlines, and tag lines for live-line work. Keep rope stored in a clean, dry location and protected from damage and contamination. Rope lines used must be constructed without wire reinforcement, and be at least 13 millimeters (1/2 inch) in diameter.

10-12.2 **Terminology of Rope Use**.

10-12.2.1 Handlines are used to raise and lower light materials and tools. They may be used for holding small transformers away from the pole during raising or lowering.

10-12.2.2 Throw lines are used to pull a larger rope into place for performing a task beyond the capacity of a hand line. They are small diameter ropes designed to be thrown over support objects such as crossarms or tree limbs.

10-12.2.3 Bull ropes are used when a handline is not strong enough to raise heavier equipment. They are used also for fastening temporary poles, for holding out heavier transformers, and for lowering trunks or heavy limbs in tree trimming operations.

10-12.2.4 Running lines are used for pulling several span lengths of wire at one time.

10-12.2.5 A sling is a looped rope assembly useful for many purposes: such as: to hoist heavy equipment; for lashing tools or materials in place; for attaching a block or a snatch block to a pole; for making temporary installations such as lashing an old pole to a new pole; and for tying up line wires.

10-12.2.6 A safety line is used only for lowering a worker to the ground.

10-12.2.7 A snatch block is a rope sheave and hook with one side of the sheave open to avoid threading the rope through a hole.

10-12.3 **Knots and Splices**. Where it is necessary to connect two aerial rope lines permanently, a splice must be made. No metal, wire, or clamps can be used in making the splices. The strength of a splice can be close to the original strength of the rope, and is always much greater than the strength of a knot.

10-12.3.1 Knots, friction tape, cord, or marlin must not be used in joining the two parts of an aerial rope line. Properly assembled splices are not normally bulky.

10-12.3.2 Each end of the rope line must be finished (served) to prevent unraveling of the strands. A handline must be dry and strong enough to be used as a safety line for lowering a person safely from a pole.

10-12.4 **Handline and Rope Line Precautions**. Although the term handline is used in the following paragraphs, these precautions apply to all rope lines.

10-12.4.1 Handlines must be at least twice as long as the height of the highest crossarm, and equipped with single sheaves. No metal must be used on any handline, except for the use of a standard hook.

10-12.4.2 Handlines with worn or frayed parts must be scrapped immediately.

10-12.4.3 Handlines must be carried up a pole uncoiled and attached to the back of body harness/belt, before any work is done. A worker climbing with a handline must take care to prevent the handline from catching on pole attachments.

10-12.4.4 Handlines must not be pulled over sharp bends, sharp edges, or surfaces with splinters.

10-12.4.5 Handlines must be kept free from solder, oil, grease, snarls, and knots.

10-12.4.6 Handlines must not be stored while they are wet.

10-12.4.7 When not in use, handlines must be rolled up and stored in a dry and protected place. Always thoroughly dry handlines before storing. Handlines must never be permitted to lie on the street or highway.

10-12.4.8 Where handlines are being let out on the poles, at least one member of the crew must be stationed at a safe distance from the base of the pole to take care of the loading and unloading of the handline, and to see that the ends are kept free from all street traffic.

10-12.4.9 One handline must be kept in reserve and maintained in a dry condition to use as a safety line in case there is a need to rescue a worker from a pole. This handline must be stored in a protected part of the truck where it cannot become wet.

10-12.5 **Tackle Blocks**. Tackle blocks used on maintenance work must be equipped with safety snaps to prevent wire grips and live tools from coming loose and falling.

10-13 **TOOLS.** Aerial line work involves the use of portable power tools and other miscellaneous tools.

10-13.1 **Portable Power Tool Precautions**. Use only approved portable power tools on poles, towers, or structures.

10-13.1.1 Keep electric tools and connected power cords a safe distance from any circuit or apparatus energized in excess of 600 V, phase to phase. Power cords must be adequately insulated and properly secured to prevent accidental contact with any conductor.

10-13.1.2 Do not use air-driven and hydraulic-driven tools when their conducting parts can come closer than the minimum working distance to any energized conductor or apparatus. Cover the energized conductors or apparatus with protective equipment appropriate for the voltage involved when the minimum clearances cannot be obtained. Supply hoses must be made of non-current carrying material throughout, be properly maintained, and secured in use to prevent accidental contact with any energized conductor or apparatus.

10-13.1.3 Use power saws in an elevated position on a pole, tower, or structure only when approved by the authorized individual-in-charge.

10-13.1.4 Non-current carrying metal parts of hand-held portable electric power tools must be grounded unless supplied from a ground-fault interrupting (GFI) circuit. Approved double-insulated tools and tools fed from ungrounded isolated power supplies need not be grounded.

10-13.2 **Miscellaneous Tool Precautions**.

10-13.2.1 Pike pole handles must be sound and free from splinters. Spear points (gaffs) must be sharp and securely fastened to a pole. When carried on trucks, pike poles must be placed to prevent injuries.

10-13.2.2 Maintain cant hooks and carrying hooks in a safe condition.

10-13.2.3 Never use jennies with cracked or broken legs, dull teeth, or loose bolts. Use only approved jennies.

10-13.2.4 Never use pole jacks with defective releases, or jacks that might slip when loaded.

10-13.2.5 Only use approved bumperboards. A bumperboard must be either 50- by 150-millimeter (2- by 6-inch) board of length 1.8- to 2.4-meters (6- to 8-feet), or 38- by 150-millimeter (1-1/2 by 6- inch) channel iron of length at least 1.8-meters (6-feet).

10-13.2.6 Never use wire reels with defects evident. All wire reels must have suitable brakes.

10-13.2.7 Close folding-type knives before placing them in toolboxes or other storage containers. Open knives must be kept in scabbards when not in use.

10-13.2.8 Maintain personal tools in good condition.

10-13.2.9 Keep hot line tools clean, dry and in good condition.

10-14 **AERIAL LIFTS AND INSULATED BUCKETS.** The use of aerial lifts and insulated buckets is covered in Chapter 5. The following provides requirements regarding their use.

10-14.1 **General Requirements**.

10-14.1.1 Test lift controls each day before use to determine that the controls are in safe condition.

10-14.1.2 Do not alter the insulated portion of an aerial lift in any manner that might reduce its insulating value.

10-14.1.3 The vehicle may become energized when the boom or the aerial basket comes in direct contact with energized conductors or equipment.

10-14.1.4 Do not depend upon the truck, boom, or aerial bucket to be “electrically insulated” without re-verification at the start of each day of use that each item provides insulation to the necessary value. Do not allow anyone to touch the truck or equipment

when aerial equipment is operating in or near energized conductors. The vehicle must be grounded, or if not grounded, must be considered as energized and properly barricaded.

10-14.1.5 The requirements for use of rubber or other protective equipment while working on poles and structures also apply to work from aerial buckets.

10-14.1.6 Use a body harness with a secured safety lanyard for any work from an aerial bucket.

10-14.1.7 Use a bucket liner if the bucket is designed to be used with a liner, and test it periodically (refer to Chapter 5).

10-14.1.8 Wear a hard hat and clothing suitable for the work at all times when working from the aerial bucket, and nearby on the ground.

10-14.1.9 Do not be permit unauthorized or unqualified persons to operate the aerial bucket boom.

10-14.1.10 Insulated aerial lifting devices used for working on energized electrical systems must be specifically designed for that sole function. Use the aerial lift only for electrical-related work.

10-14.1.11 Stay clear of pressurized oil or air escaping from a ruptured line or fitting. The pump, compressor, or engine must be stopped as soon as a leak is detected.

10-14.1.12 The manufacturer's load limits of the boom or buckets must be posted on the unit, and must not be exceeded.

10-14.1.13 All hydraulic and pneumatic tools that are used on or near energized equipment must have non-conducting hoses rated for no less than normal operating pressure.

10-14.2 **Driving Precautions**.

10-14.2.1 Drivers of aerial bucket trucks must be constantly alert to the fact that the vehicle has exposed equipment above the elevation of the truck cab, and will be sure that roadways provide the necessary overhead clearance. They must avoid the need to move the truck into the opposing traffic stream by prior planning of the order of work.

10-14.2.2 Any backing of the truck must be done slowly and under the direction of one person on the ground. This person must have an unobstructed view of the intended path of the vehicle.

10-14.2.3 Do not move a truck with the boom elevated in working position.

10-14.2.4 When traveling to and from job sites, pin-on type buckets must be removed and stored on the truck, or secured in a horizontal position to the boom, to avoid obstructing the driver's vision.

10-14.3 **Setting Up and Knocking Down at the Job Site**.

10-14.3.1 Upon arriving at the work area, legally park the truck while the vehicle and pedestrian warning signs, lights, and barricades are being placed. Give careful consideration to the location of overhead conductors and the surrounding conditions before the truck is moved into the work position. Make every effort to place the truck so that all work areas at that location may be reached by the boom without movement of the truck.

10-14.3.2 Available footing for the truck wheels and outriggers must be examined carefully and extra caution exercised if there is snow, ice, mud, soft ground, or other unusual conditions. Blind ditches, manholes, culverts, cesspools, wells, and similar construction features are additional possible hazards.

10-14.3.3 Before lowering the stabilizers, outriggers, or hydraulic jacks, the operator must be certain that no persons are close enough to be injured. Chocks or cribbing may be needed to ensure stability of the truck body.

10-14.3.4 When working on an inclined road or street, check each outrigger or jack to make sure a stable setup has been achieved. The truck must be approximately level as viewed from the rear.

10-14.3.5 A warm-up period for the truck is usually needed at the beginning of each day's work. This time must vary with different truck makes and models, and with different temperatures.

10-14.3.6 When lowering the boom to a cradled position, workers must stand clear of the path of the bucket and boom.

10-14.3.7 When work is completed the bucket must be lowered, and the boom cradled and secured by an approved tie-down.

10-14.4 **Operating at the Job Site**.

10-14.4.1 One worker must be responsible for all operations required in placing the bucket in operating position, use of the bucket, and restoring it to the traveling position.

10-14.4.1.1 This worker must check to be sure that the outriggers or stabilizers are in the down position, the truck hand brake is set, and the rear wheels of the truck chocked, when necessary.

10-14.4.1.2 If this worker has any doubt as to the stability of the truck, particularly because of the terrain, the outriggers or stabilizers must be specially checked for proper positioning before a load is lifted.

10-14.4.2 When the boom must be maneuvered over a street or highway, necessary precautions must be taken to avoid mishaps with traffic or pedestrians. Use of a flagman must be considered.

10-14.4.3 Workers must enter the bucket only with the bucket resting in the position for which entry was designed.

10-14.4.4 Observe the following precautions:

10-14.4.4.1 The operator must face in the direction in which the bucket is moving so that all obstructions are noted and avoided when the bucket or boom is raised, lowered, or rotated.

10-14.4.4.2 The operator must follow the proper sequence prescribed by the manufacturer in raising the boom section.

10-14.4.4.3 Before reaching any area containing obstructions, the operator must test all controls of the boom and bucket to ensure that they are in proper working order.

10-14.4.4.4 The operator must suspend operations upon indication the controls are not working properly.

10-14.4.4.5 Raising the bucket directly above energized conductors or equipment must be kept to a minimum.

10-14.4.4.6 When possible, locate buckets to the side of lines, to help workers aloft avoid contacting energized conductors and equipment.

10-14.4.4.7 If the work is within reach of energized conductors or equipment, a worker must be properly protected with rubber sleeves and rubber gloves of an insulation rating appropriate for the voltage level.

10-14.4.4.8 Energized conductors and equipment must be covered with protective devices when necessary to perform the work safely.

10-14.4.4.9 Adequate clearance must be maintained so that protruding tools must not come in contact with conductors, tree limbs, or other obstructions.

10-14.4.4.10 A worker must not stand on top of the bucket, or on planks placed across the top of the bucket, while performing work.

10-14.4.4.11 A worker must not belt onto an adjacent pole, structure, or equipment while performing work from the bucket.

10-14.4.4.12 The operator must ensure that handlines and tools do not become entangled with the levers that operate the boom.

10-14.4.4.13 Secure all tools not in use when working aloft.

10-14.4.5 When the bucket is being used in any manner that might result in contact between an energized conductor and the bucket, boom, or any attachment thereto, the vehicle must be considered energized at line potential, and the following safe practices observed for ground operations.

10-14.4.5.1 Materials or tools must not be passed between a worker on the vehicle and a worker on the ground, unless both workers wear rubber gloves and use other required protective devices.

10-14.4.5.2 Workers operating ground controls must be on the vehicle or insulated from the ground using rubber gloves and other protective equipment.

10-14.4.5.3 Before entering or leaving the vehicle, a worker must make sure that the boom or bucket is not in contact with or near energized equipment.

10-14.4.5.4 Workers on the ground must not work directly below the work area of the bucket.

10-14.4.5.5 Tools or materials must not be thrown to or from the elevated bucket.

10-15 **AERIAL CABLE SOLDERING**.

10-15.1 Soldering tools must be kept at grade level except when actually in use aloft.

10-15.2 When solder is being used aloft, an approved solder catcher must be placed directly under the point of soldering.

10-15.3 Refer to Chapter 11 for additional safety precautions.

10-16 **TREE TRIMMING AND BRUSH REMOVAL**. Tree trimming and brush removal is necessary to maintain the integrity of electric lines and apparatus and provide right-of-way clearance.

10-16.1 **Training Qualifications**.

10-16.1.1 Permit only workers certified as “Qualified Climbers” to climb trees.

10-16.1.2 Work accomplished from an aerial lift must only be performed by workers qualified in use of the aerial lift.

10-16.1.3 If using ladders, review the requirements for their safe use.

10-16.1.4 In all cases, only qualified workers must perform work near energized lines.

10-16.1.5 Trimming must be done in a manner that does not damage the tree, and meets ANSI Z133.1 requirements. The worker must be qualified to do tree trimming.

10-16.2 **Public Safety**.

10-16.2.1 Erect suitable signs and barriers to prevent the public from passing under trees being trimmed, and to prevent stumbling over brush on the ground.

10-16.2.2 Brush must not be piled on sidewalks, or left on streets and highways overnight.

10-16.3 **Tool Safety**.

10-16.3.1 Raise and lower tools with a handline.

10-16.3.2 Use only saws and pruning knives or shears for cutting limbs.

10-16.3.3 Do not carry unnecessary tools up the tree.

10-16.3.4 Do not hang or store tools on tree limbs.

10-16.4 **Work Near Energized Lines**.

10-16.4.1 Be aware that lines may not always be deenergized for tree trimming operations. Review the rules for live line safety, and for climbing and working on a pole. Especially be aware of the energized lines in the area and the relevant dangers.

10-16.4.2 Workers in trees must use harnesses/belts and safety straps.

10-16.4.3 When working near energized lines, arrange the safety line so that a slip or fall will carry you away from the energized lines.

10-16.5 **Climbing and Working on Trees**.

10-16.5.1 Climbing trees must be avoided unless ladders or aerial lifts cannot provide the necessary access.

10-16.5.2 Workers in trees must be careful to prevent contact with aerial electric and telephone wires passing through the trees.

10-16.5.3 If climbers are used, make sure they are tree climbers approved for the bark thickness of the tree being climbed. Never use pole climbers.

10-16.5.4 Use a harness/belt, and safety strap or lifeline. Place the strap around a tree limb of sufficient size to hold the worker's weight, but never around the tree limb being cut.

10-16.5.5 Do not stand on tree limbs too small to support your weight. Extreme care must be exercised when working in trees that have brittle wood.

10-16.5.6 Check each tree for dead or broken tree limbs when climbing. Remove unsound tree limbs during the climb. Lower cut-off tree limbs with a rope because falling tree limbs can cause injury or property damage.

10-16.6 **Felling Trees**.

10-16.6.1 Before felling trees, inspect tools to be used (such as ropes, tackle, ladders, and chain saws) to ensure they are in proper condition.

10-16.6.2 Place signs warning pedestrian and vehicular traffic of the danger from work being performed. Station flagmen if necessary.

10-16.6.3 Inspect each tree for obstructions (conductors and fences) in the line of fall. Deenergize nearby conductors, if possible.

10-16.6.4 Trees greater than 7.5-meter (25-feet) tall and greater than a 200 millimeter (8-inch) trunk diameter must have ropes attached before felling. The ropes can be used to guide the tree as it falls.

10-16.6.5 Always have a clear a path of retreat when felling a tree.

10-16.7 **Power Trimming Equipment**.

10-16.7.1 Chain-saw operators must be familiar with and follow the manufacturer's operating instructions.

10-16.7.2 Carefully inspect chain saws prior to each use. Chain saws must be clean and sharp, and in sound mechanical condition with all guards, spark arresters, mufflers, handles, and other items properly installed and adjusted.

10-16.7.3 Permit only workers trained in chain saw operation to perform the work.

10-16.7.4 Clear away brush or other material that might interfere with cutting operations before starting to cut.

10-16.7.5 Wear appropriate personal protective equipment when operating the chain saw. Eye, ear, hand, foot, and leg protection are minimum requirements.

10-16.7.6 Never operate a chain saw when physically tired or under the influence of alcohol, medication, or other drugs.

10-16.7.7 Do not store fuel near flammable materials. Fuel for chain saws must be stored in approved, vented containers clearly marked to show the contents.

10-16.7.8 Do not start the chain saw within 3 meters (10 feet) of a fuel container.

10-16.7.9 Do not fuel the chain saw with it running or hot, or with open flame nearby.

10-16.8 **Right-Of-Way Brush Removal**.

10-16.8.1 Brush clearance is part of electrical maintenance work to clear right-of-ways. Wear personal protective equipment; i.e., eye protection, hearing protection, and proper clothing.

10-16.8.2 Cutters felling heavy brush or small trees must give sufficient clearance to other personnel. Never work so close that one worker could injure another with a swinging ax or hook.

10-16.8.3 Brush chippers must be operated only when authorized. The worker must stand to the side of the chipper chute while feeding the butt end of brush into the chipper first. Use the automatic shut-off/stop control at the operator's station in an emergency.

10-16.8.4 Do not hang tools such as saws, axes, bush hooks, pruning shears, scythe blades, and pitch forks in bushes or small trees, or out of the obvious view of other workers.

10-16.8.5 Restrict personnel assigned to remove or pile brush to maintain a safe distance behind workers using the cutting tools.

10-16.8.6 When burning brush, be careful to see that the fire and sparks do not ignite adjacent vegetation. Douse hot ash piles with water. Obey local laws concerning open fires.

10-16.8.7 Do not burn poison ivy, poison oak, and poison sumac. Smoke from burning these plants is very toxic. Even the windward side of the fires may not be safe.

10-16.8.8 Learn to recognize poison ivy, poison oak, and poison sumac (refer to Chapter 16). Some people are very susceptible to the poison from these plants and must keep away from the vines and leaves. Preventive lotions are effective if used prior to exposure. If skin contact is made with these poisonous plants, obtain first-aid treatment.

10-16.8.9 Be on the alert for snakes. A snakebite kit must be carried on every job where poisonous snakes could be encountered. Refer to Chapter 16 for more information.

CHAPTER 11

UNDERGROUND LINES

11-1 **UNDERGROUND WORK**. This chapter applies to work in manholes, vaults, and handholes; work on duct lines, trenches, and underground cables; and work on ground-mounted and underground equipment associated with underground electrical lines.

11-2 **GENERAL PROTECTION REQUIREMENTS**.

11-2.1 Protect pedestrians, motorists, facility workers, and equipment by the use of barriers, warning signs, lights, flags, traffic cones, high-level standards, barricade rope, and flagmen, as appropriate for the job site.

11-2.2 Protect approaches to work areas, excavations, open manholes, and parked equipment.

11-2.3 Ensure a fully charged and operable handheld fire extinguisher is immediately accessible when performing underground work. Confirm the fire extinguisher is rated for use on electrical equipment.

11-2.4 Mark all equipment and materials with red flags by day and red lights by night when located or stored where pedestrians or vehicular traffic might be endangered.

11-2.5 Avoid parking tool carts and reels on inclined streets. Where this cannot be avoided, equipment must be placed at a slight angle to the curb so that the curb serves as a chock. Chock all wheels with blocks or other suitable items, and install a well-fastened upright brace at both the front and rear of the vehicle. Where more than one reel is parked at the same location, lag the reels together. Place and fasten chock blocks and braces so that they cannot be easily dislodged.

11-2.6 Store equipment or materials where they do not obstruct fire alarm boxes, hydrants, or fire apparatus.

11-2.7 Cover open holes along streets, driveways, walkways, and accessible places by appropriate strength covers.

11-2.8 The following applies to excavation, trenching, and backfilling.

11-2.8.1 Use ditching machines with suitable walkways, footboards, and railings, and having protective guards over gears, chains, and other moving parts. Do not stand near digging buckets while the machine is in operation.

11-2.8.2 Where possible, excavate trenches in increments to minimize the length of open trenches. On a daily basis, remove spoil to an area where it must not constitute a safety hazard.

11-2.8.3 Keep tools, stones, and dirt away from the edges of a trench. In excavations in which workers may be required to enter, excavated and other material must be kept at least 0.6 meters (2 feet) from the edge of the excavation.

11-2.8.4 Excavated material removed from trenches in streets must be kept on the traffic side of trenches until used for fill or removed. This will help vehicular traffic avoid the trench.

11-2.8.5 When workers are required to be in trenches 1.2 meters (4 feet) deep or more, at least two separate and adequate means of exit, such as ladders or steps, must be provided and located to require no more than 7.5 meters (25 feet) of lateral travel.

11-2.8.6 Sides of trenches 1.5 meters (5 feet) or more in depth must be shored, sloped, or otherwise supported to prevent collapse.

11-2.9 Wear suitable gloves when using any equipment or tools to excavate, expose, or handle direct-burial cables.

11-2.10 Carefully refill excavations and see that all refilling is well tamped.

11-3 **CABLE PULLING**.

11-3.1 Do not handle pull-wires or pulling-lines within reaching distance of blocks, sheaves, winch drums, and take-up reels.

11-3.2 Do not remain in a manhole during pulling operations.

11-3.3 Do not use wire rope to pull cable in a duct already occupied by conductors.

11-3.4 Use a nonmetallic duct fishing wire or device when fishing ducts containing energized conductors.

11-3.5 Always fish ducts in the direction that presents the least hazard. Consider stationing a worker at each end when fishing ducts.

11-4 **BURIED ELECTRICAL CABLES**.

11-4.1 Use area utility maps to locate existing buried cables and nearby utilities as accurately as possible. Locate/scope for buried cables along any intended digging areas. Obtain digging permits, if required.

11-4.2 Use extreme care when excavating near or exposing direct-burial electric underground cables. If the depth of all direct-burial cables is definitely known, power digging equipment may be used for excavating all but the last 300 millimeters (12 inches) of cover over the cables. The remaining cover must be removed by use of hand-digging tools with FRP or wooden handles. Where the depth of direct-burial

cables is not established, power-digging equipment must not be used, except to break and remove the surface pavement.

11-4.3 Do not use probe rods or bars to locate any underground direct-burial cables.

11-4.4 Take extreme care to avoid damaging the cable insulation when uncovering direct-burial cables.

11-4.5 Protect all exposed cables against damage in a work area with boards or other nonconductive materials. Utilize suitable nonflammable protective material when it is necessary to weld adjacent to cables.

11-4.6 Do not stand, sit, kneel, or lean on unprotected direct-burial cables.

11-5 **DAMAGE TO EXISTING UTILITY LINES**. If any existing utility lines are damaged then certain steps must be taken dependent upon the type of line.

11-5.1 If electric cables are damaged the cables must be deenergized and repaired.

11-5.2 If high-energy lines such as natural gas, steam, or hot water are damaged, notify the local fire department, utility office, and security or police department immediately. Shut off all sources of the utility, if possible leave the hole open until all utility line flow has been dissipated safely. Warn and evacuate any workers or residents in the area as necessary, and keep the public well clear of the area.

11-5.3 Environmentally sensitive lines, such as sewer, fuel, and oil, must be handled in accordance with applicable health and safety requirements. Notify the local fire department, utility office, environmental office, and security or police department immediately. Take measures to prevent flow into storm drains or nearby waterways. Cleanup must be initiated as soon as possible.

11-5.4 Other lines, such as communication, water, and storm drainage, must be handled by notification as soon as possible to the appropriate utility office or maintenance department. Notify the local fire department in case of damage to waterlines since this may impact fire protection systems in the area.

11-6 **PREPARING TO WORK UNDERGROUND**.

11-6.1 **General Precautions Before Entry**.

11-6.1 All equipment inside a manhole operating at medium voltage levels, including conductors, should be deenergized before allowing entry into the manhole. If the equipment inside the manhole cannot be deenergized, the Risk Category 4 PPE requirements of NFPA 70E will be applied.

11-6.2 Before entering a manhole or other underground structure:

11-6.2.1 Obtain necessary permits and follow established manhole maintenance plans.

Place all warning signs needed for protection of those working in and around the underground structure.

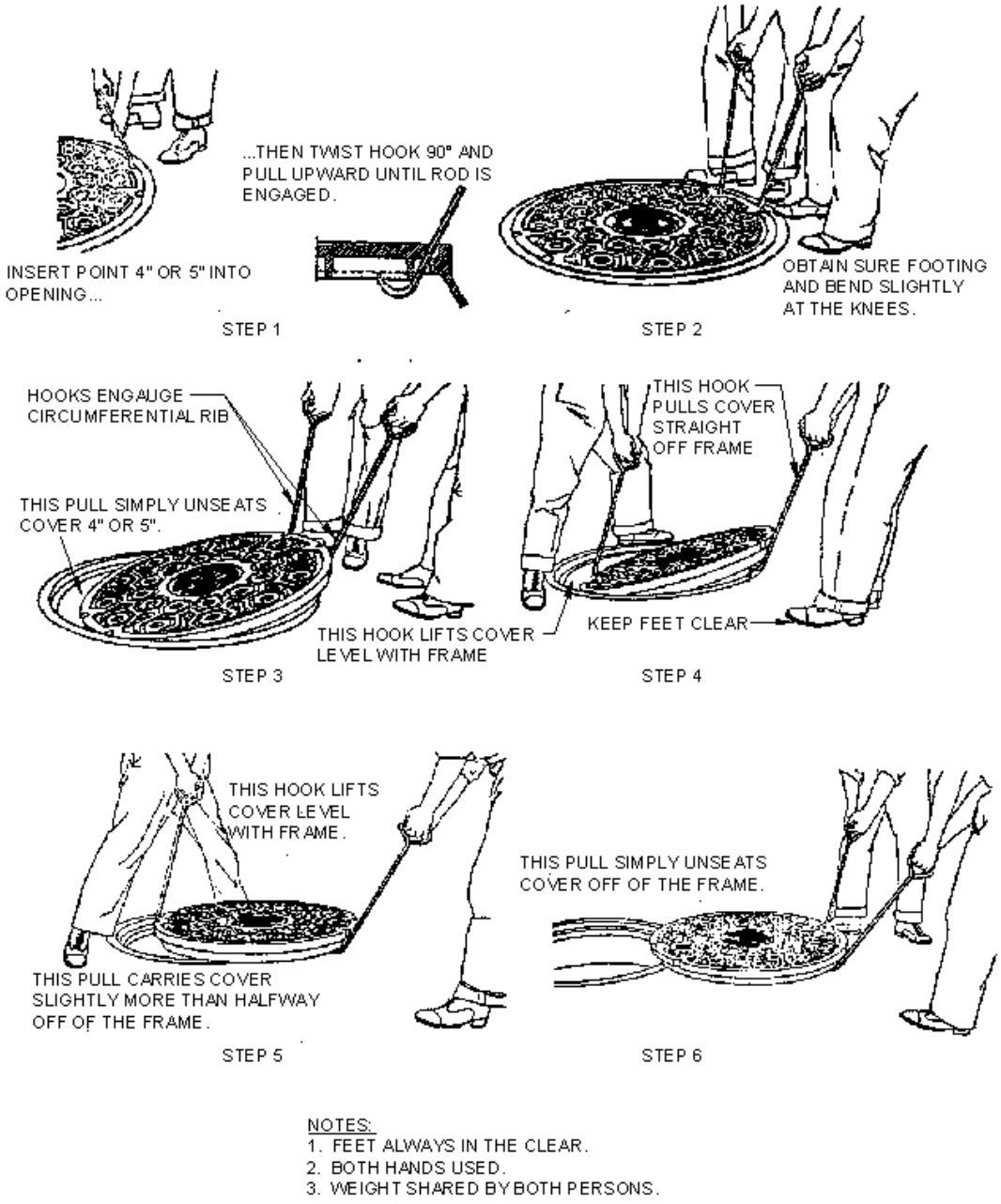
11-6.2.2 Test its atmosphere for the presence of dangerous gases.

11-6.2.3 Extinguish all smoking materials.

11-6.2 **Removing a Manhole Cover**.

11-6.2.1 A manhole cover can weigh from 90 to 160 kilograms (200 to 350 pounds). Two persons, each with a manhole cover hook or puller, are required to remove a cover. They must lift the cover using primarily their leg and arm muscles, and must place their feet in the clear in case the cover is accidentally dropped. Figure 11-1 illustrates removing a circular manhole cover.

Figure 11-1. Removing a Manhole Cover



11-6.2.2 Before removing a manhole cover, mark the cover and the frame with a piece of chalk so the manhole cover may be replaced in its original position. Improper alignment of the cover within the frame may cause considerable noise when vehicles cross over the covers. When realignment does not abate the noise condition, apply gasketing (or similar material) to fit in the seat of the frame.

11-6.2.3 Do not leave a manhole cover in a location where it can present a hazard. If the cover cannot be left near the manhole opening, skid the cover to a safe location. If necessary, place a warning device near the removed cover.

11-6.2.4 In a traffic area, the manhole cover must be removed in a direction that must prevent the workers from falling into the path of traffic must the manhole cover hook slip during cover removal. The removal position must permit observation of oncoming traffic. When possible, insert manhole-cover hooks in the hook holes on the side away from moving traffic. When this is not practical, insert the manhole-cover hooks in the holes that permit the cover to be moved in the direction of traffic. Keep the oncoming traffic under careful observation.

11-6.2.5 Place the covers of opened manholes on the side away from traffic, when conditions permit. In case of two section covers, place one section on each side of the opening.

11-6.2.6 Replace manhole covers with the same care as used for removing them. Be careful that manhole covers are properly seated when replaced. The bearing surfaces must be free from dirt or ice which might prevent them from fitting properly.

11-6.2.7 The following applies to snow and ice problems.

11-6.2.7.1 If snow, ice, or other surface conditions cause insecure footing around the manhole cover, clear the working area with a shovel or broom, or spread sand or other suitable material around the cover to provide a firm footing.

11-6.2.7.2 Do not strike the manhole cover with a steel or iron tool to remove ice since a spark may cause an explosion if a combustible gas mixture is present in the manhole. Use a hardened bronze cold chisel to remove ice from a cover. Bronze cold chisels do not produce sparks in striking the manhole cover.

11-6.2.7.3 If the manhole cover is icebound, consider using hot water to melt the ice around the edge of the cover. Do not use an open flame or salt to thaw ice around or over the manhole cover. An open flame may cause an explosion if a combustible gas mixture is present in the manhole. Do not use salt as saline solution may seep into the manhole and cause corrosion.

11-6.2.7.4 If the manhole cover cannot be located due to ice, make test holes in the ice to locate the edge of the manhole cover. A line or cable locator is useful in finding manhole cover locations when records are inadequate or when marking points are covered with ice and snow. If the exact location of the manhole is not known, a small channel may be cut from the outer edge of the general location to the center of the area where the cover must be.

11-6.2.8 If the manhole cover does not lift readily, determine if the cover may have been secured by a locking device. If a locking device is not holding the manhole cover, loosen the cover by placing a block of wood on the cover near the rim and striking the wood with a heavy hammer. Insert a manhole hook into one of the manhole cover holes. Pry the cover while the block of

wood is being struck at several different points around the circumference of the cover.

11-6.2.9 If manhole contains water and needs to be pumped, water shall not be allowed to enter storm drains, canals or waterways unless approved by local, state, and federal laws. Water is permitted to be pumped into containers and transported to an approved dumping area. If local policy permits, water may be placed back in manhole.

11-6.3 **Atmosphere Testing Before Entering Underground Structures**.

11-6.3.1 Test the atmosphere in the underground structure prior to entry to ensure it is safe for workers. Toxic or combustible gases may be present, or there may be a lack of oxygen in underground structures. No one is permitted in unvented underground vaults, manholes, or other structures unless the atmosphere is found to be safe by testing for both oxygen deficiency and the presence of toxic or explosive gases or fumes.

11-6.3.2 Manholes and other underground structures containing less than 19.5 % by volume oxygen must not be entered without the use of supplemental breathing air. Entering a manhole or other underground structure with an oxygen deficiency can cause sudden unconsciousness and death by hypoxia (oxygen starvation).

11-6.3.3 The following applies to toxic and combustible gases.

11-6.3.3.1 Consider subsurface structures hazardous until tested clear. They are subject to the accumulation of combustible or toxic gases.

11-6.3.3.2 Combustible gases found in manholes or vaults are usually natural gas or vapors from hydrocarbon fuels.

11-6.3.3.3 Toxic gases typically encountered are hydrogen sulfide, carbon monoxide, and mangrove gas (southern coastal areas).

11-6.4 **Test Equipment**.

11-6.4.1 Test the manhole or other underground structure with an approved tester prior to entry. Determine that the test instrument is in proper working order and correctly calibrated. Make tests as soon as the manhole cover is removed.

11-6.4.2 Perform oxygen deficiency tests with a safety lamp or an oxygen deficiency indicator. The safety lamp cannot be used to indicate the presence of carbon dioxide. Operate the indicator instrument in accordance with the manufacturer's instructions.

11-6.4.3 Do not rely on your sense of smell. Use one of the simple effective colormetric detectors (color changes to indicate concentration) for the detection of toxic gases. Hydrogen sulfide can be detected at concentrations as low as one part in 1,000,000. These detectors can be obtained commercially, and a universal test kit is available which can detect concentrations of carbon monoxide, hydrogen sulfide, and

numerous other gases. Use an approved portable unit to measure the amount of combustible and toxic gases in the manhole atmosphere.

11-6.4.4 Never enter a manhole until test results indicate that the manhole is safe for entry.

11-6.4.4.1 If tests made upon removing the manhole cover indicate that the atmosphere is satisfactory, the manhole or vault may be entered and worked in. Additional tests must be made when each crew begins work. The test interval must not exceed 8 hours. When the manhole is covered with a tent or tarpaulin, the test interval must not exceed 2 hours. Place the tent or tarpaulin so that an opening is left in the covering for ventilation.

11-6.4.4.2 If tests made upon removing the manhole cover indicate that the atmosphere is unsatisfactory, ventilate the manhole or vault with a power blower for a minimum of 10 minutes if more than the allowable trace of gas is found on the initial test, then make a second test with the blower running. If the test is satisfactory, the manhole or vault may be entered. Make this test away from the direct blast of the blower. If gas is again found on the second test, continue to ventilate the manhole with a power blower until the test is satisfactory. Work can then be started in the manhole, provided adequate power blower ventilation is continued. There must be enough ventilation to hold the quantity of gas in the manhole to within an allowable value until the work has been completed and the cover replaced. While working in a manhole being ventilated with a power blower because of previous gas detection, test the atmosphere every hour. If the blower stops, leave the manhole at once and do not re-enter until ventilation has been restored and the atmosphere test is satisfactory. Operate the blower outside of a manhole tent or tarpaulin down wind of the manhole.

11-6.5 **Pumping a Manhole**. After a manhole has been pumped, the removal of the water may permit gas to flow into the manhole. Make the test at any open ducts. If a test indicates that gas in entering, ventilate the manhole.

11-6.6 **Removal of Duct Plugs**. Immediately upon the removal of the duct plugs, make a test at the opened duct. If gas is entering, ventilate the manhole.

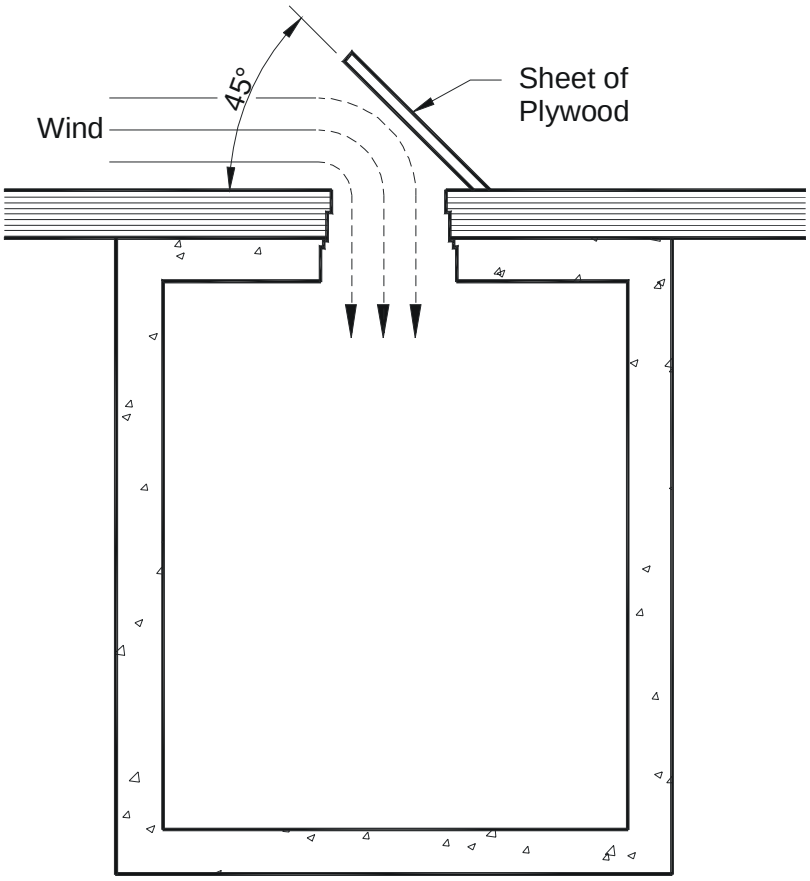
11-6.7 **Emergency Entrance**. Use an approved positive pressure respirator or self-contained breathing apparatus, and a safety belt with an attached life line attended by another worker stationed at the opening if it becomes necessary, to enter a manhole or vault where a hazardous atmosphere is present.

11-6.8 **Ventilation of Underground Structures**. There are three methods that can be used to ventilate a structure. These are the forced air, sail, and natural methods.

11-6.8.1 **Forced Air**. The forced air method consists of a power blower, blowing air into the manhole. The blower hose is placed into the manhole, forcing fresh air to circulate and oxygen-deficient air to be forced out. This is the best method of ventilating a manhole.

11-6.8.2 **Sail Method**. The sail method (refer to Figure 11-2) ventilates the manhole by using the wind. A piece of plywood or some other material is placed over the manhole. The edge of the plywood facing the wind is lifted up until the plywood forms about a 45-degree angle with the manhole opening. The wind enters the manhole, forcing possible contaminated air out of the manhole.

Figure 11-2. Sail Method of Manhole Ventilation



11-6.8.3 **Natural Method**. This method consists of taking the manhole cover off and letting the internal air escape as much as it can. This method of venting a manhole is the least effective because a gas heavier than air could remain in the bottom of the manhole. Use this method of venting a manhole only as an emergency measure, and only when determined safe.

11-7 WORK INSIDE UNDERGROUND STRUCTURES.

11-7.1 General.

11-7.1.1 Continuous adequate ventilation is required.

11-7.1.2 Provide the required additional workers while work is being performed in manholes or vaults.

11-7.1.3 Use a ladder when entering or leaving a manhole or vault. Climbing into or out of manholes or vaults by stepping on cables or cable supports is prohibited. Use of portable ladders is preferred. Ladders in manholes, if provided, may have rusted and become unsafe.

11-7.1.4 Handle tools in a manner that protects the workers and work area.

11-7.1.4.1 Place tools or materials a safe distance from manhole openings, where they must not cause a stumbling hazard or come in contact with energized conductors or equipment.

11-7.1.4.2 Do not throw tools or materials into or out of manholes. Use canvas buckets or hand lines for lowering tools or equipment into and removing them from manholes. Warn workers before lowering tools.

11-7.1.4.3 Provide when feasible: a windless hand crank; subsurface worker rescue assembly; or an approved retracting lifeline system.

11-7.1.5 Visually inspect for hazardous conditions such as burnt or cut cables, or loose or defective ladders before starting work.

11-7.1.6 When the use of open flames is necessary, consider the proximity of combustible or flammable liquids, such as a nearby gasoline service station or underground fuel storage tank. If in doubt, retest the atmosphere before lighting the open flame. Provide adequate ventilation when open flames are used in manholes.

11-7.1.7 Use only flashlights or facility approved lighting units for illumination in manholes.

11-7.1.8 Low-voltage (less than 600 V) equipment can be especially hazardous in or around subsurface structures. Tool frames and cases can become energized by electrical conductors with frayed or damaged insulation. These faults may occur only momentarily or could be prolonged through high-resistance grounding paths. Contact with these energized tool frames and cases in the vicinity of damp, well-grounded floors and walls can easily result in electrocution. Use only low-voltage (24 V) lighting systems and low-voltage tools, and or pneumatic tools in maintaining subsurface vaults and facilities.

11-7.2 **Work Precautions**.

11-7.2.1 Properly identify cables before beginning any work. Check cable tags. If tags have become illegible or lost, obtain specific instructions from the authorized individual-in-charge before starting work. Complete re-tagging before starting work.

11-7.2.2 The external appearance of medium-voltage and low-voltage cables is often very similar. Report any errors found in the cable tags or in the manhole records or

maps to the authorized individual-in-charge. Work must not continue until permission is given by the authorized individual-in-charge.

11-7.2.3 Do not remove or place an identification tag on a circuit without direct permission from the authorized individual.

11-7.2.4 All equipment inside a manhole operating at medium voltage levels, including conductors, should be deenergized before allowing entry into the manhole. If the equipment inside the manhole cannot be deenergized, the Risk Category 4 personal protective equipment requirements of NFPA 70E will be applied.

11-7.2.5 Consider cable and apparatus energized, and use personal protective equipment in accordance with NFPA 70E until the following steps have been taken.

11-7.2.5.1 Test the item with an approved device and confirm it is deenergized.

11-7.2.5.2 Ground the item from all possible sources of power (including transformer secondary back feed).

11-7.2.5.3 Grounds are provided at the work location. Grounds may be omitted or removed for test purposes with the approval of the authorized individual-in-charge after the circuit has been tested and proven to be deenergized. Omission of grounds must be permitted only if their application would increase the work hazard.

11-7.2.5.4 The cable has been grounded for a sufficient length of time to drain off any static charges.

11-7.2.6 Verify low-voltage cables are deenergized as follows.

11-7.2.6.1 Remove the insulation to expose a spot on the conductor for direct metallic contact, and test with an approved voltage detector for cables (positively identified) which are normally energized at 600 V or less, phase to phase.

11-7.2.6.2 Cables normally energized at more than 600 V, phase to phase, or any cable whose voltage or identity is questionable, must be proven deenergized by following the method for medium-voltage cables. All equipment inside a manhole operating at medium voltage levels, including conductors, should be deenergized before allowing entry into the manhole. If the equipment inside the manhole cannot be deenergized, the Risk Category 4 personal protective equipment requirements of NFPA 70E will be applied.

11-7.2.7 Verify medium-voltage cables are deenergized as follows.

11-7.2.7.1 Use an approved test device to confirm medium-voltage equipment and cables are deenergized when the cable terminals or apparatus are equipped with capacitive test points or have bare exposed parts.

11-7.2.7.2 If an approved test device cannot be used, confirm the equipment and cables are deenergized as follows.

- Isolate the equipment or cable from all possible sources of power, and positively trace it to the work location.
- Ground the equipment or cable at the work location. This can be done by the cable spike method which uses a wire tong or C-clamp device attached to a hot stick to provide a proven ground. Do not use a pike pole as a spike for this grounding method, as the pike does not have the rating of a hot stick.
- Place a temporary ground on the cable before splicing to allow dissipation of any capacitance charge and to ensure the cable is deenergized.
- Repair using an approved splice kit.

11-7.3 **Working on Cables and Apparatus**. Perform the following when working on cables and apparatus.

11-7.3.1 Maintain the required minimum working distance appropriate to the voltage level, and whether the item being worked on is energized or deenergized. Be sure what items are deenergized and what items are energized.

11-7.3.2 All cable and apparatus must be tagged properly.

11-7.3.3 Place rubber blankets or other suitable insulating barriers to prevent accidental contact when a worker is in proximity to live parts.

11-7.3.4 Consider the following special hazards.

11-7.3.4.1 Check the primary and secondary voltage of any transformer fed from a deenergized feeder cable. Ground the cable on each side of the work location.

11-7.3.4.2 Do not open neutral conductors without the prior installation of suitable bypass conductors.

11-7.3.4.3 Move energized underground cables only with the specific approval of the authorized individual-in-charge. Use extraordinary care to avoid damage to the cable insulation. Examine the cables for defects prior to moving energized electric underground cables. Defects may cause failure if the cable is moved. No energized cable will be moved where such movement requires changing bends. All energized cables must be handled with the appropriate personal protective equipment.

11-7.3.4.4 Deenergize the circuit before separating or connecting a 600 amp dead-break type separable connector. Verify the circuit is dead by using the associated capacitive test point and an approved test device. Utilize suitable live-line tools in

separating or connecting these separable connectors, unless the circuit has be verified as deenergized and is grounded.

11-7.3.4.5 Avoid sparks in connecting or disconnecting cables, apparatus, and switching devices.

11-7.3.4.6 Before operating a primary grounding switch, the authorized operator must be certain of the following.

- All personnel are at their correct location.
- The tags on the feeder cable and equipment in the vault or manhole bear the same numbers as shown on single line drawings.
- Network protectors are in the open position or, in the case of radial transformers, the secondary fuses have been removed and transformer secondaries are deenergized.

11-7.3.5 All cable to be cut should be positively identified and de-energized before each cut. Before making an opening in or removing a part of the sheath or sleeve of a cable, the line will be grounded at the first possible grounding point on each side of the work location.

11-7.3.5.1 Perform all medium and high voltage cable cutting remotely from topside using a guillotine cutter and permit no workers to remain in the space during the cutting. This will isolate workers by a safe distance in the event of an accidental arc-blast when the cut is made. If guillotine cutting is not feasible due to cable configuration, location, or other complications, hand cutting may be necessary in accordance with the following precautions.

11-7.3.5.2 Always wear rubber gloves when sawing into a cable or removing the sheathing. Install a metallic jumper between two sides of the location where a cable sheath is to be removed or cut.

11-7.3.5.3 When a medium-voltage cable is to be cut, a short section of the shielding, if any, must be removed completely from around the cable. Make tests with two statiscopes, cable spikes or other approved testing devices, to determine whether or not the cable is deenergized. If no indication of a live cable is obtained, the worker may proceed with the work.

11-7.3.5.4 When opening a splice in a medium-voltage cable, the sleeve over the splice must be cut completely around near the splice, and then cut lengthwise and removed. Make no effort to remove the compound under the splice. With the splice removed, test over each side of the conductor with two statiscopes, cable spikes or other approved testing devices. If no indication of a live cable is obtained, the compound may be removed. If shielding tape is then encountered, remove it and make another test over each side of the conductor with two statiscopes, cable spikes or other approved testing devices. If no indication of a live cable is then obtained, the splice may be cut through

until the saw touches one of the conductors. Before sawing further, make a statiscope test on the blade of the saw.

11-7.3.5.5 When cutting or opening splices on low-voltage cables use the same procedure as outlined above for medium-voltage cables except in testing. To determine whether the cable is energized the insulation may be cut away to the conductor and tested with an approved tester. Cut only one conductor at a time on multiple-conductor cables, and make complete tests on at least two conductors before proceeding with the work.

CHAPTER 12

MEDIUM- AND LOW-VOLTAGE INTERIOR SYSTEMS

12-1 WORKING ON INDOOR EQUIPMENT.

12-1.1 **Restricted Space**. Be alert that older installations might not meet current NEC clearance and entrance requirements for electrical rooms. Where installations do not conform to current NEC/OSHA requirements, additional safety precautions and instruction must be provided to maintenance workers. Give special attention to the guarding of live parts where current NEC clearances are not met. Ensure that unobstructed emergency exit routes are provided. Space is usually at a premium. Clearances provided are usually less generous than in outdoor installations.

12-1.2 **Grounding Systems**. Verify that existing permanent electrical system grounds are adequate for personnel protective grounding, and provide additional temporary grounding as necessary.

12-1.3 **Disconnection of Power Sources**. Be sure to check single line diagrams and verify that all inputs and interconnections to any electric power source are locked and tagged open. Remember the single line diagram may not be accurate, so verify single line diagram connections with the actual line connections of the applicable equipment.

12-1.4 **Related Building Systems**. Do not disable or work on any fire protection and fire alarm systems without prior notification and approval of the local fire department. If the room's ventilation system is affected by the work, ensure that adequate temporary ventilation is provided.

12-1.5 **Other Work Area Precautions**. Inform the custodial service personnel when areas must be locked, or if additional trash removal is needed. Noise abatement may be needed to not unduly disturb personnel working in adjoining spaces.

12-2 MEDIUM-VOLTAGE SYSTEMS.

12-2.1 Many of the same safety requirements apply as for outdoor medium-voltage substations. Refer to Chapter 9 for medium-voltage work precautions. Accomplish the work with only qualified electrical workers with training and experience on medium-voltage circuits.

12-2.2 Consult the manufacturer's instruction manual for the apparatus before starting work, if available.

12-2.3 Work is not permitted on energized circuits unless specifically approved. Use temporary ground wires to ensure there are no voltages and currents from live circuits, stored energy devices, and equipment metal guards before starting work.

12-3 LOW-VOLTAGE SYSTEMS.

12-3.1 Overview.

12-3.1.1 Complete any work with only qualified electrical workers with training and experience on low-voltage circuits. Electrical workers must be familiar with NEC requirements and must have work experience with low-voltage systems. Inform the foreman when installations do not meet the requirements of applicable codes and standards, such as the NEC. Electrical workers must understand electrical safety requirements for low-voltage systems.

12-3.1.2 Consult the manufacturer's instruction manual if available for the apparatus before starting work.

12-3.1.3 Unless specifically approved, work is not permitted on energized circuits. Use temporary ground wires to drain off induced voltages and currents from live circuits, stored energy devices, and equipment metal guards before starting work.

12-3.1.4 In most cases only contract personnel or specially trained workers must repair complex controls and special equipment.

12-3.2 **Battery Room Hazards**. The battery safety rules provided in Section 9-11 apply to low-voltage systems.

12-3.3 **Fire Alarm Systems**. Maintaining fire alarm systems with their appropriate safety requirements requires special training. Workers must have completed one or more of the following certifications or specialized training.

- Factory trained and certified, or
- Certified by the National Institute for Certification in Engineering Technologies (Fire Alarm Systems), or
- Certified by the International Municipal Signaling Association (Fire Alarm Systems), or
- Certified by state or local authority, or
- Trained and qualified by an organization listed by a nationally recognized testing laboratory for the servicing of fire alarm systems.

12-3.4 **Solid-State Equipment**. Adjustable-speed motor controllers and uninterruptible power supply (UPS) equipment are complex solid-state devices that must generally be maintained by manufacturers or specially trained contract personnel. Facility personnel are not normally trained for such work. Even with after initial training, maintenance work is usually done on such an infrequent basis that facility workers must not be considered qualified. Facilities with these installations must contain cautionary

labeling to warning facility workers of the electric shock dangers involved in operating and maintaining these types of equipment.

12-3.5 **Low-Voltage Work Precautions**.

12-3.5.1 Assume all parts of an electric circuit are energized until proven otherwise. Personally inspect circuits before starting work to be sure circuits are deenergized.

12-3.5.2 Use only insulated hand tools when working on equipment where the tool could contact an energized source of 50 V or higher.

CAUTION
Older plastic or rubber coated tools are often not certified by the manufacturer for insulating ability, and the coating is only provided as a comfort feature for the user. If the tool has not been tested, it must be assumed to not meet OSHA requirements for use of insulated hand tools.

12-3.5.3 Unless specific permission is provided, no work will be performed on energized electrical circuits or equipment operating at more than 50 V phase-to-phase. Follow the safe clearance requirements of Chapter 6. If work is performed on live energized circuits, select the appropriate personal protective equipment in accordance with the criteria provided in Chapter 4.

12-3.5.4 The supply or line side of switches or fuses can be energized when all work to be performed on the load side of such switches or fuses has sufficient clearance between energized and deenergized parts so that work can be done safely.

12-3.5.5 Before starting work on deenergized circuits or equipment, verify zero voltage on the circuit with a confirmed properly operating voltmeter

12-3.5.6 When working on or near energized circuits, workers must stand on a dry surface, other than cement or masonry, or wear electrician's rubber footwear.

12-3.5.7 If using fish tape near energized parts, cover live parts with rubber equipment.

12-3.5.8 If working near running machinery, use extreme care and provide barricades, if necessary.

12-3.5.9 Place all tools clear of machinery before starting machinery. Never use a wrench on running machinery.

12-3.5.10 Provide adequate illumination.

12-3.5.11 Use extreme care when working in constrained locations to avoid injury to head, arms, and other parts of your body. Never work on energized electrical

equipment in constrained spaces. With respect to electrical equipment, a constrained space is a location with less than required working room and clear space.

12-3.5.12 Wear safety goggles when soldering joints or tinning lugs on connectors.

12-3.5.13 Remove tripping hazards before starting work and do not work on slippery surfaces.

12-3.5.14 Tape or cover bare or exposed places on one energized conductor before exposing another energized conductor. Never leave joints or loose ends of wire untapped or otherwise unprotected.

12-3.5.15 An open knife switch can be hazardous because of the exposure to live parts and because of the arc formed when the switch is opened. Only use switches knife switches that are enclosed in grounded metal cabinets having the control lever operable from outside the cabinet. Install a knife switch so that the blades are deenergized when the switch is open and oriented so that gravity will not tend to close the switch. Mount double-throw switches horizontally so that their operation will not be affected by gravity.

12-3.5.16 Provide fuses and circuit breakers in accordance with the NEC, properly sized to protect the downstream conductors and equipment. Substitution of conductors for fuses is not permitted. Remove fuses only after opening the upstream disconnect device. Use an insulated fuse puller. Use both a fuse puller and rubber gloves for circuits operating at 300 to 600 V.

12-3.5.17 Use properly grounded portable electric tools, particularly in damp locations or near grounded equipment or piping. Do not open a ground connection to a water pipe or ground rod until the ground wire has been disconnected at the equipment.

12-4 **ROTATING MACHINERY**.

12-4.1 **Hazards of Rotating Machinery**. Ensure guards are provided to protect workers from accidental contact with live electrical parts, rotating parts, and hot machine surfaces. Be aware that rotation can loosen grounding connections, hold-down bolts, and fray flexible or cord connections. Be alert to sparking of brushes and insulation failures that may cause flame or molten metal to be ejected from open type motors or generators. Interior electrical work often must be done in close proximity of rotating electrical equipment such as motors and generators. Do not operate rotating machinery without protective guards.

12-4.2 **Motors and Generators**.

12-4.2.1 After work has been performed on circuits to rotating machines, check direction of rotation.

12-4.2.2 Always take positive steps to ensure that rotating equipment under repair cannot be set into motion.

12-4.2.3 A megohmmeter (megger) can be used to check insulation of motor and generating windings using a current of high voltage and low amperage. Never start a megohm test if there is any external voltage in the test circuit.

12-4.2.4 Follow appropriate mechanical safety precautions if operating a generator, including:

12-4.2.4.1 Ensure engine coolant is at the proper level and has the proper amount of antifreeze. Make sure engine lubricant and fuel are at the proper levels. Check hoses for good condition.

12-4.2.4.2 Ensure sure engine air requirements for combustion are met. Check air filters and cleaners for cleanliness and good condition.

12-4.2.4.3 Verify the engine, generator, and related equipment are clean. Keep oil-soaked rags out of the generating facility to avoid a fire hazard.

12-4.2.4.4 Guard against accidental or unintentional starting when work is being done on the engine or associated equipment.

CHAPTER 13

SHORE-TO-SHIP ELECTRICAL POWER CONNECTIONS

13-1 **CONNECT/DISCONNECT RESPONSIBILITIES**. Electrical shore facilities are utilized to provide dockside electrical service to ships operating in a cold iron mode. The shore's electrical supervisor (SHORES ES) is responsible for the power provision of cables connected to shore receptacles in pier electrical outlet assemblies and rigged to the ship. The ship's electrical officer (SHIPS EO) is in ultimate charge in providing cable connections to the ship's electrical bus fed by the ship's generators and dictating when shore electrical power is energized or deenergized to supply this bus. General steps and performance responsibilities are provided in Tables 13-1 and 13-2 for ship connects and disconnects with references to specific subsections for step-by-step procedures.

Table 13-1. Shore-to-Ship Electrical Connect Responsibilities

Item	Description	Reference Section
1	Ships logistic requirements sent to shore before docking by SHIPS EO.	13-5.2.2
2	Shore provision before ship docks by SHORES ES.	
	a. Laying, inspection, and testing cable assemblies on dock.	13-7.1.1
	b. Checking shore receptacles.	13-7.1.2
	c. Inserting cable plugs into shore receptacles.	13-7.1.3
3	Shore-to-ship cable rigging after ship docks by SHORES ES.	13-8
4	Ship's transfer from ship's generators to shore electrical power by SHIPS EO.	13-9

Table 13-2. Shore-to-Ship Electrical Disconnect Responsibilities

Item	Description	Reference Section
1	Ships transfer from shore electrical power back to the ship's generator by SHIPS EO.	13-10
2	Shore provision of disconnecting cable plugs and unrigging and removing cables by SHORES ES.	13-11

13-2 **SHIP'S MAIN ELECTRICAL SERVICE COMPONENTS**. The specific safety requirements given apply to the cable assemblies from the pier's electrical outlet assemblies (commonly called "turtlebacks" on Mil-C receptacle systems, and "Connection Stations" on single pole panel mount connector systems) to the ship's electrical bus. There are other components of the shore's medium-voltage electrical distribution system used to supply substations that in turn supply the pier electrical outlet assemblies. The safety requirements for the pier electrical outlet assemblies that supply line side components are covered by earlier sections. Because they are provided for ships power in addition to permanent pier electrical loads, these components are also described here to enable a clearer understanding of the dockside electrical distribution system.

13-2.1 **Shore Medium-Voltage Distribution System**. The facility's primary electrical distribution system normally operates in the medium-voltage range between 5 kV and 35 kV. For permanent pier service, dual primary feeders from the shore's primary system is preferred. Pier systems can also be furnished with single feeders. These feeders serve substations, which step down the distribution system's primary voltage to the required secondary voltage for ships electrical service of 13.2 kV, 4.16 kV or 480 V.

13-2.2 **Pier Substations**. Substations might consist of above ground installed on the top of a pier or units installed in vaults located under the pier. Vault substations are fed by shielded power cables installed in electrical duct. Above deck substations are skid-mounted and are supplied by either shielded power cables installed in duct or mine power cable installed on the pier connected to the electrical distribution system via cable coupler plugs to coupler receptacles in electrical connection outlet assemblies. Both types of substations may include one or more primary fused switches or be fed from a pad mount switchgear vacuum fault interrupter switch way, the step-down transformer, and secondary circuit breakers supplying the pier electrical outlet assemblies for ship-to-shore power cables. Figures 13-1 through 13-6 show these component elements.

Figure 13-1. Electrical Connection Outlet Assembly with a 15-kV Receptacle

Figure 13-2. Close-Up of Electrical Connection Outlet Assembly

Figure 13-3. Inside a Pier Vault Housing a Substation

Figure 13-4. Skid-Mounted Substation

Figure 13-5. Skid-Mounted Substation with Single-Pole Connections

Figure 13-6. Newer Double-Deck Pier Switchgear

13-2.3 **Ship-to-Shore Pier Electrical Outlet Assemblies**. Ships service is from pier electrical outlet assemblies that contain either multiples of single pole or three-pole,

500-ampere receptacles rated either for 450-V ships service or 4.16-kV ships service as appropriate to the pier's ship electrical service requirement. Receptacles are interlocked with their associated substation secondary circuit breaker for safety reasons. Figures 13-7 and 13-8 show three-pole outlet assemblies for 480-V and 4.16-kV services respectively.

Figure 13-7. 480-Volt Pier Electrical Outlet Assembly Without Cable Connections

Figure 13-8. 4.16-kV Pier Electrical Outlet Assembly and Outlets

13-2.4 **Ship-to-Shore Power Cables and Connectors**. Portable shore-to-ship power cables are rated 8000 V for operating at 4160 V, three-phase, three-wire, ac or 600 V for operating at 450 V, three phase, three-wire ac. Both 4160 V and 480 V shore power systems are ungrounded (the transformer neutrals are isolated from ground).

Note: Splices are not allowed in 4.16-kV power cables. Figures 13-9 through 13-12 show examples of cables in place and various connections.

Figure 13-9. 480-Volt Pier Electrical Outlet Assembly and Cable Connections

Figure 13-10. 480-Volt Shore-Cable to Ship-Cable Splice Connection in Place

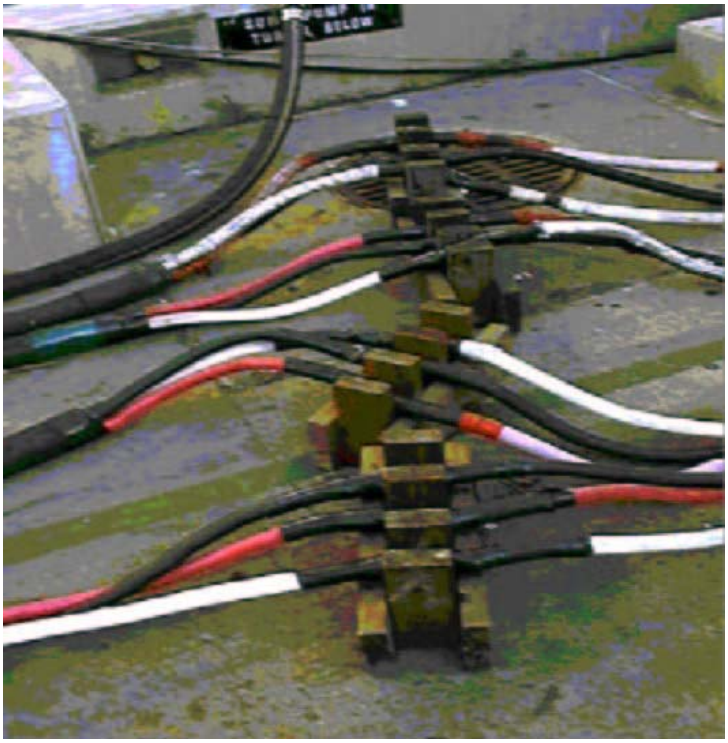
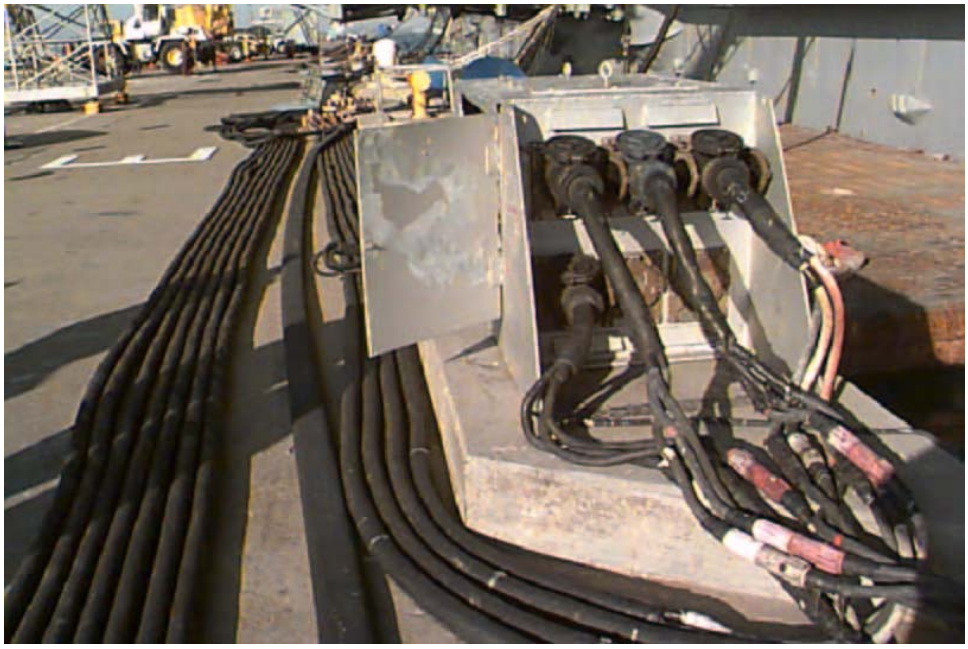


Figure 13-11. 480-Volt Shore-Cable to Ship-Cable with Single-Pole Connection

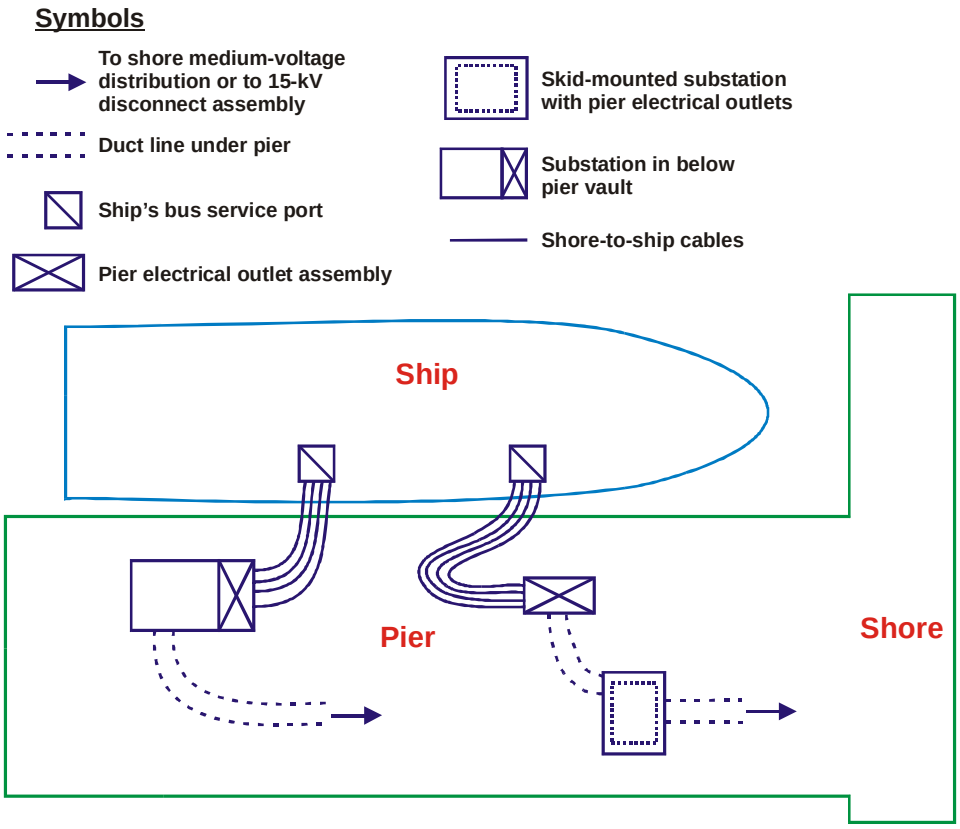
Figure 13-12. 480-Volt Shore-Cable to Ship-Cable Plug and Receptacle Connection In Place



13-3 **SHIP'S ELECTRICAL SERVICE COMPONENT RELATIONS**. An understanding of the physical and electrical arrangements of these components is necessary in understanding the safety problems involved in the basics of utilizing portable power cables to feed shore electrical power to a ship's electrical bus.

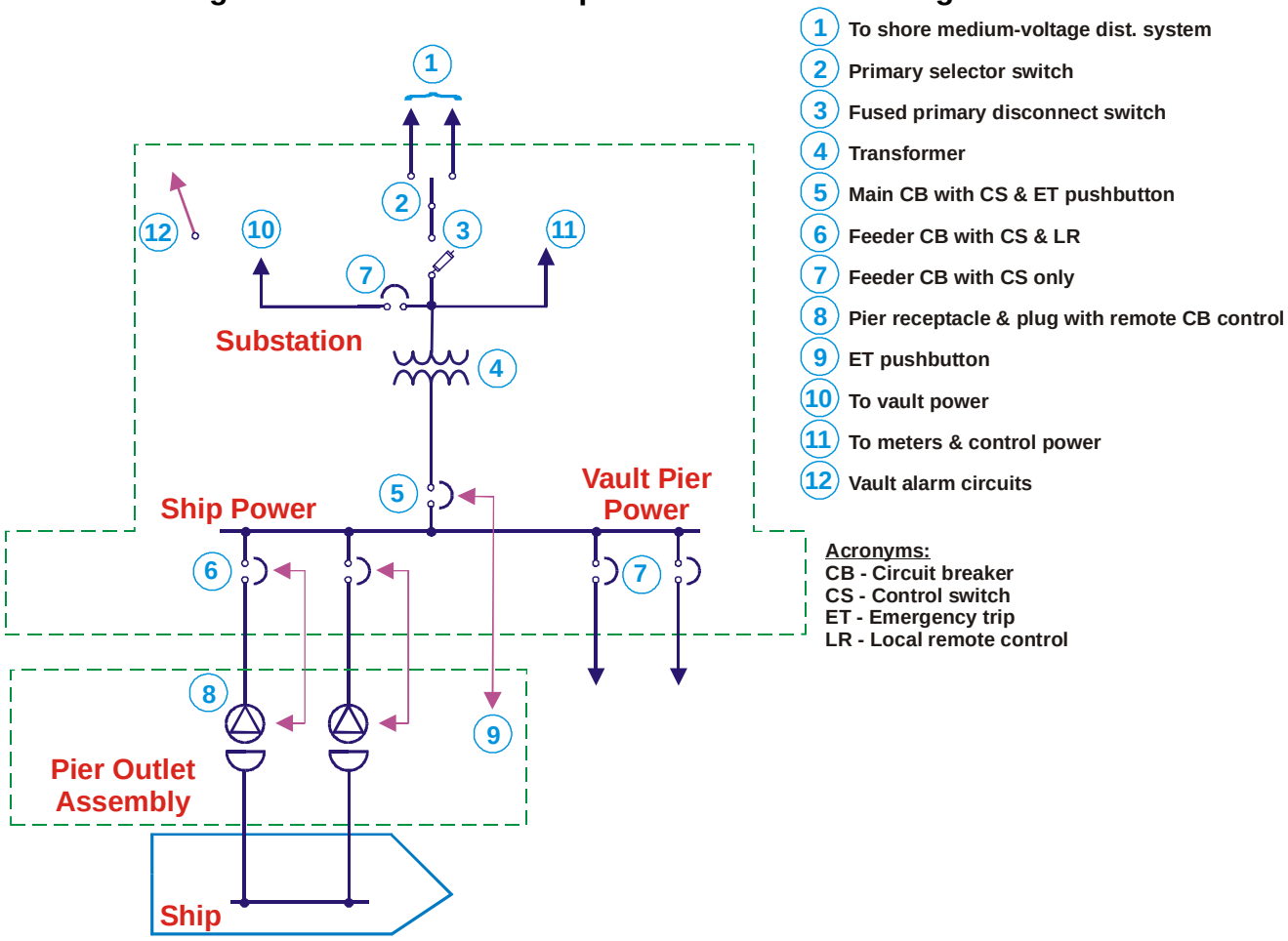
13-3.1 **Equipment Physical Relationships**. Figure 13-13 shows diagrammatically the physical relation of the ship and its power cable connections to the pier electrical power service. Ships might have one, two, or three service ports requiring connections to pier electrical outlets. Power cables need to be positioned to have equal length and no sharp bends. Power cables might need protection as described in later sections.

Figure 13-13. Shore-to-Ship Portable Power Cable Location Diagram



13-3.2 **Electrical Circuit Arrangement**. Figure 13-14 shows a simplified one-line diagram showing the ship's main electrical service components in a typical vault substation arrangement. The primary selective system shown is preferred, but is not always provided. Additional information and diagrams including typical circuit arrangements for skid-mounted substations are shown in UFC 4-150-02, *Design: Dockside Utilities for Ship Service*.

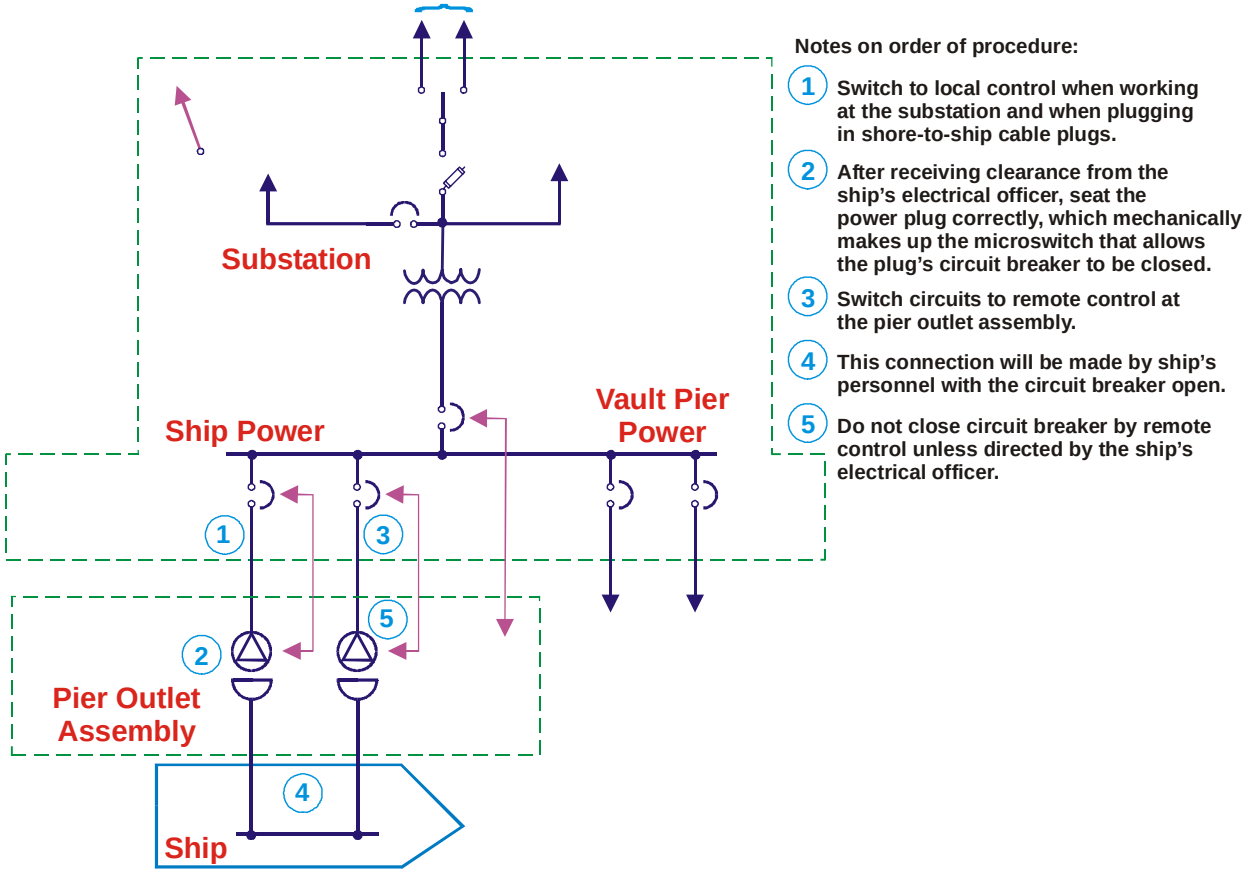
Figure 13-14. Preferred Ship-to-Shore Circuit Arrangement



13-3.2.1 **General Electrical System Safety**. The maintenance and operation safety aspects of the medium-voltage distribution system, substations, vaults, and low-voltage cables in duct lines is covered in previous sections.

13-3.2.2 **Specific Shore-to-Ship Electrical System Safety**. This section covers connection of portable power cables to shore electrical outlet assemblies and ship electrical buses. Connection is a divided responsibility as shown in Table 13-1. Follow the Standard Operating Procedure (SOP) established by the Shore ES. An example of the SOP for a typical vault substation arrangement to ensure that energizing the ship is accomplished safely is shown in Figure 13-15.

Figure 13-15. Procedure for Safely Energizing a Ship From a Shore Electrical Circuit



13-4 **UNUSUAL SHORE-TO-SHIP SYSTEM HAZARDS**. The additional risks posed by shore-to-ship power cable connections include:

- Split personnel shore/ship responsibilities.
- Portable power cable and outlet safety assurance.
- Electrical equipment accessibility and working space.
- An ungrounded, adequate and correctly phased electrical power input.
- Minimizing any parallel operations.

13-4.1 **Split Personnel Responsibilities**. It cannot be overemphasized how important standard operating procedures are in eliminating the hazards of split responsibilities between shore and ship. Navy-wide standard training of both shore and ship personnel is necessary to assure safety while connecting and disconnecting cables between a pier and a ship.

13-4.2 **Portable Power Cable and Outlet Safety Assurance**.

WARNING
Harsh waterfront environments provide salt spray, high humidity, and cold temperature conditions. All these result in more rapid deterioration of permanent installations. Portable power cables, if not adequately barricaded are subject to abuse from the wheels of vehicles used in industrial operations. Families welcoming Naval personnel home from the sea and even Naval personnel and contractor personnel working on piers have no understanding of the dangers from a damaged energized power cable which is installed in a position accessible to the public.

13-4.3 **Electrical Equipment Accessibility and Working Space**.

WARNING
Electrical equipment in underground vaults is not readily accessible and might not meet current NEC working space requirements.

13-4.3.1 **Readily Accessible**.

WARNING
The NEC defines ready accessible as capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, or other such devices. Therefore all workers in vaults must meet the confined space requirements of Section 3.

13-4.3.2 **Working Space**. The NEC defines working space as sufficient access provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment.

13-4.3.2.1 Working space in vaults has been provided in accordance with the NEC requirements applying at the time the vault was built.

13-4.3.2.2 As with all safety aspects affecting both the public and workers, safety requirements have become more rigorous over the years.

13-4.3.2.3 Although current NEC requirements do not apply to vaults built to previous NEC editions, the NEC current requirements should be compared by each activity with actual working space provisions.

13-4.3.2.4 Each activity should evaluate the comparisons as to their effect on workers safety and provide SOP's as necessary to assure safe working conditions.

13-4.4 **Ship's Electrical Power Input Safety**. Ship's electrical input cables must provide an ungrounded correctly phased, correctly-cable-oriented system providing an adequate number of power cables to serve the ship's load.

13-4.4.1 The ship's hull serves as the ground for the ship's electrical service. A ground connection between the shore ground and the ship's ground can result in damaging circulating currents.

13-4.4.2 Improper matching of phase rotation will result in the ship's motors operating in the wrong direction. Connecting two or more power cables to a ship requires that all the same phase cables be connected together.

13-4.4.3 The number of power cables should meet the ship's electrical officer's request that is based upon the ship's activity in port. When more than one feeder cable is required, all cables will be of the same length and size (within plus or minus 10 percent) to minimize unequal load distribution. Low-voltage receptacles have a power supply capability of 386 kVA.

Note: Per NEC Table 310-17, 75°C for 500 kcmil at 450 V for continuous service or 620 amperes x 450 V x 1.732 x 0.80 ÷ 1,000 = 386 kVA). Medium-voltage outlets have a power supply capability of 2075 kVA (minimum cable rating is 360 amperes or 360 amperes x 4,160 V x 1.732 x 0.80 ÷ 1,000 = 2,075 kVA).

13-4.5 **Parallel Operation**.

WARNING
Parallel operation of the ship and shore systems can be performed only in accordance with the following precautions.

13-4.5.1 Parallel operation of the ship generators and the shore power system is prohibited except for short periods of time to allow for load transfer to or from shore power. Transfer time should not exceed 10 seconds.

13-4.5.2 Paralleling shore transformers through the ship's electrical bus without prior activity approval is a violation of safety practices and can result in circulating currents, overheated cables, unbalanced loads, and excessive shore circuit current which could damage property and result in personal injury.

13-5 **SUPPORTING SHORE-TO-SHIP SAFETY REQUIREMENTS**. The previous sections cover the general electrical safety requirements for operating and maintaining shore electrical distribution systems. The unique power cable connection/disconnection operations for shore-to ship electrical power service requires specialized training and appropriate SOPs.

13-5.1 **Specialized Shore-to-Ship System Training**. Qualifying for this work requires training that addresses the operation, maintenance, and testing of the power cable/connector assemblies; the ability to connect cable extensions; and the understanding of cable phasing and paralleling checking methods. Workers should also be able to lay and protect cables on piers and to operate cable rigging devices at both the ship's cable access ports and at the cable storage areas. They should be familiar with operating the ungrounded electrical connection required to be compatible with the ship's electrical system. Workers should be qualified for working on and be familiar with the safety requirements for medium-voltage distribution systems supplying substations and electrical power outlet assemblies supplying shore-to-ship electrical power.

13-5.2 **Specific SOPs**.

Note: SOPs applying to this work should be based on requirements given herein as adjusted for the activity's operating procedures. The SOPs should address the following areas and be used in the day-to-day pre-job briefing.

13-5.2.1 **SOP Preparation Responsibility**. The activity responsible for shore-to-ship electrical service should prepare general SOPs with space for each individual organization requirement correctly filled in for each specific ship's service and for each service period. SOPs will be distributed to all personnel involved.

13-5.2.2 **Specific Organization Requirements**. The names of shore personnel and their responsibilities will be listed. The name of the ship and the docking location will be given. The ship's specific requirements as to the following will be noted.

- Voltage of the estimated ampere load requirements including supershore electrical power.
- Number of ship-to-shore power cables required.
- Type of cable terminations, in-line connections, jumpers, as required.
- Identification of any interface problems.
- Special paralleling requirements if any longer than 10 seconds for ship-to-shore paralleling or paralleling between shore transformers.

13-5.2.3 **Priorities**.

13-5.2.3.1 Determine if there are any unusual job hazards. Identify the power cable rigging device (boom trucks, cranes, fork lifts) as shown in Figure 13-16 and whether their location requires structural approval by a facility engineer of their proposed location. Verify that any construction work will not interfere with power cable placing and rigging. Determine special safety provisions.

Figure 13-16. Cable Being Reeled by a Boom Truck.

13-5.2.3.2 Power cable protection might require barricades to protect them from damage as shown in Figure 13-17. Contractor work might require crossing power cables with vehicular equipment of sufficient weight to cause cable damage. Welcoming crowds at a ship's homecoming might require crowd control from security forces to maintain safe approach distances. Identification of cable voltage and other appropriate safety hazard information should be provided on all cables in conformance with activity requirements.

Figure 13-17. Cable Protection Safety Barricades

13-5.2.3.3 If there is any possibility that pier vault access is required, emergency rescue equipment will be readily available.

13-5.2.4 **Normal Procedures**. List purpose of the SOP, potential energy sources, tools and personal protective equipment, references to other SOPs, this manual's sections, and OSHA sections and procedures, as applicable. The procedures can be broken down into individual SOPs such as the following activities.

- Reel truck operation.
- Boom truck operation.
- Moving power cables on pier.
- Setting up berths for shore electrical power.
- 480-volt ship connect.
- 480-volt ship disconnect.
- 4160-volt ship connect.
- 4160-volt ship disconnect.

- Shore power location of accidental grounds on ship's service electrical power called in by ships.
- Remote operation of shore circuit breakers from the pier electrical outlet assembly.
- Shore power cable assembly.
- Operating camlock vulcanizers.

13-5.2.5 **Emergency Procedures**. Emergency procedures should be set up for mishap reporting and summoning medical aid. Foul weather conditions requiring changes to normal procedures will be covered.

13-6 **PORTABLE SHORE POWER CABLES AND RECEPTACLES**. Portable shore power cables and receptacles conform to specific specification requirements.

13-6.1 **Low-Voltage (480-Volt) Power Cable Specification**. Cable will be three conductor, flexible, unshielded, 600-volt, type THOF-500 kcmil complying with MIL-C-915, *Cable and Cord Electrical, for Shipboard Use*, for 450-volt three-phase, 60-hertz ungrounded ship's service power (order number THOF-500-NSN 6154-01-008-4568). Single-conductor cables can be used at some installations but is not recommended.

13-6.2 **Medium-Voltage (4,160-Volt) Power Cable Specification**. Cable will be three conductor, 8000-volt with an overall ethylene propylene jacket designed for continuous flexing service and operation in severe environments. Cable should be similar to SHD-GC commercial mining cable without the ground or ground-check conductors. Comply with NEMA WC-8 (ICEA S-68-516), *Ethylene-Propylene-Rubber-Insulated Cable for the Transmission and Distribution of Electrical Energy*. Cable will be rated for at least 360 amperes.

13-6.3 **Power Cable-in-Use Insulation Resistance Values**.

WARNING
Test the insulation resistance of each cable before each use.

13-6.3.1 **Shore Criteria for Cable Assemblies**. Cables having insulation readings below 1 megohm for 480-volt service cables and 5 megohms for 4,160-volt service cables will not be placed in service. Shop testing and repair will be initiated for cable not meeting these requirements.

13-6.3.2 **Ship Criteria for 480-Volt Power Cable**. Ship's service voltage is a 480-volt system using 600-volt cable. Insulation resistance should not be less than 280 megohms per meter (920 megohms per foot) in warm ambient temperature or 1,676 megohms per meter (5,500 megohms per foot) in cold ambient temperature. A warm ambient temperature is defined as a climate or a condition in which the entire cable is in

a heated space and not in contact with the ship's hull. A cold ambient temperature is defined as a cold climate or a condition in which most of the cable is in an unheated space or in contact with the ship's hull.

13-6.3.3 **Explanation of Criteria Differences**. The shore criteria is based on a cable assembly of 38 meters (125 feet) plus or minus 7.6 meters (25 feet).

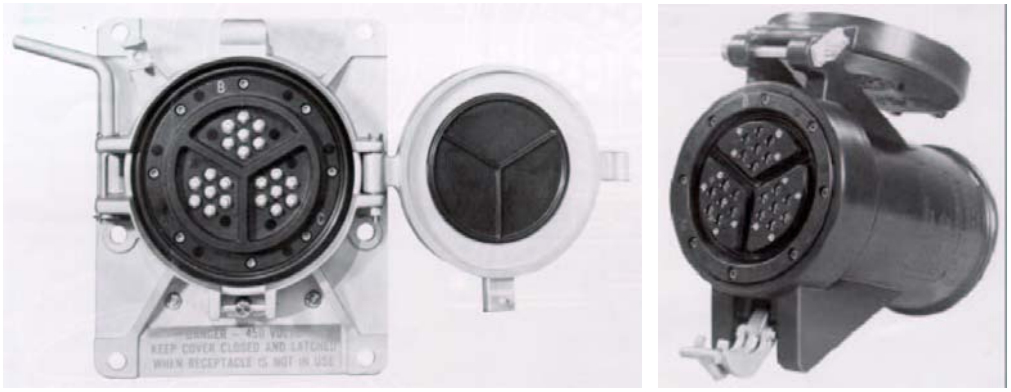
13-6.4 **Low-Voltage Receptacles, Plugs, and Protective Circuit Breakers**. The system provides a 480-volt, three-phase, three-wire, ungrounded 60-hertz source to the ship.

13-6.4.1 **Shipboard Connections**. Generally use a MIL-C-24368, *Connector Assemblies, Plug Assembly, Power Transfers, Shore-to-Ship and Ship-to-Ship*, Type 1 connector (plug) in accordance with DOD-STD-1399, *Interface Standard for Shipboard Systems, Section 300, Electrical Power Alternating Current*, Figure E15 except as follows.

- Portable shore power cable jumper supplied by the ship where piers do not have MIL-C-24368, Type 2 receptacle and plug assemblies.
- Cables serving submarines will have MIL-C-24368, Type 5 outboard plug connection permanently attached to the shipboard end.
- In-line connection (used only where operationally necessary) can be single-pole connectors (MIL-C-24368 type 4) or three-pole connectors (Cage 90129 male and female).

13-6.4.2 **Pier Low-Voltage (480-Volt) Electrical Outlet Assemblies**. The assembly utilizes a MIL-C-24368, Type 1 three-pole 500-ampere 480-volt receptacle with matching plug or single-pole panel mount type female connectors with mating in-line type male connectors. Details of units are shown on NAVSEA Electric Plant Installation Standard Methods (EPISM) Section 2, Group E, sheets 13 through 19 with sheets 14 and 15 determining shore power phase rotation. Refer to Figure 13-18.

Figure 13-18. Low-Voltage (480-Volt) Shore Receptacle



13-6.4.3 **Low-Voltage (480-Volt) Receptacle Protective Circuit Breakers**. These low-voltage, metal-enclosed drawout type power circuit breakers are air-magnetic, electrically operated, with 120-volt ac close, 48-volt dc trip or 120-volt ac trip, and have current limiting fuses. For installations utilizing MIL-C-24368 receptacles/plugs, Circuit breakers are interlocked with their associated receptacles so that the circuit breaker will trip automatically if an attempt is made to remove the assembly plug or open the receptacle cover and a remote close/trip of the circuit breaker is provided at the receptacle assembly.

13-6.5 **Medium-Voltage (4,160-Volt) Receptacles, Plugs, and Protective Circuit Breakers**. The system providers a 4,160-volt, three-phase, three-wire, ungrounded, 60-hertz source.

13-6.5.1 **Shipboard Connection**. Generally use a MIL-E-16366, *Terminal, Electrical Lug and Connector Splices, Crimp Style*, two-hole bolted lug type terminals.

13-6.5.2 **Pier Medium-Voltage (4,160-Volt) Electrical Outlet Assemblies**. The assembly utilizes a three pole, 500-ampere, 4,160-volt receptacle with a matching plug. Units have the Mine Health Safety Administration approval, are provided with a safety interlock, and have been modified to remove a ground cable connector. Refer to Figure 13-19.

Figure 13-19. Medium-Voltage Shore Receptacle

13-6.5.3 **Medium-Voltage, (4,160-Volt) Receptacle Protective Circuit Breakers**. These medium-voltage, 4,160-volt, air or vacuum type, circuit breakers have a long time trip set at 400 amperes and are key-interlocked with their associated receptacles to prevent insertion/removal of the receptacle connector unless the circuit breaker is open.

13-7 **SHIP CONNECTION PROCEDURES BEFORE SHIP DOCKS**. A Logistics Requirement (LOGREQ) message, which describes power and general berthing requirements, will normally be received from the arriving ship prior to entering port. This information, in conjunction with the berthing assignment received from Waterfront Operations, will allow the Shore-to-Ship Group to prepare the berth prior to the ship's arrival.

13-7.1 **Laying, Inspecting, and Testing Power Cable Assemblies**. Power cables should be removed from shore storage and transported to the pier where the ship will dock. Qualified personnel should proceed as follows for each cable assembly connection.

13-7.1.1 **Laying Power Cable Assemblies**. This procedure involves moving the power cables from the storage place to where it is laid out on the pier.

13-7.1.1.1 The only vehicles authorized to drag power cables on the piers are a shop mule, a line truck, a reel truck, or a boom truck. Operators should have a valid state commercial drivers license (CDL), should have a current medical examination, and should be physically and mentally fit to operate the vehicle. In addition, boom truck operators should have a valid category 4 crane operator's license.

13-7.1.1.2 Use vehicle in accordance with SOP.

13-7.1.1.3 Check pier area for obstructions that may prevent the shore power set up. If obstacles are present contact your work leader or foreman to inform them of the problem.

13-7.1.1.4 Place vehicle in position. Whenever possible, use a second person when backing up or placing in tight space.

13-7.1.1.5 Whenever loading or unloading the operator should ensure:

- The vehicle is operated safely in accordance with training procedures.
- Barriers are set to proper distance.
- Wheel chocks are placed down.
- Sets of cables are connected together.
- No unauthorized persons are in the area that may be struck from swinging or falling cable.
- For boom trucks, outriggers are not blocked by any obstructions and are not set on top of vault covers, steam covers, or manholes. The boom should not swing forward of the outriggers.

- For reel trucks, place stabilizer jacks.

13-7.1.2 **Moving Power Cable Assemblies on Pier**. Be sure each set of power cables is dragged as a unit.

13-7.1.2.1 Cables should not be permitted to lay on sharp or ragged objects such as gunwales. Sharp bends should be avoided. The cables should lay in wooden saddles or be wrapped in canvas. Splices and connectors should be raised from the deck or pier for protection against water contamination. Ensure cables are of sufficient length to allow enough slack for the rise and fall of the tide, but not of sufficient length to permit them to dip into the water or become wedged between the ship and pier.

13-7.1.2.2 Lay out the cables between the supplying shore power outlet and the ship's cable port. Lay out excess cable in a manner so as to minimize damage and abuse from vehicle and pedestrian movement.

13-7.1.2.3 Never use feet to hold the cable in place as this may result in a foot or leg injury.

13-7.1.2.4 Keep vehicles off cable.

13-7.1.2.5 Ensure cables are of proper length and visually appear to be arranged neatly and safely.

13-7.1.2.6 Ensure ends of cables are not connected to any shore or vehicle device.

13-7.1.3 **Inspecting and Testing Power Cable Assemblies**.

WARNING
Connecting, energizing, and testing shore power cable assemblies should be under the direct supervision of the ship's electrical officer, a qualified leading electrician's mate, and shore activity personnel.

13-7.1.3.1 Test shore power cable assemblies with voltage tester to ensure cables are deenergized prior to handling.

13-7.1.3.2 Lay out and visually inspect shore power cable assemblies for any sign of defects such a cracks, bulges, or indications of overheating. Inspect cable sheath for cuts, nicks, and gouges. When required, strip insulation from any existing cable splice(s) and inspect for cleanliness, tightness, and good surface contact. Repair all defects and reinsulate. When required, splice and insulate 3 meters (10 feet) of cable length with a plug to each cable of a shore power cable assembly.

13-7.1.3.3 Open shore power cable assembly covers. Clean covers and cable plugs. Inspect cover gaskets for cuts, tears, cracks, and deformation. Inspect each plug conducting surface for pitting, corrosion, and evidence of overheating. Inspect cable

connectors for pitting, corrosion, and evidence of overheating. Apply a light coat of approved grease to cable connectors.

13-7.1.3.4 Use a megohmeter to measure the insulation resistance between cable assembly conductors and each conductor and ground. A 500-volt megohmeter can be used for 450-volt cables but a 5,000-volt megohmeter should be used for 4,160-volt cables. Record insulation resistance values. Record lowest acceptable value on ship connect/disconnect form. If the cable does not meet insulation resistance requirements (refer to section 15.6.3), it should be replaced. Initiate shop testing and repair for such cables.

13-7.1.3.5 Use the megohmeter to verify phase identification markings of the cable assembly to ensure proper orientation.

13-7.1.3.6 Tag shore power cable assembly with "DANGER-HIGH VOLTAGE" signs. Barricade the work area surrounding the ship's shore power receptacles. Hang plugs on the pier electrical outlet assembly to which they will be connected.

13-7.2 **Checking Shore Receptacles**.

WARNING
Tag out shore power receptacle circuit breakers in accordance with below listed tag out procedures or local activity prepared procedures. Disconnect equipment such as meters or indicating lights that could be damaged by a megohmeter test or cause a false reading.

13-7.2.1 Remove indicator light and phase meter fuses. Ensure multimeter is in proper operating condition by testing the meter on a known energized source before testing shore receptacle power terminals.

13-7.2.2 Open access cover to each shore power receptacle and use a multimeter to test terminals in each shore power receptacle to ensure that they are deenergized. Clean each cover and receptacle. Inspect each cover gasket and each receptacle gasket for cuts, tears, cracks, and deformation. Inspect each receptacle conducting surface for pitting, corrosion, and evidence of overheating. Operate each receptacle interlock switch manually; movement should be smooth with no binding or sticking.

13-7.2.3 Use a suitable megohmeter and test the insulation resistance between each receptacle terminal and between each terminal and ground. Minimum insulation resistance is one megohm for 480-volt receptacles and 5 megohms for 4,160-volt receptacles. Reinstall indicator light and phase meter fuses. Close shore power receptacle access covers. Remove "DANGER" from shore power circuit breakers and receptacle circuit breakers and replace with "CAUTION" tags in accordance with tag out procedures. Indicate on 'CAUTION" tags that if shore receptacle power interlock and/or power control power transformer fuses are removed or blown, shore receptacle power

cover safety interlock will be inoperative and warn that high voltage will be present if interlock fails.

13-7.2.4 Test shore power receptacle cover interlock switches and indicator lights as follows:

13-7.2.4.1 Close shore power receptacle circuit breakers.

13-7.2.4.2 Shore power receptacles should be energized.

13-7.2.4.3 Ensure indicating lights are illuminated.

13-7.2.4.4 Open shore power receptacle access cover; receptacle circuit breaker should trip and indicating light should extinguish.

13-7.2.4.5 Use an approved potential difference tester and ensure it is in proper operating condition by checking the tester on a known energized source before testing shore power receptacle terminals.

13-7.2.4.6 Test shore power receptacle with the tester to ensure it has been deenergized.

13-7.2.4.7 Close shore power receptacle access cover.

13-7.2.4.8 Open shore power receptacle circuit breakers.

13-7.2.4.9 Remove “CAUTION” tags and attach “DANGER” tags to shore power circuit breakers in accordance with tag out procedures.

13-7.3 **Inserting Cable Plugs Into Receptacles**.

WARNING
Connections are to be made from the ship’s electric bus toward the shore power receptacle. When distance from ship’s electric bus to the shore power receptacle requires splicing of two or more cables, splicing should be completed prior to making any ship or shore power receptacle connections.

13-7.3.1 Use an approved potential difference tester and ensure it is in proper operating condition by testing the meter on a known energized source before testing shore power receptacle terminals.

13-7.3.2 Open shore power receptacle access covers.

13-7.3.3 Use the tester to test the terminals in shore power receptacles to ensure they are deenergized.

13-7.3.4 Insert shore power cable plugs into the shore power receptacle.

13-8 **SHORE-TO-SHIP POWER CABLE RIGGING AFTER SHIP DOCKS**. Upon ship's arrival contact ship's electrical officer, determine cable connection time, provide necessary personnel, and receive ship connect/disconnect form.

13-8.1 Check all cable assemblies for proper phase rotation.

13-8.2 Check all cable assemblies for proper cable orientation.

13-8.3 Check all cables to ensure they are still deenergized.

13-8.4 Load cable assemblies from shore to ship for extension by ship's personnel to ship's electrical bus connection.

13-8.5 The ship's electrical officer should give permission to shore personnel that shore personnel are to energize shore power at a stated time. At that time after checking that electrical power is supplied to the ship's electrical bus the ship's electrical officer will transfer the ship's electrical load within 10 seconds of shore power input.

13-9 **SHIP'S TRANSFER TO SHORE POWER**.

WARNING
After the ship has notified that transfer has been completed, the "DANGER" tags will be removed and necessary forms filled out and signed. During the times cables are energized they are prohibited from being moved.

13-10 **SHIP'S TRANSFER BACK TO THE SHIP'S GENERATOR**.

WARNING
Deenergizing and disconnecting shore power cable assemblies should be performed under the direct supervision of the ship's electrical officer, a qualified leading electrician's mate, and shore activity personnel.

13-10.1 The ship's electrical officer should give permission to shut down shore power at a stated time after the ship's generators have been started, synchronized, and have assumed the electrical load. Paralleling of ship's generators and shore power should be limited to 10 seconds or less.

13-10.2 The ship's electrical officer should receive notification that all shore power receptacle circuit breakers are open and that "DANGER" tags have been attached on shore power receptacle circuit breakers in accordance with tag out procedures.

13-11 SHORE DISCONNECTION OF CABLE PLUGS AND REMOVAL OF CABLE ASSEMBLIES.

WARNING
Ensure shore power receptacle circuit breakers are open and tagged, shore power energized indicting lights are extinguished, and shore power cable assemblies disconnected at the source.

13-11.1 Disconnect cable assemblies by removing plugs from shore power receptacles.

13-11.2 Close shore power receptacle access covers.

13-11.3 Remove “DANGER” signs.

13-11.4 Lower cable assemblies from the ship onto the pier and reel for shipment to the cable storage area.

13-11.5 Notify the ship that all connections have been removed and necessary forms signed and filled out.

CHAPTER 14

ELECTRICAL WORKER RESCUE

14-1 **RESCUE TRAINING**. Rescues must be accomplished in a manner that provides the best first aid treatment for the victim without endangering workers involved in the rescue operation. Special rescue methods are needed for unconscious or injured workers on poles or in manholes. All workers engaged in electrical work must receive training in resuscitation, and in methods of rescue from poles, structures, manholes, aerial baskets, confined spaces, and other field work areas present on the facility. This chapter provides guidance on pole-top rescue and manhole rescue methods. Rescue operations may vary, depending upon the prevailing situation. Preplanning and training for a possible emergency is important. Size up the situation. The rescue effort can be far more effective if a few seconds are devoted to full identification of the situation. Always try to get the power turned off, deenergize the lines if at all possible, and as soon as possible.

14-2 **POLE-TOP RESCUE.** Artificial respiration can be applied to an unconscious victim on a pole. CPR may not be effective and must not be tried. If CPR is required, the victim must be lowered as quickly as possible, and then CPR administered. If no aerial lift devices are available for rescue, the following procedures must be followed:

14-2.1 Get help. Call or assign someone to call the local emergency medical service (EMS) or fire department.

14-2.2 Climb to rescue. Climb the pole and free the victim from the energized line if necessary. Take great care to ensure that the rescuer is not also electrocuted. If CPR is not required, mouth-to-mouth resuscitation can be attempted before lowering the injured worker to the ground. If necessary, the best position for the rescuer is slightly above the victim. When the victim begins breathing naturally, keep the victim in position and under control until additional help is available for lowering the victim to the ground, using rope rigging if possible. Refer to Figures 14-1 and 14-2 for pole rescue illustrations.

14-2.3 Lower the victim from the pole. When CPR is necessary, the rescuer must lower the victim to the ground to begin CPR. CPR might not be effective on the pole.

14-2.3.1 Take a position below the victim on the pole and place your safety strap around the pole. Then climb up the pole with the victim's legs straddling your safety strap, and with the victim's body between you and the pole. When the your safety strap is sufficiently high the victim's weight can then be taken on the your safety strap. Do not unfasten the victim's safety strap. Refer to Figure 14-1.

14-2.3.2 Use a handline to lower the victim for either one or two rescuers.

14-2.3.3 If not already done, help must be summoned by whatever means are available without delaying the CPR. Commence CPR and continue until relieved by EMS personnel.

Figure 14-1. Position to Support Victim's Body Weight

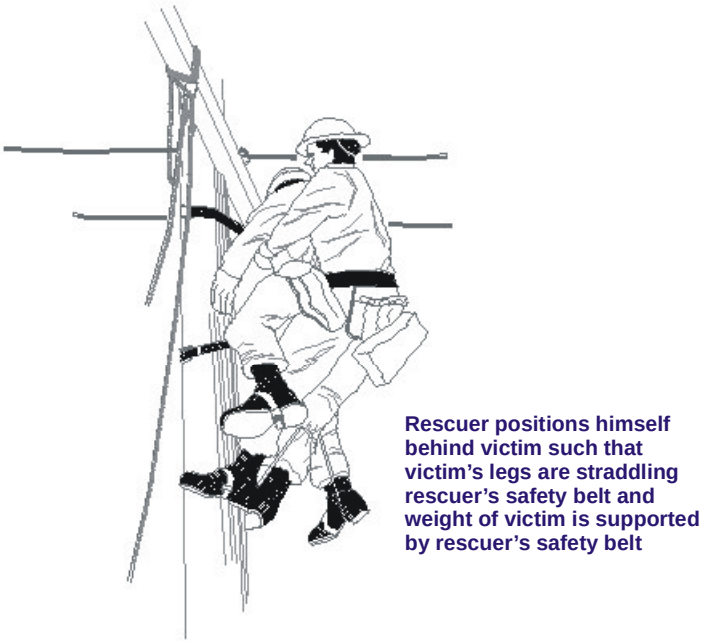
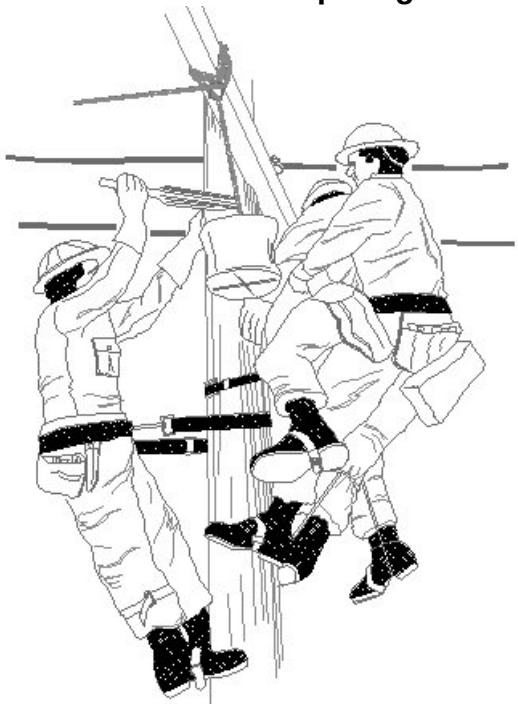


Figure 14-2. Two Rescuers Preparing to Lower Victim



14-3 **RESCUE FROM A MANHOLE**. Rescue from a manhole becomes necessary when workers in a manhole are overcome by gas or otherwise injured. Workers engaged in rescue attempts must protect themselves. In cases of asphyxiation or gas

poisoning it is advisable to ventilate with a blower or wind sail while preparing for the rescue.

Note: All manholes must be evaluated and classified to determine if they must be classified as a permit required confined space. If the space meets the requirements of a permit required space, entry must occur under a confined space permit system.

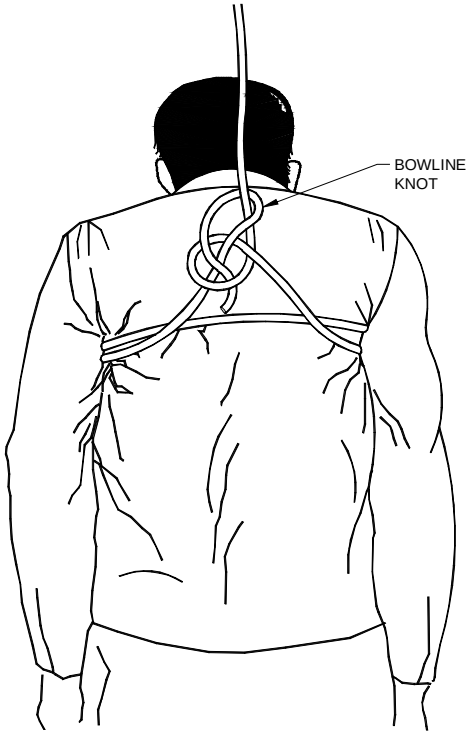
14-3.1 Get help. Call or assign someone to call the local emergency medical service (EMS) or fire department.

14-3.2 Observe all measures of safety. If at all possible, there must be another worker present to help with the rescue before you go into the manhole. If no other worker is available, you may proceed with the rescue only in cases where asphyxiation or gas poisoning can be definitely ruled out. If atmospheric hazards cannot be ruled out by atmospheric monitoring, a worker must not assume the manhole is safe for entry. If in doubt, obtain help by contacting the local rescue team (normally the installation fire department), before starting the rescue. Organizational rescue teams may be used only if rescue personnel are trained on all required equipment to include appropriate PPE, including respiratory protection equipment necessary for entry into confined spaces, and with rescue and retrieval equipment suitable for the type of confined space involved.

14-3.3 There are many ways in which a rescue can be accomplished. Two methods are described here, commonly described as the Windlass System (One-Worker) Rescue and the Two-Worker Manual Rescue.

14-3.4 Both rescue methods use a rescue rope. The rescue rope must be wrapped twice around the body under the arms of the victim. Tie the rope with a bowline at the back of the body for the Two-Worker Manual Rescue (shown in Figure 14-3) or at the front of the body for the Windlass System (One-Worker) Rescue.

Figure 14-3. Bowline Position for Two-Worker Manual Rescue from a Manhole



14-3.5 The Windlass System (One-Worker) Rescue is the best method for both the victim and the rescuer. It is the preferred method, unless time is of the essence. With this method one worker can perform the rescue, and even the smallest individuals can rescue a large victim.

14-3.5.1 This method depends on the use of a manhole guard. Therefore, you must use a manhole guard anytime manhole work is done. Install winch on the top of the guard. Use the rescue rope or retractable lanyard only if a rescue is needed.

14-3.5.2 If two rescuers are available, tie a rope around the rescuer entering the manhole. This is a safety precaution in case the rescuer collapses upon entering the manhole.

14-3.5.3 After entering the manhole, wrap the rope around the victim with a bowline knot in front of the victim (similar to Figure 14-3, except place the bowline knot in front of the victim). This allows the head to lean back, keeping the air passage open.

14-3.5.4 Use the windlass to raise the victim until the victim's buttocks clear the manhole rim.

14-3.5.5 Position the victim with the victim's back toward the opening of the manhole guard.

14-3.5.6 Tip the manhole guard so the victim is lying face up.

14-3.5.7 Commence CPR, if necessary, and continue until relieved by EMS personnel.

14-3.6 The Two-Worker Manual Rescue method is usually the fastest if a second worker is available. It might be the only feasible method if a windlass system was not already installed.

14-3.6.1 The rescuers must have two ropes. One must be tied around the rescuer entering the manhole. This is a safety precaution in case the rescuer collapses upon entering the manhole. The second rope is tied around the victim as shown in Figure 14-3. The two rescuers work together to lift and push the victim out of the manhole.

14-3.6.2 The rescue rope must be at least 13 millimeters (one-half inch) in diameter. The length of the rescue rope must be at least the depth of the manhole plus 4.5 meters (15 feet).

14-3.6.3 Once the victim is out of the manhole, lay the victim face up. Commence CPR, if necessary, and continue until relieved by EMS personnel.

14-4 **ELECTRICAL SHOCK**. Electric shock is an ever-present hazard for electrical workers. An alternating current of a few tenths of an ampere can be fatal if it passes through vital organs. The average current at which muscle control is lost and release from an electrified object is not possible is only about 10 to 16 milliamperes. Workers must understand possible electric shock effects, the necessity to quickly free victims, and also be properly trained to provide resuscitation and rescue.

14-4.1 **Effects**. Electricity acting on the human body can result in the following conditions:

14-4.1.1 **Burns**. Electric current passing through the body or the actions of electric arcs contacting the body can cause surface and interior burns.

14-4.1.2 **Cessation of Respiration and Heartbeat**. An electric shock might paralyze the area of the brain controlling respiration (asphyxia). The natural rhythms of the heart may be disturbed with ceasing of circulation and disappearance of the pulse (ventricular fibrillation). Muscle spasm action on the muscles of respiration can interfere with breathing. An automatic external defibrillator (AED) should be available at the work site whenever there is the possibility of a severe electrical shock.

WARNING

A delay of several minutes before AED application can worsen the outcome from prolonged ventricular fibrillation. One estimate is that each minute's delay reduces survival likelihood by 10 percent. For this reason, the AED must be readily accessible in order to be effective.

14-4.2 **Freeing the Victim**. Muscle spasms might have thrown the victim clear of the electrical contact, but in many low-voltage contacts the victim may still be touching live equipment. Quickly release the victim from the current, being very careful to avoid receiving a shock. Use a nonconductor such as rubber gloves, clothing, wood, or rope to remove either the victim or the conductor. Beware of any hidden metal or moisture. If both of the victim's hands are grasping energized conductors, try to free one hand at a time.

14-4.3 **Training**.

14-4.3.1 Electrical workers must receive periodic special training in resuscitation techniques, since a common result of electrical shock is failure of some part of the nervous system which controls breathing. Proper use of an AED is an important part of this training.

14-4.3.2 Electrical workers must also be periodically trained in rescuing unconscious shock victims from locations such as poles and underground structures.

CHAPTER 15

UNUSUAL HAZARDS FOR ELECTRICAL WORKERS

15-1 POISONOUS AND NON-POISONOUS SNAKEBITES.

15-1.1 Take a snakebite victim to a hospital as quickly as possible, even in cases when only a nonpoisonous snakebite is suspected. All snakebites must receive professional medical attention.

15-1.2 Provide the following first aid:

15-1.2.1 Keep the victim from moving around.

15-1.2.2 Keep the victim as calm as possible, preferably lying down.

15-1.2.3 Immobilize the bitten extremity and keep it at or below heart level.

15-1.2.4 Take precautions for shock.

15-1.2.5 If breathing stops, give mouth-to-mouth resuscitation. If breathing stops and there is no pulse, perform cardiopulmonary resuscitation (CPR).

15-1.2.6 The bitten area may be washed with soap and water and blotted dry with sterile gauze. Dressings and bandages can be applied, but only for a short period of time.

15-1.2.7 Do not apply cold compresses ice, dry ice, chemical ice packs, spray refrigerants, and other methods of cold therapy in the first aid treatment of snakebites.

15-1.2.8 Do not give alcohol, sedatives, aspirin, or other aspirin-containing medications. Over the counter pain medications not containing aspirin can be given to the victim for relief of pain.

15-1.2.9 Do not apply a tourniquet, administer electric shock, or cut the wound.

15-1.2.10 Use a snakebite kit if one is available. Use only suction-type devices that extract the venom through the fang puncture wounds. Do not use the older-style snake bite kits that require cutting the skin around the wounds. Only qualified emergency medical personnel must use these older-style kits.

15-1.3 Identify the Snake. If the snake can be killed without risk or delay, it must be brought, with care, to the hospital for identification.

15-1.4 Symptoms of snakebite may range from mild to severe.

15-1.4.1 Mild to moderate symptoms include mild swelling or discoloration and mild to moderate pain at the wound site with tingling sensations, a rapid pulse, weakness, dimness of vision, nausea, vomiting, and shortness of breath.

15-1.4.2 Severe symptoms include rapid swelling and numbness, followed by severe pain at the wound site. Other effects include pinpoint pupils, twitching, slurred speech, shock, convulsions, paralysis, unconsciousness, and no breathing or pulse.

15-2 **NONPOISONOUS INSECT BITES**.

15-2.1 There are a variety of insects that have biting or stinging mouthparts that may inject toxic materials into the skin.

15-2.2 These insect bites are usually of minor medical importance, causing temporary pain, irritation, and general discomfort. However, infection may develop if the wound is not properly cared for. Be aware that some people develop a severe allergic reaction to an insect sting that can be life threatening.

15-2.3 If a tick bite is suspected, and a rash or flu-like symptoms develop, consult a physician.

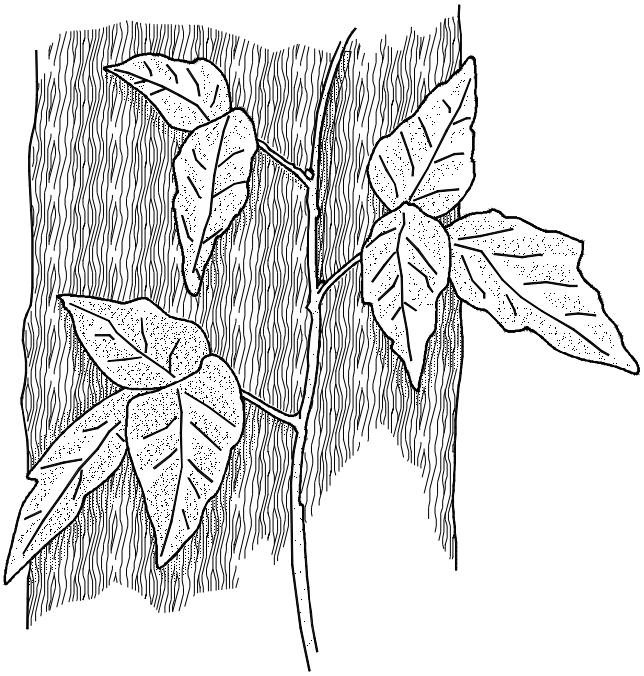
15-2.4 Workers known to be particularly allergic to any insect venom (anaphylaxis) must be seen by a physician without delay. Such workers must carry an anaphylaxis kit (available by prescription only), if they are aware of this condition.

15-3 **POISONOUS PLANTS.** Learn to recognize and avoid poisonous plants, such as poison ivy, poison oak, and poison sumac. Poison can be absorbed through the skin if the worker contacts poisonous plants.

15-3.1 **Poison Ivy**. A climbing vine, shrub or small tree. Poison ivy grows on poles, trees, along fence rows, shores of streams, rivers, and lakes, along the borders of woods, and openings in the woods. Leaves always grow in groups of three. Leaf size varies from less than a half inch to over two inches long. Leaves are reddish when new in the spring, green during the summer, and various shades of yellow, orange, or red in the fall. Leaves are oval, pointed, glossy, and lobed or toothed. Flowers are greenish-white and clustered in the axils of leaves. Fruits are whitish green to yellow, clustered, round, and waxy. Refer to Figures 15-1 and 15-2.

Figure 15-1. Poison Ivy

POISON IVY
(TOXICODENDRON RADICANS)



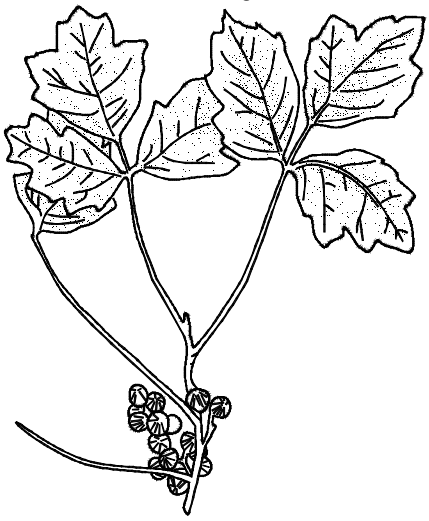
DISTRIBUTION: ALL CONUS.
GROWS IN THICKETS AND ALONG FENCES
OFTEN ASCENDING IN HIGH TREES.

Figure 15-2. Poison Ivy Photographs

15-3.2 **Poison Oak**. Western poison oak grows a twining vine on tree trunks or as erect shrub up to 1.8 meters (6-feet) high. Eastern poison oak grows only as low branching shrub, up to 1 meter (3-feet) high. Leaves are always found in groups of three, irregularly lobed, toothed or sinuate-margined. Flowers are greenish-white and clustered in the axils of leaves. Fruits are berry-like, whitish or brownish, and smooth or covered with short hairs. Refer to Figure 15.3.

Figure 15-3. Poison Oak

POISON OAK
(TOXICODENDRON DIVERSILOBUM &
TOXICONDENDRON QUERCIFOLIUM)



DISTRIBUTION: US SOUTHEAST AND WEST COAST
GROWS IN DRY WOODLANDS AND OPEN PLACES.

15-3.3 **Poison Sumac.** Poison sumac is a tall shrub or small tree, up to 7.5 meters (25 feet) high with a trunk diameter up to 6-inches. Leaf groups are 15 to 38 centimeters (6 to 15 inches) long with 6-13 leaflets arranged in pairs, and an additional single leaflet at the end of the midrib. Flowers are small yellowish green, borne in clusters in the axils of leaves. Fruits are clusters of small berries, gray, smooth, and mature into whitish green groups almost two inches long. The male and female flowers of poison sumac are on separate plants, as in poison ivy and western poison oak. Although nonpoisonous sumac species have leaves similar to those of poison sumac, the nonpoisonous species have red fruits that form distinctive, erect, cone-shaped terminal heads, not the hanging whitish green fruits of poison sumac.

Figure 15-4. Poison Sumac
POISON SUMAC
(TOXICODENDRON VERNIX)

DISTRIBUTION: US MIDWEST TO EAST COAST.
GROWS IN SWAMPS.

Figure 15-5. Poison Sumac Photographs

15-3.4 **Prevention and Recommended Actions**.

15-3.4.1 Shirts with full-length sleeves must be worn, with the sleeves rolled down and buttoned, if working in areas where poisonous plants might be found. Trouser cuffs must be fastened around the ankles. All exposed areas of the skin must have a film of approved protective ointment applied as a preventive measure.

15-3.4.2 Avoid breathing or contacting smoke of burning brush that may contain any poison plants. Severe cases have occurred from sap-coated soot in the smoke of burning plants.

15-3.4.3 The poisonous sap is released when the plant is bruised, making it easier to contact in the spring and early summer when leaves are tender. Sap may be deposited on the skin by direct contact with the plant or by contact with contaminated objects, such as shoes, clothing, tools and animals. Recommend such clothing be turned inside out as removed to minimize possible infection from bruised poisonous plants. Take

care also when laundering clothing that has contacted poisonous plants. Care must be used in cleaning contaminated clothing to avoid re-infection.

15-3.4.4 Symptoms are most commonly observed within 12 to 24 hours after contact, although they may appear within a few hours or be delayed several days. Symptoms can include a red rash, inflammation, swelling, and blisters. The rash spreads by the poisonous sap, not as the result of contamination from sores.

15-3.4.5 If you suspect you have had any contact with a poisonous plant, start treatment to avoid more severe symptoms.

15-3.4.5.1 Skin absorbs the poison in the sap within the first three minutes. Dermatitis cannot be prevented without medical treatment. Wash the affected skin area as soon as possible with water to minimize the severity of the rash and prevent the spread of the sap to uninfected parts of the body. Soap and water are superior to water alone in removing the sap, but soap also removes a natural protective layer that helps keep the poison from being absorbed through the skin.

15-3.4.5.2 Apply an approved medicated ointment to the affected area to reduce discomfort.

15-3.4.5.3 Avoid scratching the affected area.

15-3.4.5.4 In severe cases, obtain medical attention.

15-4 **GAS POISONING.** Gas poisoning is a particular danger when working in below grade structures.

15-4.1 A rescuer must not enter a gas-filled area without appropriate precautions.

15-4.2 When gas, or lack of oxygen overcomes a person, quickly move the victim to fresh air. However, be aware that many victims have emerged from a warm gas-filled space into the outside cold air only to collapse.

15-4.3 Take precautions to keep the victim warm until medical assistance is provided. If the victim is not breathing, or is breathing weakly, apply artificial respiration as needed.

GLOSSARY

Abbreviations and Acronyms:

ac—Alternating Current

AED—Automatic External Defibrillator

AFA—Forced-Air Cooled Transformer

AFCESA—Air Force Civil Engineer Support Agency

AFI—Air Force Instruction

AFJMAN—Air Force Joint Manual

AFMAN—Air Force Manual

AFOSH—Air Force Occupational and Environmental Safety, Fire Prevention, and Health

AFPAM—Air Force Pamphlet

AFSC— Air Force Specialty Code

AHJ—Authority Having Jurisdiction

ANSI—American National Standards Institute

ASTM—American Society for Testing and Materials

ATS—Automatic Transfer Switch

AWG—American Wire Gauge

BCE—Base Civil Engineer

BIL—Basic Impulse Insulation Level

CDL—Commercial Drivers License

CFR—Code of Federal Regulations

CPR—Cardiopulmonary Resuscitation

CT—Current Transformer

dB—Decibel

dc—Direct Current

DoD—Department of Defense

EI—Engineering Instruction

ELF—Extremely Low Frequency

EM—Electromagnetic

EMCS—Energy Management and Control System

EMF—Electromagnetic Field

EMS—Emergency Medical Service

EO—Electrical Officer

EPA—Environmental Protection Agency

ER—Engineering Regulation

ES—Electrical Supervisor

ETL—Engineering Technical Letter

IEC—International Electrotechnical Commission

FPN—NEC Fine Print Note

FR—Flame Resistant

FRP—Fiberglass-Reinforced Plastic

ft—Feet

GFCI—Ground Fault Circuit Interrupter

GFP—Ground Fault Protection

HQ—Headquarters

HVAC—Heating, Ventilating, and Cooling

hp—Horsepower

Hz—Hertz

I^2R—Resistive Heat Loss

I—Amperes

ICEA—Insulated Cable Engineers Association

IEEE—Institute of Electrical and Electronics Engineers

IESNA—Illuminating Engineering Society of North America

IMC—Intermediate Metal Conduit

in—inch

JHA—Job Hazard Analysis

JSA—Job Safety Analysis

kg—Kilogram

kW—Kilowatts

kWh—Kilowatt Hours

kV—Kilovolts

kVA—Kilovolt-Amperes

kVAR—Kilovolt-Amperes Reactive

lb—Pound

LEL—Lower Explosive Level

LVPB—Low-Voltage Power Breaker

MAJCOM—Major Command

MCC—Motor Control Center

MCCB—Molded Case Circuit Breaker

MCOV—Maximum Continuous Overvoltage Rating

MCP—Military Construction Program

MCP—Motor Circuit Protector

MDF—Main Distribution Frame

mG—Milligauss

MI—Mineral Insulated

MIL HDBK—Military Handbook

mm—Millimeter

MOV—Metal Oxide Varistor

MSDS—Material Safety Data Sheet

MTS—Maintenance Testing Specifications

MVA—Megavolts-Ampere

NAVFAC—Naval Facilities

NAVOSH— Navy Occupational Safety and Health

NEC—National Electrical Code

NECA—National Electrical Contractors Association

NEIS—National Electrical Installation Standards

NEMA—National Electrical Manufacturers Association

NESC—National Electrical Safety Code

NETA—International Electrical Testing Association

NFPA—National Fire Protection Association

O&M—Operations and Maintenance

OEM—Original Equipment Manufacturer

ORM— Operational Risk Analysis

OSHA—Occupational Safety and Health Administration

PCB—Polychlorinated Biphenyl

PF—Power Factor

PPE—Personal Protective Equipment

PT—Potential Transformer

PUB—Publication

PWC—Public Works Center

R—Resistance

RE—Remote

RMS—Root-Mean-Square

RPM—Revolutions Per Minute

SCBA—Self-Contained Breathing Apparatus

SE—Service Entrance

SF_6—Sulfur Hexafluoride

SHIPS EO—Ship's Electrical Officer

SHORES ES—Shore's Electrical Supervisor

SOP—Standard Operating Procedure

SP—Surge Protector

SPD—Surge Protective Device

TM—Technical Manual

TVSS—Transient Voltage Surge Suppressor

UF—Underground Feeder

UFC—Unified Facilities Criteria

UFGS—Unified Facilities Guide Specifications

UL—Underwriters Laboratories

UPS—Uninterruptible Power Supply

US—United States

USACE—U.S. Army Corps of Engineers

V—Volt

V/M—Volts Per Meter

VAC—Volts Alternating Current

VDC—Volts Direct Current

VRLA—Valve-Regulated Lead Acid

W—Watts

X—Reactance

X/R—Ratio of Reactance to Resistance

Terms:

Note: The terms listed here are provided for clarification of the design criteria provided in this manual. Refer to IEEE 100, *IEEE Standard Dictionary of Electrical and Electronics Terms*, for additional electrical-related definitions.

Accessible—Easily entered or vacated by a physically disabled person.

Ampacity—The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

Approved—Sanctioned, endorsed, accredited, certified, or accepted as satisfactory by a duly constituted and nationally recognized authority or agency.

Arc Duration—The time span of an arc from initiation to extinction, usually specified as a number of cycles of 60 Hz current.

Arc Energy—The total energy discharged to a surrounding area by an electric arc.

Arc Thermal Protective Value—For protective clothing is the minimum incident thermal energy that causes the onset of a second degree burn based on the energy transmitted through the clothing.

Area of Refuge—A floor or fully sprinklered building that has at least two accessible rooms or spaces separated from each other by smoke partitioning; or a space in a means of egress that is protected from the effects of fire and smoke, either by separation from the other spaces in the same building or by virtue of location, thereby permitting delay in egress travel from any level.

Authorized Person—A person approved or assigned by a supervisor to perform a specific duty or duties or to be at a specific location or locations at the job site.

Available Short-Circuit Current—The maximum current that the power system can deliver through a given circuit point to any negligible impedance short circuit applied at the given point, or at any other point that will cause the highest current to flow through the given point.

Barricade—A physical obstruction such as tape, cones, or structures intended to provide a warning about and to limit access to a hazardous area.

Barrier—A physical obstruction that is intended to prevent contact with equipment or live parts, or to prevent unauthorized access to a work area.

Blocking—Placing a switch in the open or closed position and mechanically ensuring the position of the switch cannot be accidentally changed.

Bolted Fault—The highest magnitude short circuit current for a particular fault location. The impedance at the fault location is usually very low or zero for a bolted fault.

Bonding—A reliable connection to assure electrical conductivity. In terms of grounding, the permanent joining of metallic parts to form an electrically conductive path to assure electrical continuity with the capacity to conduct safely any current likely to be imposed.

Bonding Conductor—A conductor used specifically for the purpose of bonding.

Cardiopulmonary Resuscitation (CPR)—An emergency medical procedure which includes opening and maintaining an airway, providing ventilation through rescue breathing, and providing artificial circulation through the use of external cardiac compression.

Circuit Breakers Incorporating Ground Fault Protection—Circuit breakers that perform all normal circuit breaker functions and also trip when a current to ground exceeds some predetermined value.

Clearing Time—The total elapsed time between the beginning of an overcurrent and the final interruption of the circuit at rated voltage. For a fuse, the clearing time is considered the sum of the melting time and the arcing time. For a breaker, the clearing time is the elapsed time between the actuation of a release device and the instant of arc extinction on all poles of the primary arcing contacts.

Conductor—A material (usually a wire, cable, or bus bar) for carrying an electric current. Note: This term is used only with reference to current carrying parts which are sometimes alive (energized).

Cycle—One cycle equals 1/60th of a second for 60 Hz current.

Dead Front—Without live parts exposed to a person on the operating side of the equipment.

Earth Ground—An electrical connection to earth obtained by a grounding electrode system.

Emergency Lighting System—A system capable of providing minimum required illumination specified in NFPA 101, *Life Safety Code*, Section 5.9. It includes the lighting units, related backup power source(s), and required connections.

Equipment—A general term which includes fittings, devices, appliances, fixtures, and apparatus, and like items used as part of, or in connection with, an electrical power transmission and distribution system, or communication systems.
• Equipment - Climbing. Includes body belts, safety and climber straps, climbers and ladders.

• Equipment - Electrical Inspecting and Testing. Electrical and mechanical devices such as voltmeters, ammeters, ohmmeters, phase meters, and similar devices.
• Mobile and Portable - Large Equipment. Relatively large equipment items easily transported for maintenance, which must include line trucks, aerial lift trucks, motor-generator sets, pole hole diggers, and similar apparatus.
• Equipment - Protective. Includes rubber gloves, line hose, matting, blankets, insulator hoods, and sleeves, in addition to barricades and warning devices.

Equipment Grounding Conductor—The conductor used to connect the non-current carrying parts of conduits, raceways, and equipment enclosures to the grounded conductor (neutral) and the grounding electrode at the service equipment (main panel) or secondary of a separately derived system, such as an isolation transformer.

Flash Hazard—A dangerous condition associated with the release of energy caused by an electric arc.

Flash Protection Boundary—The distance from an arc source (energized exposed equipment) at which the potential incident heat energy from an arcing fault on the surface of the skin is 1.2 calories/cm^2. Within this boundary, workers are required to wear protective clothing, such as flame resistant shirts and pants and other PPE.

Ground—A conducting connection, either intentional or accidental, by which an electric circuit or equipment is connected to the earth, or to some conducting body of relatively large extent that serves in place of the earth.

Grounded—An electrical connection that gives a circuit a direct positive path to ground.

Grounded Neutral—A point of an electrical system that is intentionally connected to ground.

Grounded, Solidly—Connected directly through an adequate ground connection in which no impedance has been intentionally inserted.

Ground-Fault Circuit Interrupter—A device intended for the protection of personnel that functions to deenergize a circuit or portion thereof within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply input.

Heat Flux—The thermal intensity of an arc that is incident by the amount of energy transmitted per unit area and per unit of time, measured in calories per square centimeters per second (cal/cm^2/sec).

Horizontal Exit—A passage from one building to an area of refuge and access to a means of egress (per NFPA 101) in another building on approximately the same level; or a passage through or around a fire barrier (2 hour minimum) to an area of refuge with access to a means of egress (per NFPA 101) on approximately the same level in the

same building, that affords safety from fire and smoke originating from the area of incidence and communicating areas.

I^2t—Heating caused by current as a function of time.

Incident Heat—The energy, measured in calories, on the receiving surface.

Job Hazard Analysis (JHA)—see Job Safety Analysis.

Job Safety Analysis (JSA)—A method for studying a job in order to identify hazards or potential hazards associated with each step or task involved. Additionally, it is used to develop controls or solutions to eliminate or mitigate those hazards identified. Also, referred to as a Job Hazard Analysis (JHA).

Limited Approach Boundary—A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which is not to be crossed by unqualified persons unless escorted by a qualified person.

Listed—Applies to equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction. The organization periodically inspects production and certifies that the items meet appropriate standards or tests as suitable for a specific use.

Live—(Energized) “Hot” electrically connected to a source of potential difference or electrically charged to have a potential significantly different from the earth in the vicinity. The terms “live” or “hot” are sometimes used in place of the term “current carrying” where the intent is clear to avoid repetition of the longer term.

Live Front—With live parts exposed to a person on the operating side of the equipment.

Live-Line (Hotline) Work—Maintenance of energized high voltage electrical conductors or equipment using approved hotline tools and rubber protective goods. Does not include routine operations such as opening and closing hook switches and fuse cutouts or installation of hotline clamps; does not include working in manholes on dead circuits.

Low Voltage System—An electrical system having a maximum root-mean-square (rms) voltage of less than 1,000 V.

Mishap—An unplanned or unsought event or series of events that results in death, injury, or occupational illness or damage to or loss of equipment or property.

Medium Voltage System—An electrical system having a maximum RMS ac voltage of 1,000 V to 15 kV. Some documents define the medium voltage upper limit as 100 kV, but this definition is inappropriate for facility applications.

Prohibited Approach Boundary—A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which, when crossed by a body part or object, requires the same protection as if direct contact is made with a live part.

Qualified—A person with a recognized degree, certificate, or professional standing or who by knowledge, training, and experience has successfully demonstrated the ability to solve problems relating to the subject matter, the work, or the project.

Supervisor—Refers to the supervisor of “employees or workers” as used in this instruction. Generally includes the supervisor responsible for exterior electrical systems, the zone supervisor or foreman, and the infrastructure support element supervisor. Titles are necessary to assign specific responsibilities to a specific individual.

Switch—A device for opening and closing or changing the connection of a circuit. In this instruction, the term is generic for all oil circuit breakers, air switches, network protectors, disconnects (either fusible or plain), hot clamps, and other devices which open an electrical circuit.

Restricted Approach Boundary—A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which, due to its proximity to a shock hazard, requires the use of shock protection techniques and equipment when crossed.

Tag—A system or method of identifying circuits, systems, or equipment being worked on.

Tagging—Placing a safety tag directly on a circuit opening device or equipment for additional safety to ensure it is not used or its position altered.

Tags—Temporary signs (usually attached to a piece of equipment or part of a structure) to warn of existing or immediate danger.

Voltage—The effective RMS potential difference between any two conductors or between a conductor and ground. Voltages are usually listed as nominal values. The nominal voltage of a system or circuit is the value assigned to a system or circuit of a given voltage class to provide a convenient nomenclature. The operating voltage of the system may vary above or below this value.
• Secondary Voltage. Lines and equipment operating at and below 600 V (nominal phase-to-phase).
• Distribution Voltage. Lines and equipment operating above 600 V(nominal phase-to-phase) up to and including 36kV (nominal phase-to-phase). Note the NESC refers to high voltage as above 750 V.
• Transmission Voltage. Lines and equipment operating above 36 kV (nominal phase-to-phase).

APPENDIX A

REFERENCES

Note: *The most recent edition of referenced publications applies, unless otherwise specified.* [1]

Air Force Publications

AFI 32-1064, *Electrical Safe Practices.*
AFI 91-302, *Air Force Occupational and Environmental Safety, Fire Prevention, and Health (AFOSH) Standards.*
AFOSH Standard 91-10, *Civil Engineering.*
AFOSH Standard 91-66, *General Industrial Operations.*

Navy Publications

OPNAV P-45-117-6-98, *Electrical Worker Field Safety Guide.*
OPNAVINST 5100.23 Series, *Navy Occupational Safety and Health (NAVOSH) Manual*.
UFC 4-150-02, *Design: Dockside Utilities for Ship Service*.

The following link provides access to various Navy-related documents as well as numerous SOPs related to electrical work:

http://www.navfac.navy.mil/safety/site/topics/electrical.htm

U.S Army Corps of Engineers Publications

Engineer Memorandum 385-1-1, *Safety and Health Requirements Manual.*

American National Standards Institute (ANSI)

Note: Many ANSI documents are sponsored or co-sponsored by other organizations, such as NEMA, IEEE, or IESNA. Some ANSI documents are listed with the sponsoring organization.

ANSI B30.9, *Slings.*

---

[1] Addresses for standards:

1. American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036
2. ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, Pennsylvania, USA 19428-2959
3. BICSI, 8610 Hidden River Parkway, Tampa, FL 33637-1000
4. Cordage Institute, 994 Old Eagle School Road, Suite 1019, Wayne, PA 19087
5. Illuminating Engineering Society of North America, 345 East 47th Street, New York, NY 10017
6. Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017
7. Insulated Cable Engineers Association, Box P, South Yarmouth, MA 02664
8. National Fire Protection Association, One Batterymarch Park, P.O. Box 9101, Quincy, MA 02269
9. Underwriter's Laboratories, Inc., 333 Pfingston Road, Northbrook, IL 60062

ANSI C2, *National Electrical Safety Code.*
ANSI Z89.1, *Personal Protection, Protective Headwear for Industrial Workers, Requirements.*
ANSI Z133.1, *Tree Care Operations, Pruning, Trimming, Repairing, Maintaining, and Removing Trees, and Cutting Brush, Safety Requirements.*
ANSI/SIA A92.2, *Vehicle-Mounted Elevating and Rotating Aerial Devices.*
ANSI Z359, *Safety Requirements for Personal Fall Arrest Systems, Subsystems, and Components.*

American Society for Testing and Materials (ASTM)

ASTM A 603, *Specification for Zinc-Coated Steel Structural Wire Rope.*
ASTM A 906, *Specification for Alloy Steel Chain Slings for Overhead Lifting.*
ASTM F 18-Series, *Standard on Electrical Protective Equipment for Workers.*
ASTM F 855, *Specifications for Temporary Grounding Systems to be Used on Deenergized Electric Power Lines and Equipment.*

Institute of Electrical and Electronics Engineers (IEEE)

ANSI/IEEE 450, *Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.*
ANSI/IEEE 484, *Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications.*
ANSI/IEEE 516, *Guide for Maintenance Methods on Energized Power-lines*.
ANSI/IEEE 524, *Guide for Installation of Overhead Transmission Conductors.*
ANSI/IEEE 935, *Guide on Terminology for Tools and Equipment to Be Used in Live Line Working*.
ANSI/IEEE 957, *Guide for Cleaning Insulators.*
IEEE 978, *Guide for In-Service Maintenance and Electrical Testing of Live-Line Tools.*
IEEE 1048, *Guide for Protective Grounding of Power Lines.*
ANSI/IEEE 1106, *Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.*
IEEE 1187, *Installation Design and Installation of Valve Regulated Lead-Acid Batteries for Stationary Applications.*
IEEE 1188, *Maintenance, Testing and Replacement of Valve Regulated Lead-Acid Batteries for Stationary Applications.*
IEEE 1584, *Guide for Arc Flash Hazard Analysis.*

National Fire Protection Association (NFPA)

NFPA 10, *Standard for Portable Fire Extinguishers.*
NFPA 70, *National Electrical Code.*
NFPA 70B, *Electrical Equipment Maintenance.*
NFPA 70E, *Electrical Safety in the Workplace.*

Occupational Safety and Health Administration

Note: The following OSHA regulations can be downloaded from www.osha.gov.

29 CFR 1910, *Occupational Safety and Health, General Industry Standards*.
29 CFR 1926, *Occupational Safety and Health, Safety and Health Regulations for Construction*.

APPENDIX B

OPNAV P-45-117-6-98, ELECTRICAL WORKER FIELD SAFETY GUIDE

Note: This handbook will be included in the final document as an appendix if each service agrees.