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BY ORDER OF THE
SECRETARY OF THE AIR FORCE

AIR FORCE MANUAL 32-1185
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Civil Engineering

ELECTRICAL WORKER SAFETY

COMPLIANCE WITH THIS PUBLICATION IS MANDATORY

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This manual implements AFI 32-1085, *Electrical Safe Practices*. It provides requirements to allow base civil engineering personnel to safely operate and maintain electrical systems and facilities. AFH 32-1285, *Electrical Worker Field Safety Guide*, provides additional safety requirements. Users should send comments and suggested improvements on AF Form 847, *Recommendation for Change of Publication*, through major commands (MAJCOM) and HQ AFCESA/CESM, 139 Barnes Drive, Suite 1, Tyndall AFB FL 32403-5319, to HQ USAF/ILEO, 1260 Air Force Pentagon, Washington DC 20330-1260.

SUMMARY OF REVISIONS

This is the initial publication of AFMAN 32-1185, including requirements previously provided in AFR 91-12.

Chapter 3 – Basic Personnel Safe Working Practices

Chapter 4 – Apparel, Tools, and Material Handling

Chapter 5 – Outdoor Substations

Chapter 6 – Overhead Lines and Associated Electrical Components

Chapter 11 – Rescue of Personnel

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Chapter 1

PURPOSE AND APPLICABILITY

1.1. Electrical Safety Publications. The need for readily available electrical safety guidance has increased as electrical systems have become more complex. This manual is to provide overall safety direction and guidance for electrical workers. This manual will soon be supplemented by a more portable field handbook: AFH 32-1285, *Electrical Worker Field Safety Guide,* issued to summarize many important safety rules in an easily transportable, pocket-sized format. (Note: AFH 32-1285 will supersede AFH 32-1011).

1.1.1. Supplementary Information. References are provided in this manual, as appropriate, to AFH 32-1285 and to applicable Air Force Occupational, Safety and Health (AFOSH) standards.

1.1.2. Use. Use this manual in conjunction with AFH 32-1285 to establish safe electrical working practices in the field.

1.2. Purpose. This manual provides safety standards for electrical workers to assist in eliminating conditions, practices, and actions that may result in mishaps involving people and property.

1.2.1. Need. There is risk of injury to electrical personnel involved in operating and maintaining electrical facilities whenever electrical systems and components are not safely handled. The hazards to personnel can be dramatically reduced by the adoption of safe electrical practices.

1.2.1.1. Prevention of Mishaps. (Note: The term “accidents” is not used in this manual. The standard Air Force term “mishaps” is instead used.) Mishap prevention is a basic responsibility of every worker. Personal safety, your fellow workers’ safety, and the general public's safety depend upon compliance with this manual's requirements. Safety takes precedence over work production.

1.2.1.2. Familiarity with Requirements. Each worker is required to 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 Air Force electrical worker for reference and study.

1.2.2. Causes of Mishaps. 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 de-energizing a circuit. Unsafe equipment, tools, and conditions must be reported immediately and corrected. Good housekeeping is also important for safety.

1.2.3. Unclear Conditions. Where rules of this manual do not cover the working conditions or job requirements are unclear, workers must obtain specific instructions from an authorized individual-in-charge before proceeding with the work.

1.2.4. Codes and Standards. A number of codes and standards apply to basic electrical practices. These codes cover electrical work rules, safety procedures, and requirements for electrical installations. All applicable provisions of the current issues of these codes must be complied with. These codes are as follows:

1.2.4.1. National Electrical Safety Code (NESC), American National Standards Institute (ANSI) C2.

1.2.4.2. National Electrical Code (NEC), National Fire Protection Association (NFPA) 70.

1.2.4.3. Electrical Safety Requirements for Electrical Work Places, NFPA 70E.

1.2.4.4. Air Force Occupational Safety and Health (AFOSH) standards.

1.2.5. Other Related Publications. Safety procedures are referenced in other service publications, including:

1.2.5.1. Facilities Engineering Design Manuals.

1.2.5.1.1. AFMAN 32-1180(I), *Electric Power Supply and Distribution*. (was 32-1080, and before that, AFM 88-9, Ch 1, and is Army TM 5-811-1*)

1.2.5.1.2. AFMAN 32-1181(I), *Electrical Design - Interior Electrical Systems*.

(was AFM 88-9 Ch 2, and is Army TM 5-811-2*)

1.2.5.2. Facilities Operations and Maintenance Engineering Manuals.

1.2.5.2.1. AFMAN 32-1280(I), *Facilities Engineering - Electrical Exterior Facilities*.

(was 32-1082, and before that, AFM 91-3, and is Army TM 5-684*)

1.2.5.2.2. AFMAN 32-1281(I), *Facilities Engineering - Electrical Interior Facilities*.

(was 32-1083, and before that, AFM 91-17, and is Army TM 5-683*)

*Available in Army Web-Site: http://www.usace.army.mil/inet/usace-docs/armytm/

1.3. Applicability:

1.3.1. Authority. This manual will help you comply with Air Force Instruction 32-1085, Electrical Safe Practices.

1.3.2. Persons Covered. The persons covered are those Air Force 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 may be a supervisor, a foreman, or a lead electrician depending upon local policy.

1.3.3. Type of Work Covered. The type of work covered is electrical construction, installation, maintenance, operation, repair, and testing of base and facility electrical systems.

1.4. Variances from Normal Safety Practices. The safety requirements of this manual apply to most commonly encountered working conditions. Occasionally, there may 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 should analyze and discuss alternatives with the crew prior to commencing work. If time permits, obtain required approvals according to local directives.

1.4.1. 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.

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

Chapter 2

RESPONSIBILITIES AND CLASSIFICATIONS OF ELECTRICAL WORKERS

2.1. Responsibilities. The following titles and responsibilities are typical assignments for electrical workers at most facilities. However, titles and responsibilities may 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. These responsibilities are usually general and include duties of a management nature. Supervisors have the major responsibility for worker competency, personnel safety training, work procedure instructions, safety meetings, testing, and job hazard responsibility and Operational Risk Analysis (ORM). Another typical duty of the Supervisor is to ensure compliance with safety requirements on the job site. The Supervisor often delegates authority to a foreman or lead electrician to accomplish these duties on a particular project or job site. Specific responsibilities include:

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

2.1.1.2. 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 should relay those orders and instructions to the workers. Only in emergencies, or in the absence of an authorized individual-in-charge, should the supervisor direct the actions of individual workers.

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

2.1.1.4. Establishing the minimum number of workers on a particular job site, considering the nature of the work and the conditions under which it must be performed (e.g., confined areas where working clearances are restricted, remote or isolated locations, darkness, or inclement weather). AFH 32-1285 provides guidance on the minimum number of workers needed for various tasks.

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

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

2.1.1.7. Testing the workers' knowledge of safety requirements.

2.1.1.8. Conducting and documenting a job hazards on potentially hazardous work using the Operational Risk Management process.

2.1.2. Foreman or Lead Electrician. (Note: The term “foreman” is often identical with the term “lead electrician”, and local preference determines which term is used.) The foreman provides worker instruction and direction at the job site, and is directly in charge of one work group or crew. The foreman is responsible for job site safety conditions, on-the-job training, mishap handling, and equipment use. The foreman must exercise close supervision over the work crew at all times, issue detailed instructions when necessary, and see that all instructions are followed. Specific responsibilities for the foreman are as follows:

2.1.2.1. 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.

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

2.1.2.2. 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.

2.1.2.3. 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.

2.1.2.4. 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.

2.1.2.5. 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.

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

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

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

2.1.3. Crewmembers. The electrical crewmember will be assigned work depending on the training and abilities of the individual. No crewmember may be assigned work for which the crewmember is not trained, unless working under the direction of another crewmember that is trained, or unless no significant safety hazards exist. Crewmembers should 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 should 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 which they consider unduly hazardous based on their own capabilities, for which they are not trained or qualified, or when they are not properly protected from injury. In a case where the safety requirements are not clear, the worker shall obtain direction from the authorized individual-in-charge.

2.2.1. Carelessness. A worker must challenge the carelessness of 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 shall enforce compliance with safety requirements.

2.2.3. Violations of Rules. Each safety rule must be strictly enforced. Workers failing to observe the rules may be subject to penalties. The severity of the penalty should be related to the seriousness of the offense. Listed below are typical penalties, although local policy and labor agreements determine actual penalties.

2.2.3.1. First offense. One or more of the following:

2.2.3.1.1. Verbal reprimand.

2.2.3.1.2. Called off the job to study safety rules.

2.2.3.1.3. Layoff without pay, one day.

2.2.3.1.4. Demotion.

2.2.3.1.5. Discharge (Usually used only for cases of deliberate or willful failure to observe written regulations that endangers personnel safety.)

2.2.3.2. Second offense. One or more of the following:

2.2.3.2.1. Written reprimand.

2.2.3.2.2. Layoff without pay, 2 to 5 days.

2.2.3.2.3. Demotion.

2.2.3.2.4. Discharge.

2.2.3.3. Third offense. Either of the following:

2.2.3.3.1. Layoff without pay, 6 to 10 days.

2.2.3.3.2. Discharge.

2.3. Safety Meetings. Safety meetings should 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. Scheduling meetings twice a month is recommended. Schedule safety meetings at least once a month, otherwise it tends to de-emphasize the importance of safety. Supervisory personnel should conduct most of 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.

2.3.1.1. Safety Topics. A typical meeting would discuss one or more safety topics, as appropriate for each work group. Suggested safety topics include:

2.3.1.1.1. Two or three safety rules from this manual until all rules are covered; then starting over again.

2.3.1.1.2. Safety rules, methods, and hazards connected with present work in progress.

2.3.1.1.3. Pole climbing.

2.3.1.1.4. Use of lifts, platforms, and ladders.

2.3.1.1.5. Inspecting protective equipment.

2.3.1.1.6. Unsafe practices and consequences.

2.3.1.1.7. A thorough discussion of recent mishaps at civilian, Air Force, or other military facilities.

2.3.1.1.8. Safe driving, and use of motorized equipment and trailers.

2.3.1.1.9. Accident reports, safety bulletins, posters, and other material furnished by the installation safety director.

2.3.1.1.10. Electrical safe clearance procedures.

2.3.1.1.11. Work in underground facilities.

2.3.1.1.12. Work on or near machinery.

2.3.1.1.13. Work in elevated positions.

2.3.1.1.14. Grounding systems and equipment.

2.3.1.1.15. Electric shock procedures.

2.3.1.1.16. Methods of artificial respiration applied pole-top and on the ground, and cardiopulmonary resuscitation (CPR). All workers must complete buddy care or standard first aid training (such as taught by the American Red Cross or the American Lung Association). Practice sessions for artificial respiration and CPR should be held frequently.

2.3.1.1.17. 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. Discussion during this meeting must cover 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 should be prepared for unusual or complicated work activities. (Working with non-hazardous materials or de-energized equipment in accessible locations generally does not require written work procedures.) The special hazard analysis should include as a minimum:

2.4.1. Identification of the work site.

2.4.2. Description of the work to be done.

2.4.3. Specific hazards and how to minimize or eliminate them by use of safety equipment.

2.4.4. Instructions covering special practices for grounding, unusual equipment and tools, and first aid requirements for hazardous materials.

2.4.5. Sequence of major steps or a detailed step-by-step work listing.

2.4.6. An Operational Risk Analysis (ORM).

2.5. Mishap Handling. Refer to AFH 32-1285, and AFI 91-204, *Safety Investigations and Reports.*

2.6. Work Site Safety. Maintaining acceptable work site safety involves good housekeeping, fire prevention, and maintenance of protective measures.

2.6.1. 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:

2.6.1.1. 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.

2.6.1.2. 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.

2.6.1.3. Place small parts in containers when dismantling equipment.

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

2.6.1.5. 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.

2.6.1.6. 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.

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

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

2.6.1.9. Stack wire reels with three strips of wood between reels.

2.6.1.10. 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.

2.6.1.11. 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.

2.6.2. 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:

2.6.2.1. Workers shall not smoke except in authorized smoking areas.

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

2.6.2.3. Dispose of oily rags only in approved covered metal containers. At the close of each day these containers should be emptied and the contents disposed of in such a way as not to create a fire hazard. Do not keep oily or soiled rags in lockers.

2.6.2.4. Do not burn rubbish or waste within 50 feet (15 meters) of a combustible structure, or within 25 feet (7.5 meters) 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.

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

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

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

2.6.3. Protective Measures. Machinery guards and warning signs must be provided to protect workers.

2.6.3.1. 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 should not be operated unless suitable temporary guards are provided pending replacement of the permanent guards.

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

2.7. Personal Conduct:

2.7.1. 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 should 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 de-energizing a circuit. Workers must stop working immediately when they feel unqualified for or unable to handle the job.

2.7.2. Not Taking Chances. Before starting a job, take the time needed to establish a safe procedure and to 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 safety, must not be permitted.

2.7.3. Practical Jokes. Indulgence in practical jokes, horseplay, scuffling, and wrestling while on the job site, or in transit to or from the job site, is prohibited.

2.7.4. 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 should 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.

2.7.5. 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.

2.7.6. Wearing of Protective Equipment. It is the workers responsibility to wear clothing, body protection, and supplemental protective equipment appropriate for the work to be done.

2.7.7. Consideration of Others. Workers should 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 should not enter the workspaces or facilities of other work groups where they have no business.

2.7.8. Carelessness. Workers should 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 should be reported immediately by the worker to the authorized individual-in-charge.

2.8. Electrical Work Classifications. These classifications provide suggested civilian work classifications based on Air Force Specialty Code (AFSC) qualifications for military electrical system workers. Work classifications for civilian electrical system workers should be adapted as necessary to meet local requirements. Additional requirements for foreman/lead electrician are covered in paragraph 2.1. The foreman/lead electrician should have a work classification equal to or higher than any of the crew being supervised. No worker may do any work of a higher-rated classification than qualified for; however, a worker can be required to do work in a lower classification when, in the opinion of the foreman/lead electrician, such assignment is safe, practical and economical.

2.8.1. Electrical System Helper (AFSC 3E011 equivalent). An electrical system helper should have completed high school with courses in science, mathematics, and shop mechanics. A helper should be qualified to operate government vehicles. The helper works only on the ground. Such work as clearing right-of-way, digging pole holes, aligning poles, work site cleanup, and similar duties may be performed. The helper should not act as an attendant of a wire reel, handle in any manner conductors being pulled-in near any energized conductors, or guide the butt of a pole being set in an energized line. The helper is considered an “Unqualified Worker” in regards to minimum approach distances to an energized or ungrounded conductor (see AFH 32-1285).

2.8.2. Electrical System Apprentice (AFSC 3E031 equivalent). An electrical system apprentice must possess the qualifications of an electrical system helper, must have completed a basic electrical systems course, and must be competent in performing CPR. An apprentice also must have normal color vision and freedom from fear of heights. The apprentice works under the direction of an electrical system journeyman or craftsman. This includes work on the ground and work that requires climbing poles. The apprentice must become acquainted with the tools and work practices used by the journeyman, and gain the knowledge level and skills required for promotion to journeyman. The apprentice may not perform maintenance or repairs on energized equipment, act as attendant of a wire reel, handle in any manner conductors being pulled-in near other energized conductors, or guide the butt of a pole being set in an energized line.

2.8.3. Electrical System Journeyman (AFSC 3E051 equivalent). An electrical system journeyman must possess all the qualifications of an electrical system apprentice, plus additional knowledge and experience. The journeyman must understand basic facts and general principles in the areas of: electrical facilities safe clearance; ventilation and testing for safe entry into manholes; pole top, manhole, and aerial lift rescue; safety inspection and maintenance of hotline tools, rubber protective equipment, and climbing equipment; handling of hazardous materials; use of radios, hand signals, and airdrome signals; electrical system-related and safety-related Air Force instructions and manuals; National Electrical Code, National Electrical Safety Code, and other commercial publications; HQ AFCESA Engineering Technical Letters; wiring diagrams, schematics, specifications, drawings, staking sheets, and one-line diagrams; construction of basic electrical circuits; computation of voltage, current, resistance, and power; use of test instruments and equipment to measure electrical properties; electronic principles and terms; reading meters; and, foreign electrical systems (for workers at overseas bases). The journeyman must be competent to perform installation, maintenance, troubleshooting and repair tasks in the following systems: overhead distribution; underground distribution; interior distribution; airfield lighting; substation equipment; street, security and recreational lighting; motor control circuits; electrical grounding; and, special purpose systems, including fire alarm, intrusion alarm, emergency lighting, cathodic protection, electrical appliances, power conditioners, traffic control and base warning equipment. The journeyman must be competent in both operating high reach trucks with insulated buckets and line maintenance trucks, and be knowledgeable of the required operator’s maintenance of such vehicles.

2.8.4. Electrical System Craftsman (AFSC 3E071 equivalent). An electrical system craftsman must possess all the qualifications of an electrical system journeyman, plus experience in supervision and training functions. The craftsman must be able to analyze facts and principles and evaluate conditions to make proper decisions in the installation, maintenance, troubleshooting, and repair of electrical systems. The craftsman can perform electrical system tasks at the highly proficient level and can tell or show others how to do the task. The craftsman is highly proficient in planning functions, including: facility surveys; manpower, budget and equipment requirements; cost estimates for in-service work; engineering performance standards applying to job planning and cost estimating; and, coordination of plans with other activities.

Chapter 3

BASIC PERSONNEL SAFE WORKING 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:

3.2.1.1. 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.

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

3.2.1.3. 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.

3.2.1.4. 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.

3.2.1.5. 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.

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

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

3.2.1.8. Engaging in distracting or startling acts, including "practical jokes," horseplay, teasing, quarreling, and annoying behavior.

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

3.2.2. Unsafe Conditions. Unsafe conditions may also cause or contribute to mishaps. Commonly found unsafe conditions include:

3.2.2.1. Lack of shields or guards.

3.2.2.2. Unbarricaded or makeshift barriers for floor openings or excavations.

3.2.2.3. Insufficient warning signs.

3.2.2.4. Lockout/tagout not properly applied.

3.2.2.5. Absent or inadequate grounding systems.

3.2.2.6. Poor housekeeping.

3.2.2.7. Inadequate illumination.

3.2.2.8. Inadequate ventilation.

3.2.3. Precautions for Normal Industrial Work. Observe the following precautions for normal industrial work:

3.2.3.1. 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.

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

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

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

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

3.2.3.6. Never work so closely to fellow workers that the swinging of picks, shovels, or similar tools may endanger them.

3.2.3.7. Use nail pullers when removing nails from boxes or crates.

3.2.3.8. Do not use wood or metal files without proper handles.

3.2.3.9. 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.

3.2.3.10. Do not stand or allow others to stand near ropes or cables under strain.

3.2.3.11. 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.

3.2.3.12. 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.

3.2.3.13. Keep away from dangerous places, unless the work requires you to be there.

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

3.2.3.15. Do not install fuses that are of an improper type or rating.

3.2.3.16. 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.

3.2.3.17. Ensure the casings of electric motors mounted on workbenches or on metal bases fastened to the floor are grounded before operating the motors.

3.2.3.18. 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. This work usually does not require special protective apparel; however, special protective apparel might be needed if hazardous substances are present, such as battery acid. These 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 de-energized. If ladders or scaffolds are used, workers should conform to the additional requirements of AFOSH Standard 91-22, *Walking Surfaces, Guarding Floor and Wall Openings and Holes, Fixed Industrial Stairs, and Portable and Fixed Ladders*.

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. If ladders or scaffolds are used, workers should conform to the additional requirements of AFOSH Standard 91-22.

3.3.3. Underground Work. Most underground work is normally considered work in a confined space. Refer to AFOSH Standard 91-25, *Confined Spaces*, for requirements for confined space entry. Basement areas are not usually considered underground work when accessible by stairs and adequately ventilated. Openings to the work area should be fenced or guarded against accidental entry by the public. Supplemental ventilation or pumping of water may be necessary for worker entry. Energized lines in the immediate vicinity of the work should 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. See ANSI/SIA A92.2.*Vehicle-Mounted Elevating and Rotating Work Platforms,* and AFOSH Standard 91-2, *Manually-Propelled and Self-Propelled Mobile Work Platforms, and Scaffolds (Towers),* for additional safety requirements. Aerial work is often done on energized lines or close to energized lines. Protective apparel and tools are almost always required.

3.4. Providing Warnings to the Public. 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. Be sure to immediately remove warning devices when no longer needed.

3.4.2. Flagmen. Flagmen should 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 should wear brightly colored and highly reflective warning vests.

3.5. Noise Control. AFOSH Standard 48-19, *Hazardous Noise Program*, provides requirements to prevent occupational hearing damage and whole body effects from noise. Note that AFOSH Standard 48-19 requires noise protection for workers 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 duration of exposure. 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, 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. Adequate illumination of the working area is necessary. Provide temporary lighting where natural or installed artificial illumination is not sufficient. Do not use matches or open flames to provide temporary illumination. See AFH 32-1285 for additional requirements.

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 lamps 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. Metal-case sockets must be grounded. Do not be 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 volts 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 material safety data sheet (MSDS).

3.8. Hazardous Materials. Hazardous materials most commonly encountered by electrical workers include asbestos, polychlorinated biphenyls (PCB), and sulfur hexafluoride (SF_6). These materials require special handling, as do preservative treatments for wood products. 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.

3.8.1. Asbestos. Asbestos is prohibited for new installations, but may 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 should be done by authorized and trained personnel in accordance with AFOSH Standard 161-4, *Exposure to Asbestos*.

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. Contact the facility’s Environmental Flight for latest rules relating to liquid and non-liquid PCBs.

3.8.2.1. PCB liquid is a "strong solvent" and prolonged contact can result in removing the natural skin oils. Nonabsorbent gloves, face shields, and protective clothing should be worn when handling PCBs. Nonabsorbent footwear may be required when dealing with the cleanup after an outdoor spill. If you accidentally come in contact with PCB liquid, wash contacted body parts immediately with soap and water.

3.8.2.2. Workers should make every effort to handle PCBs in closed containers. Where you might be exposed to PCB, 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 noncorrosive. It is shipped in a liquid state but would transition to a gaseous state if released at atmospheric pressure. Being about five times heavier than air, the gas can act as an asphyxiant. 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 may 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 deal with SF_6 should 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. De-energize 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 a non-flammable gas, SF_6 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, and water-borne or oil-borne preservatives used for the treatment of wood products should 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 at 50- or 60-hertz in frequency) emit only an extremely low frequency (ELF) EMF field. To the date of publication of this manual, no conclusive evidence exists that demonstrates that EMF from ELF sources is harmful. The following paragraphs provide supplemental information on EMF.

3.9.1. Electromagnetic Field. Electric and magnetic fields are produced whenever electric power is used. They are usually interacting fields, and together are commonly referred to as the electromagnetic field. 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 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 150,000-volts 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 138,000-volts is 0.125-milliampere, or if energized at 345,000-volts is 0.395-milliampere. Working near electric lines at the voltage levels found on most Air Force installations (generally under 138,000-volts) 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 should 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.

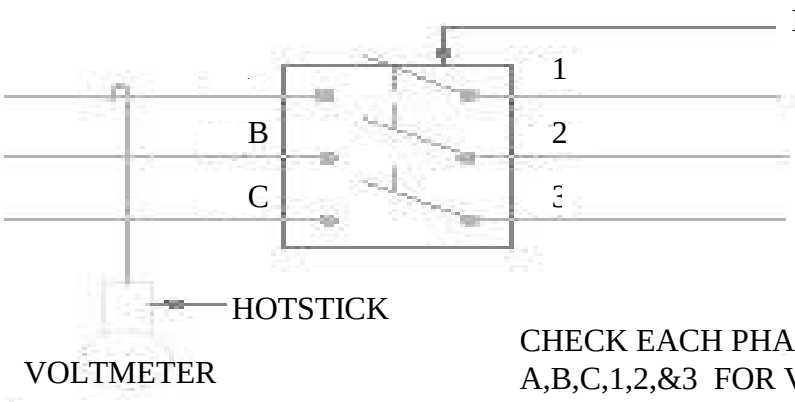
3.11. Phase Differences. When it is necessary to parallel two or more circuits together, the phases must first be checked using a hot-stick phasing tester, potential transformers, or other suitable instruments to determine the correct connections. Extremely hazardous high voltage levels can occur if 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. (See AFH 32-1285, Chapter 9.)

3.11.2. Hot-Stick Phasing Tester. A typical phasing tester consists of two high-resistance units on hot sticks connected through a voltmeter. For connections see Figure 3.1.

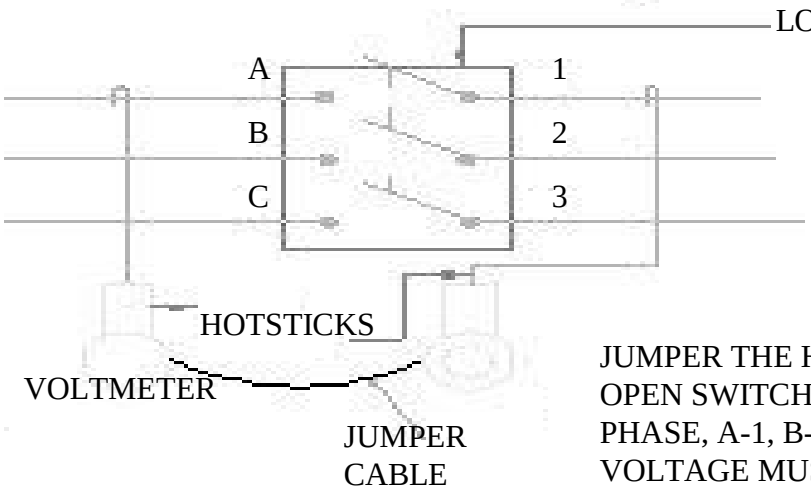
3.11.3. Potential Transformers. If potential transformers are available, a voltmeter can be used to measure voltages. For connections see Figure 3.2.

Figure 3.1. Phasing Check Using Hot-Stick Phasing Testers.



CHECK EACH PHASE, INDIVIDUALLY
A,B,C,1,2,&3 FOR VOLTAGE

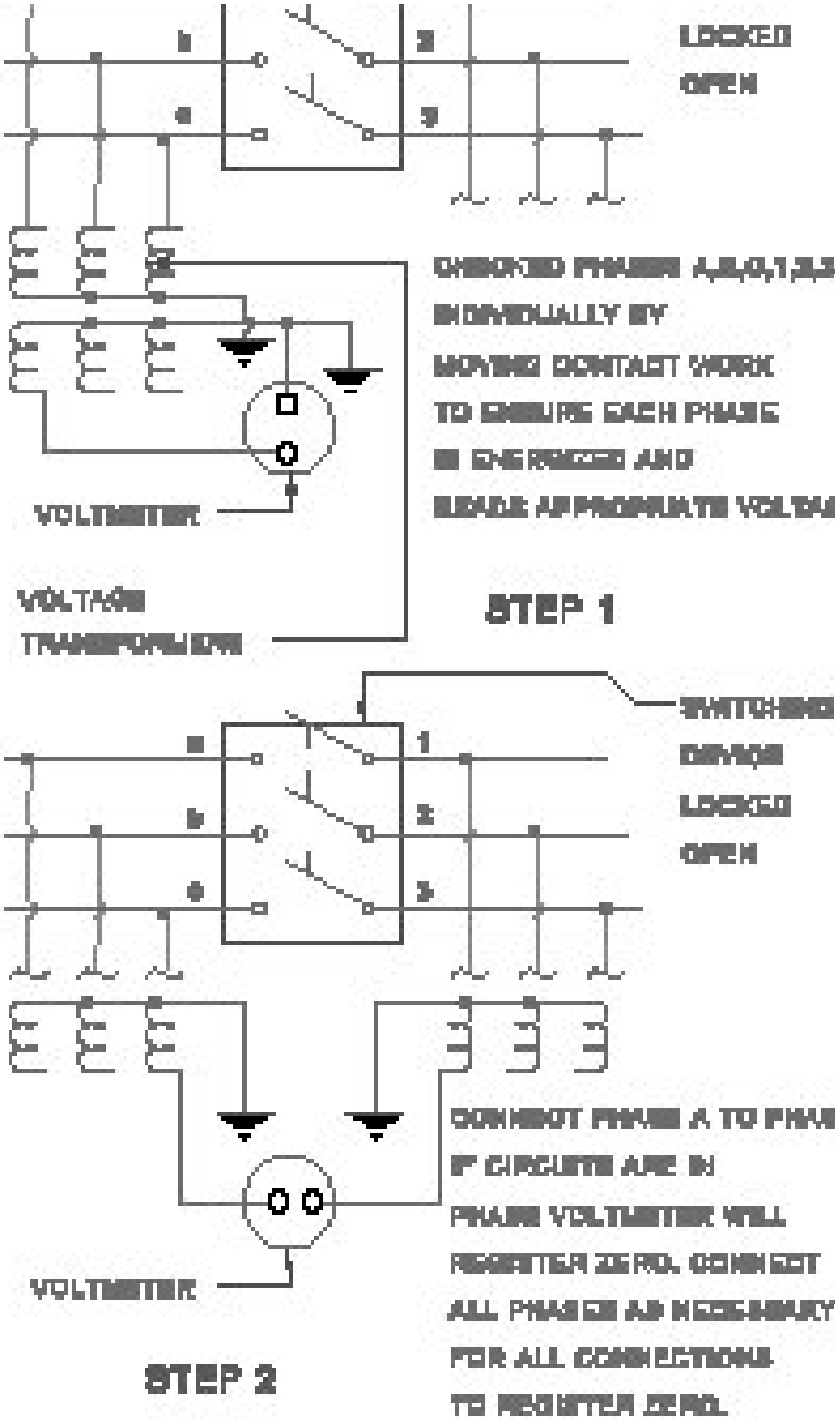
STEP 1



JUMPER THE HOTSTICKS ACROSS THE
OPEN SWITCH AND CHECK EACH
PHASE, A-1, B-2, & C-3
VOLTAGE MUST BE ZERO

STEP 2

Figure 3.2. Phasing Check Using Existing Potential Transformers.



3.12. 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.

3.12.1. Exceptions. An exception to the general rule permits low-voltage control circuits (48 volts or less) to be worked on while energized. Also, low-voltage power and control circuits (277 volts or less to ground) may 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.

3.12.2. 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.

3.12.2.1. Minimum Approach Distances. Minimum approach distances are listed for an unqualified worker in AFH 32-1285. 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.

3.12.2.2. Minimum Working Distances. AFH 32-1285 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.

3.12.3. Categories of Work. The approved work procedures to be used for work on energized circuits are provided in AFH 32-1285 and depend on the potentials at which the worker operates. These include:

3.12.3.1. 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.

3.12.3.2. 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.

3.12.3.3. 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 barehand technique and is prohibited for Air Force electrical workers.

3.13. Feedback Precautions. Be aware 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 (e.g., lightning strikes). Safety can only be assured through a thorough understanding of the particular circuitry along with proper lockout/tagout and grounding provisions.

3.14. Number of Workers Required. All work must be performed with a sufficient number of workers to provide safe working conditions. See AFH 32-1285 for the number of workers required in relation to the hazard exposure.

3.15. Safe Clearance and Lockout/Tagout Procedures. The basic safety rule behind 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 being used, all lines and apparatus should be grounded with approved grounding methods. 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.

3.15.1. Development of Procedures. Establish safe clearance and lockout/tagout procedures at each base or facility. Use AF Form 269, “Electrical Facilities, Safe Clearance”, or develop a similar form to suit local conditions. Safe clearance and lockout/tagout procedures should be developed for all work performed on lines and equipment normally energized above 600 volts. Use forms as described in AFOSH Standard 91-45, *Hazardous Energy Control and Mishap Prevention Signs and Tags*, including AF 979, “Danger”; AF 980, “Caution”; AF 981, “Out of Order”; and AF 982, “Do Not Start”.

3.15.2. 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 should 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 should include provisions for other means to provide a level of safety equivalent to that obtained by a lockout.

3.15.3. 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 a 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.

3.15.4. Preparation of the Safe Clearance Form. The details and the person preparing the Safe Clearance should include:

3.15.4.1. 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.

3.15.4.2. 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.

3.15.5. 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 should 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:

3.15.5.1. Inclusion of the correct switching and equipment operations sequence.

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

3.15.5.3. 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.

3.15.5.4. 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 should have previously been approved in writing as one authorized to receive a Safe Clearance.

3.15.5.5. 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.

3.15.6. Safe Clearance Form Description. Detailed information follows section by section, for completing the Safe Clearance form.

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

3.15.6.2. 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.

3.15.6.3. 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.

3.15.6.4. 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 should 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.

3.15.6.5. 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.

3.15.6.6. 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.

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

3.15.6.8. 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.)

3.15.6.9. 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.

3.15.6.10. Time Removed. (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.) 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.

3.15.6.11. Return the completed Safe Clearance form to the office that retains Safe Clearance records.

3.15.7. Lockout and Tagout Precautions.

3.15.7.1. 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, should be used on single blade stick-operated disconnect switches, fused cutouts, open jumpers, and similar visible line breaks.

3.15.7.2. Gang-operated switches are normally designed to be locked open and a single danger tag should be tied on the locked switch.

3.15.7.3. A turbine throttle valve can usually be locked in the closed position. A danger tag should also be provided.

3.15.7.4. On overhead lines, a visible line break should 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 should 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 de-energized. Also, temporary grounds must be installed on overhead systems as close as practical to the circuit protective device.

3.15.7.5. On underground systems, it is usually 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 de-energized. Also, temporary grounds must be installed on underground system as close as practical to the circuit protective device.

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

3.15.7.7. A Caution tag should 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 should 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 should be updated with the new position and the date and time the change was effected

3.16. De-Energized Line Work Rules. These rules apply to both low and medium voltage levels.

3.16.1. Low Voltage Levels (600 volts and below). Safe Clearance procedures do not normally apply to low voltage levels. The use of lockout/tagout procedures is locally determined for low voltage levels. Lines and equipment must be positively proven to be de-energized before work is begun. A locally approved voltage detector must be used for this test. The detector must be checked on a conductor known to be energized both before and after checking the de-energized line or equipment. A voltmeter known to be in good condition may be used in lieu of the voltage detector if an energized conductor is

not available. All energized conductors or equipment within reach of workers must be covered with insulating material or approved rubber protective equipment. Temporary grounding should 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 should 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.

3.16.2. 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 & distribution line industry standards define high voltage circuits as ones with voltage levels from 115 to 230 kilovolts.)

3.16.2.1. Maintain the minimum approach and working distances given in AFH 32-1285 until the lines and equipment are positively proven to be de-energized. 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 de-energized 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 may also be used.

3.16.2.2. After the lines or equipment have been proven de-energized, 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, 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.

3.16.2.3. All electric lines and equipment (energized at 600- to 7,500-volts 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.

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

3.16.2.5. Cutting Cable. Before a cable is cut, or an opening is made in cable covering or fireproofing, be sure the cable has been correctly identified. 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. In addition, check the cable identity with an exploring coil. This includes listening for a pulsating beat imposed by an interrupter signal. 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. Alternatively, if preferred, a spiker can be used, as described in section 7. Before cutting cable with a hacksaw, place the hacksaw on exposed cable insulation adjacent to and touching the grounded metallic shield or sheath, or adjacent to and touching the temporary ground on the shield or sheath.

3.16.2.6. Prove that reactors and connected equipment are de-energized and grounded before touching or approaching within the minimum working distances.

3.16.2.7. Discharge surge arresters and stored energy devices in accordance with manufacturer’s recommendations or local instructions.

3.17. Grounding Systems:

3.17.1. Purpose of Grounding Systems. Proper electrical grounding is essential for personnel and equipment safety, as well as for satisfactory equipment operation. Improper methods and techniques can create extreme safety and fire hazards, result in personnel injury or death, and costly damage to the facility and its contents. A safe and effective grounding system for a facility must perform a number of functions, including: system grounding; equipment grounding; lightning protection grounding; static grounding; and signal reference grid grounding. Be sure all grounding electrodes are bonded to the facility grounding electrode system. Connections to "separate" or "dedicated" grounding electrodes that are not bonded to the facility grounding electrode system are prohibited.

3.17.2. Terminology. Sometimes, the term "ground" can refer to a connecting to reference point or plane. An aircraft in flight uses its internal metal frame as reference ground. Equipment on the ninth floor of a modern steel-structured building has a reference ground consisting of the building frame, attached metal equipment, or the other electrical grounding methods present in the working area. Usually it is the earth for facilities and outdoor substations.

3.17.3. Types of Grounds. There are five basic types of grounding systems: electrical system grounds, equipment grounds, lightning grounds, static grounds, and signal reference grid grounds. These grounds are all installed in the same basic manner, but their purposes are quite different.

3.17.3.1. Electrical System Ground. System grounding is required for all facilities. It provides a stable system voltage reference for equipment operation; limits overvoltages caused by lightning, switching surges, ground faults and other conditions; and enables proper operation of circuit protective devices by providing a low impedance path for fault current. An electrical system ground refers to the condition of having one wire or point of an electrical circuit connected to earth. The most likely place to make the connection is at the electrical neutral (system ground). Examples are generator or transformer neutral points connected to earth and the grounded neutral of an interior wiring system. For most electrical systems below 600 Vac, the ground resistance on the system grounds should be 25 ohms or less. This is low enough to ensure activation of circuit protection devices, but does not insure prevention of electrical shock. Medium voltage systems (1 kV to 15 kV) are frequently grounded through a resistor or reactor and the system ground resistance may exceed 25 ohms. This limits the amount of ground fault current to a manageable level. Certain system grounding connections must be made to be in compliance with the National Electrical Code (NEC). The NEC defines the grounded neutral as a grounded conductor (this is different from a grounding conductor or grounding connection) and it is considered part of the power distribution system.

3.17.3.2. Equipment Grounds. Equipment grounding is required for all facilities. It eliminates the voltage shock hazard to personnel caused by unintentional contact of an energized circuit conductor with exposed non-current-carrying metal parts (e.g., metal frame or enclosure), and also provides a nondestructive current-carrying path for fault current so a protective device can interrupt it. Equipment grounding is the interconnecting and connecting to earth of all non-current-carrying metal parts of an electrical wiring system and equipment connected to it. The equipment ground ensures that metal parts personnel may come in contact with are at or near zero volts (with respect to ground). Equipment grounding must be capable of carrying the maximum ground fault current possible without causing a fire or explosive hazard. The grounding system must have the capacity to carry the ground fault current until the circuit protective device clears the fault. One example of an equipment ground is the bare copper wire or green insulated conductor connected to the frame of an electric motor. Connect the equipment ground to an electrical system ground (neutral) only at the building electrical service entrance. Conductors used to ground non-current carrying metallic elements of equipment are defined by the NEC as grounding conductors. The NEC has specific requirements, as does the National Electrical Safety

Code (NESC). Note that neutrals or other grounded conductors cannot be used as equipment grounding conductors. See the NEC for additional information on the difference between grounded and grounding conductors.

3.17.3.3. Static Grounds. The generation of static electricity is usually not a personnel hazard in and of itself. The hazard arises when an accumulated electrical charge subsequently discharges as a spark in occupancies where flammable or explosive liquids, gases, dusts, or fibers are present. In these occupancies, electrostatic grounding is required to eliminate sparking. Electrostatic shock can be a safety hazard to personnel when it startles personnel and they fall or accidentally contact energized equipment or machinery in motion. Static electricity manifestations are more noticeable in dry weather (less than 30 percent relative humidity). A moist atmosphere contributes to surface conductivity and provides an electrical leakage path which usually drains away static charges as fast as they are generated. Further information on the nature, origin, and dissipation control of static electricity may be found in National Fire Protection Association (NFPA) Standard 77, *Static Electricity*.

3.17.3.3.1 A static ground is a connection between a piece of equipment and earth to drain off static electricity charges before they reach a sparking potential. Typically, static grounding involves connecting large metal objects such as fuel tanks or aircraft to earth through a ground rod. National Fire Protection Association (NFPA) 77 and Institute of Electrical and Electronics Engineers (IEEE) Standard 142 state that resistances as high as 10,000 megohms often provide an adequate leakage path for static electricity. But when electrical charges rapidly generate, the resistance may need to be just 1 megohm. NFPA 407 recommends aircraft grounding systems be 10,000 ohms or less.

3.17.3.3.2 The Air Force criterion is 10,000 ohms maximum for all static grounds. Remember that static grounds are not necessarily part of an electrical power system; but if an equipment grounding conductor is adequate for power circuits, it is also adequate for static grounding.

3.17.3.4. Lightning Grounds. Protection from direct strikes involves installing one or more strike termination devices (lightning rods, masts, or elevated/catenary wires) designed to intercept lightning strokes, and connecting them to earth by down conductors and/or the metal building frame or skin. Protection of explosives facilities requires the protection contained in AFMAN 91-201, *Explosive Safety Standards*. The purpose of a lightning ground is to safely dissipate lightning strokes into the earth. It is one of several parts that make up a complete lightning protection system. A complete lightning protection system usually consists of strike termination devices (lightning rods), down conductors, arresters and connectors or fittings. The lightning protection system protects the building, its occupants and contents from the thermal, mechanical, and electrical effects of lightning.

3.17.3.4.1. Structures. How a facility is used, combined with the lightning frequency isokeraunic level (average annual number of thunderstorm days) at that location will establish the level of lightning protection needed. Lightning protection systems can usually be recognized by air terminals or lightning rods installed on roofs, or by lightning masts around a facility.

3.17.3.4.2. Electrical lines. Substation equipment and aerial line equipment, such as transformers, and aerial-to-underground risers need protection from lightning strikes. Lightning protection systems can also provide protection from the surges resulting from opening and closing lines, and from short-circuit faults. Overhead ground wires or shields (static wires) are the means of protection most often provided. Surge arresters are also provided to safely dissipate energy away from equipment. Surge arresters must always be considered to be at the associated power-line potential until determined otherwise.

3.17.3.4.3. For further information on lightning protection see AFI 32-1065, *Grounding Systems*. Information may also be found in National Fire Protection Association (NFPA) Standard 780, *Standard for the Installation of Lightning Protection Systems*

3.17.3.5. Isolated Grounding Electrodes. Connections to "separate" or "dedicated" grounding electrodes which are not bonded to the facility grounding electrode system are prohibited.

3.17.3.6. Signal Reference Grid Grounds. Signal reference grids should be provided in data processing/computer room installations and other areas where sensitive electronic equipment are installed and interconnected by high frequency signal cables. These grids must be grounded for safety, just as all other conducting members near energized electrical conductors must be grounded. Sensitive electronic equipment must be installed on and bonded to signal reference grids to minimize the impedance and stray currents between them. These grids must be grounded to minimize the adverse effects of any surge or differential voltages causing currents that may be occur on the grounding system where these grids are installed.

3.17.3.7. Subsystem Grounds. Each of the grounding systems previously described may exist as a subsystem of the total grounding system of a facility. NFPA 780 and NFPA 70 require all grounds and subsystems within a facility to be bonded together. MIL HDBK 419, *Grounding, Bonding, and Shielding for Electronic equipment and Facilities*, contains information and sketches to help explain grounding subsystems' interconnections.

3.17.4. Temporary Grounding. Temporary grounding is provided to protect workers engaged in de-energized 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 should cause an inadvertently energized line to become de-energized 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.

3.17.4.1. Testing. Test the line to be sure it is de-energized before installing protective grounds. Voltage detection methods are described in section 4.

3.17.4.2. 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 may 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 should 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 should wear insulated footwear or use other protective measures to minimize the hazard.

3.17.4.3. 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.

3.17.4.4. 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 should 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 2/0 AWG copper to withstand possible fault currents for 15 cycles for substation use and for 30 cycles for line use. Derate the maximum fault currents given in AFH 32-1285 by 10 percent for multiple ground cables when they are used together to carry the fault current. Multiple ground cables must be of the same size and length.

3.17.4.5. 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.

3.17.4.6. Ground Connection and Electrodes. Temporary grounds should 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. 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 given in AFH 32-1285.

3.17.4.7. Vehicle Grounding. Ground vehicles being used in electrical maintenance when within the minimum approach distances of AFH 32-1285. 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 working distances given AFH 32-1285. Workers and the vehicle operator need to be cognizant of step potential hazards near vehicles as well as near permanent and temporary ground rods and electrodes.

3.17.4.7.1. Aerial Lift Truck. Provide an equipotential zone for work done from an aerial lift truck by bonding the truck as indicated in AFH 32-1285.

3.17.4.7.2. Other Work Vehicles. Diggers, cranes, and other work vehicles should be bonded, if practical, to the common temporary or permanent ground electrode provided when performing work on de-energized circuits.

3.17.5. Summary of Grounding Rules for Aerial Lines. The following summary of grounding rules applies for the grounding of de-energized aerial lines.

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

3.17.5.2. The grounding connector should consist of a screwed clamp and should 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 should be a rubber-insulated copper grounding cable not smaller than No. 2/0 AWG, and preferably of the extra flexible welding type meeting ASTM F 855. A screwed clamp should 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.

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

3.17.5.4. 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.

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

3.17.5.5.1. Circuits energized up to 7,500 volts must be covered with suitable rubber protective devices.

3.17.5.5.2. Circuits energized above 7,500 volts and up to 15,000 volts must either be moved out to a safe distance with live-line tools, or be covered with suitable rubber protective devices.

3.17.5.5.3. Circuits energized at over 15,000 volts must be de-energized. These circuits are not permitted to be moved out with live-line tools.

3.17.5.6. When personnel have taken the necessary precautions as outlined above, they may proceed with the installation of grounding equipment.

3.17.5.6.1. The number of sets of grounding devices and their locations:

3.17.5.6.1.1. If possible, establish an equipotential zone in the work area by bonding all conductors together and to earth. See 3.17.4.5.

3.17.5.6.1.2. Otherwise, use one or more grounding devices based on the following:

3.17.5.6.1.2.1. 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 should be done no farther than 1.6 kilometers (one mile) from the grounding device.

3.17.5.6.1.2.2. 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 shall the work be done farther than 1.6 kilometers (one mile) from the grounding device.

3.17.5.6.1.2.3. 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 shall the work be done farther than 1.6 kilometers (one mile) from the grounding device.

3.17.5.6.1.2.4. 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 should be located not more than 3.2 kilometers (2 miles) apart.

3.17.5.6.1.2.5. 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 shall not be located more than 3.2 kilometers (2 miles) apart.

3.17.5.6.1.2.6. 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 shall not be located more than 3.2 kilometers (2 miles) apart.

3.17.5.6.2. When work is to be done on de-energized 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.

3.17.5.6.3. When electrical testing requires that circuits or equipment be ungrounded, remove protective grounds only for the immediate period of the test. All disconnecting devices isolating the circuit or equipment must be locked or blocked open and suitable tags hung.

3.17.5.6.4. When installing grounding equipment on de-energized 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 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.

3.17.5.6.5. 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.

3.17.5.6.6. 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.

3.18. 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 should 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.

3.18.1. Permitted Work. Energized line work must not be performed at any facility without authorization (see AFH 32-1285).

3.18.2. Statement of Qualifications. Each worker authorized to perform work on energized lines or equipment must be 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. All statements of qualifications should be maintained in the base civil engineer (BCE) office.

3.18.3. Insulated Buckets. Use of insulated buckets is discussed in section 4. Personnel working in insulated buckets shall 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 should be suspended when an electrical storm occurs in the work area, during inclement weather, and at night.

3.18.4. Work Methods for Voltage Levels. Energized line work methods and the minimum working distances must be in accordance with AFH 32-1285. The maximum use voltage for rubber equipment must be in accordance with the ASTM F 18 standards listed in AFH 32-1285.

3.18.5. Required Checks. The following items must be checked before work starts on energized lines.

3.18.5.1. Voltage rating of the circuits to be worked on.

3.18.5.2. Clear distance to the earth of lines and other energized equipment.

3.18.5.3. Voltage limitations of the bucket equipment, if used.

3.18.5.4. Proper operating condition of conductive shoes, clips, and other devices used to connect the bucket liner to the worker.

3.18.5.5. Automatic reclosing devices made inoperative while work is being performed.

3.18.6. Energized Line Precautions. The following precautions apply to all energized line work.

3.18.6.1. 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.

3.18.6.2. 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.

3.18.6.3. 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 should be applied to the nearest and lowest item first, and removed in reverse order.

3.18.6.4. Exercise special care when working in the proximity of fuses, surge arresters, and similar equipment. Consider procedures to bypass them for the duration of the work.

3.18.6.5. Protective equipment should be removed at the end of each working day.

Chapter 4

APPAREL, TOOLS, AND MATERIAL HANDLING

4.1. Introduction. This chapter addresses the apparel, tools, and 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 OSHA and AFOSH regulations, and the requirements of AFMAN 32-1280(I). 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 should 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. Clothing and Protective Apparel. The basic requirements for protective apparel are described AFOSH Standards 91-66, *General Industrial Operations*, and 91-10, *Civil Engineering*. Wearing of additional protective apparel may be specified by this manual or AFH 32-1285 for specific work activities, may be required by the authorized individual-in-charge, or may be recommended by the manufacturer of a specific tool or item of equipment.

4.3.1. Suitable Clothing. Wear clothing appropriate for the weather conditions and for the job to be accomplished.

4.3.1.1. General Clothing Requirements for Electrical Work.

4.3.1.1.1. Always wear a top shirt or similar garment with at least short sleeves. Long sleeves are preferred since they provide protection from cold and sun. (Loose sleeves must not be worn around moving machinery.)

4.3.1.1.2. 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 should 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.

4.3.1.1.3. 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.

4.3.1.1.4. Wear approved goggles or head shields, and gloves while operating welding equipment. Wear the type of goggles that are appropriate for the method of welding to be performed.

4.3.1.1.5. 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. Also 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 B requirements (20,000 volts ac tests for 3 minutes).

4.3.1.1.6. Wear appropriate safety equipment when using a chain saw, including work gloves, work shoes with safety toe, hard hat, and goggles with clear lenses. Industrial earmuffs should be worn to protect against exposure to excessive noise. U.S. Forest Service-approved protective chaps should be worn when using chain saws.

4.3.1.1.7. Wear safety-colored fluorescent clothing when working around vehicular traffic.

4.3.1.1.8. Eyeglasses must be fastened with a head or neckband, or otherwise restrained under safety goggles so they cannot fall into energized circuits.

4.3.1.1.9. Long hair must be secured to prevent entanglement in moving machinery.

4.3.1.2. Additional Clothing Requirements for Work on or near Energized Equipment.

4.3.1.2.1. Wear flash-resistant, non-synthetic clothing when working on or near (within 10 feet (3 meters) energized equipment of greater than 300 V. Alternately, flame resistant overalls equivalent in flame resistance to those made of at least 4-ounce weight Nomex™ material may be worn over non-flame resistant clothing.

4.3.1.2.2. Long sleeves must be rolled down and buttoned while working on or near live equipment and electric lines of greater than 300 V, and while working on or near very hot or very cold equipment. Garments with exposed metallic fasteners should not be worn.

4.3.1.2.3. Wear a blast suit (with a flash hood) with flame resistance 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:

4.3.1.2.3.1. Persons located within 10 feet (3 meters) must wear a blast suit unless protected by a structural building member (wall, floor, ceiling, etc.) of substantial construction. Note: Sheet metal and gypsum building materials generally should not be considered to be “substantial construction” for the purposes of this section.

4.3.1.2.3.2. Persons located at a distance 10 to 21 feet (3 to 6.4 meters) must wear a blast suit or flash-resistant overalls unless protected by a structural building member (wall, floor, ceiling, etc.) of substantial construction. Note: Sheet metal and gypsum building materials generally should not be considered to be “substantial construction” for the purposes of this section.

4.3.1.2.4. Wear face shields, such as those made of polycarbonate material, to provide eye protection from ultraviolet light when working on or near energized equipment of greater than 300 V. Face shields are worn in addition to required eye protection. Face shields should attach to the hard hat, except for those used in blast suits. Face shields are not required for aerial work.

4.3.1.2.5. Face shields in blast suits should be of the permanently sewn-in design, instead of the removable design. Eye protection is required in addition to the face shield.

4.3.1.3. Clothing Prohibitions.

4.3.1.3.1. Do not wear metal wristbands, or watch chains when working on energized electrical equipment.

4.3.1.3.2. Metal rings are discouraged, but may be worn if fully covered by an insulating rubber glove, and if the ring is not of a design that could cut, puncture, or otherwise damage the rubber glove.

4.3.1.3.3. 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, is generally unsafe for work on or near energized equipment of greater than 300 V, unless covered by flame resistant overalls or blast suit.

4.3.1.3.4. 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.

4.3.1.3.5. Do not wear shirts with sleeves rolled up.

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

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

4.3.1.3.8. 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.

4.3.1.3.9. Do not wear shoes with metal heel or toe plates, or with hobnails.

4.3.2. 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.

4.3.3. 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 should be provided with the most comfortable apparel feasible. This applies not only to apparel but 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 should be trained in maintenance and inspection requirements. An authorized individual must be responsible for the repair or replacement of unacceptable equipment.

4.4. 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 safe support of workers when working on wooden poles, associated structures, and on any portion of a tree, is covered in Chapter 6. The use of ladders, scaffolds, and boatswain's chairs as temporary work locations can result in injuries if safe practices are not followed carefully. Comply with AFOSH Standards 91-22, *Walking Surfaces, Guarding Floor and Wall Openings and Holes, Fixed Industrial Stairs, and Portable and Fixed Ladders*, and 91-10, *Civil Engineering*, for elevated work.

4.4.1. Boatswain's chair. A boatswain's chair used for elevated work must be constructed to meet the following minimum safety requirements:

4.4.1.1. 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.

4.4.1.2. 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.

4.4.1.3. 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.

4.4.1.4. The worker must be protected by a safety harness attached to a lifeline. (Note: A safety belt is not acceptable as a means of fall protection.) 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.

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

4.4.1.6. 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.

4.5. General Tool Safety. Refer to AFOSH Standards 91-66, *General Industrial Operations*, 91-10, *Civil Engineering*, and 91-12, *Machinery*.

4.6. Materials Handling Safety. Refer to AFOSH Standards 91-10, *Civil Engineering*, 48-8, *Controlling Exposures to Hazardous Materials*, 91-43, *Flammable & Combustible Liquids*, 91-68, *Chemical Safety*, and 161-4, *Exposure to Asbestos*. Materials of particular concern in electrical maintenance, such as PCBs and SF_6 gas, are covered in Chapter 3.

4.7. 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.

4.7.1. Fiber Rope. Fiber ropes may be made of synthetic materials or natural vegetable fibers.

4.7.1.1. Materials. Synthetic fibers used for rope are nylon, polypropylene, polyester, and polyethylene. Natural fibers used are manila and sisal. Natural fiber ropes should not be used because they have high moisture absorbing factors and low loading strengths. Synthetic rope sizes to strength characteristics are given in Table 4.1. 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 should always be used in determining actual safe lifting capacity.

Table 4.1. 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)

4.7.1.2. 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.

4.7.1.3. Conductivity. Generally, rope should 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 4.2. Additionally, when rope becomes wet, dirty, or contaminated, its electrical conductivity will increase. Recall that 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 4.2. Moisture Regain of Fiber Ropes.

Type	Moisture regain percent
Polypropylene	0
Polyethylene	0
Polyester	0.4
Nylon	4.5

4.7.1.4. 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.

4.7.1.5. Care of rope. Rope should be cared for as follows:

4.7.1.5.1. 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.

4.7.1.5.2. 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.

4.7.1.5.3. A rope with a kink or hockle (reverse kink) should be removed from service. Wet ropes are especially likely to kink.

4.7.1.5.4. 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.

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

4.7.1.5.6. A wet rope may absorb moisture, and therefore, it may 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.

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

4.7.1.5.8. Always finish (serve) the ends of fiber rope to prevent unraveling.

4.7.1.5.9. The ends of all synthetic fiber ropes should be prevented from fraying by first whipping and serving and then melting.

4.7.1.5.10. Avoid excessive stretching of nylon rope by surging loads to prevent surface abrasion.

4.7.1.6. Inspection of Ropes. A rope should be inspected each time it is used.

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

4.7.1.6.2. 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.

4.7.1.6.3. 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 may reduce the safe working load down to 80 or 90 percent of a new rope. A hitch in the rope may reduce the rope strength to 45 percent and should not be permitted. A bowline knot (which may reduce the rope strength to 60 percent) may be used.

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

4.7.1.6.5. 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.

4.7.1.7. Use of rope. Be aware of the following requirements when using rope:

4.7.1.7.1. 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.

4.7.1.7.2. 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.

4.7.1.7.3. Never use wet rope on or near energized conductors.

4.7.1.7.4. 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.

4.7.1.7.5. Do not exceed the safe loads for rope indicated in Table 4.1.

4.7.1.7.6. Avoid sudden jerks or strains.

4.7.1.7.7. Reverse rope ends periodically so all sections of the rope receive equal wear.

4.7.1.7.8. 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.

4.7.1.7.9. When bent around a rounded surface the radius around which the rope is bent should not be less than six times the rope diameter (preferably, eight times).

4.7.1.7.10. Use pulleys while lifting or lowering loads as necessary to prevent chaffing ropes.

4.7.2. 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.

4.7.2.1. Care of Wire Rope.

4.7.2.1.1. Never overload wire rope beyond its safe load.

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

4.7.2.1.3. Never store wire rope by winding it too tightly.

4.7.2.1.4. Never store wire rope in a wet or damp storage area.

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

4.7.2.1.6. 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.

4.7.2.2. 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:

4.7.2.2.1. Corrosion of the wire rope or attachments caused by acids or bases.

4.7.2.2.2. 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.

4.7.2.2.3. 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.

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

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

4.7.2.2.6. Evidence of heat damage.

4.7.2.2.7. End attachments that are cracked, deformed, or worn.

4.7.2.3. Use of Wire Rope. Handle wire rope in accordance with the following requirements:

4.7.2.3.1. Never use wire rope on or near energized conductors.

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

4.7.2.3.3. Wire rope should 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.

4.7.2.3.4. 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 should not be so large that the rope will flatten.

4.7.3. 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.

4.7.3.1. Care of Chains.

4.7.3.1.1. Never store chains in a wet or damp storage area.

4.7.3.1.2. Normalize or anneal chains periodically as recommended by the manufacturer.

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

4.7.3.2. 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

4.7.3.2.1. Nicked or cracked links.

4.7.3.2.2. Lifted linkwelds.

4.7.3.2.3. More than 10 percent elongation of any link or section.

4.7.3.2.4. When wear of 20 percent of the diameter of any link has occurred.

4.7.3.3. Use of Chains.

4.7.3.3.1. 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.

4.7.3.3.2. Chains are conductors - they must never be used near live conductors or energized equipment.

4.7.3.3.3. Never shorten or lengthen a chain by use of kinks or bolts.

4.7.4. 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 ASME 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. Note, this reduces the capacity of the sling by 50 percent (sine 30 degrees = 0.5).

4.7.4.1. Store slings so they can not be damaged.

4.7.4.2. To prevent sling-related mishaps, do the following:

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

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

4.7.4.2.3. Do not use knots or other devices to shorten slings.

4.7.4.2.4. Keep sling legs free of kinks.

4.7.4.2.5. Keep the load within the sling's capacity.

4.7.4.2.6. Balance loads supported by basket hitches to prevent slippage.

4.7.4.2.7. Securely attach the slings to the load.

4.7.4.2.8. Keep suspended loads clear of obstructions.

4.7.4.2.9. Keep people clear of suspended loads and loads about to be lifted.

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

4.7.4.2.11. Place blocks under the load so slings may be removed without damaging them.

4.7.4.2.12. Remove damaged slings from use and destroy them.

4.7.5. 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.

4.8. 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.

4.8.1. Operation of Equipment near Energized Electrical Facilities. Equipment and workers must take into account the safe operating requirements for such an operation.

4.8.1.1. 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.

4.8.1.2. 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 given in AFH 32-1285. This applies to any medium- or high-voltage (600 volts and above) line or installation unless the line is de-energized, a safe clearance is secured, and the line or equipment is grounded. To maintain the minimum safe approach distances given in AFH 32-1285, the worker may:

4.8.1.2.1. Install adequate guards or barriers, or

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

4.8.2. Equipment Operation. Comply with the requirements for lifting equipment given in AFOSH Standard 91-10, *Civil Engineering*.

4.9. 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,* and AFOSH Standard 91-2, *Manually-Propelled and Self-Propelled Mobile Work Platforms, and Scaffolds (Towers).*

4.9.1. 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 AFH 32-1285 if all of the following conditions are met:

4.9.1.1. A job hazard Operational Risk Analysis (ORM) has been done.

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

4.9.1.3. The distances between energized parts and the aerial lift equipment is monitored while the aerial lift equipment is being moved and/or repositioned.

4.9.1.4. The aerial lift equipment is grounded.

4.9.1.5. 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.

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

4.9.2.1. Extensible boom platforms.

4.9.2.2. Aerial ladders.

4.9.2.3. Articulating boom platforms.

4.9.2.4. Vertical towers.

4.9.2.5. A combination of any of the above.

4.9.3. Manufacture. Aerial equipment may be made of metal, wood, fiberglass-reinforced plastic (FPR), or other materials. They may 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 shall not be "field modified" unless such modification is certified acceptable by the manufacturer.

4.9.4. OSHA Aerial Lift Rules. OSHA mandates the following rules:

4.9.4.1. 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.

4.9.4.2. 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 should be tested on a monthly basis when not in use.

4.9.4.3. Only authorized persons may operate an aerial lift.

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

4.9.4.5. 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.

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

4.9.4.7. Do not exceed the manufacturers boom and bucket load limits.

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

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

4.9.4.10. 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.

4.9.4.11. Do not wear climbers while performing work from an aerial lift.

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

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

4.9.5. Insulated Buckets. Insulated buckets may be required for work in accordance with requirements of AFH 32-1285. An insulated bucket of an aerial lift is provided with a conductive bucket liner.

4.9.5.1. 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.

4.9.5.2. 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 should be made at the start of each day, each time a high

voltage is to be worked hot, and when changed conditions indicate a need for additional tests. Keep a record of all tests. Work operations must be suspended immediately upon any indication of a malfunction in the equipment.

4.9.6. 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.

4.10. 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 de-energized and grounded lines, or for other maintenance activities.

4.10.1. 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 de-energize and ground lines for de-energized line working. This paragraph discusses their terminology and use.

4.10.1.1. 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."

4.10.1.1.1. 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.

4.10.1.1.2. 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.

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

4.10.1.2.1. 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.

4.10.1.2.2. 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.

4.10.1.2.3. 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.

4.10.1.2.4. 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.

4.10.1.2.5. Small Individual Hand Tools. These are insulating or insulated hand tools for use with rubber gloves.

4.10.1.2.6. 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.

4.10.1.2.7. Positioning Equipment. Positioning equipment includes body belts, bucket trucks, ladders, suspension attachments, platforms, and seats.

4.10.1.2.8. Handling and Anchoring Equipment. Includes ropes, slings, rope block yokes, gin poles, saddles, and various accessory devices.

4.10.1.2.9. Measuring and Testing Equipment. Includes dynamometers, gap and wire gages, measuring sticks, phasing testers, and voltage detectors.

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

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

4.10.3. 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 (both are covered in Chapter 6). Use of aerial line tools is covered in Chapter 6.

4.11. Care and Inspection of Live-Line (Hot-Line) Tools. These 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.

4.11.1. Manufacture. Tool should 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 should 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:

4.11.1.1. FRP. A FRP tool must have withstood 100,000 volts ac per foot (305 millimeters) of length for 5 minutes.

4.11.1.2. Wood. A wooden tool must have withstood 75,000 volts ac per foot (305 millimeters) of length for 3 minutes.

4.11.2. Authorized Types of Tools. All new tools must be FRP tools. Replace existing wooden tools with new FRP tools.

4.11.3. Records. Records must be maintained for all live-line tools to demonstrate satisfactory accomplishment of laboratory, shop and field-testing.

4.11.4. 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.

4.11.5. 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:

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

4.11.5.2. 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.

4.11.6. 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:

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

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

4.11.6.3. 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.

4.11.7. 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.

4.11.8. 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 dry tested before being returned to service after any waxing.

4.11.9. Repairs and Refinishing. Only competent personnel should 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.

4.11.10. 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:

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

4.11.10.2. 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 by HQ AFCESA/CESM.

4.11.11. 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:

4.11.11.1. Laboratory testing (wet) in accordance with IEEE 978. FRP tools require an application of 75,000 volts per foot (305 millimeter) for one minute.

4.11.11.2. 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 by HQ AFCESA/CESM.

4.11.12. 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 by HQ AFCESA/CESM. 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:

4.11.12.1. 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.

4.11.12.2. Support the tool in a horizontal position during the test.

4.11.12.3. 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.

4.11.12.4. 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.

4.11.12.5. 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.

4.11.13. Transportation. Live-line tools must transported with care and protected from mechanical damage. Exposure to inclement weather should be avoided. Containers should be padded to prevent damage to insulating surfaces from abrasive surfaces and bumping motions, and to minimize contamination buildup.

4.11.14. 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 padded bins and racks away from dirt, moisture and sunlight (and other sources of ultraviolet light).

4.11.15. 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 AFH 32-1285. Additional requirements on the use of live-line tools include:

4.11.15.1. Where tools used have quick-change heads they must not be used without a “quick change safety clip”.

4.11.15.2. 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.

4.11.15.3. 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.

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

4.11.15.5. 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.

4.11.15.6. 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.

4.12. 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.

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

4.12.1.1. Each line truck and service/trouble vehicle should carry enough rubber protective equipment for the crew's needs for work on voltages up to 15,000-volts phase-to-phase. Transport the protective equipment in waterproof, lightproof, and dustproof compartments or containers.

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

4.12.2. Use of Rubber Protective Equipment. Rubber protective equipment shall be used on all conductors or energized parts which could be contacted by a worker climbing to or reaching from a work position.

4.12.2.1. Protective equipment should be positioned to protect workers against unforeseen hazards such as slipping, cutting out, leaning back, or falling.

4.12.2.2. Protective equipment should 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.

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

4.12.2.2.2. In cases where the voltage is too high for safe use of rubber protection, the lines and taps near the work area should be covered as necessary for the voltage level, de-energized, discharged to ground, and grounded on all sides, preferably within sight of the work area.

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

4.12.3. Use of Rubber Gloves. Wear rubber gloves with leather gloves suitable for the purpose, and gauntlets, 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.

4.12.3.1. Use only the gloves assigned, except in case of emergency.

4.12.3.2. Keep sleeves of wearing apparel tucked inside the cuffs of the rubber gloves.

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

4.12.3.4. Do not remove gloves until out of the reaching distance of live wires or parts.

4.12.3.5. Use rubber gloves and protector gloves (leather gauntlets) only for the specific purposes for which they are intended.

4.12.3.6. Take care to keep hands away from contact points where an arc may form.

4.12.3.7. Wear rubber gloves when possible to contact a live conductor such as when:

4.12.3.7.1. Working on circuits, wiring, or equipment in accordance with the requirements of AFH 32-1285.

4.12.3.7.2. Removing or replacing fuses.

4.12.3.7.3. Changing surge arresters.

4.12.3.7.4. Changing capacitors.

4.12.3.7.5. Applying or removing grounding devices unless insulating sticks are used of the proper length.

4.12.3.7.6. Working on equipment or lines which parallel power circuits and which may be subjected to induced voltage or accidental contact with live conductors.

4.12.3.7.7. Working on street lighting, runway lighting, or other series circuits.

4.12.3.7.8. Working on signals and signal wires.

4.12.3.7.9. Working alone in wet weather, or when working on equipment with hazardous exposed parts. Do not allow work in wet weather, except in extreme emergencies. Do not allow a worker to work alone on or near energized conductors or equipment, regardless of weather conditions.

4.12.3.7.10. Assigned as a pulling, tensioning, or reel attendant.

4.12.3.7.11. Assigned as ground worker who may contact conductors being installed on poles and equipment.

4.12.3.7.12. Handling poles or structures that are being erected in or between existing energized lines.

4.12.4. Use of Rubber Sleeves. Wear rubber sleeves whenever there is a possibility of arms coming within the working distance of AFH 32-1285. Rubber sleeves are normally worn in conjunction with rubber glove work. Wear rubber sleeves when performing live line pole or bucket working within contact distance of a live line.

4.12.5. Care and Inspection. Rubber protective equipment should 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.

4.12.5.1. General Care. Wipe dry all protective equipment before storing. Protect it from contact with oil, paint, creosote, kerosene, gasoline, acids, and other harmful materials. Testing frequencies are covered in AFH 32-1285. Rubber protective equipment should be turned in to an experienced testing laboratory for cleaning, inspection, and electrical tests. Shorter inspection periods should be considered where frequent use of equipment is made.

4.12.5.2. Care of Rubber Gloves. When not in use, rubber gloves should be carried in glove bags. When in use, take the following precautions:

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

4.12.5.2.2. Talcum and similar powders may be used after washing rubber gloves to avoid skin irritation and to prevent the rubber from sticking together.

4.12.5.3. 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.

4.12.5.4. 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.

4.12.5.5. 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.

4.12.5.6. 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.

4.12.5.7. Care of Line Hose and Insulator Hoods. Spread open line hose and insulator hoods to dry and permit free circulation of air on the inner side. Store hoses and hoods in compartments so that no part is strained or distorted.

4.13. 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 (see Glossary of References at the end of this manual for ordering information). 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.

4.13.1. 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. It is very important that the user 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 can not be used on ungrounded circuits or to detect lower voltages.

4.13.2. Phasing Testers. Use phasing testers to determine the phase relationships and approximate voltages on energized lines.

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

4.13.4. 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.

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

4.13.6. 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.

4.14. Insulating Oil Handling Operations. De-energize oil-insulated equipment, if possible. Observe the following additional precautions during oil filtering, oil reclaiming, and other oil-handling operations:

4.14.1. Always de-energize potential and current transformers before taking oil samples.

4.14.2. Have appropriate types and sizes of fire extinguishers readily available.

4.14.3. 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 5
OUTDOOR SUBSTATIONS

5.1. Substation Work. This chapter covers the safety precautions for electrical apparatus and lines found in outdoor substations.

5.2. System Information:

5.2.1. 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 de-energized 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.

5.2.1.1. Diagrams and Schematics. Electrical diagrams and schematics of the substations should be available at the BCE’s or facility's engineering office and should be kept up-to-date. Diagrams and schematics should 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. Note: Blocking requires permission from an authorized individual.

5.2.1.2. Engineering Guidance. Diagrams and schematics should be kept up to date under the supervision of the facility's engineering staff. Engineering staff guidance should 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.

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

5.2.1.3.1. 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.

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

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

5.2.1.4. 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 should always be de-energized before any work is done. All abnormal operating equipment and electrical components should be de-energized and tagged.

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

5.2.1.5.1. 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.

5.2.1.5.2. 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.

5.2.1.5.3. It should 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 should 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.

5.3. 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.

5.3.1. Pre-visit Briefing. A pre-visit briefing shall be carried out to familiarize workers with the work area. The briefing should 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 shall be conducted to familiarize all assigned workers with the new conditions.

5.3.2. 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 should keep the substation access key.

5.3.3. De-energizing 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.

5.3.3.1. Switching. Station operators must notify maintenance workers before doing any switching that affects their work.

5.3.3.2. 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.

5.3.3.3. 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.

5.3.3.3.1. It is recommended that solid red barricade tape is used to enclose work areas, and a white-with-a-red-stripe barricade tape is used to isolate temporary hazard areas. Only assigned electrical workers may 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.

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

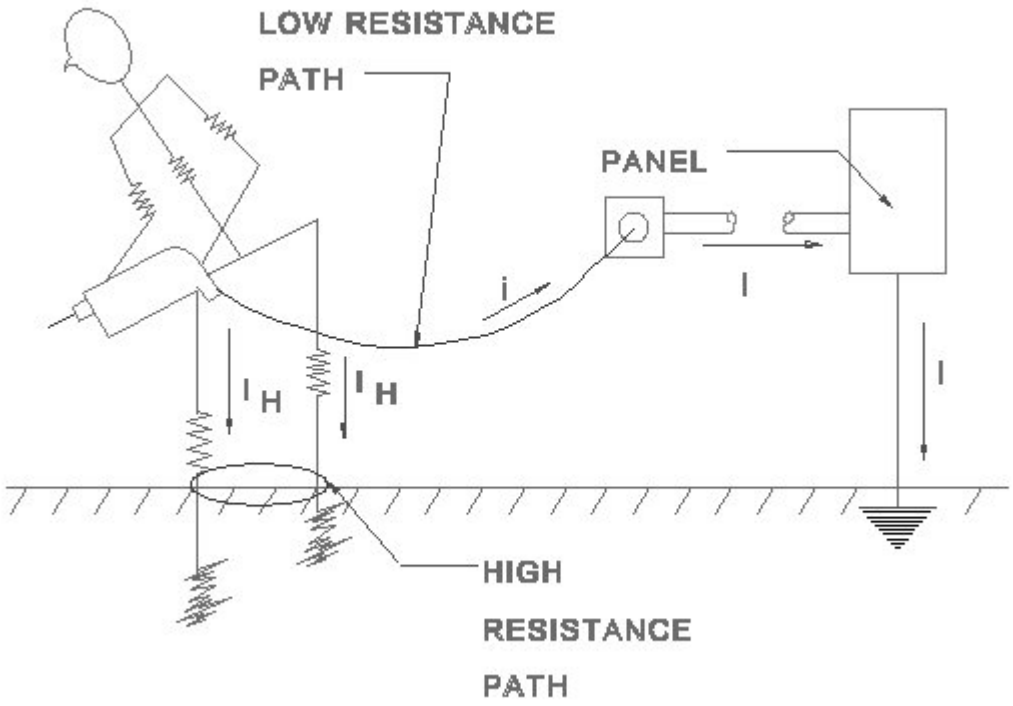
5.3.3.3.3. Temporary barriers and barricade tape shall not be used as a substitute for guard railings, for work platforms, or for protection from holes in the floor.

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

5.3.3.4. De-energized Proof Testing. All lines and equipment on which de-energized work is to be performed shall be tested to be sure they are de-energized before protective grounds are applied.

5.3.3.5. Grounding. After indication that all circuitry in the work area is de-energized, provide protective grounds as covered in Chapter 3. 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. See Figure 5.1.

Figure 5.1. Grounding Path.



5.3.3.6. 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 shall be covered with rubber protective equipment. Bare communications conductors shall be treated as energized lines and must be protected accordingly.

5.3.3.6.1. 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.

5.3.3.6.2. 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.

5.3.3.7. 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 shall be used as appropriate for the work being done.

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

5.3.4.1. Equipment hazards such as lack of guards or safety devices.

5.3.4.2. Material hazards such as sharp, worn, slippery, corroded, or rough items or areas.

5.3.4.3. Work station weather hazards such as wind, rain, ice, or dust.

5.3.4.4. Arrangement hazards such as congestion, unsafe storage in place, or improper workers' tool provisions and storage.

5.3.4.5. Lack of fire prevention and first aid equipment, and inadequate working equipment and tools.

5.3.4.6. Insufficient testing equipment, protective apparel and equipment, or safety forms and tags.

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

5.4. Safety Requirements Summary. The following minimum requirements are mandatory to assure worker or equipment safety:

5.4.1. 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.

5.4.2. Lighting Level. The lighting level shall be sufficient for safe work. Temporary self-contained lighting systems should be provided where natural or installed lighting is not available or sufficient.

5.4.3. Working Period. Normally no worker should 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 should be preceded and followed by a minimum of 8 hours off duty. Extended work periods should not exceed a maximum of 12 hours.

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

5.4.5. Coworker Requirement. No one should work alone within a substation. Jobs generally acceptable for one electrical worker are listed in AFH 32-1285.

5.4.6. 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.

5.4.7. Equipment Preparation.

5.4.7.1. All control power must be de-energized and all stored-energy mechanisms must have been discharged.

5.4.7.2. All stationary (bolted or plug-in) non-drawout type circuit breakers must be de-energized on both the line and load side.

5.4.7.3. 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.

5.5. Requirements for Testing. When performing electrical tests take the following precautions:

5.5.1. Check all test devices for normal operation and proper calibration before starting testing.

5.5.2. 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.

5.5.3. Protect testing personnel and others, particularly their eyes, from flashover hazards using personnel protective equipment as specified in Chapter 4.

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

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

5.5.6. Testing for absence of voltage on a transformer or regulator shall 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.

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

5.5.7.1. 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 de-energized 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.

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

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

5.6. Requirements for Switching:

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

5.6.2. 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, there is a large magnetizing current from a transformer, or if there is a heavy charging current from an unloaded transmission line. Be sure to know the interrupting capabilities of a switch being opened or closed.

5.6.2.1. Disconnect Switches. Disconnect switches of the non-load break-type should 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 shall 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:

5.6.2.1.1. Disconnect switches may be used to open a live line when not under load.

5.6.2.1.2. Disconnect switches may be used to open sections of de-energized lines where these lines parallel other medium- or high-voltage lines. Use caution since under certain conditions induced voltages can build up in the de-energized line and create dangerous switching conditions.

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

5.6.2.2. 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 should be of the permanently insulated-type, and be effectively grounded when operated.

Ground mats shall be provided for the operator to stand on and be large enough for both feet. Either fixed or portable small iron-mesh mats should be used. The mats shall 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 should wear rubber gloves.

5.6.2.2.1. The hinges of airbreak switches should 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.

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

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

5.6.2.3. 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.

5.6.2.4. 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.

5.6.3. Oil Switches. The consequences of operating a faulty oil switch, or closing into a faulted circuit with an oil switch are likely to be devastating and, possibly, fatal. Switching procedures shall 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 de-energized before switching. Switch position and grounding conditions must be verified before operation. In addition, no medium-voltage oil switch should 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 should be reported to an authorized individual.

5.6.4. 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.

5.7. Fuses:

5.7.1. Remember that a fuse is a single-phase device. Fuses can be subject to partial melting or damage by currents that may not have been of sufficient magnitude to blow the fuse.

5.7.2. Fuse Handling. Fuses should normally not be handled, except when they need to be replaced. Pull them as speedily as possible, and remove them completely. When replacing fuses in primary fuse cutouts, do not use your free arm in an attempt to shield your eyes from possible flashes. Instead, use safety glasses. The worker changing the fuses should stand firmly on a level surface. Where operating in an elevated position, the worker shall 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.

5.7.3. Operation of Energized Fuses. Open all lines protected with energized fuses in the same manner as for air switches. De-energize 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 from before the time of the fuse replacement.

5.7.4. 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.

5.7.5. 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.

5.7.6. 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.

5.8. Energy Storing Protective Devices:

5.8.1. Electrical Charge. 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 de-energized. Always wear eye protection when de-energizing or energizing these devices.

5.8.2. 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 done.

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

5.8.2.2. 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.

5.8.2.3. Horn gap switches should be fully opened and completely separated from all live lines and equipment, whenever it is necessary to work near a surge arrester.

5.8.2.4. 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.

5.8.3. 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.

5.8.4. 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 dead immediately after being disconnected from an energized line. Capacitors on electric lines should be provided with discharge devices to discharge the voltage to 50 volts or less, within 5 minutes after the capacitors have been completely disconnected from the circuit.

5.8.4.1. Discharge Circuits. These circuits are intended to discharge capacitors after the circuit is de-energized. Since there could be no indication that the circuit is burned out or otherwise not functioning, always assume capacitors are fully charged until tested for voltage.

5.8.4.2. 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 de-energized for at least 5 minutes to allow time for the voltage level to reduce.

5.8.4.3. 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 must be used.

5.8.4.4. After disconnecting all capacitor banks, wait 5 minutes. Short together and ground all terminals. All operations must be performed using rubber gloves or a hot stick. On wye-connected banks, the neutral may or not be floating. In either case, it must be grounded.

5.8.4.5. Grounds and terminal shorts on capacitors must be left on until the work is completed.

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

5.8.4.7. 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.

5.8.5. Coupling Capacitors. These capacitors have an extremely high impedance, which results in a long discharge period. This characteristic of coupling capacitors is typically forgotten, which makes them particularly hazardous to personnel if not properly grounded. To minimize the hazard, the following are required:

5.8.5.1. During shipping or storage, a coupling capacitor must always have a shorting wire.

5.8.5.2. 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 to ensure discharge.

5.9. Instrument Transformer Safety:

5.9.1. 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.

5.9.2. Potential (Voltage) Transformers (PT):

5.9.2.1. These units provide a means of obtaining low voltage from a higher voltage circuit. They are designed and selected to operate within certain accuracy limits and burdens.

5.9.2.2. Replacement transformers must have characteristics identical with the original units.

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

5.9.2.4. There are certain hazards inherent in the maintenance and removal of these units.

5.9.2.4.1. 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.

5.9.2.4.2. Replacing A Blown Primary-Winding Fuse - Modern Switchgear. On most modern switchgear a drawout arrangement automatically disconnects and grounds the transformers, when access to the fuses is necessary.

5.9.2.4.3. Replacing A Blown Primary-Winding Fuse - Obsolete Switchgear. Fuse replacement is potentially dangerous when the primary circuit to the transformer remains energized. Follow these additional safety precautions:

5.9.2.4.3.1. The authorized individual-in-charge shall 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.

5.9.2.4.3.2. 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 shall arrange for de-energizing the primary circuit. Replacing a primary fuse when the potential transformer is not isolated is particularly hazardous, and requires specific approval of the BCE or installation commander.

5.9.2.4.3.3. 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 may be used in addition; however, note that a dark lamp, connected on the low-voltage side of a voltage transformer, is not an adequate indication that the primary side of the transformer is de-energized.

5.9.2.4.3.4. The secondary fuses should also be removed before replacing the primary fuse, and then reinstalled before the transformer is re-energized.

5.9.2.4.3.5. While the transformer is de-energized, the worker should visually inspect for obvious symptoms of trouble such as a smoked or burned case, a damaged bushing, or a damaged fuseholder.

5.9.3. Current Transformers (CT):

5.9.3.1. These units provide a method of obtaining a low amperage current at low-voltage from a higher amperage current at higher voltage.

5.9.3.2. The most serious hazard associated with the maintenance of current transformers occurs when the secondary side is opened while the primary side is energized. This causes a very high voltage to be set up 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.

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

5.9.3.4. Current transformer cases and secondary circuits shall be grounded before energizing any current transformer.

5.10. Power Transformers and Regulators:

5.10.1. Power transformers are designed to significantly 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 line-drop exceeds acceptable limits. Their protective and circuit disconnecting means are not necessarily similar. Both require regular servicing. Chapter 6 provides additional power transformer safety requirements.

5.10.2. Transformers.

5.10.2.1. 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.

5.10.2.2. When transformers are installed or replaced, the secondary terminals shall be checked for correct voltage and for phase rotation (if applicable).

5.10.2.3. 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.

5.10.2.4. When removing transformers, case and neutral grounds must be disconnected last.

5.10.2.5. When working on or near an energized three-phase, wye-connected transformer or transformer bank, verify the transformer neutral is properly grounded. Note if it is not grounded, the neutral is considered as floating and it is possible to have full phase-to-ground voltage present on the neutral.

5.10.2.6. No-load (or manual) tap changers shall never be operated when the transformer is energized. Only load-tap-changing (LTC) type tap changers may be operated when the transformer is energized. When re-energizing 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.

5.10.2.7. 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.

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

5.10.2.9. 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.

5.10.2.10. Transformers or tanks shall 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.

5.10.2.11. Energized pad-mounted transformers and associated equipment shall be locked or otherwise secured when unattended.

5.10.3. Voltage Regulators.

5.10.3.1. Voltage regulators are normally installed with bypass and disconnect switches. 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.

5.10.3.2. When regulators are maintained as spares in substations, their bushings shall be short-circuited and grounded.

5.11. Metalclad Switchgear:

5.11.1. Metalclad switchgear is normally safe to operate and maintain if manufacturer's instructions and the following rules are followed:

5.11.2. Do the following prior to drawout (rack out) of a circuit breaker operating mechanism:

5.11.2.1. De-energize the switchgear (including control power) and ground as much of the switchgear as permitted by operating conditions.

5.11.2.2. Open the circuit breaker.

5.11.2.3. Discharge the stored-energy mechanism, if provided.

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

5.11.2.5. Ensure that all workers in the vicinity know the circuit breaker is being racked out.

5.11.3. Access to switchgear terminals through portholes for maintenance in circuit breaker cells shall be limited to the following:

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

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

5.11.4. Ground and Test Device. A manufacturer-approved model of this device may be used for access to terminals for procedures such as the application of protective grounds, phase identification on de-energized 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.

5.11.4.1. Do not install the device with ground cables already connected. Connect ground cables after installing the device.

5.11.4.2. 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.

5.11.4.3. After installing the device, verify by using a voltage detector that exposed studs are de-energized.

5.11.4.4. Install the ground cables, with the device end of the ground cables connected last (and disconnected first upon removal of the ground cables).

5.11.4.4.1. Stud-Type Device. The ground cables must be connected with the device in the "disconnect" position.

5.11.4.4.2. Bale-Type Device. The ground cables may be connected with the device in either the "disconnect" or the "engage" position.

5.12. Network Protector.

5.12.1. A secondary network system provides a high degree of continuity of service in heavy-load density areas. Two or more medium-voltage feeders supply a grid of interconnecting low-voltage cables through transformers having secondary network protectors. Network protectors are typically used in large buildings with heavy loads since the loss of one point of supply does not cause complete loss of service.

5.12.2. Do not close a network protector manually, unless specifically instructed to do so, and only after verifying the medium-voltage feeder is in service, the transformer is energized, and phase relations are correct. When closed by relay, only an electrical worker trained in the operation and maintenance of network protectors should perform the operation.

5.12.3. Extensive barriers and interlocks are designed into network protectors to provide greater safety to maintenance personnel. Keep barriers in place and immediately replace any that have been broken. Although barriers and interlocks are provided, insulated tools or insulated gloves are still required to remove the roll out unit from the enclosure, to remove fuses, and for the initial installation of the network protector in the system.

5.12.4. Since network protectors are used where a large amount of power is distributed to heavy-load density areas, any short circuit at any point in the system involves very high fault currents. Extreme care should be exercised when installing or working on an energized network protector.

5.12.5. Maintenance.

5.12.5.1. De-energize the network protector before performing maintenance on or removing a network protector from service.

5.12.5.2. Perform electrical tests using the appropriate three-phase network protector test kit before installing or operating the network protector.

5.12.5.3. Network protectors are designed to operate within the current and voltage limitations given on their nameplates. Do not use network protectors when system currents or voltages exceed these limits.

5.12.5.4. Only electrical workers familiar with their construction and operation, and trained on the hazards involved should be permitted to work on network protectors.

5.12.5.5. There are several interlocks on a network protector for personnel or equipment protection. Do not disable these interlocks without approval from the authorized individual-in-charge.

5.12.5.6. Roll out the network protector's removable element before making any adjustments or doing other maintenance.

5.12.5.7. Never energize the network protector without all arc chutes and barriers in place.

5.12.5.8. Be sure all network protector hardware is in place and bolts properly torqued before placing a network protector into its housing for operation.

5.12.6. On the first trial operation or on the first operation of a network protector after repairs have been made on its mechanism or circuit breaker, the door of the network protector should be closed and latched.

5.12.7. Always have a network protector blocked open when installing or removing secondary fuses, to prevent the possibility of the network protector closing automatically.

5.13. Stationary Storage Batteries.

5.13.1. AFPAM 32-1186, Valve-Regulated Lead-Acid Batteries for Stationary Applications, discusses safety requirements for valve-regulated, lead-acid batteries (VRLA).

5.13.2. AFOSH Standard 91-10, *Civil Engineering*, provides safety requirements for batteries.

5.14. Phasing Checks. Use phasing testers when it is necessary to tie two or more circuits together. Never tie any circuits together without first checking their phase relations on all phases.

Chapter 6

OVERHEAD LINES AND ASSOCIATED ELECTRICAL COMPONENTS

6.1. 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.

6.1.1. 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.

6.1.2. Qualified Climber. Only workers who meet "Qualified Climber" requirements should be permitted to do work which requires climbing poles or trees. Each facility should establish these requirements for both facility personnel and contract personnel. They should apply to all persons whose work involves climbing. AFH 32-1285, *Electrical Worker Field Safety Guide*, discusses typical qualifications for climbing.

6.2. 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.

6.2.1. 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 should, 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 should be used when carrying poles.

6.2.2. Pole Contact Precautions. Creosote, which is usually applied to poles as a preservative, can cause skin burns on contact. The following precautions should be taken to avoid burns:

6.2.2.1. Keep arms covered with long sleeved shirts when handling poles.

6.2.2.2. Always wear gloves.

6.2.2.3. Keep neck well covered with a collar or a handkerchief.

6.2.2.4. Keep trousers as long as practical to protect ankles.

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

6.2.2.6. 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.

6.2.3. 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.

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

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

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

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

6.2.3.5. Binding wires should be cut with long-handled wire cutters. Never cut binders from the top of the load.

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

6.2.4. Ground Handling. Once on the ground the poles can be positioned by the use of cant hooks. Special precautions should be taken while using these hooks:

6.2.4.1. Hooks must be kept sharp, and should be protected when not in use.

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

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

6.2.4.4. 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.

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

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

6.2.4.7. 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.

6.2.4.8. 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.

6.2.5. Long Term Pole Storage.

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

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

6.2.5.3. Poles should be stored according to size, and to make them as accessible as possible.

6.2.5.4. 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.

6.2.6. Temporary Pole Storage.

6.2.6.1. Poles stored temporarily on or near roadways, before erection or removal, should 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.

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

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

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

6.2.7. Hauling Poles. Pole hauling must be done in a manner to not endanger workers or the public.

6.2.7.1. Poles, after being loaded on a vehicle, 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.

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

6.2.7.3. Poles should not be hauled at night.

6.2.7.4. Poles extending more than 1.2 meters (4 feet) beyond the back of a truck or trailer shall 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.

6.3. Pole Installation, Replacement, and Removal. Poles for new aerial lines are often installed by contract workers, however, facility workers may 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.

6.3.1. 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 should 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.

6.3.2. 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.

6.3.3. 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.

6.3.4. 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.

6.3.5. Setting Poles. Pole setting is a hazardous job even with experienced personnel using the best equipment. The methods authorized for setting poles are the pike pole method, the winch line method, and the gin pole method.

6.3.5.1. Pike Pole Method. Figure 6.1 illustrates the pike pole method. This is the earliest method of raising poles and is often 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 6.1.

Figure 6.1. Pike Pole Method.

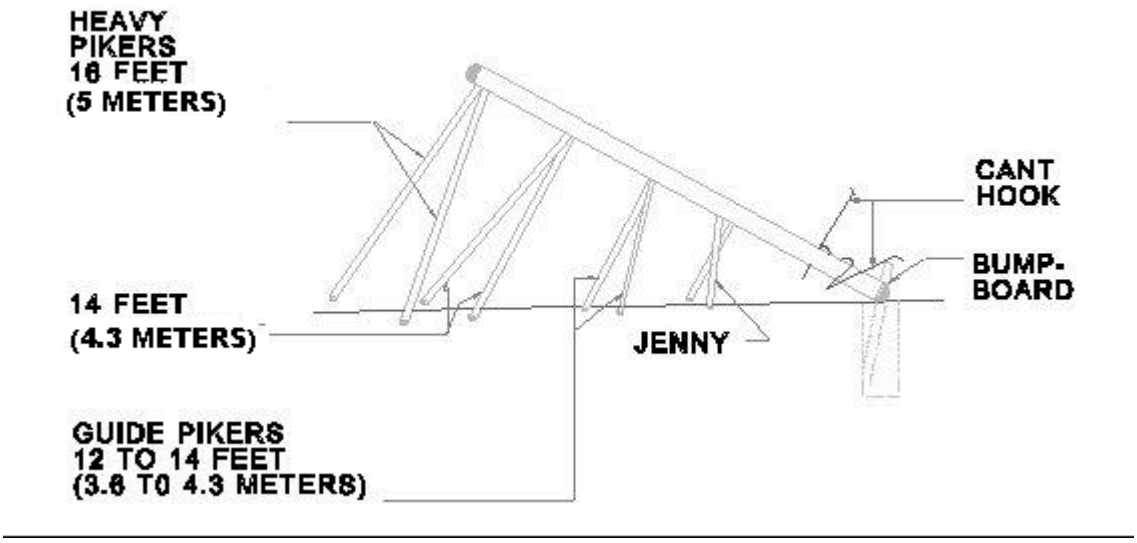


Table 6.1. Average Size of Crew Required to Raise Poles of Different Lengths by Piking.

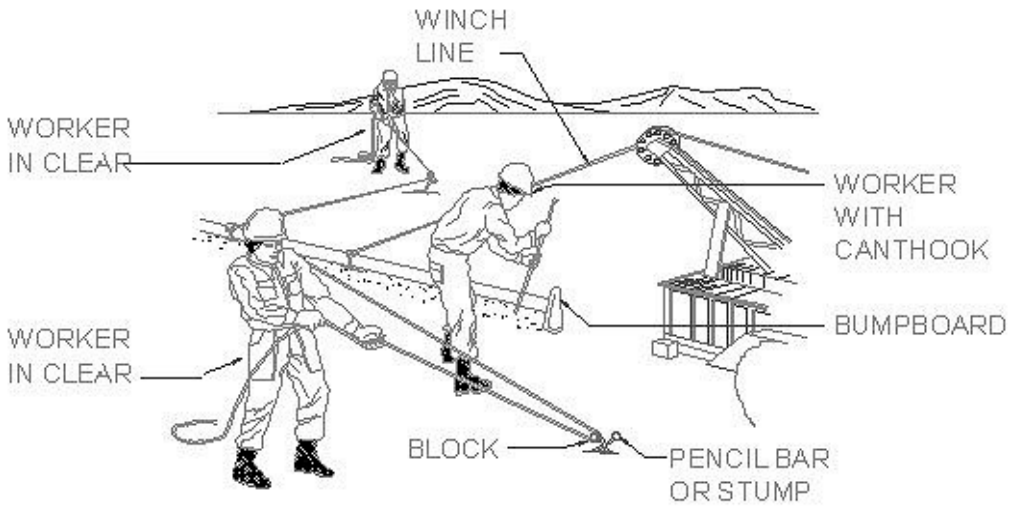
Pole length in Meters (Feet)	Size of Crew	No. of Pikers	No. of Jennymen	No. of People at Butt
7.5 (25)	5	3	1	1
9 (30)	6	4	1	1
10.5 (35)	7	5	1	1
12 (40)	8	6	1	1
13.5 (45)	9	7	1	1
15 (50)	10	8	1	1

6.3.5.1.1. 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 should use the jenny. The angle of contact between the pole and jenny should be maintained as close to 90 degrees as possible.

6.3.5.1.2. At least three experienced workers must be used in addition to the authorized individual-in-charge. One person should 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.

6.3.5.2. Winch Line Method. Figure 6.2 illustrates the winch line method.

Figure 6.2. Winch Line Method.



6.3.5.2.1. 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.

6.3.5.2.2. Side guys used in setting poles or structures should be attached to pencil bars driven into the ground. Tie lines or other guy lines must never be wrapped around any worker's body.

6.3.5.3. 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).

6.3.6. Pole Setting Trucks. Pole setting trucks should be parked, where feasible, so that the boom will never be closer than 10 feet (3 meters) 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 de-energized and grounded before work is begun. When it is not possible to de-energize 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.

6.3.7. Setting Poles in Energized Lines. Only an electrical worker qualified as a Journeyman or Craftsman should be permitted to guide poles through energized conductors.

6.3.7.1. When a pole of any type is being set or removed between or near conductors energized at more than 600 volts, 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. In all cases, exercise extreme care to keep the pole from contacting conductors.

6.3.7.2. Wood poles should not be considered as providing adequate insulation from energized lines.

6.3.8. 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.

6.3.9. Dismantling Poles. Pole dismantling from a live line is a particularly hazardous operation. Exercise extraordinary care.

6.3.9.1. 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:

6.3.9.1.1. Make two turns around the pole with a sling and tie securely.

6.3.9.1.2. Tie three lines around the sling at the proper angles.

6.3.9.1.3. Insert pike poles under two sides of the sling well up the pole.

6.3.9.1.4. Snub off securely by pencil bars driven into solid ground or by any other substantial snub.

6.3.9.2. Always check the pole to see if additional support may be necessary because of pole conditions or strains.

6.3.9.2.1. 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.

6.3.9.2.2. 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.

6.3.9.2.3. 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 should not climb a pole that is under an abnormal strain.

6.3.9.2.4. 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.

6.3.10. 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.

6.3.11. All members of a crew who are not actively engaged in pole removal must stand well clear in case the pole should fall. Where appropriate, stop all pedestrians and traffic during pole removal.

6.3.12. When a pole is being removed, dismantle the pole before beginning the excavation around the butt.

6.4. Climbing and Working on Poles. Workers should 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.

6.4.1. General Rules.

6.4.1.1. Do not work at the base of a structure or a pole while others are working above.

6.4.1.2. Before climbing a pole the worker must first determine:

6.4.1.2.1. What circuits are energized and their voltage, and any unusual conditions which might pose a hazard.

6.4.1.2.2. The types and locations of circuits, and the direction of feeds.

6.4.1.2.3. The best climbing space to avoid all live wires, grounded wires, and signal circuits.

6.4.1.3. 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.

6.4.1.4. 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.

6.4.1.5. Extraordinary care is required of the workers when it becomes necessary for one worker to work above the other.

6.4.1.6. 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.

6.4.2. 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 and that it can be safely climbed based on the following:

6.4.2.1. Determine age, physical condition, and treatment of the pole.

6.4.2.2. Determine if the configuration of conductors and equipment on the pole will provide adequate climbing space.

6.4.2.3. Determine if the removal of supporting conductors or guys may affect the safety of workers.

6.4.2.4. 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.

6.5. Pole Climbing Equipment.

6.5.1. General Rules.

6.5.1.1. 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.

6.5.1.2. 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.

6.5.1.3. The authorized individual-in-charge, or a designated worker, should 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.

6.5.1.4. Body harnesses, meeting the requirements of AFOSH Standard 91-31, *Personal Protective Equipment*, 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 should be used while on the pole). Inspect body harnesses and straps before use each day to determine they are in safe working condition.

6.5.1.5. Body Belts. Use body harnesses instead body belts for fall protection.

6.5.2. 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.

6.5.2.1. Climbers should meet the following requirements:

6.5.2.1.1. Leg iron (shank) to be made of spring steel.

6.5.2.1.2. Gaff (spur) to be forged from tool steel.

6.5.2.1.3. Leg iron length should be in the range from 380 to 460 millimeters (15 to 18 inches) from the instep to end of the shank.

6.5.2.1.4. Two leather straps should be provided, each at least 26 millimeters (1-1/4 inches) wide and 560 millimeters (22 inches) long.

6.5.2.1.5. Pads should adequately protect the calves.

6.5.2.2. Climbers, pole straps, and other leather items that have any of the following defects must not be used until repaired:

6.5.2.2.1. Cracked, dry, or rotten leather.

6.5.2.2.2. Leather which is worn thin.

6.5.2.2.3. Cuts or worn places which are of sufficient depth to weaken the leather.

6.5.2.2.4. Broken stitches or loose rivets at buckles, D-rings, or snaps.

6.5.2.2.5. Snaps which have weak springs behind the tongue or loose rivets which hold the tongue.

6.5.2.2.6. Loose tongues in buckles.

6.5.2.2.7. Buckles, D-rings, or snaps that show considerable wear or which have been cracked or bent.

6.5.2.3. Leather equipment in regular use should be cleaned and dressed at least every three months, and more frequently when the equipment is frequently wet from rain or perspiration, or is frequently soiled with dirt or mud. Leather equipment not in regular use should be cleaned and dressed at least every six months

6.5.2.3.1. 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.

6.5.2.3.2. 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.

6.5.2.3.3. Leather should 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.

6.5.2.3.4. 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 should be wrapped in pairs and fastened with their straps.

6.5.2.4. 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 should inspect climbers in regular use at least weekly. If any of the following conditions are found, repair or replace the climbers before using:

6.5.2.4.1. Loose gaff.

6.5.2.4.2. Nicks and depressions in the gaff.

6.5.2.4.3. Ridge of gaff not in alignment.

6.5.2.4.4. Dull gaffs.

6.5.2.4.5. Broken or distorted gaff points.

6.5.2.4.6. Broken, loose leg or foot strap loop.

6.5.2.4.7. Excessively worn, cracked, or torn straps and pads.

6.5.2.4.8. Enlarged buckle holes in the straps.

6.5.2.4.9. Broken or damaged strap buckles.

6.5.2.4.10. Fractured or cracked leg irons and stirrups.

6.5.2.4.11. Excessively worn stirrups.

6.5.2.4.12. Fractured leg iron sleeves.

6.5.2.4.13. Broken or loose rivets or screws on sleeves and straps.

6.5.2.4.14. Defective strap rings.

6.5.2.4.15. Broken or damaged loop clip-on straps.

6.5.2.4.16. Gaff guards not in good condition.

6.5.2.4.17. Improper length of gaffs.

6.5.2.5. 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.

6.5.2.6. Sharpen climbers using a gaff-shaping bit as follows:

6.5.2.6.1. Place the climber between wood in a vise with the leg iron horizontal and the gaff on the topside.

6.5.2.6.2. 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.

6.5.2.6.3. The outer ridge of the gaff should 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.

6.5.2.6.4. 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 should 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 should also be removed with the stone.

6.5.2.6. Never use a climber with a gaff shorter than 26 millimeters (1-1/4 inches), as measured on the flat side.

6.5.2.7. Restore damaged or dull gaffs to original shape (see Figure 6.3) by filing and honing (see Figure 6.4). If gaffs cannot be restored, replace them. Three methods are normally used to determine if gaffs are properly sharpened:

Figure 6.3. Comparison of Correct and Incorrect Gaff Shapes.

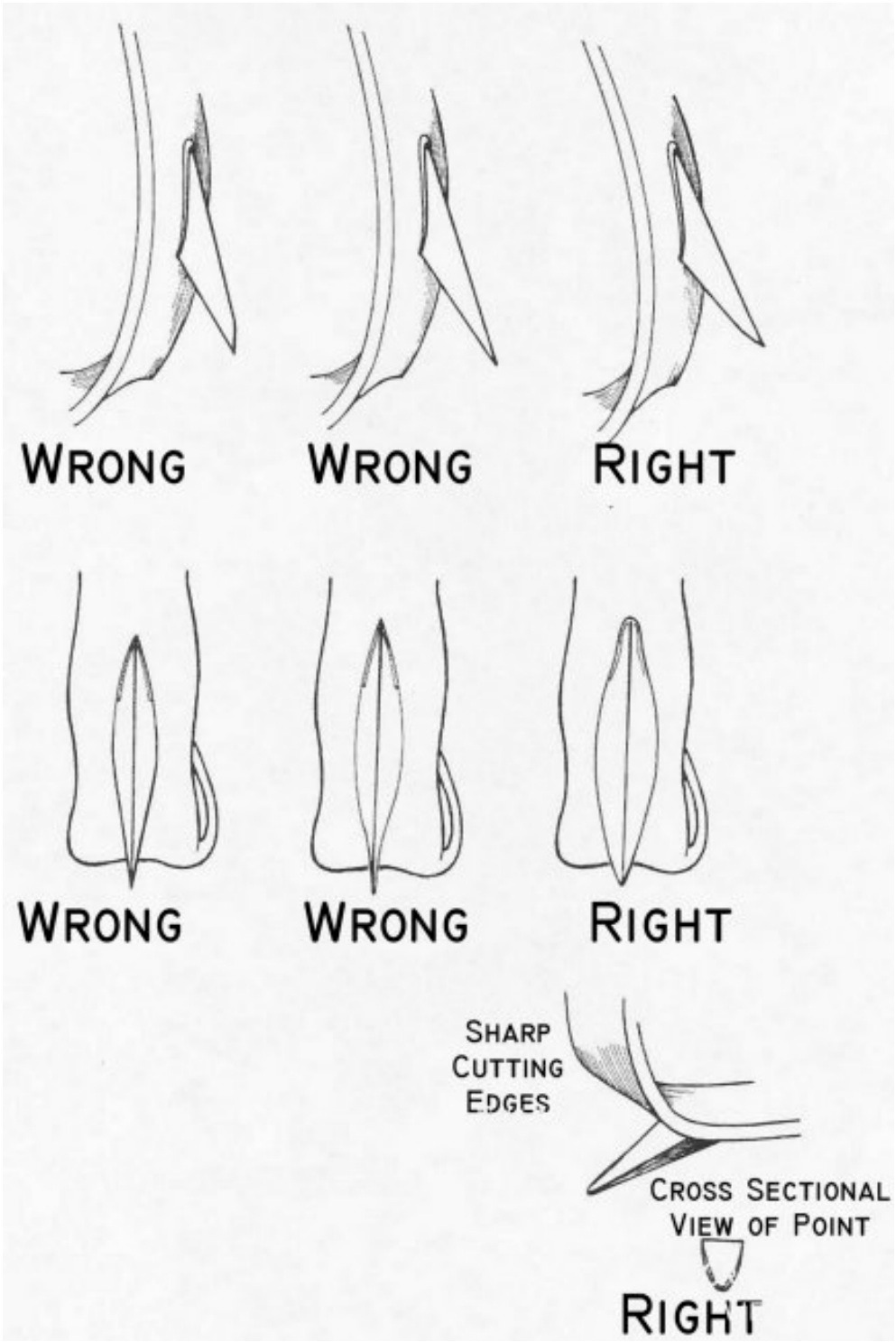


Figure 6.4. Honing a Gaff.

6.5.2.7.1. 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 should always be used if available.

6.5.2.7.1.1. 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.

6.5.2.7.1.2. 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.

6.5.2.7.2. 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.

6.5.2.7.2.1. 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.

6.5.2.7.2.2. 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.

6.5.2.7.3. Pole Cutout Method. The pole cutout method is used after climbers have been machine sharpened or gauged (and as often as required thereafter). The gaffs are tested on a pole as shown in AFH 32-1285.

6.5.2.8. 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.

6.5.2.9. Do not wear climbers when:

6.5.2.9.1. Working on the ground.

6.5.2.9.2. Traveling to and from a job.

6.5.2.9.3. Piking poles

6.5.2.9.4. Walking through underbrush or rough terrain

6.5.2.9.5. Riding in motor vehicles.

6.5.3. Concrete and Steel Pole Climbing.

6.5.3.1. Fall Protection Required. OSHA standards (29CFR1926) require fall protection for certain working heights above grade. Acceptable fall protection includes the use of a body harness. A body belt is no longer acceptable as a means of fall protection. Additionally, a positive fall protection system should be provided whenever the anchor point strength requirement can be met.

6.5.3.1.1. A fall arresting device must always be considered whenever the worker will be working more than 6 feet (1.8 meters) above ground level on line or substation structures/equipment where a feasible anchor point is available. Workers should be secured for fall arrest while climbing or changing work positions. Workers should be secured for position security while working in place. Where both hands are required for working from a ladder, the requirements for either fall arrest, position security, or both, must be applied dependent upon the working height.

6.5.3.1.2. 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.

6.5.3.1.3. 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.

6.5.3.1.4. Harnesses should 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.

6.5.3.1.5. Manufacturer's instructions in regard to height and weight should 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.

6.5.3.2. 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.

6.6. 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 de-energized 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.

6.6.1. General Pole Climbing Precautions.

6.6.1.1. Arrange tools and equipment to allow both hands to be free for climbing.

6.6.1.2. Do not stand on mailboxes, signs, fire alarm boxes, or similar equipment that may be attached to the pole or located near it.

6.6.1.3. Do not race up and coast down poles.

6.6.1.4. 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 should be used. The use of rope safeties is prohibited.

6.6.1.5. 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.

6.6.1.6. 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.

6.6.1.7. 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.

6.6.1.8. 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.)

6.6.1.9. 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 should 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.

6.6.1.10. Minimize the number of tools carried in tool belts. Keep all other tools on the ground until they are required. Needed tools should be raised and lowered by means of a canvas bucket attached to a handline.

6.6.1.11. 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.

6.6.2. Wooden Pole Climbing Precautions.

6.6.2.1. Seat gaffs securely. Be especially vigilant when the pole is ice or sleet covered.

6.6.2.2. Use pole steps whenever they are available, but only after checking that they can be used safely.

6.6.2.3. Use climbers carefully on the pole to avoid injury to another worker on the pole.

6.6.2.4. 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.

6.6.3. Concrete and Steel Pole and Tower Climbing Precautions.

6.6.3.1. 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.

6.6.3.2. Carefully wear and regularly inspect the safety harness since steel and concrete surfaces can easily damage or cut the harness.

6.6.4. 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.

6.6.5. Safety straps must be worn at all times when handling wires or apparatus while on a pole or structure. The following precautions must be taken:

6.6.5.1. 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.

6.6.5.2. Always be sure that safety straps are connected and not twisted while in use.

6.6.5.3. Never depend on a crossarm or crossarm pins and braces for support.

6.6.5.4. 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 2 feet (0.6 meters) to the top of the pole. In this case take precautions to assure that the strap does not slip off. Ideally the strap should be below the top pole attachment, except where that attachment is above eye level.

6.6.5.5. 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.

6.6.5.6. Do not attach metal hooks or other metal devices to body harnesses. Metal chains and keepers should 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.

6.6.6. Take the following precautions when hoisting or lowering materials:

6.6.6.1. Drop material that cannot be lowered safely only if there is no danger to workers or the public.

6.6.6.2. Position workers engaged in hoisting tools and materials so that they can not be injured by a falling item.

6.6.6.3. Do not leave materials and tools overhead in an insecure position. Large objects must be securely lashed.

6.7. Crossing Structures.

6.7.1. 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.

6.7.2. 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.

6.7.3. Never cross through an open-air switch unless both sides are de-energized.

6.7.4. Do not use air switch arcing horns for support in walking timbers since these horns break easily and a fall could result.

6.7.5. Never walk along an H-frame crossarm with the line energized.

6.8. Stringing or Removing De-energized Conductors and Overhead Ground Wires.

6.8.1. 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 de-energized conductors or overhead ground wires.

6.8.2. Work Adjacent to Energized Lines.

6.8.2.1. 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.

6.8.2.2. Ground the payout reel. The authorized individual-in-charge must approve any deviation in grounding the payout reels.

6.8.2.3. A bull line, which must be of dry polypropylene rope not smaller than 13 millimeters (1/2-inch) diameter, should 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.

6.8.2.4. 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.

6.8.2.5. Do not touch any conductors or wires on the ground without rubber gloves.

6.8.2.6. 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 volts or less. Positively and constantly ground conductors carrying more than 5,000 volts during the stringing operation. Ground the wire with standard grounding devices as soon as it is ready to be dead-ended.

6.8.2.7. Electrical charges may appear on the line from a lightning strike or from induced static charges from a very dry atmosphere. Discontinue operations when there is any indication of lightning within five miles, at the minimum.

6.8.2.8. Keep wires being strung along or across streets or highways higher than any expected car or truck traffic. Traffic should be blocked when this line elevation is not possible.

6.8.3. Grounding. Requirements for grounding of de-energized lines are covered in Chapter 3. Other grounding requirements are as follows:

6.8.3.1. Permanent Ground Wires. 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 should be treated as if it is energized at full voltage.

6.8.3.2. Install ground wires clear of all metallic line equipment (except that which is normally grounded), hardware, and street lighting fixtures.

6.8.3.3. 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.

6.8.3.4. 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.

6.8.4. 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:

6.8.4.1. Reels. Use adequate braking to stop all payout reels. Do not touch or attempt to hand stop a revolving reel.

6.8.4.2. 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 payed 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.

6.8.4.3. Grounding. Bond and ground all stringing equipment, such as reel stands, trailers, pullers, or tensioners. See also AFI 32-1065, & AFH 32-1285.

6.8.5. 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 should 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 should be assigned to direct traffic.

6.8.5.1. Stringing Wire. Stringing by facility personnel should 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.

6.8.5.1.1. 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.

6.8.5.1.2. Before changing the strains on a pole by adding wires, an engineering evaluation should be completed to ensure that the pole can safely stand the new strain.

6.8.5.2. 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.

6.8.5.2.1. 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 should 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.

6.8.5.2.2. 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. (See Chapter 3 for more information.)

6.8.5.2.3. Be sure that the phase wires are not crossed when turning the vertical angle on three-phase lines; that is, phase wires should take the same position leaving an angle as coming into it.

6.8.6. 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.

6.8.6.1. De-energize and ground nearby or adjacent energized lines before stringing secondary wires. As an exception, service wires may 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.

6.8.6.2. Take care not to injure the weatherproof covering when handling and stringing of weatherproof-covered wires.

6.8.7. Removing Lines. Use the same general precautions as stringing wires when removing or salvaging wires. Where practical, the wire to be removed should 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.

6.8.7.1. Never change the strains on a pole by removing wires until certain that the pole must safely stand the altered strain. Where a pole must be weakened by the removal of the wires, it should be guyed before these wires are removed. All wires should be lowered with a handline. Use care before cutting a wire aloft to avoid contact with other wires.

6.8.7.2. 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.

6.8.7.3. 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.

6.8.8. Guying. No installation or removal of guys should ever be attempted without engineering guidance.

6.8.8.1. Installation. Install guys to meet the following requirements:

6.8.8.1.1.When insulators are used they should be connected into the guy wire line before the guy wire is set in place. In new work, guys should generally be installed before line wires are strung. In reconstruction work, guys should 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.

6.8.8.1.2. Install guys so that there is minimal interference with the climbing space, and to clear all energized wires.

6.8.8.1.3. Provide guy strain insulators to obtain necessary insulation when required by building or safety codes.

6.8.8.1.4. 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 should 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.

6.8.8.1.5. 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) should be yellow.

6.8.8.1.6. Install guy wires so that they do not rub against messenger or signal cables.

6.8.8.1.7. Do not use guy wire containing snarls or kinks for line work. It is preferable to use guy wires of the correct length and avoid splices.

6.8.8.2. 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.

6.8.8.2.1. Brace the pole temporarily if the removal of guys from a pole can change the strain and present a dangerous condition.

6.8.8.2.2. 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 should not be used on poles which must be climbed.

6.8.9. 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 may break off, cutting gloves or hands.

6.9. Energized Line Work. General energized line work requirements are discussed in Chapter 3. 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 should consider implementing additional work requirements applicable to the particular job.

6.9.1. Overhead lines should be worked de-energized 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.

6.9.2. The authorized individual-in-charge must supervise the workers closely, and advise them as appropriate.

6.9.3. 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.

6.9.4. Maintain safe working distance from all energized wires at all times. (See AFH 32-1285 covering qualified worker minimum working distances.) In congested locations where this is impossible, first obtain a Safe Clearance (see Chapter 3).

6.9.5. Use gloving or live line tools to work on energized lines carrying more than 600 volts between conductors, (see AFH 32-1285). 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.

6.9.6. Obtain close cooperation from every worker on the job.

6.9.7. Avoid unnecessary conversation that could distract attention and create a hazard.

6.9.8. Do not be permit haste inconsistent with safety .

6.9.9. Do not perform live line maintenance work at night or in wet weather.

6.9.10. Do not depend on another worker to hold a live conductor clear.

6.9.11. Use wire tongs, blocks & clamps or boom mounted auxiliary arms when moving heavy conductors so that these lines may be moved slowly and carefully.

6.9.12. Do not perform other work of any nature on the same pole or structure while live-line work is in progress.

6.9.13. For circuits on wood poles or attached to wooden structures, all wood members should be considered to be at ground potential.

6.9.14. Place all protective devices and do all work from a position below live conductors or apparatus whenever possible.

6.9.15. 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.

6.9.16. 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.

6.9.17. When the minimum working distance is approached because the nature of the work requires close access calibrated insulated measuring sticks or equivalent may 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 (see AFH 32-1285) for the circuit being worked. Equivalently, each live-line stick should be equipped with a flexible rubber hand guard to indicate where a worker can safely hold the stick.

6.9.18. Personnel performing structure-type live line maintenance should not carry hand tools in their belts, particularly when working from ladders. Hand tools should be raised to a worker on a structure in a canvas tool bag. Hand tools should be returned to their canvas tool bags after each use.

6.9.19. Use tested fiberglass-reinforced plastic (FRP) hotsticks, if possible. Wooden hotsticks should be replaced by FRP hotsticks.

6.9.20. 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 should keep their safety straps wrapped around the ladder except when mounting or discounting, and should 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.

6.9.21. Link stick lines should be handled as follows:

6.9.21.1. 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.

6.9.21.2. 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.

6.9.21.3. One worker at a time should work and the other should 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.

6.9.21.4. 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.

6.9.21.5. 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.

6.9.21.6. Do not allow rope to lie across energized conductors.

6.9.22. Do not permit live-line, bare-hand work.

6.9.23. 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.

6.10. Street Lighting. Streetlighting circuits may be either low-voltage multiple circuits or medium-voltage series circuits. It is important that the type of circuit be identified before starting work because of the different voltage levels involved. There is usually no reason that street lighting circuits cannot be de-energized for daytime work.

6.10.1. Street lighting lines, fixtures, and wires should be considered energized and must be worked while wearing personnel protective equipment, unless a Safe Clearance is obtained and the line grounded. The voltage of street lighting circuit should be treated as that of the highest voltage occupying any of the poles on which the street lighting circuit is run.

6.10.2. Multiple Street Lighting Circuits. Multiple street lighting circuits should 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.

6.10.3 Series Street Lighting Circuits. Before a series street lighting circuit is opened and work is performed, the following procedures must be followed:

6.10.3.1. Disconnect the circuit from the source of supply by opening disconnecting switches or other cutouts in accordance with a Safe Clearance. Do not depend on time switches or other automatic devices.

6.10.3.2. Jumper the circuit to avoid an open-circuit condition.

6.10.3.3. In replacing 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 may 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 when removing or installing lamps where lamp changers cannot be used.

6.10.4. 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 carefully trimmed.

6.10.5. 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.

6.11. Working On or Around Pole-Mounted Equipment. See Chapter 5 for the basic equipment safety rules. 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 may have been installed in accordance with these regulations. Transformers connected to an energized circuit should be considered as being energized at the full primary voltage unless positive verification is made that they are adequately grounded.

6.11.1. 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.

6.11.2. Switches and Fuses. The maintenance of switches and fuses may 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 de-energized in order for repair work to proceed.

6.11.3. Capacitors. Chapter 5 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.

6.11.4. Power Transformers and Voltage Regulators.

6.11.4.1. Work on energized pole-mounted transformers and lines is prohibited except for testing, replacement of fuses, and switching.

6.11.4.2. Installation.

6.11.4.2.1. Carefully inspect all frames and tackles used in erecting pole-type transformers before each use. Repair defects before the frames and tackles are used.

6.11.4.2.2. Wherever possible, junction poles, subsidiary poles, and street lighting poles should 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.

6.11.4.2.3. 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.

6.11.4.2.4. 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 should be removed.

6.11.4.2.5. When transformers are installed, the pole climbing space should be carefully protected so that it must not be necessary for climbing workers to come too close to the transformer case.

6.11.4.3. Pole-type transformers should not be installed until they are supplied with a sufficient amount of good quality oil.

6.11.4.3.1. When a three-phase bank of pole-type transformers is replaced, the new transformers should be carefully checked for phase rotation before service is restored, so that the new service connections must be the same as before the change. Incorrect transformer phase rotation will cause connected motorized equipment to revolve in the wrong direction.

6.11.4.3.2. 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".

6.11.4.4. Inspection and Maintenance. Only "Qualified Climbers" should 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.

6.11.4.4.1. Disconnect all energized connections to transformers and provide a Safe Clearance from all live circuits before changing or replenishing transformer oil.

6.11.4.4.2. Do not use lighted matches or open flames of any kind when opening transformers.

6.11.4.5. Fusing. When installing fuses, workers should 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).

6.11.4.5.1. Before installing fuses in new cutouts, replacing fuses, or opening disconnects, workers must protect their eyes. Flash shields on the hard hats are preferred, but are not required for aerial line work. If flash shields are not available, workers should protect their eyes by using goggles and turning their heads. They should also use their arms to further protect their eyes and faces from any flashes or arcs that may occur. It is mandatory for the workers to wear rubber gloves and/or to use a "hot stick" as appropriate for the task and the voltage level. Workers must secure themselves to the pole with their safety belts.

6.11.4.5.2. When fuses are taken out of the circuit they should be removed entirely from the fuse enclosures or cutouts.

6.11.4.5.3. 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.

6.11.4.6. Service Connections. Do not string service wires from a transformer pole if it is possible to install them at some other location. Service wires should not be installed on transformer poles, unless a minimum separation requirements can be maintained between the service wires and the energized primary conductors or apparatus.

6.11.4.6.1. Use at least two workers in stringing services from a transformer pole whenever primary conductors energized at 5,000 volts or more are within contact distance of the secondary wires.

6.11.4.6.2. Connect the neutral wire first when making connections to secondary buses, connect energized wires last. Reverse the procedure when disconnecting services.

6.11.4.7. Testing. Qualified personnel should 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, should be securely supported on the pole and should clear all vehicular traffic. The positions of these leads should not interfere with the climbing space or with other maintenance work which may be required while the testing is in progress.

6.12. Aerial Rope. Workers working on aerial lines use ropes. Rope qualities and use in rigging for general lifting is covered in Chapter 4.

6.12.1. 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.

6.12.2. Terminology of Rope Use.

6.12.2.1. 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.

6.12.2.2. 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.

6.12.2.3. 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.

6.12.2.4. Running lines are used for pulling several span lengths of wire at one time.

6.12.2.5. A sling is a looped rope assembly usful 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.

6.12.2.6. A safety line is used only for lowering a worker to the ground.

6.12.2.7. A snatch block is a rope sheave and hook with one side of the sheave open to avoid threading the rope through a hole.

6.12.3. Knots and Splices. Where it is necessary to connect two aerial rope lines permanently, a splice should be made. No metal, wire, or clamps should 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.

6.12.3.1. Knots, friction tape, cord, or marlin should not be used in joining the two parts of an aerial rope line. Properly assembled splices are not normally bulky.

6.12.3.2. Each end of the rope line should be finished (served) to prevent unraveling of the strands. A handline should be dry and strong enough to be used as a safety line for lowering a person safely from a pole.

6.12.4. Handline and Rope Line Precautions. Although the term handline is used in the following paragraphs, these precautions apply to all rope lines.

6.12.4.1. 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.

6.12.4.2. Handlines with worn or frayed parts should be scrapped immediately.

6.12.4.3. Handlines should 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 should take care to prevent the handline from catching on pole attachments.

6.12.4.4. Handlines must not be pulled over sharp bends, sharp edges, or surfaces with splinters.

6.12.4.5. Handlines must be kept free from solder, oil, grease, snarls, and knots.

6.12.4.6. Handlines should not be stored while they are wet.

6.12.4.7. When not in use, handlines should 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.

6.12.4.8. Where handlines are being let out on the poles, at least one member of the crew should 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.

6.12.4.9. One handline should 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 should be stored in a protected part of the truck where it cannot become wet.

6.12.5. 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.

6.13. Tools. Aerial line work involves the use of portable power tools and other miscellaneous tools.

6.13.1. Portable Power Tool Precautions. Use only approved portable power tools on poles, towers, or structures.

6.13.1.1. Keep electric tools and connected power cords a safe distance from any circuit or apparatus energized in excess of 600 volts, phase to phase. Power cords must be adequately insulated and properly secured to prevent accidental contact with any conductor.

6.13.1.2. 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 (see AFH 32-1285). Cover the energized conductors or apparatus with protective equipment appropriate for the voltage involved when the minimum clearances cannot be obtained. Supply hoses should 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.

6.13.1.3. Use power saws in an elevated position on a pole, tower, or structure only when approved by the authorized individual-in-charge.

6.13.1.4. 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.

6.13.2. Miscellaneous Tool Precautions.

6.13.2.1. 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.

6.13.2.2. Maintain cant hooks and carrying hooks in a safe condition.

6.13.2.3. Never use jennies with cracked or broken legs, dull teeth, or loose bolts. Use only approved jennies.

6.13.2.4. Never use pole jacks with defective releases, or jacks that might slip when loaded.

6.13.2.5. Only use approved bumperboards. A bumperboard should 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).

6.13.2.6. Never use wire reels with defects evident. All wire reels must have suitable brakes.

6.13.2.7. Close folding-type knives before placing them in toolboxes or other storage containers. Open knives must be kept in scabbards when not in use.

6.13.2.8. Maintain personal tools in good condition.

6.13.2.9. Keep hot line tools clean, dry and in good condition.

6.14. Aerial Lifts and Insulated Buckets. The use of aerial lifts and insulated buckets is covered in Chapter 4. (See AFH 32-1285 for voltage levels at which their use is mandatory.)

6.14.1. General Requirements.

6.14.1.1. Test lift controls each day before use to determine that the controls are in safe condition.

6.14.1.2. Do not alter the insulated portion of an aerial lift in any manner that might reduce its insulating value.

6.14.1.3. Be aware that the vehicle may become energized when the boom or the aerial basket comes in direct contact with energized conductors or equipment. Likewise, the vehicle may become grounded when the boom or the aerial basket comes in direct contact with grounded conductors or equipment.

6.14.1.4. 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 should be grounded, or if not grounded, must be considered as energized and properly barricaded. Information on grounding aerial lift trucks is given in AFH 32-1285.

6.14.1.5. The requirements for use of rubber or other protective equipment while working on poles and structures also apply to work from aerial buckets.

6.14.1.6. Use a body harness with a secured safety for any work from an aerial bucket.

6.14.1.7. Use a bucket liner if the bucket is designed to be used with a liner, and test it periodically (see Chapter 4).

6.14.1.8. Wear a hard hat and clothing suitable for the work at all times when working from the aerial bucket, and nearby on the ground.

6.14.1.9. Do not be permit unauthorized or unqualified persons to operate the aerial bucket boom.

6.14.1.10. 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.

6.14.1.11. Stay clear of pressurized oil or air escaping from a ruptured line or fitting. The pump, compressor, or engine should be stopped as soon as a leak is detected.

6.14.1.12. The manufacturer's load limits of the boom or buckets must be posted on the unit, and must not be exceeded.

6.14.1.13. 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.

6.14.1.14. An aerial crew shall include a minimum of two qualified workers.

6.14.2. Driving Precautions.

6.14.2.1. Drivers of aerial bucket trucks shall be constantly alert to the fact that the vehicle has exposed equipment above the elevation of the truck cab, and shall be sure that roadways provide the necessary overhead clearance. They should avoid the need to move the truck into the opposing traffic stream by prior planning of the order of work.

6.14.2.2. Any backing of the truck must be done slowly and under the direction of one person on the ground. This person should have an unobstructed view of the intended path of the vehicle.

6.14.2.3. Do not move a truck with the boom elevated in working position.

6.14.2.4. 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.

6.14.3. Setting Up and Knocking Down at the Job Site.

6.14.3.1. 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.

6.14.3.2. 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.

6.14.3.3. 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.

6.14.3.4. When working on an inclined road or street, check each outrigger or jack to make sure a stable setup has been achieved. The truck should be approximately level as viewed from the rear.

6.14.3.5. 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.

6.14.3.6. When lowering the boom to a cradled position, workers must stand clear of the path of the bucket and boom.

6.14.3.7. When work is completed the bucket must be lowered, and the boom cradled and secured by an approved tie-down.

6.14.4. Operating at the Job Site.

6.14.4.1. One worker shall be responsible for all operations required in placing the bucket in operating position, use of the bucket, and restoring it to the traveling position.

6.14.4.1.1. 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.

6.14.4.1.2. 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.

6.14.4.2. When the boom must be maneuvered over a street or highway, necessary precautions shall be taken to avoid mishaps with traffic or pedestrians. Use of a flagman should be considered.

6.14.4.3. Workers shall enter the bucket only with the bucket resting in the position for which entry was designed.

6.14.4.4. Operator Precautions.

6.14.4.4.1. The operator should 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.

6.14.4.4.2. The operator shall follow the proper sequence prescribed by the manufacturer in raising the boom section.

6.14.4.4.3. Before reaching any area containing obstructions, the operator shall test all controls of the boom and bucket to ensure that they are in proper working order.

6.14.4.4.4. The operator shall suspend operations upon indication the controls are not working properly.

6.14.4.4.5. Raising the bucket directly above energized conductors or equipment should be kept to a minimum.

6.14.4.4.6. When possible, locate buckets to the side of lines, to help workers aloft avoid contacting energized conductors and equipment.

6.14.4.4.7. 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.

6.14.4.4.8. Energized conductors and equipment shall be covered with protective devices when necessary to perform the work safely.

6.14.4.4.9. Adequate clearance must be maintained so that protruding tools must not come in contact with conductors, tree limbs, or other obstructions.

6.14.4.4.10. A worker shall not stand on top of the bucket, or on planks placed across the top of the bucket, while performing work.

6.14.4.4.11. A worker shall not belt onto an adjacent pole, structure, or equipment while performing work from the bucket.

6.14.4.4.12. The operator must make sure that handlines and tools do not become entangled with the levers that operate the boom.

6.14.4.4.13. When working aloft, secure all tools not in use.

6.14.4.5. 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.

6.14.4.5.1. Materials or tools shall 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.

6.14.4.5.2. Workers operating ground controls shall be on the vehicle or insulated from the ground using rubber gloves and other protective equipment.

6.14.4.5.3. Before entering or leaving the vehicle, a worker shall make sure that the boom or bucket is not in contact with or near energized equipment.

6.14.4.5.4. Workers on the ground should not work directly below the work area of the bucket.

6.14.4.5.5. Tools or materials shall not be thrown to or from the elevated bucket.

6.15. Aerial Cable Soldering.

6.15.1. Soldering tools must be kept at grade level except when actually in use aloft.

6.15.2. When solder is being used aloft, an approved solder catcher must be placed directly under the point of soldering.

6.15.3. See Chapter 7 for additional safety precautions.

6.16. Tree Trimming and Brush Removal. Tree trimming and brush removal is done to maintain the integrity of electric lines and apparatus and provide right-of-way clearance.

6.16.1. Training Qualifications.

6.16.1.1. Permit only workers certified as "Qualified Climbers" to climb trees.

6.16.1.2. Work accomplished from an aerial lift shall only be performed by workers qualified in use of the aerial lift.

6.16.1.3. If using ladders, review the requirements for their safe use in AFOSH Standards 91-22, *Walking Surfaces, Guarding Floor and Wall Openings and Holes, Fixed Industrial Stairs, and Portable and Fixed Ladders*, and 91-10, *Civil Engineering*.

6.16.1.4. In all cases, only qualified workers shall perform work near energized lines.

6.16.1.5. 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.

6.16.2. Public Safety.

6.16.2.1. Erect suitable signs and barriers to prevent the public from passing under trees being trimmed, and to prevent stumbling over brush on the ground.

6.16.2.2. Brush should not be piled on sidewalks, or left on streets and highways overnight.

6.16.3. Tool Safety.

6.16.3.1. Raise and lower tools with a handline.

6.16.3.2. Use only saws and pruning knives or shears for cutting limbs.

6.16.3.3. Do not carry unnecessary tools up the tree.

6.16.3.4. Do not hang or store tools on tree limbs.

6.16.4. Work Near Energized Lines.

6.16.4.1. Be aware that lines may not always be de-energized 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.

6.16.4.2. Workers in trees must use harnesses/belts and safety straps.

6.16.4.3. When working near energized lines, arrange your safety line so that a slip or fall will carry you away from the energized lines.

6.16.5. Climbing and Working on Trees.

6.16.5.1. Climbing trees should be avoided unless ladders or aerial lifts cannot provide the necessary access.

6.16.5.2. Workers in trees shall be careful to prevent contact with aerial electric and telephone wires passing through the trees.

6.16.5.3. If climbers are used, make sure they are tree climbers approved for the bark thickness of the tree being climbed. Never use pole climbers.

6.16.5.4. 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.

6.16.5.5. Do not stand on tree limbs too small to support your weight. Extreme care should be exercised when working in trees that have brittle wood.

6.16.5.6. 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.

6.16.6. Felling Trees.

6.16.6.1. Before felling trees, inspect tools to be used (such as ropes, tackle, ladders, and chain saws) to ensure they are in proper condition.

6.16.6.2. Place signs warning pedestrian and vehicular traffic of the danger from work being performed. Station flagmen if necessary.

6.16.6.3. Inspect each tree for obstructions (conductors and fences) in the line of fall. De-energize nearby conductors, if possible.

6.16.6.4. Trees greater than 25-feet (7.5-meter) tall and greater than a 8-inch (200 millimeter) trunk diameter should have ropes attached before felling. The ropes can be used to guide the tree as it falls.

6.16.6.5. Always have a clear a path of retreat when felling a tree.

6.16.7. Power Trimming Equipment.

6.16.7.1. Chain-saw operators should be familiar with and follow the manufacturer's operating instructions.

6.16.7.2. Carefully inspect chain saws prior to each use. Chain saws should be clean and sharp, and in sound mechanical condition with all guards, spark arresters, mufflers, handles, and other items properly installed and adjusted.

6.16.7.3. Permit only workers trained in chain saw operation to perform the work.

6.16.7.4. Clear away brush or other material that might interfere with cutting operations before starting to cut.

6.16.7.5. Wear appropriate personal protective equipment when operating the chain saw. Eye, ear, hand, foot, and leg protection are minimum requirements.

6.16.7.6. Never operate a chain saw when physically tired or under the influence of alcohol, medication, or other drugs.

6.16.7.7. Do not store fuel near flammable materials. Fuel for chain saws must be stored in approved, vented containers clearly marked to show the contents.

6.16.7.8. Do not start the chain saw within 3 meters (10 feet) of a fuel container.

6.16.7.9. Do not fuel the chain saw with it running or hot, or with open flame nearby.

6.16.8. Right-Of-Way Brush Removal.

6.16.8.1. Brush clearance is part of electrical maintenance work to clear right-of-ways. Wear personal protective equipment as appropriate for power trimming equipment.

6.16.8.2. 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.

6.16.8.3. Brush chippers shall be operated only when authorized. The worker should 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.

6.16.8.4. 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.

6.16.8.5. Restrict personnel assigned to remove or pile brush to maintain a safe distance behind workers using the cutting tools.

6.16.8.6. 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.

6.16.8.7. 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.

6.16.8.8. Learn to recognize poison ivy, poison oak, and poison sumac (see Chapter 10). Some people are very susceptible to the poison from these plants and should keep away from the vines and leaves. Preventive lotions are effective if used prior to exposure. On contact with these poisonous plants, obtain first-aid treatment.

6.16.8.9. Be on the alert for snakes when cutting the right-of-way. A snakebite kit should be carried on every job where poisonous snakes could be encountered. (See Chapter 10 for more information.)

Chapter 7

UNDERGROUND CABLES, STRUCTURES, AND ASSOCIATED ELECTRICAL COMPONENTS

7.1. 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.

7.2. General Protection Requirements:

7.2.1. 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.

7.2.2. Protect approaches to work areas, excavations, open manholes, and parked equipment.

7.2.3. Ensure a fully charged and operable handheld fire extinguisher is immediately accessible when performing underground work.

7.2.4. 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 .

7.2.5. Avoid parking tool carts and reels on inclined streets. Where this cannot be avoided, equipment should 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.

7.2.6. Store equipment or materials where they do not obstruct fire alarm boxes, hydrants, or fire apparatus.

7.2.7. Cover open holes along streets, driveways, walkways, and accessible places by appropriate strength covers.

7.2.8. Excavation, Trenching, and Backfilling.

7.2.8.1. 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.

7.2.8.2. 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.

7.2.8.3. 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 shall be kept at least 0.6 meters (2 feet) from the edge of the excavation.

7.2.8.4. Excavated material removed from trenches in streets should be kept on the traffic side of trenches until used for fill or removed. This will help vehicular traffic avoid the trench.

7.2.8.5. 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.

7.2.8.6. Sides of trenches 1.5 meters (5 feet) or more in depth shall be shored, sloped, or otherwise supported to prevent collapse.

7.2.10. Wear suitable gloves when using any equipment or tools to excavate, expose, or handle direct-burial cables.

7.2.11. Carefully refill excavations and see that all refilling is well tamped.

7.3. Cable Pulling:

7.3.1. Do not handle pull-wires or pulling-lines within reaching distance of blocks, sheaves, winch drums, and take-up reels.

7.3.2. Do not remain in a manhole during pulling operations.

7.3.3. Do not use wire rope to pull cable in a duct already occupied by conductors.

7.3.4. Use a nonmetallic duct fishing wire or device when fishing ducts containing energized conductors.

7.3.5. Always fish ducts in the direction that presents the least hazard. Consider stationing a worker at each end when fishing ducts.

7.4. Buried Electrical Cables:

7.4.1. Use area utility maps to locate existing buried cables and nearby utilities as accurately as possible.

7.4.2. 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 shall 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 should not be used, except to break and remove the surface pavement.

7.4.3. Do not use probe rods or bars to locate any underground direct-burial cables.

7.4.4. Take extreme care to avoid damaging the cable insulation when uncovering direct-burial cables.

7.4.5. 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.

7.4.6. Do not stand, sit, kneel, or lean on unprotected direct-burial cables.

7.5. Damage to Existing Utility Lines. If any existing utility lines are damaged then certain steps must be taken dependent upon the type of line.

7.5.1. If electric cables are damaged the cables must be de-energized and repaired.

7.5.2. 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.

7.5.3. 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 should be initiated as soon as possible.

7.5.4. Other lines, such as communication, water, and storm drainage, should 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.

7.6. Preparing to Work Underground:

7.6.1. General Precautions before entry.

7.6.1.1. Before entering a manhole or other underground structure, place all warning signs needed for protection of those working in and around the underground structure.

7.6.1.2. Before entering a manhole or other underground structure, test its atmosphere for oxygen level and the presence of dangerous gases (see Section 7.6.3).

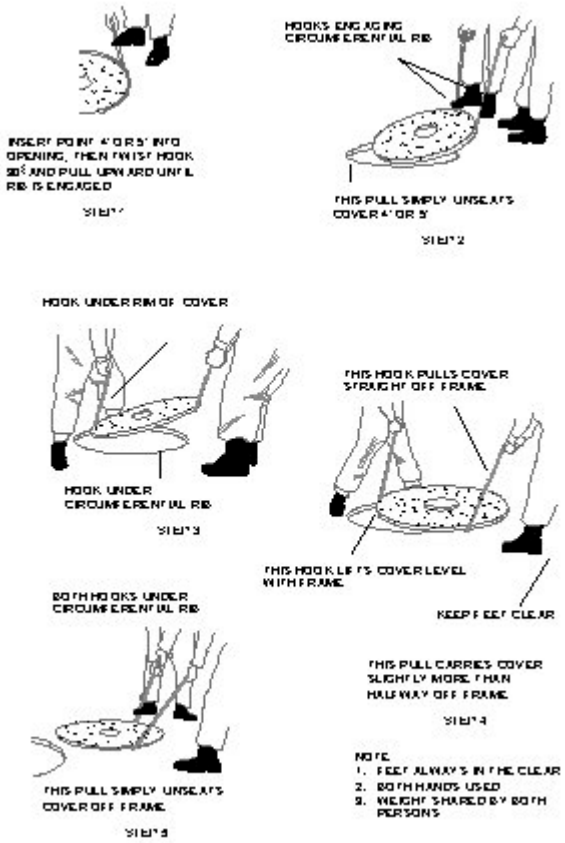
7.6.1.3. Extinguish all smoking materials before entering a manhole or other underground structure. Smoking is not permitted in manholes and other underground structures.

7.6.2. Removing a manhole cover:

7.6.2.1. A manhole cover may weigh from 90 to 160 kilograms (200 to 350 pounds). Two persons, each with a manhole cover hook, are required to remove a cover. They should 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 7.1 illustrates removing a circular manhole cover.

7.6.2.2. 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.

Figure 7.1. Removing a Manhole Cover.



7.6.2.3. 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.

7.6.2.4. In a traffic area, the manhole cover should be removed in a direction that must prevent the workers from falling into the path of traffic should the manhole cover hook slip during cover removal. The removal position should 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.

7.6.2.5. 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.

7.6.2.6. 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.

7.6.2.7. Snow and Ice Problems:

7.6.2.7.1. 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.

7.6.2.7.2. 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.

7.6.2.7.3. 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.

7.6.2.7.4. 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 should be.

7.6.2.8. Stuck Manhole Cover. 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.

7.6.3. Atmosphere Testing before Entering Underground Structures:

7.6.3.1. 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 explosive gases or fumes.

7.6.3.2. Manholes and other underground structures containing less than 19.5 percent by volume oxygen shall 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).

7.6.3.3. Toxic and Combustible Gases:

7.6.3.3.1. Consider subsurface structures hazardous until tested clear. They are subject to the accumulation of combustible or toxic gases.

7.6.3.3.2. Combustible gases found in manholes or vaults are usually natural gas or vapors from hydrocarbon fuels.

7.6.3.3.3. Toxic gases typically encountered are hydrogen sulfide, carbon monoxide, and mangrove gas (southern coastal areas).

7.6.3.4. Test Equipment:

7.6.3.4.1. 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.

7.6.3.4.2. 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.

7.6.3.4.3. 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.

7.6.3.5. Never enter a manhole until test results indicate that the manhole is free of combustible or toxic gases.

7.6.3.5.1. Satisfactory Tests. 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 shall not exceed 8 hours. When the manhole is covered with a tent or tarpaulin, the test interval shall not exceed 2 hours. Place the tent or tarpaulin so that an opening is left in the covering for ventilation.

7.6.3.5.2. Unsatisfactory Tests. 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.

7.6.3.6. 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 just above any open ducts. If a test indicates that gas in entering, ventilate the manhole.

7.6.3.7. Removal of Duct Plugs. Immediately upon the removal of the duct plugs, make a test just above the opened duct. If gas is entering, ventilate the manhole.

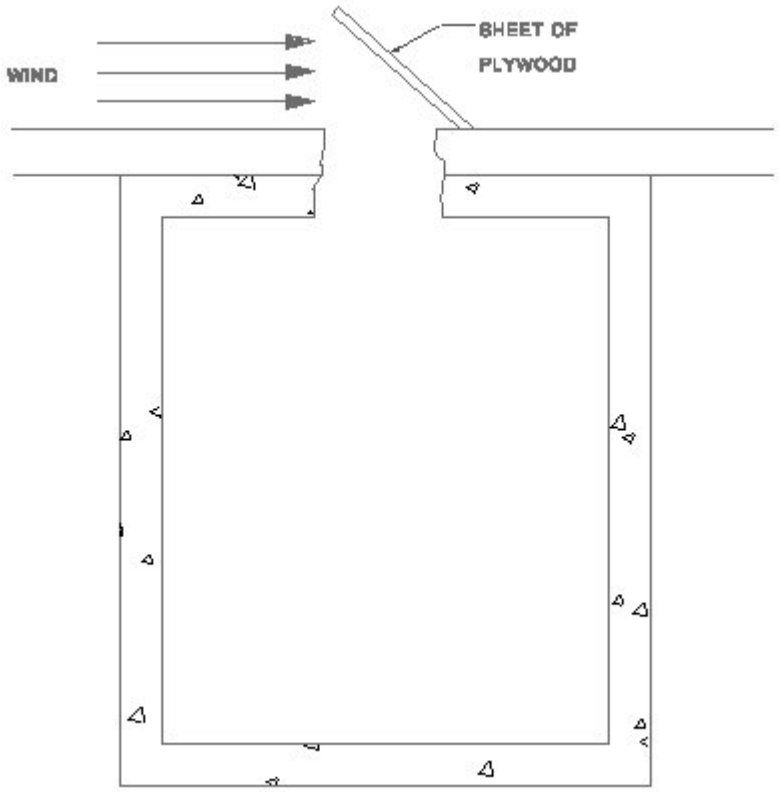
7.6.3.8. Emergency Entrance. If, in an emergency, it becomes necessary for a worker to enter a manhole or vault where gas is present, the worker must use an approved gas mask and a safety belt with an attached life line attended by another worker stationed at the manhole or vault opening.

7.6.4. 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.

7.6.4.1. 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.

7.6.4.2. Sail Method. The sail method (see Figure 7.2) 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 7.2. Sail Method of Manhole Ventilation.



7.6.4.3. 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.

7.7. Work Inside Underground Structures:

7.7.1. General:

7.7.1.1. Continuous adequate ventilation is required.

7.7.1.2. While work is being performed in manholes or vaults, provide the additional workers as discussed in AFH 32-1285.

7.7.1.3. 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.

7.7.1.4. Handle tools in a manner that protects the workers and work area.

7.7.1.4.1. 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.

7.7.1.4.2. 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.

7.7.1.4. 3. Provide when feasible: a windless hand crank; subsurface worker rescue assembly; or an approved retracting lifeline system.

7.7.1.5. Visually inspect for hazardous conditions such as burnt or cut cables, or loose or defective ladders before starting work.

7.7.1.6. 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.

7.7.1.7. Use only flashlights or facility approved lighting units for illumination in manholes.

7.7.1.8. Low-voltage (less than 600 volts) 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 volt) lighting systems and low-voltage tools, and/or pneumatic tools in maintaining subsurface vaults and facilities.

7.7.2. Precautions before Commencing Work:

7.7.2.1. 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.

7.7.2.2. 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 should not continue until permission is given by the authorized individual-in-charge.

7.7.2.3. Do not remove or place an identification tag on a circuit without direct permission from the authorized individual.

7.7.3. Before cutting into a cable, be absolutely sure that the cables are de-energized. Remove the cable sheathing (lead or other) and test for voltage. Use only approved voltage detectors.

7.7.4. Work on cable and equipment only after de-energizing the cable or equipment, when feasible.

7.7.5. Consider cable and apparatus energized, and use personal protective equipment until the following steps have been taken:

7.7.5.1. Test the item with an approved device and been prove it is de-energized.

7.7.5.2. Ground the item from all possible sources of power (including transformer secondary backfeed).

7.7.5.3. 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 de-energized. Omission of grounds should be permitted only if their application would increase the work hazard.

7.7.5.4. The cable has been grounded for a sufficient length of time to drain off any static charges.

7.7.6. Proving Low-Voltage Cables De-energized at the Work Location:

7.7.6.1. 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 volts or less, phase to phase.

7.7.6.2. Cables normally energized at more than 600 volts, phase to phase, or any cable whose voltage or identity is questionable, shall be proven de-energized by following the method for medium-voltage cables.

7.7.7. Proving Medium-Voltage Cables De-energized at the Work Location:

7.7.7.1. Use an approved test device to prove medium-voltage equipment and cables are de-energized when the cable terminals or apparatus are equipped with capacitive test points or have bare exposed parts.

7.7.7.2. If an approved test device cannot be used, prove the equipment and cables are de-energized as follows:

7.7.7.2.1. Isolate the equipment or cable from all possible sources of power, and positively trace it to the work location.

7.7.7.2.2. 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.

7.7.7.3. Place a temporary ground on the cable before splicing to allow dissipation of any capacitance charge and to ensure the cable is de-energized.

7.7.8. Working on Cables and Apparatus:

7.7.8.1. Maintain the required minimum working distance (see AFH 32-1285) appropriate to the voltage level, and whether the item being worked on is energized or de-energized. Be sure what items are de-energized and what items are energized.

7.7.8.2. All cable and apparatus must be tagged properly.

7.7.8.3. Place rubber blankets or other suitable insulating barriers to prevent accidental contact when a worker is in proximity to live parts,

7.7.8.4. Special Hazards:

7.7.8.4.1. Check the secondary voltage of any transformer fed from a de-energized feeder cable. Ground the cable on each side of the work location.

7.7.8.4.2. Do not open neutral conductors without the prior installation of suitable bypass conductors.

7.7.8.4.3. 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 shall be moved where such movement requires changing bends. All energized cables must be handled with rubber gloves, and, if required, hot-line tools as appropriate to the voltage level (see AFH 32-1285).

7.7.8.4.4. De-energize the circuit before separating or connecting a 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 de-energized and is grounded.

7.7.8.4.5. Avoid sparks in connecting or disconnecting cables, apparatus, and switching devices.

7.7.8.4.6. Before operating a primary grounding switch, the authorized operator shall be certain of the following:

7.7.8.4.6.1. All personnel are at their correct location.

7.7.8.4.6.2. The tags on the feeder cable and equipment in the vault or manhole bear the same numbers as shown on single line drawings.

7.7.8.4.6.3. Network protectors are in the open position or, in the case of radial transformers, the secondary fuses have been removed and transformer secondaries are de-energized.

7.7.8.5. Cutting of Cables. Before making an opening in or removing a part of the sheath or sleeve of a cable, the line must be grounded at the first possible grounding point on each side of the work location.

7.7.8.5.1. 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.

7.7.8.5.2. 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 or other approved testing devices, to determine whether or not the cable is de-energized. If no indication of a live cable is obtained, the worker may proceed with the work.

7.7.8.5.3. 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 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 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.

7.7.8.5.4. 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.

7.7.9. Cable Splicing Precautions. Heat materials and equipment for splicing cable in such manner to avoid hazards to those working in manholes or vaults, and to vehicular or pedestrian traffic.

7.7.9.1. Wear gloves while heating or working with hot insulating compound.

7.7.9.2. Do not be place or store furnaces and tanks containing liquefied petroleum gas, such as butane or propane, in a manhole or vault.

7.7.9.3. Use only approved soldering pots, furnaces, and ladles in good condition.

7.7.9.4. Safely position heating pots for solder, oil, or compound so that the contents cannot enter the vault or manhole in the event of spillage.

7.7.9.5. Keep torches or furnaces at a safe distance from flammable and combustible material.

7.7.9.6. Keep lighted furnaces or torches 1.2 meters (4 feet) or more from manhole openings, when practical, and where they will be the least possible hazard to property, workers, and the public.

7.7.9.7. Provide adequate ventilation to provide sufficient air for workers and support combustion if it is necessary to use torches or furnaces in manholes.

7.7.9.8. Heat solder ladles before use. Be sure that scraps of cold solder are dry before re-melting. Do not permit moisture and molten metal to contact another because this may cause a splash of hot metal. Bars or pigs of solder, tools, and ladles should be heated over the furnaces before being put into a pot of hot solder. Note: This precaution should be emphasized for inexperienced workers.

7.7.9.9. Ignite furnaces carefully, and guard them with a three-sided windshield at all times when burning in public places. Never light or burn furnaces in dangerous locations. Never leave them unattended. Do not transport lit or hot torches or furnaces in vehicles.

7.7.9.10. Take special care not to splash solder on any person or equipment.

7.7.9.11. Do not place soldering pots on furnaces without a pot guard.

7.7.9.12. Do not attempt to do soldering unless another worker is stationed as a guard. If necessary, rope off a safe area for the work.

7.7.9.13. Warn those in the manholes to stand clear before lowering hot solder or compound into a manhole, . Do not lower anything into a manhole until given instructions from below.

7.7.9.14. If compound kettles have no breathers, punch holes through the top crust of the compound to the bottom before heating so that air and moisture can escape. Heat the compound slowly.

7.7.9.15. Place compound kettles on the hoods or plates provided, and never directly on top of the furnaces.

7.7.9.16. Do not allow heated paraffin to exceed a temperature of 198 degrees C (390 degrees F).

7.7.9.17. Follow the manufacturer's instructions for all operations when using bottled liquid fuels, including installation and removal of the fuel cylinder, lighting and use of the torch, and cleaning of the torch orifice.

7.7.9.18. Use bottled liquid fuels only in well-ventilated areas.

7.7.9.19. Do not store bottled liquid fuel cylinders near heat or fire, in underground structures, or in living spaces.

Chapter 8

INTERIOR MEDIUM-VOLTAGE SYSTEMS

8.1. Overview:

8.1.1. This chapter discusses additional requirements needed to work safely on and around the specialized electrical equipment used in interior medium-voltage electrical systems.

8.1.2. Many of the same safety requirements apply as for outdoor medium-voltage substations (see Chapter 5). Accomplish the work with only qualified electrical workers with training and experience on medium-voltage circuits.

8.1.3. Consult the manufacturer's instruction manual for the apparatus before starting work, if available.

8.1.4. 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.

8.2. Hazards of Rotating Machinery. Be sure guards are provided to protect workers from accidental contact with live electrical parts, rotating parts, and hot machine surfaces. Be aware that rotation may loosen grounding connections and 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.

8.3. Working on Indoor Equipment:

8.3.1. Restricted Space. Be alert that older installations may not meet current NEC clearance and entrance requirements for electrical rooms. Where installation 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.

8.3.2. Grounding systems. Verify that existing permanent electrical system grounds are adequate for personnel protective grounding, and provide additional temporary grounding as necessary (see Chapter 3).

8.3.3. 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.

8.3.4. 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.

8.3.5. 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.

Chapter 9

INTERIOR LOW-VOLTAGE SYSTEMS

9.1. Overview:

9.1.1. This chapter reviews some of the additional knowledge needed to work safely on and around the specialized electrical equipment used in interior low-voltage electrical systems.

9.1.2. Accomplish the work with only qualified electrical workers with training and experience on low-voltage circuits.

9.1.3. Consult the manufacturer's instruction manual if available for the apparatus before starting work, .

9.1.4. 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.

9.1.5. In most cases only contract personnel or specially trained workers should repair complex controls and special equipment.

9.2. Hazards of Battery Rooms:

9.2.1. Be familiar with storage battery safety rules (see Chapter 5).

9.2.2. Check that there is adequate ventilation, either forced or natural, to prevent buildup of explosive mixtures.

9.2.3. Check that warning signs are securely attached and in legible condition.

9.2.4. Check that eyewash apparatus is in operable condition. If none is permanently installed provide temporary eyewash apparatus.

9.2.5. Verify that cell ventilation openings are unobstructed.

9.3. Work on Fire Alarm Systems. Maintaining fire alarm systems with their appropriate safety requirements requires special training. Workers should have completed one or more of the following certifications or specialized training:

9.3.1. Factory trained and certified, or

9.3.2. Certified by the National Institute for Certification in Engineering Technologies (Fire Alarm Systems), or

9.3.3. Certified by the International Municipal Signaling Association (Fire Alarm Systems), or

9.3.4. Certified by state or local authority, or

9.3.5. Trained and qualified by an organization listed by a nationally recognized testing laboratory for the servicing of fire alarm systems.

9.4. Work on Motors and Generators:

9.4.1. After work has been performed on circuits to rotating machines, check direction of rotation.

9.4.2. Always take positive steps to ensure that rotating equipment under repair cannot be set into motion.

9.4.3. 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.

9.5. Work on Solid-State Equipment. Adjustable-speed motor controllers and uninterruptible power supply (UPS) equipment are complex solid-state devices that should 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 should not be considered qualified. Facilities with these installations should contain cautionary labeling to warning facility workers of the electric shock dangers involved in operating and maintaining these types of equipment.

9.6. Summary of Low-Voltage Work Precautions.

9.6.1. Assume all parts of an electric circuit are energized until proven otherwise. Personally inspect circuits before starting work to be sure circuits are de-energized.

9.6.2. Use only insulated hand tools when working on equipment where the tool could contact an energized source of 50 volts 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 should be assumed to not meet OSHA requirements for use of insulated hand tools.

9.6.3. Whenever possible, de-energize circuits adjacent to the work area. If the minimum qualified working distances cannot be maintained, the work shall be classified as work on energized equipment,

and prior approvals are required. (See AFH 32-1285 for Qualified Worker Minimum Working Distances.)

9.6.4. Use a reliable voltage detector before beginning work on de-energized circuits or equipment, to prove the circuit and equipment dead. Where considerable work is to be performed, it is good practice to short-circuit and ground the circuits and equipment.

9.6.5. The supply or line side of switches or fuses can remain energized when all work is to be performed on the load side of such switches or fuses, provided the following conditions are met:

9.6.5.1. Sufficient clearance exists between energized and de-energized parts so that work can be done safely; and

9.6.5.2. The voltage is 300-volts or less phase-to-phase and phase-to-ground.

9.6.5.3. Otherwise, obtain prior approvals and take precautions for energized work.

9.6.6. Work on equipment with voltages less than 50-volts. Prior approval is not required since this is not considered work on energized equipment. However, exercise normal care and avoid contact with conductors.

9.6.7. Work on Energized Equipment of 50 to 300-volts:

9.6.7.1. Prior approval is required.

9.6.7.2. When working on or near energized circuits, workers shall stand on a dry surface, other than cement or masonry, or wear electrician's rubber footwear.

> 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 should be assumed to not meet OSHA requirements for use of insulated hand tools.

9.6.7.3. Assign at least two qualified electrical workers to the job. (See AFH 32-1285 for requirements for number of qualified workers based on the hazard exposure.)

9.6.8. Work on Energized Equipment of 301 to 600-volts. Prior approval is required. Follow requirements given in AFH 32-1285.

9.6.9. Routine electrical measurements may be performed on energized interior electric circuits or equipment when the operating at 600 volts ac and 250 volts dc, or less, between conductors.

9.6.10. Switches:

9.6.10.1. Use only load-break rated switches. When feasible, install replacement switches enclosed in grounded metal cabinets having the control lever operable from outside the cabinet. An open knife switch may be particularly hazardous because of the exposure of live parts, and because of the arc that might be formed when the switch is opened.

9.6.10.2. Install a knife switch so that the blades are dead when the switch is open, and so gravity can not tend to close the switch.

9.6.10.3. Install double-throw switches horizontal so that their operation can not be affected by gravity. Provide a locking device to hold movable blades in the correct position on vertically mounted double-throw switches.

9.6.11. Fuses and Circuit Breakers:

9.6.11.1. Provide fuses and other overcurrent devices in accordance with the NEC, rated and sized to interrupt the maximum short circuit current available.

9.6.11.2. Replace a blown fuse with one having identical rating and characteristics. Obtain an engineering evaluation before changing fuse types, and document the change on facility drawings and schedules. Do not substitute copper wires or other conductors for fuses.

9.6.11.3. Take fuses entirely out of holders when removing them from circuits. A fuse should be pulled only with an insulated fuse puller. On circuits energized from 301- to 600 volts, use both fuse tongs and rubber gloves. Open the operating switch, if provided, to remove the load when it is necessary to remove a cartridge fuse.

9.6.12. Control Equipment:

9.6.12.1. Do not permit the working areas to be used for storage in front, behind, or near switchgear, switchboards motor control centers or panelboards . Keep this space clear of rubbish.

9.6.12.2. Ensure good illumination is provided for the working areas at the front and rear of switchgear, switchboards motor control centers or panelboards.

9.6.12.3. Ensure the switchgear, switchboards motor control centers or panelboards framework is grounded in accordance with the NEC.

9.6.12.4. Maintain the connections, wiring, and equipment of switchgear, switchboards motor control centers and panelboards in an orderly arrangement. Switches, fuses, and circuit breakers must be plainly marked, labeled, and arranged to afford ready identification of the circuits and equipment they supplied.

9.6.13. Grounding:

9.6.13.1. Many low-voltage electrical mishaps are caused by a failure to understand the hazards of low-voltage wiring. The most misunderstood subject is the “grounding.”

9.6.13.2. Routinely review the grounding requirements of the NEC.

9.6.13.3. Use properly grounded portable electric tools, particularly in damp locations or near grounded equipment or piping.

9.6.13.4. Do not open a ground connection to a water pipe or ground rod until the ground wire has been disconnected at the equipment.

9.6.13.4.1. Be alert for ground connections where a plumber could inadvertently open the ground circuit by maintenance or repair work. In this case, relocate the electrical ground conductor to a proper grounding location.

9.6.13.4.2. Be particularly alert for grounds on metal natural gas lines that may have been mistaken for potable water lines. Relocate these electrical ground conductors to a proper grounding location.

Chapter 10

UNUSUAL HAZARDS FOR ELECTRICAL WORKERS

10.1. Poisonous and Non-poisonous Snakebites:

10.1.1. Take a snakebite victim to a hospital as quickly as possible, even in cases when only a nonpoisonous snakebite is suspected. All snakebites should receive professional medical attention.

10.1.2. First Aid:

10.1.2.1. Keep the victim from moving around.

10.1.2.2. Keep the victim as calm as possible, preferably lying down.

10.1.2.3. Immobilize the bitten extremity and keep it at or below heart level.

10.1.2.4. Take precautions for shock.

10.1.2.5. If breathing stops, give mouth-to-mouth resuscitation. If breathing stops and there is no pulse, perform cardiopulmonary resuscitation (CPR).

10.1.2.6. 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.

10.1.2.7. 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.

10.1.2.8. 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.

10.1.2.9. Do not apply a tourniquet, administer electric shock, or cut the wound.

10.1.2.10. 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 should use these older-style kits.

10.1.3. Identify the Snake. If the snake can be killed without risk or delay, it should be brought, with care, to the hospital for identification.

10.1.4. Symptoms of snakebite may range from mild to severe.

10.1.4.1. 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.

10.1.4.2. 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.

10.2. Nonpoisonous Insect Bites:

10.2.1. There are a variety of insects that have biting or stinging mouthparts that may inject toxic materials into the skin.

10.2.2. 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.

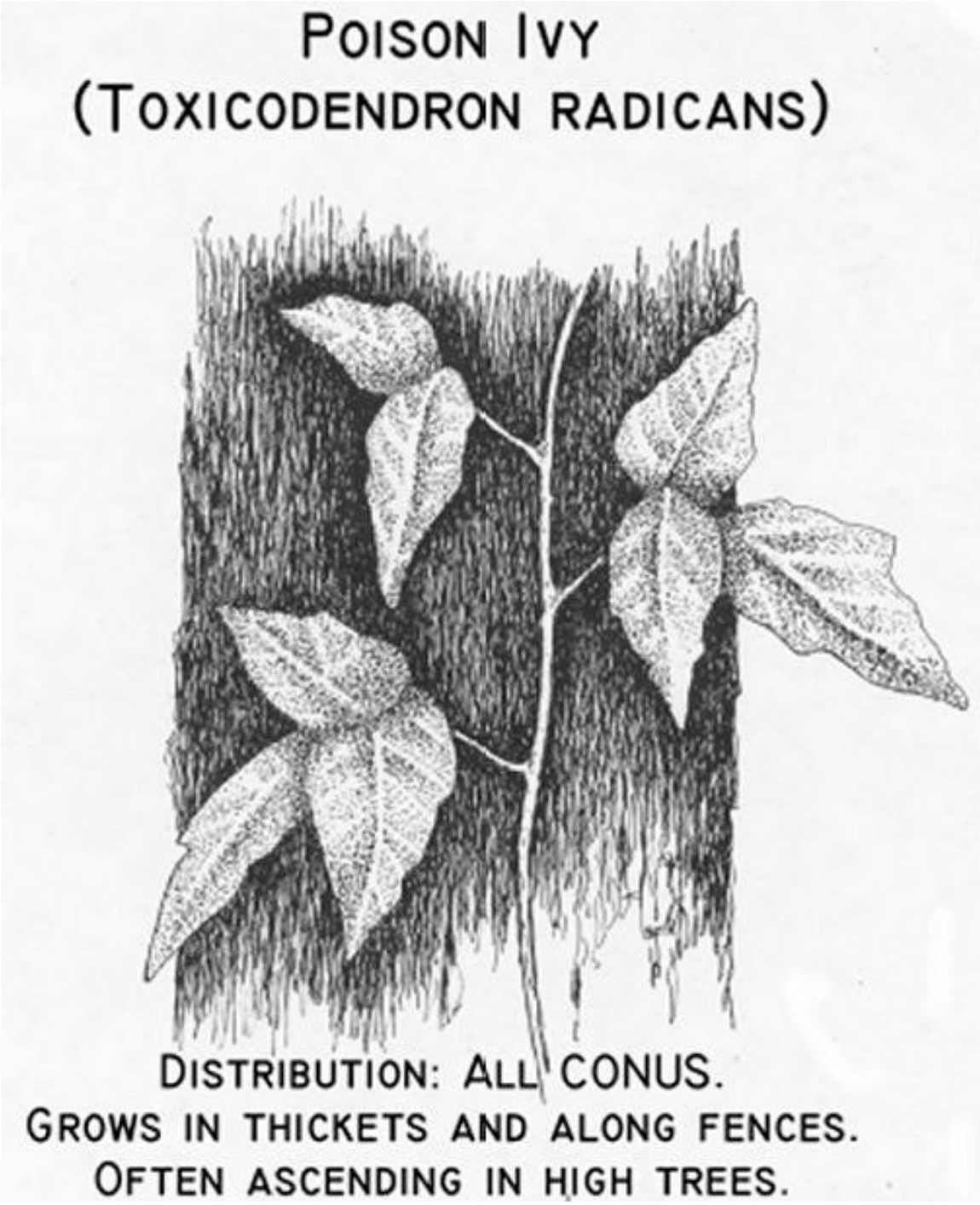
10.2.3. If a tick bite is suspected, and a rash or flu-like symptoms develop, consult a physician.

10.2.4. Workers known to be particularly allergic to any insect venom (anaphylaxis) should be seen by a physician without delay. Such workers should carry an anaphylaxis kit (available by prescription only), if they are aware of this condition.

10.3. Poisonous Plants. Learn to recognize and avoid poisonous plants. Poison can be absorbed through the skin if the worker contacts poisonous plants such as poison ivy, poison oak, and poison sumac.

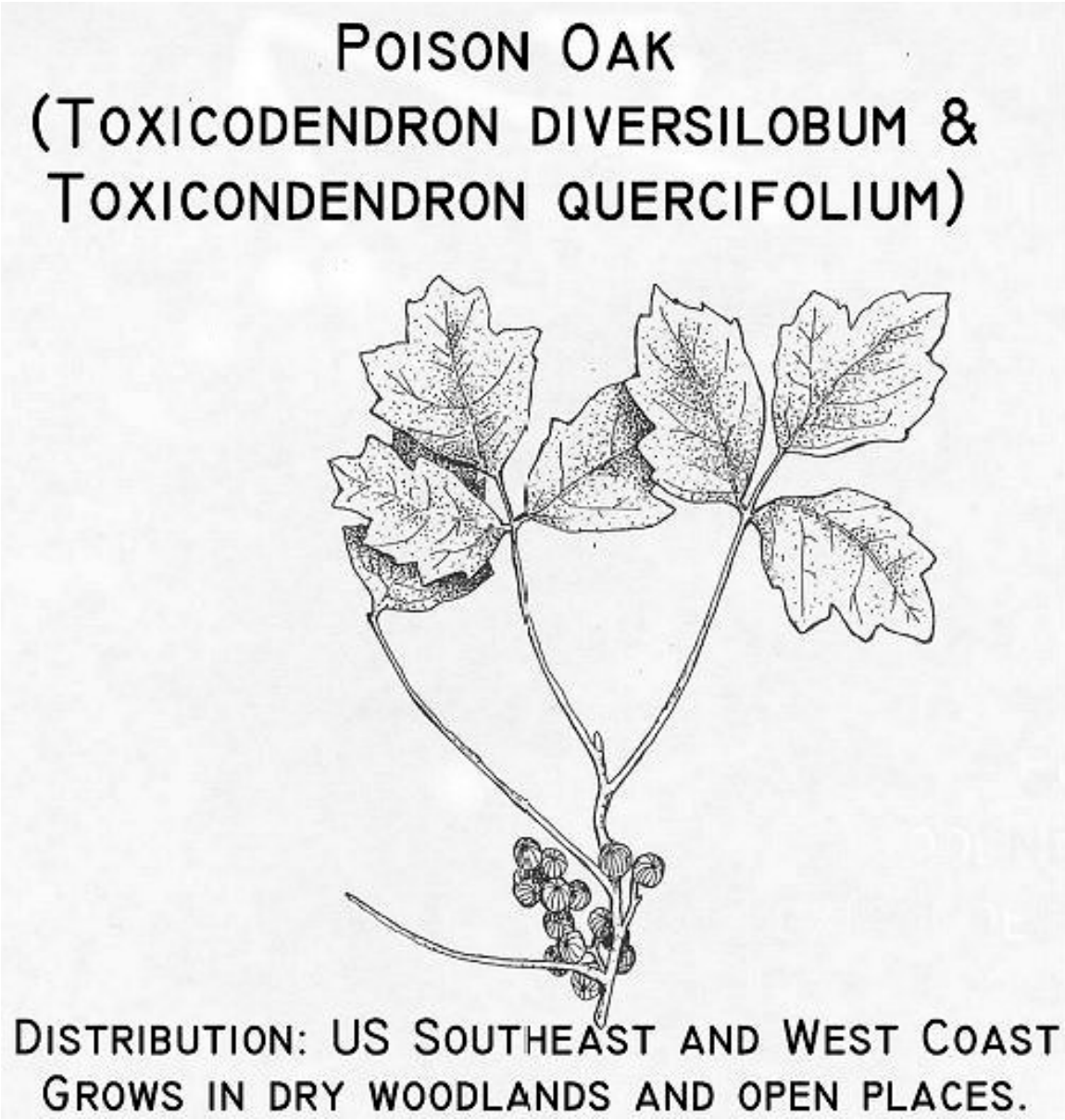
10.3.1. **Poison Ivy**. A climbing vine, shrub or small tree. Poison ivy grows on poles, trees, along fence rows, shores of streams, rivers, and lakes, along the borders of woods, and openings in the woods. Leaves always grow in groups of three. Leaf size varies from less than a half inch to over two 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. See Figure 10.1.

Figure 10.1. Poison Ivy.



10.3.2. Poison Oak. Western poison oak grows a twining vine on tree trunks or as erect shrub up to 6-feet high. Eastern poison oak grows only as low branching shrub, up to 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. See Figure 10.2.

Figure 10.2. Poison Oak.



10.3.3. **Poison Sumac.** Poison sumac is a tall shrub or small tree, up to 25 feet high with a trunk diameter up to 6-inches. Leave groups are 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 10.3. Poison Sumac

10.3.4. Prevention consists of avoiding contact by observing these precautions

10.3.4.1. If working in areas where poisonous plants may be found, shirts with full-length sleeves should be worn, with the sleeves rolled down and buttoned. Trouser cuffs should be fastened around the ankles. All exposed areas of the skin should have a film of approved protective ointment applied as a preventive measure.

10.3.4.2. 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.

10.3.4.3. 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 should be used in cleaning contaminated clothing to avoid re-infection.

10.3.5. 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.

10.3.6. If you suspect you have had any contact with a poisonous plant, start treatment to avoid more severe symptoms.

10.3.6.1. 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.

10.3.6.2. Apply an approved medicated ointment to the affected area to reduce discomfort.

10.3.6.3. Avoid scratching the affected area.

10.3.6.4. In severe cases, obtain medical attention.

10.4. Gas Poisoning. Gas poisoning is a particular danger when working in below grade structures.

10.4.1. A rescuer shall not enter a gas-filled area without appropriate precautions.

10.4.2. 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.

10.4.3. 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.

10.5. Electric Shock. Electric shock is an ever-present hazard for facility 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.

10.5.1. Electricity acting on the human body can result in the following conditions:

10.5.1.1. Burns. Electric current passing through the body or the actions of electric arcs contacting the body can cause surface and interior burns.

10.5.1.2. Cessation of Respiration and Heartbeat. An electric shock may 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.

10.5.2. Freeing the Victim. Muscle spasms may 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.

10.5.3. Electrical workers should 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.

10.5.4. Electrical workers should also be periodically trained in rescuing unconscious shock victims from locations such as poles and underground structures (see Chapter 11).

Chapter 11

RESCUE OF PERSONNEL

11.1. 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.

11.1. Pole-top Rescue. Artificial respiration can be applied to an unconscious victim on a pole. CPR may not be effective and should not be tried. If CPR is required, the victim should be lowered as quickly as possible, and then CPR administered. If no aerial lift devices are available for rescue, the following procedures should be followed:

11.1.1. Get Help. Call or assign someone to call the local emergency medical service (EMS) or fire department.

11.1.2. Climb to Rescue. A worker (rescuer) must 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 should be applied on the pole. The best position 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. See AFH 32-1285, and Figures 11.1 and 11.2 for pole rescue illustrations.

11.1.3. Lowering the Victim from the Pole. When CPR is necessary, the rescuer should lower the victim to the ground to begin CPR. CPR may not be effective on the pole.

11.1.3.1. 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. (See Figure 11.1).

11.1.3.2. Finally, use a handline to lower the victim as illustrated in AFH 32-1285 for either one or two rescuers.

11.1.3.3. If not already done, help should be summoned by whatever means are available without delaying the CPR. Commence CPR and continue until relieved by EMS personnel.

Figure 11.1. Position to Support Victim’s Body Weight.

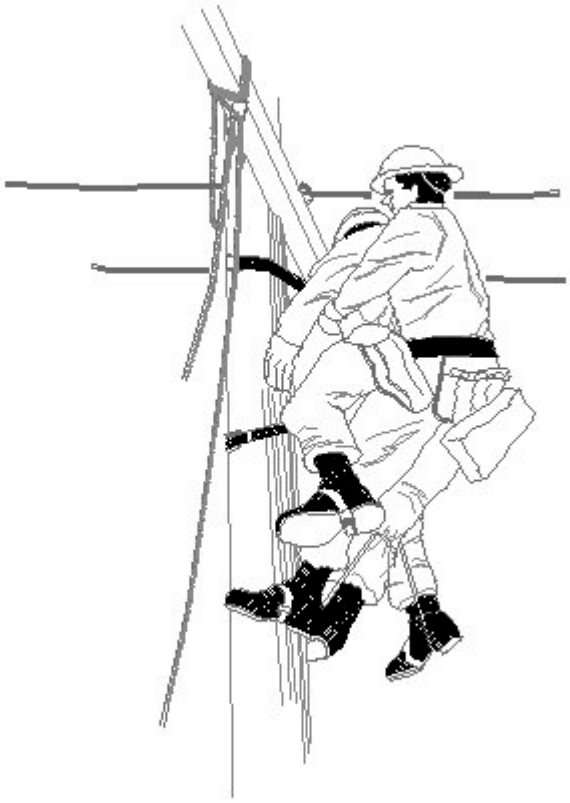
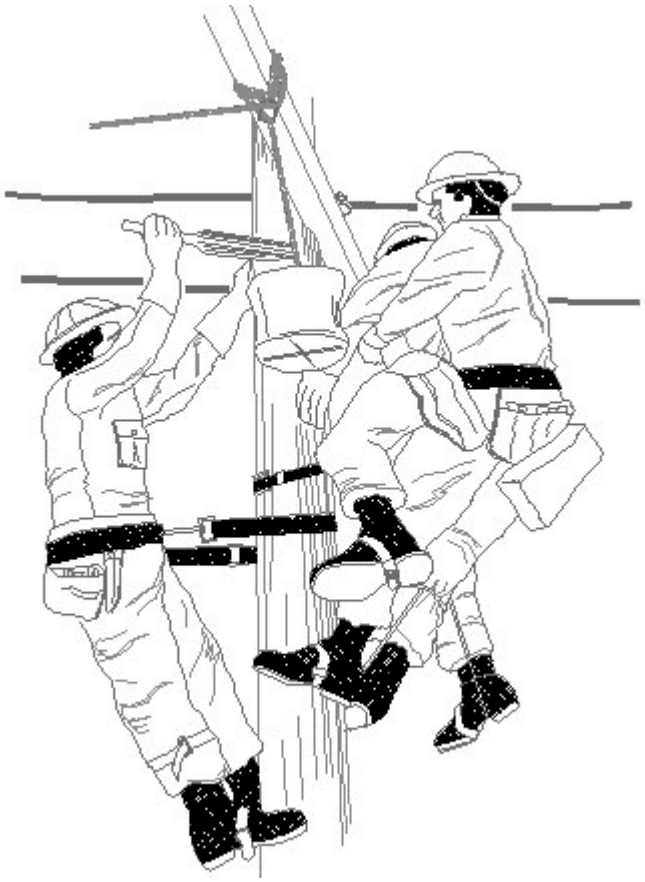


Figure 11.2. Two Rescuers Preparing to Lower Victim.



11.2. 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 (see Figure 7.2) while preparing for the rescue.

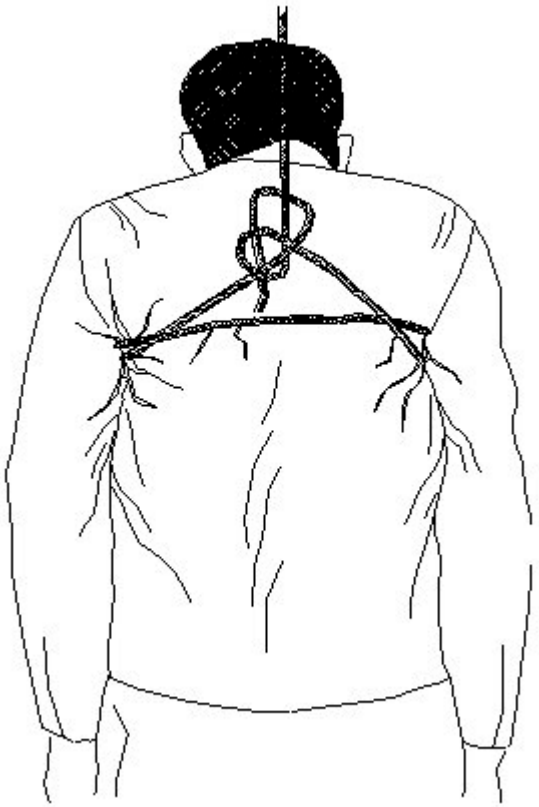
11.2.1. Get Help. Call or assign someone to call the local emergency medical service (EMS) or fire department.

11.2.2. Observe all measures of safety. If at all possible, there should 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 in doubt, obtain help before starting the rescue.

11.2.3. There are many ways in which a rescue can be done. The most modern method is illustrated in AFH 32-1285 utilizing fall retrieval equipment. Two other methods are described here, commonly described as the Windlass System (One-Worker) Rescue and the Two-Worker Manual Rescue

11.2.4. Both rescue methods use a rescue rope. The rescue rope should 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 11.3) or at the front of the body for the Windlass System (One-Worker) Rescue.

Figure 11.3. Bowline Position for Two-Worker Manual Rescue from a Manhole.



11.2.5. Windlass System (One-Worker) Rescue. This 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.

11.2.5.1. This method depends on the use of a manhole guard. Therefore, you should use a manhole guard anytime manhole work is done. Install a windlass handcrank on the top of the guard. Use about 8 meters (25 feet) of 13-millimeter (1/2-inch) rescue rope or Polydak line. Keep this system installed for material handling operations and it will be ready if a rescue is needed.

11.2.5.2. 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.

11.2.5.3. After entering the manhole, wrap the rope around the victim with a bowline knot in front of the victim (similar to Figure 11.3, except place the bowline knot in front of the victim). This allows the head to lean back, keeping the air passage open.

11.2.5.4. Use the windlass to raise the victim until the victim’s buttocks clear the manhole rim.

11.2.5.5. Position the victim with the victim’s back toward the opening of the manhole guard.

11.2.5.6. Tip the manhole guard so the victim is lying face up.

11.2.5.7. Commence CPR, if necessary, and continue until relieved by EMS personnel.

11.2.6. Two-Worker Manual Rescue. This rescue method is usually the fastest if a second worker is available. It may be the only feasible method if a windlass system was not already installed.

11.2.6.1. 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 11.3. The two rescuers work together to lift and push the victim out of the manhole.

11.2.6.2. The rescue rope should be at least 13 millimeters (one-half inch) in diameter. The length of the rescue rope should be at least the depth of the manhole plus 4.5 meters (15 feet).

11.2.6.3. Once the victim is out of the manhole, lay the victim face up. Commence CPR, if necessary, and continue until relieved by EMS personnel.

JOHN W. HANDY, Lt General, USAF
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Note: The most recent edition of referenced publications applies, unless otherwise specified.

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AFOSH Standard 91-31, *Personal Protective Equipment*
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Terms

ANSI—American National Standards Institute.

Approved—Sanctioned, endorsed, accredited, certified, or accepted as satisfactory by a duly constituted and nationally recognized authority or agency.

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.

Blocking—Placing a switch in the open or closed position and mechanically ensuring the position of the switch cannot be accidentally changed.

Cable—A conductor with insulation or a stranded conductor with or without insulation and other coverings (single conductor cable or a combination of conductors) insulated from one another (multiple conductor cable). ***Note: A cable sheath may consist of multiple layers of which one or more are conductive.***

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.

Certified or Certification—The accomplishment of curriculum as specified in this publication.

Circuit—For purposes of this instruction only, a conductor or system of conductors through which an electric current is intended to flow.

Circuit Breaker—A device to open and close a circuit and to open the circuit automatically at a predetermined overload of current, without injury to itself, when properly applied within its rating.

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).***

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.

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 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.

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.

NOTE:—The NEC states low voltage is 600v and below.

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.

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 volts (nominal phase-to-phase). • *Distribution Voltage.* Lines and equipment operating above 600 volts (nominal phase-to-phase) up to and including 36kV (nominal phase-to-phase). Note the NESC refers to high voltage as above 750 volts.

• *Transmission Voltage.* Lines and equipment operating above 36 kV (nominal phase-to-phase).