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ELECTRICAL SAFETY FIELD GUIDE

DEPARTMENT OF THE NAVY

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NAVY HANDBOOK 45-117-6-98
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ELECTRICAL SAFETY FIELD GUIDE

This handbook summarizes safety requirements for electrical workers in the field.

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Contents

Chapter 1 Electrical Hazards and Mishaps

1-1 Scope..... 1
1-2 Reminder of Electrical Hazards in the Field. 2
1-3 Mishap Handling 8

Table 1-1 Effects of 60-hertz current on humans . 4
Table 1-2 Hazardous materials..... 5
Table 1-3 Precautionary Step for Asbestos Exposure 7
Table 1-4 Knowing what to do..... 9

Chapter 2 Worker/Crew Responsibilities

2-1 Levels of Responsibility..... 11
2-2 Electrical Work Qualifications..... 11
2-3 Safety Observances..... 12
2-4 Compliance with Safety Rules..... 15

Table 2-1 Levels of safety accountability 11
Table 2-2 Prohibited actions 13
Table 2-3 Unsafe worker indications 13
Table 2-4 Presite job requirements 13
Table 2-5 Significant unsafe actions and conditions 14

Chapter 3 Presite Safety Management

3-1 Work Area Aspects Affecting Safety..... 17
3-2 Electrical Aspects Affecting Safety..... 23
3-3 Verifying System and Equipment Provisions 29

Table 3-1 Minimum illumination requirements 18
Table 3-2 Excavation pre-survey checklist..... 20
Table 3-3 Excavation involving private utilities.... 21
Table 3-4 Performing excavations..... 21
Table 3-5 Backfilling..... 22
Table 3-6 Damage during backfilling of trenching 22
Table 3-7 Limits of approach 24
Table 3-8 Qualified worker minimum working Distances..... 25
Table 3-9 Unqualified worker minimum approach Distances..... 25
Table 3-10 Jobs requiring two electrical workers.... 28
Table 3-11 Jobs working in confined spaces requiring additional workers 28
Table 3-12 Jobs generally acceptable for one Electrical worker 29

Chapter 4 Personal Protective Equipment

4-1 General Body Protection 30
4-2 Additional Worker Protection for Pole/ Tree Climbing and for Fall Protection 31

Table 4-1 Apparel and body protection requirements..... 33
Table 4-2 Qualifications for climbing..... 37
Table 4-3 In-use check of pole climber gaffs..... 38

Chapter 5 Work Area Protective Equipment

5-1 Temporary Protective Electrical Insulation .. 41
5-2 Energy Hazard Detection 48

Table 5-1 ASTM F 18 rubber goods..... 42
Table 5-2 Ladder inspections..... 45
Table 5-3 Proper care and storage of ladders 45
Table 5-4 Proper setup and use of ladders 46

Chapter 6 De-Energized Line Clearance

6-1 Safe Clearance Procedures..... 50
6-2 Lockout/tagout/tryout Instructions 51
6-3 Hazardous Energy Elimination 51

Table 6-1 Sequence of lockout/tagout/tryout steps..... 51
Table 6-2 Hazardous energy control 52

Chapter 7 De-Energized Line Grounding

7-1 Grounding Provision..... 53
7-2 Why Temporary Grounds are Necessary..... 54
7-3 Equipotential (Single Point) Grounding..... 55
7-4 Placement of Grounds..... 55
7-5 Temporary Grounding System Components..... 57
7-6 Temporary Grounding of Aerial Lines..... 60
7-7 Temporary Grounding of Substation Current-Carrying Equipment Components... 61
7-8 Aerial Lift Truck Vehicle Grounding..... 65
7-9 Temporary Grounding of Underground Lines..... 68
7-10 Opening or Splicing De-Energized Conductors..... 68
7-11 Grounding for Stringing and Removing Lines..... 68

Table 7-1 Causes of hazardous induced potential differences 54
Table 7-2 Temporary grounding connection/ removal procedure..... 56
Table 7-3 Maximum fault current capability for grounding cables 58
Table 7-4 Temporary ground rod minimum requirements..... 59
Table 7-5 Substation protective grounding procedures..... 63
Table 7-6 Grounding of substation equipment..... 64
Table 7-7 Grounding of equipment during oil handling..... 65
Table 7-8 Procedures for grounding insulated and uninsulated aerial lift trucks..... 66
Table 7-9 Stringing/removing conductor ground locations..... 71
Table 7-10 Conductor ground location after pulling 71

Chapter 8 Energized Line Work

8-1 Normal Work Methods 73
8-2 Permitted Energized Line Work Methods 73
8-3 Voltage Levels and Approved Work Methods and Equipment..... 74
8-4 Prework Procedures..... 79
8-5 General Job-in-Progress Procedures..... 80

Table 8-1 Categories of energized line maintenance work 74
Table 8-2 Approved energized work methods by voltage class..... 75
Table 8-3 Insulating tools for electrical workers ... 76
Table 8-4 Insulating plastic guards/platforms for electrical workers..... 77
Table 8-5 Prework procedures..... 79
Table 8-6 Energized work precautions..... 80
Table 8-7 Voltage level work procedures..... 81

Chapter 9 Substations and Switchgear

9-1 Safety Precautions..... 84
9-2 Major Equipment Hazards and Safety Precautions..... 84

Table 9-1 Major device important safety reminders 85

Chapter 10 Aerial Lines

10-1 Safety Precautions 89
10-2 Climbing and Working on Poles 89
10-3 Aerial Rope Use 90

Table 10-1 Pole climbing and working precautions 90

Chapter 11 Underground Lines

11-1 Safety Precautions 91
11-2 Underground Structure Precautions..... 92
11-3 Work in Underground Structures 93

Table 11-1 Precautions before entering underground structures 92
Table 11-2 Precautions when working on underground structures..... 93
Table 11-3 Underground structure cable work precautions..... 94

Chapter 12 Shore-to-Ship Electrical Connection

12-1 Safety Precautions 95
12-2 Responsibilities 96
12-3 Distribution Systems 98
12-4 Substation Assemblies 100
12-5 Outlet Assemblies 103
12-6 Cables..... 107
12-7 Circuit Arrangements 112
12-8 Connection/Disconnection Procedures..... 119

Table 12-1 Shore-to-Ship electrical connection Responsibilities 96
Table 12-2 Shore-to-Ship electrical disconnect Responsibilities 96
Table 12-3 Specific SOP requirements 97
Table 12-4 Power cable specifications 110
Table 12-5 Portable cable and outlet safety Concerns..... 111
Table 12-6 Logistics requirements..... 121
Table 12-7 Unloading/loading equipment Precautions 122
Table 12-8 Rigging truck precautions 122
Table 12-9 Power cable setup precautions 123
Table 12-10 Power cable assemblies inspection 124
Table 12-11 Tagout procedures for shore power receptacles circuit breakers 125
Table 12-12 Inserting cable plugs into receptacles . 127
Table 12-13 Power cable rigging after ship docks .. 128
Table 12-14 Transfer back to ship’s generators..... 129
Table 12-15 Disconnection and removal of cable assemblies 130

Chapter 13 Electrical Worker Rescue
13-1 Rescue Needs 131
13-2 Pole-Top Rescue 131
13-3 Rescue from a Manhole 135
13-4 Aerial Lift Rescue 135

Appendix A 136

Table 13-1 Method for lowering a victim 133

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CHAPTER 1. ELECTRICAL HAZARDS AND MISHAPS

1-1. Scope. This handbook provides safety requirements and rules pertinent to electrical work in the field as performed by electrical supervisors, foremen, and crew members involved in inspection, switching, maintenance, line clearance, testing, and fault-locating. No phase of electrical operations and maintenance is of greater importance than mishap prevention. Your safety will be in direct proportion to your adherence to Navy safety directions.

a. Use. Use this handbook as a safety reminder. It has been sized to be carried on your person. Rules are limited to reminders of safe working practices with no attempt to explain the reasons for such practices unless they touch on major safety concerns. Such concerns are the damaging effects of electricity on the human body and the ever-present possibility of voltage differences occurring on de-energized electrical lines. Major causes of electrical mishaps are carelessness around electrical hazards, ignorance of the dangerous potentials that can occur on de-energized lines, and lack of suitable fall protection.

b. Supplementary Information. Additional safe performance of work directions are given in *MIL-HDBK 1025/10 (MIL-HDBK 1025/10 HANDBOOK FOR SAFETY OF ELECTRICAL TRANSMISSION AND DISTRIBUTION SYSTEMS)* which amplifies and complements this handbook. Reference is provided, where appropriate, to *OPNAVINST 5100.23, Navy Occupational Safety and Health (NAVOSH) Program Manual.*

1-2. Reminder of Electrical Hazards in the Field. Always identify the electrical hazards applying to the work being done. Rules, apparel, tools, and tests, if correctly used, will protect you from the destructive effects of electric shocks, arcs, and blasts and the hazards of elevated and confined workplaces.

a. Dangers From Electric Shock. Electric shock results from setting up an electric current path within the human body. The current flows because there is a potential gradient (voltage difference) between an energized object and the grounded worker. *Figure 1-1* shows potential gradients and the safe area or equipotential zone which has no potential gradient. *Figure 1-2* indicates current flow paths. *Table 1-1* indicates the effects of 60-hertz current on humans.

b. Danger from Arcs And Blasts. Arcs result from the passage of electric current through air; the air failing as an insulator but serving as a conducting medium for ionized gases. Blasts result when the metal at the arc site expands and vaporizes. Arcs can reach temperatures up to four times the temperature of the sun's surface. Water expands 1,670 times when it becomes steam; copper expands 67,000 times when it vaporizes. High energy arcs can be fatal even at distances of 10 feet (3 meters).

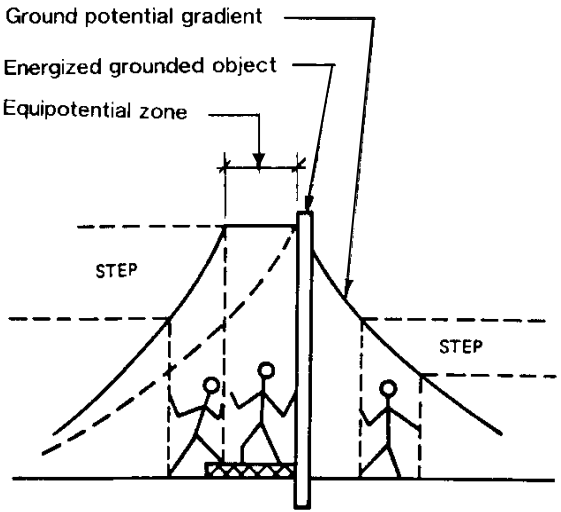
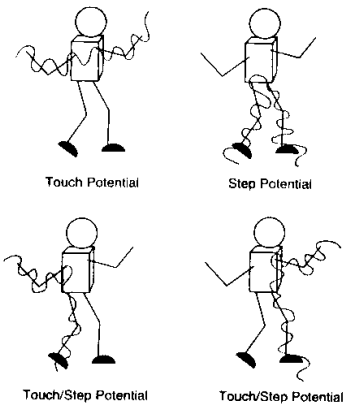


Figure 1-1
Ground potential gradient



The current path will determine which tissues and organs will be damaged or destroyed. The pathway is differentiated into three groups: touch potential, step potential, and touch/step potential.

Figure 1-2
Current path flow

Table 1-1. Effects of 60-hertz current on humans

	Effect	Milliamperes Men	Milliamperes Women[1]
1.	Slight sensation on hand	0.4	0.3
2.	Perception threshold	1.1	0.7
3.	Shock, not painful and muscular control not lost	1.8	1.2
4.	Painful shock, painful but muscular control not lost	9	6
5.	Painful shock let-go threshold	16	10.5
6.	Painful and severe shock, muscular contractions, breathing difficult	23	15
7.	Ventricular fibrillation, threshold	75	75
8.	Ventricular fibrillation, fatal (usually fatal for shock duration of 5 seconds or longer)	235	235
9.	Heart paralysis (no ventricular fibrillation), threshold (usually not fatal; heart often restarts after short shocks)	4,000	4,000
10.	Tissue burning (usually not fatal unless vital organs damaged)	5,000	5,000

[1]The current values for women are lower because women typically have less body mass than men.

c. Dangers from Workplaces. The dangers of a fall from an elevated workplace is self-evident. *Table 1-2* indicates typical hazardous materials which may be found in enclosures or confined work spaces. Check the applicable material safety data sheets (MSDS).

Table 1-2. Hazardous materials

Material	Source
Asbestos*	Insulation, underground manholes, under houses; crawl spaces, old electric equipment, fire protecting tape, duct banks, arc chutes
Polychlorinated biphenyl (PCB)	Old liquid-filled transformers, capacitors, ballasts, lead-sheathed cables
Sulfur hexofluoride (SF_6)	Toxic decomposition products from electric arcs or faults acting on SF_6 insulation
Combustible gases	Sewer or natural gas accumulations or from outgassing of lead-acid batteries
Carbon monoxide	Cable faults, combustion engine exhausts
Hydrogen chloride	Faults or fires involving polyvinyl chloride (PVC) conduits or PCB oils.
Inadequate oxygen	Displaced by heavier-than-air gases

* Asbestos was a widely used insulator. If insulation is not marked as being “Asbestos Free”, consider it to contain Asbestos. Avoid disturbing the material, getting on clothing, or anything that could make the fiber air borne. See paragraph **d:** Health for Hazards of Asbestos.

d. Health Hazards of Asbestos: Asbestos is a known human carcinogen. It's primary route of entry to the body is by inhalation, however exposure can occur by ingestion. Asbestos is not absorbed through the skin. The diseases caused by long term exposure to asbestos are: cancer of the lungs, plura sack surrounding the lungs, bronchus, oropharynx, stomach, and colon.

Symptoms are shortness of breath, dry cough, and clubbing of the fingers. These symptoms generally do not show up for 20 years or more after initial exposure.

The potential for a material containing asbestos to release breathable fibers depends on the material's degree of friability. Friable means that the material can be crumbled with hand pressure. When working around materials suspected of containing asbestos, it is important not to bump, brush or disturb the materials in any way. Wetting the materials can help to reduce the emission of fibers.

Note: Employees who are not qualified to work with asbestos are not to handle or remove materials containing asbestos fibers. Refer to *29 CFR 1015.1001(Asbestos*) for worker qualifications and requirements for handling asbestos containing materials.

Table 1-3. Precautionary steps for prevention to asbestos exposures

1. Have unknown material tested for asbestos. 2. Keep unknown fibers off clothing. Wear disposable coveralls.	3. Wear proper respiratory protection: either full face or half face respirators with P-100 Filter if working with fibrous materials. 4. After working with materials, wash hands prior to eating, drinking or taking a break.

1-3. Mishap Handling. Each worker should know what to do when a mishap occurs. Additionally, each worker should know how to report injuries and other mishaps.

a. Knowing What To Do. First aid and cardiopulmonary resuscitation training requirements for electrical workers. A medical professional must evaluate all shock victims for possible immediate hospitalization. *Table 1-4* summarizes the first aid knowledge required of each worker. As a preplanning aid, an emergency telephone number list should be prepared to include the location and telephone numbers of the nearest ambulance or emergency medical treatment responders, the nearest hospital with an emergency room, the nearest helicopter evacuation service, and the nearest burn trauma center.

Table 1-4. Knowing what to do

Item	Instructions/training
First aid	How to control bleeding and apply artificial respiration and cardiopulmonary resuscitation (CPR). How to provide pole top and manhole rescues of mishap victims. Familiarity with electric shock symptoms.
Medical provisions	Location, contents, and use of first aid kits and where located in electric line and aerial lift vehicles. How to get medical assistance.

b. Work Injuries and Mishap Reports. Report injuries, even minor ones, to your immediate supervisor in accordance with *OPNAVINST 5100.23, (Navy Mishap Investigation, Reporting, and Recordkeeping Program)* and *NAVFACINST 5100.11.* Additionally, every mishap involving personnel injury, property damage, or near misses must be investigated to determine the cause and the corrective action needed to prevent recurrence. Cognizant safety personnel conduct investigations. The safety staff must be notified of all mishaps that involve personnel injuries or property damage.

CHAPTER 2. WORKER/CREW RESPONSIBILITIES

2-1. Levels of Responsibility. Operation and maintenance of electrical distribution systems are a single work group responsibility. The same personnel will frequently perform both functions. All personnel are responsible for safety at all times. The safety accountability duties are given in *Table 2-1* from the top down.

Table 2-1. Levels of safety accountability

Title	Electric safety accountability
Installation commander	Ultimate safety responsibility
Base civil engineer	Base systems safety responsibility
Electric supervisor (if assigned)	Systems safety responsibility
Supervisor/lead electrician	Systems safety and specific work task safety responsibilities
Crew members	Crew members' safety responsibility is limited to doing only work for which they are qualified

2-2. Electrical Work Qualifications. Qualifications for electrical workers are normally established locally. Refer to *Appendix A* for typical qualification requirements. Workers are classified as Qualified or Unqualified.

a. Qualified Workers. Persons who by training and demonstration are familiar with the skills and techniques for: (1) distinguishing exposed live parts from other parts of electric equipment; (2) determining the nominal voltage of exposed live parts; and (3) maintaining minimum clearance distances corresponding to the voltages to which that person will be exposed.

b. Unqualified Workers. Persons not meeting the requirements for Qualified Worker. However, to be on the job these persons must be trained in all electrically related practices that are necessary for their safety.

2-3. Safety Observances. Avoid prohibited actions (*Table 2-2*) and report unsafe worker indications (*Table 2-3*). Meet presite requirements (*Table 2-4*). Significant unsafe actions and conditions are given in *Table 2-5*.

Table 2-2. Prohibited actions

Taking chances
Playing jokes
Carelessness
Smoking
Use of intoxicants or drugs
Throwing material
Quarreling
Disobedience
Unnecessary talking or noise
Working while ill or under emotional stress

Table 2-3. Unsafe worker indications

Lacks information
Lacks skills
Lacks experience
Unaware of safe practices
Doesn't realize danger

Table 2-4. Presite job requirements

Regular safety meetings
Job hazard analysis if safe clearance (*Chapter 6*) requires it or energized line work (*Chapter 8*) will be done
Written work procedures covering existing conditions
Tailgate briefings

Table 2-5. Significant unsafe actions and conditions

	Unsafe actions
1.	Operating without authority; failure to secure or warn others
2.	Operating or working at unsafe speeds
3.	Making safety devices inoperative without proper authorization
4.	Using unsafe equipment (hands instead of equipment) or equipment unsafely
5.	Taking unsafe positions or postures
6.	Working on moving or dangerous equipment
7.	Distracting, teasing, abusing, startling
8.	Failing to use safe attire or personal protective devices
9.	Failing to lock-out energized circuits
	Unsafe conditions
1.	Improperly guarded facilities
2.	Defects of facilities
3.	Hazardous arrangement or procedure
4.	Improper ventilation
5.	Improper illumination
6.	Unsafe dress or apparel

2-4. Compliance with Safety Rules. A requirement of employment is compliance with and knowledge of the rules in this handbook.

a. Enforcement. Supervisors and foremen are responsible for enforcing safety rules and are subject to penalties for violations as are crew members.

b. Interpretation. In any case where rules are not clear a worker should ask the foreman or supervisor for an interpretation.

c. Violations. The severity of the penalty will be related to the seriousness of the offense. Violations can range from a reprimand, layoff without pay, demotion, or discharge. Discharge is applicable to cases of deliberate or willful failure to observe written regulations whenever such failure endangers the safety of persons or property.

CHAPTER 3. PRESITE SAFETY MANAGEMENT

3-1. Work Area Aspects Affecting Safety. The location and the public access to the work site impose additional protective or regulatory requirements.

a. Location of Work. The location of the work will determine whether climbing or confined space training along with fall and/or respiratory protection are mandatory (see *Chapter 4*). Safety standards require protection from excessive noise and provision of minimum illumination at any applicable work site.

(1) Noise. *OPNAVINST 5100.23, (Hearing Conservation and Noise Abatement Program)* requires a listing of hazardous noise areas, physical boundaries, and conditions of required hearing protection and a monitoring program. Where hazardous noise area signs are posted, hearing protection must be used as prescribed.

(2) Minimum Illumination. The minimum illumination for area safety is given in *Table 3-1*. Additional illumination may be necessary dependent upon the work required. Generally additional illumination should only be needed for work in confined spaces and for work approved for non-daylight hours.

Table 3-1. Minimum illumination requirements

Foot-candles	Location
50	Office areas, work shops, etc.
10	Exit ways, walkways, ladders, and mechanical/electrical rooms
5	Indoor construction areas, access ways, and outdoor field maintenance areas
3	Parking areas and general outdoors

b. Public Safety. Protect the public around the work area by safely guiding traffic away from workers, equipment, and excavations.

(1) Warning Devices. Locate appropriate barriers, warning signs, traffic cones, and lights at approaches to and at work areas, excavations, open manholes, parked equipment, and other hazards. Take special precautions for any areas where reduced visibility occurs, such as night operations or in fog. Immediately remove warning devices after removal of hazards and equipment. Provide flagmen if there is any doubt as to whether the warning devices will be adequate as controls, such as in areas with obstructed vehicular traffic.

(2) Excavations. Provide barricades around every excavation area. Keep warning barricade (cones, tape, and other items providing no physical protection) 5 feet (1.5 meters) from the excavation. A protective barricade may be placed closer since it provides both a warning and physical protection. Protective barricades must have a withstand rating of at least 200 pounds (90 kilograms) in any direction with minimal deflection. Never enter an excavation deeper than 4 feet which does not have a safe accessway, which has not been inspected by a competent person before allowing an entrance, or which has equipment working next to the edge. Comply with requirements stated in *29 CFR 1926, Subpart P, (Excavations), and MIL-HDBK 1025/10 Handbook for Electrical Transmission* and *Distribution Safety,MIL-HDBK 1025/10.* Always identify underground lines and services prior to starting excavations.

Table 3-2. Excavation pre-survey checklist

Prior to leaving the Shop.	1. Ensure location of underground cables has been established. 2. Verify that field sketch is available. 3. Obtain as-built/maps from facility owner(s). 4. Have subsurface facility engineering performed. 5. Conduct pre-construction meetings with facility owner(s).
On the Job Site.	1. Check for field sketch. 2. Verify all facility marks on ground. 3. Verify all service feeds from houses or buildings. All should be marked or noted above ground. Draw sketch. Check for: pedestals, risers, and new trench lines. 4. Verify position of dig area to sketch. 5. Check for private facilities not marked. 6. Advise facilities owner of excavation.

Table 3-3. Excavation involving private utilities

1. Inquire with homeowner(s) as to location of utility location.
2. Locate any septic lines in dig area.
3. Locate private power lines. *(Lines to sheds, wells, invisible fences*)
4. Locate private gas or propane lines.
5. Locate sprinkler lines, heads, and drip systems.

Table 3-4. Performing Excavations

1. Maintain 24 inches from marks.
   If digging within 24 inches, expose lines to verify.
2. Expose all major facilities within 5 feet of work area.
3. If paralleling: expose to verify location and depth of facilities every 100 feet.
4. Hand dig within 5 feet of pedestals, risers, meters, flags, whiskers, etc.
5. Bore away from facilities.
6. Verify depth of any facilities boring across, change route or depth as required.
7. Do not place excavation dirt on locate marks, flags, whiskers, etc.
8. Support all lines exposed during excavation to avoid kinks or other damage.

Table 3-5. Backfilling

1. Prior to backfilling, contact facility owner to inspect exposed facility.
2. “Shade” all lines placed or exposed with good fill dirt.
3. Verify all fill dirt is free from rocks, cable trash, and large dirt clods.
4. No cable or personal trash may be backfilled into the trench.

Table 3-6. Damage during backfilling of trenching

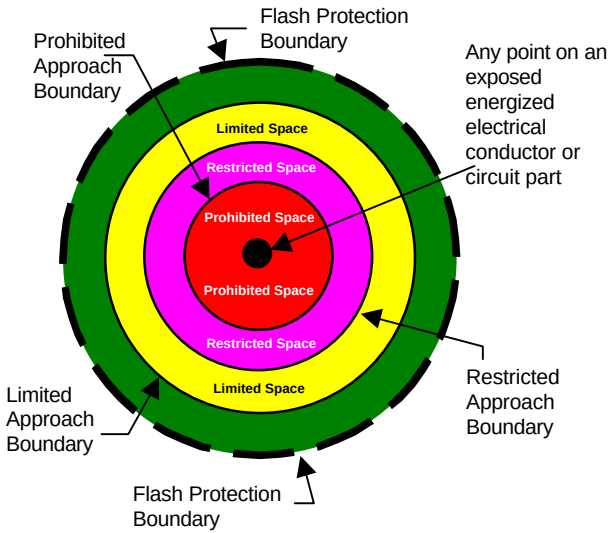
For detailed information note *MIL-HDBK 1025/10 Handbook for Safety of Electrical Transmission and Distribution Safety, MIL-HDBK 1025/10 (Chapter 8; Underground Cables, Structures, and Associated Electrical Components).*

1. If damage involves a potential risk of life, health or significant property damage, call 911 or local emergency response number.
2. All damage, including kinking or sheath damage, must be reported immediately to a supervisor and facility owner or operator.
3. Photograph the damage.
4. If a water line, other than a main, attempt to stop the damage.
5. If a gas or power line, evacuate the area, if necessary, and notify others working in the area.
6. Complete damage investigation report.

3-2. Electrical Aspects Affecting Safety. Working on or near normally energized lines or parts requires observance of rules applying to safe working distances, work methods related to whether the line has been de-energized or left hot, and recognition of work hazards which require more than one worker for safety.

a. Safe Working Distances. Only workers qualified by electrical training may work in areas on or with unguarded, uninsulated energized lines or parts of equipment operating at 50 volts or more (see *paragraph 2-2*). All electric lines and equipment will be treated as energized unless de-energized and grounded. Maintain the minimum clearances of *Tables 3-7* and *3-8* based on the voltage range. See *paragraph 8-3* for approved work methods by voltage level.

Table 3-7 Limits of Approach



Safe Working Procedures

1. PROHIBITED approach which allows for space between the worker and the live equipment large enough to prevent flash-over, due to disturbance of electrical fields.
2. RESTRICTED approach between the worker and the live conductor which provides space to allow for inadvertent action or reflex jerk movement of the body.
3. LIMITED approach with space for qualified workers to position.
4. FLASH PROTECTION BOUNDARY approach distance beyond which flash protection (flame-resistant clothing) is required.

These boundaries are all created for the qualified worker. It also defines flash protection boundary.

Table 3-8. Qualified worker minimum working distances

1	2	3	4	5		6
Nominal System Voltage Range.	Flash Protection Boundary	Limited Approach Boundary		Minimum Working Distance [1] and Clear Hot Stick Distance [2]		Prohibited Approach Boundary
	From Phase to Phase Voltage	Exposed Movable Conductor	Exposed Fixed Circuit Part	Includes Standard Inadvertent Movement Adder		Includes Reduced Inadvertent Movement Adder
				Phase To Phase[3]	Phase To Ground[4]	
50 V to 300 V	3ft 0in	10ft 0in	3ft 6in	Avoid Contact		
301 V to 750 V	3ft 0in	10ft 0in	3ft 6in	1ft 0in	1ft 0in	0ft 1in
751 V to 2 kV	4ft 0in	10ft 0in	4ft 0in	2ft 3in	2ft 2in	0ft 3in
2.001 kV to 15 kV	16ft 0in	10ft 0in	5ft 0in	2ft 3in	2ft 2in	0ft 7in
15.001 kV to 36 kV	19ft 0in	10ft 0in	6ft 0in	2ft 10in	2ft 7in	0ft 10in
36.001 kV to 48.3 kV	21ft 0in	10ft 0in	8ft 0in	2ft 10in	2ft 10in	1ft 5in

1- Distance between energized parts and grounded objects without insulation, isolation, or guards.
2- Between worker's hand and working end of stick.
3- Work on 3-phase delta systems, and on more than one phase of 3-phase wye systems.
4- Work on single-phase systems, and work on one phase only of 3-phase wye systems.

Table 3-9. Unqualified worker minimum approach distances

Voltage to ground	Distance
50 kV or below	10 ft (3 m)

b. Work Methods In Relation To Workers' Safety. All work will be done de-energized unless energized line work has been specifically authorized.

(1) De-energized Electrical Line Work. Follow the safe clearance (lockout/tagout/tryout) procedures given in *Chapter 6*. Remember lines are considered energized if the de-energized systems have not been provided with proper protective grounding (see *Chapter 7*).

(2) Energized Electrical Line Work. Work on energized lines and equipment only when written authorized by the Commanding Officer, Activity Civil Engineer, the Public Works Officer (PWO) or other designated authority (per local organization) based on the need to support a critical mission, to prevent injury to persons, or to protect property. Insulating means must be provided to isolate workers from a source of potential difference along with written job specific operating procedures. When authorized, perform energized line work per *Chapter 8*. Barehand liveline work is prohibited.

c. Number of Qualified Workers Per Hazard Exposure. *29 CFR 1910.269 (Electrical power generation, transmission, and distribution)* requires more than one worker where the hazard exposure of the work is considered to be significantly reduced by the presence of additional workers. *Tables 3-10* and *3-11* cover these requirements. *Table 3-12* indicates acceptable work where only one worker is needed. These tables indicate the minimum number of workers required. More workers may be necessary to provide safe working conditions in some circumstances.

Table 3-10. Jobs requiring two electrical workers

Hazard exposure	Working on
Installation, removal, or repair when working on or near lines or parts energized at more than 600 volts ac or 250 volts dc	1. Energized lines 2. De-energized lines with possible energized parts contact 3. Equipment with possible energized line contact 4. Mechanical equipment operation (except insulated aerial lifts) near energized parts 5. Other work with equal or greater hazard exposure

Table 3-11. Jobs working in confined spaces requiring additional workers

Hazard exposure	Additional worker requirement
Installation, removal, or repair when working in a confined space. Manhole or vault requirements are generally classified as confined spaces.	1. An attendant with first-aid and CPR training will be available on the surface in the immediate vicinity. 2. If a hazard exists within the space, or a hazard exists or is created because of traffic patterns outside the space, the attendant may not enter the confined space. 3. If the restrictions of Item 2 above do not apply, the attendant may enter the confined space to provide assistance, but only for a brief period (other than in an emergency). For extended periods of assistance, a second worker in addition to the attendant is required.

Table 3-12. Jobs generally acceptable for one electrical worker

- Work on de-energized systems with nominal system voltages of 600 volts ac or 250 volts dc, or less.
- Routine electrical measurements on energized systems with nominal system voltages of 600 volts ac or 250 volts dc, or less.
- Routine operation of metal-enclosed switchgear with nominal system voltages of 600 volts ac or 250 volts dc, or less.
- Routine electrical measurements or switching using gloves and live-line tools if the worker is positioned out of reach or possible contact with energized parts.
- Emergency repair work to safeguard the general public, if previously authorized.

3-3. Verifying System and Equipment Provisions. Be familiar with the electrical system you are working on by reviewing the system's single line diagram. Check out the equipment needed such as insulating tools, hot sticks, and grounding cables.

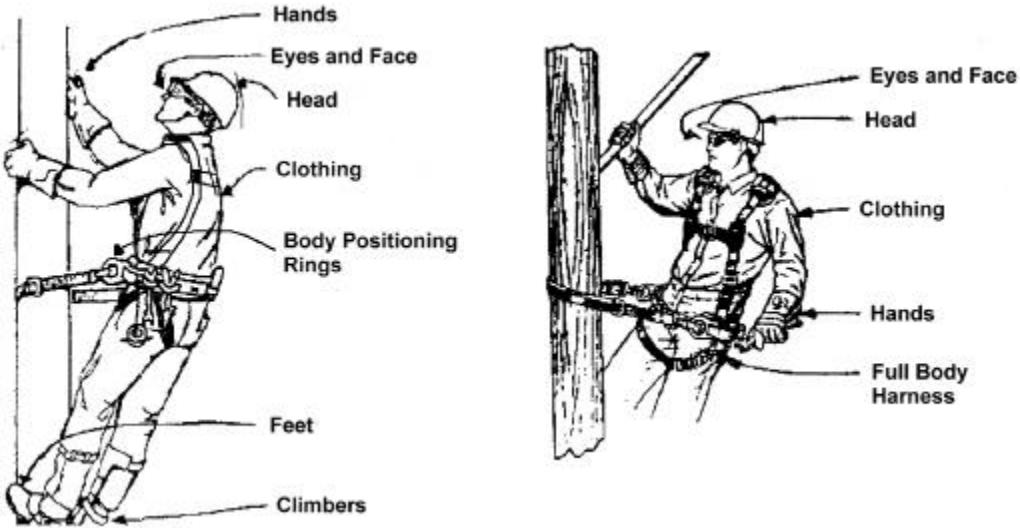
CHAPTER 4. PERSONAL PROTECTIVE EQUIPMENT

4-1. General Body Protection. Always wear personal protective clothing as required by your supervisor and as appropriate to the work area, work methods, and site hazards. Wear these items because it is impossible or impractical to totally eliminate all work site hazards and they will reduce your chance of injury or illness. *OPNAVINST 5100.23, (Personal Protective Equipment)* requires assessment of workplace hazards and provisioning of appropriate equipment to protect employees from the hazards present. *OPNAVINST 5100.23, (Respiratory Protection Program)* applies where confined spaces or hazardous gases mandate respirators. Restrictions on the wearing of jewelry are covered in *MIL-HDBK 1025/10*. Items appropriate for work on a wood pole are shown in *Figure 4-1.* A summary of apparel requirements is given in *Table 4-1.*

4-2. Additional Worker Protection For Pole/Tree Climbing and for Fall Protection. Pole and tree climbing requires additional personal protective equipment to prevent falls.

a. Climbing Protection. Use climbers only when engaged in work requiring their use. Never wear climbers: when working in trees, on ladders, or in aerial lifts; when in vehicles; when setting, removing or handling poles; when working on the ground or inside buildings; or while working on roofs.

(1) Fall Protection. Climbers provide the only fall protection when ascending or descending poles.



Note: Full body harness with body positioning rings shall be used for fall protection.

Figure 4-1

Personal protection for working on a pole

Table 4-1. Apparel and body protection requirements

Clothing - general

1. Nonelectrical industrial activities wear
   - Full length pants
   - Shirts with at least short sleeves
2. Around machinery you may **not wear** or have
   - Dangling sleeves
   - Neckties
   - Unsecured long hair
3. Around vehicular traffic or on the flightline wear
   - Safety color fluorescent clothing with approximately 3.5 square feet (0.33 square meters) of reflective area above the waist
4. On or near energized lines/equipment wear
   - Long-sleeved apparel with
     - No acetate, nylon, polyester, or rayon alone or in blends
     - No metallic items (fasteners)
     - No jewelry items
     - No celluloid items
   - Flame-resistant clothing (Refer to Table 3-7 and Table 3-8)
5. Within Flash Protection Boundaries wear
   - Fire-resistant clothing (Refer to Table 3-7 and Table 3-8)

Table 4-1. Apparel and body protection requirements (cont.)

Head
Wear a *ANSI Z89.1 (Protective Headware for Industrial Workers)* type B hard hat which has a rating of 20,000 volts, 60 hertz for 3 minutes, provides a suspension to 1.5 inches (38 millimeters) above the head, and can include an optional cold weather liner and chin strap. Wear where exposed to energized lines/equipment and falling objects such as exterior substations, overhead and underground lines, construction sites, fuse changing, voltage readings, and maintenance of batteries and medium-voltage equipment.
Eyes and face
Wear *ANSI Z87.1 (Occupational and Educational Eye and Face Protection)* eye and face protection with impact-resistant lenses and side shields. Contact lenses do not provide eye protection. Face shields do not provide impact eye protection. Filter lenses are required for radiant energy protection.

Table 4-1. Apparel and body protection requirements (cont.)

Skin	
	Apply appropriate protective ointment if needed for exposed areas. Ointment must not be damaging to rubber goods.
Hands	
	Use rubber gloves where required in other chapters of this handbook. Use leather palm gloves for protection when rubber gloves are not required. Use welders' gloves when welding.
Feet	
	Wear *ANSI Z41 (Protective Footwear),* P591, C75 or I75 shoes rated for 75 pounds (34 kilograms) crushing strength and having no heel or toe plates or hobnails. Use electrically insulated shoes for de-energized line work within 10 feet (3 meters) of grounded items. Use conductive shoes where needed for protection from static discharges.

Table 4-1. Apparel and body protection requirements (cont.)

Hearing
Ear plugs or inserts go in ear canals and provide 25 to 30 decibel attenuation. Ear muffs go over the outside of the ear and provide 22 to 27 decibel attenuation. A combination of both ear plugs with ear muffs can provide up to 35 to 37 decibel attenuation. All need careful fitting.
Respiratory
Provide per the confined space entry plan and/or the hazardous material regulated area requirement. Use *NIOSH* certified device if the hazard type has a *NIOSH* performance requirement. Use for emergencies only; correct hazardous atmospheric conditions with ventilation. Requires special training and fitting.

(2) Training. Climb only if **qualified to climb**, or if in training and under direct supervision and observation as covered in *Table 4-2*. Use climbers meeting *ASTM F 887 (Specifications for Personal Climbing Equipment).*

Table 4-2. Qualifications for climbing

1. Current annual physical fitness examination (when locally required) plus continuing supervisor's observation of satisfactory performance.
2. Two years of documented climbing training including
   - Hazard recognition
   - Hands on climbing
   - Hands on rescue
3. Has routinely climbed structures within the last 5 years, which are similar to facility structures.
4. Can be a worker in training under the direct supervision and observation of a worker who meets the first three qualifications.

(3) Climber Gaff Field Check. Always perform a pole cutout test *(Table 4-3)* before climbing. Check failed gaffs with your gaff gauge to determine the reason for failure and correct the deficiency.

Table 4-3. In-use check of pole climber gaffs

Check
Initial placement. Place the climber on the leg, holding the sleeve with the hand, palm facing the pole. With the leg at about a 30 degree angle to the pole and the foot about 12 inches (0.3 meters) off the ground, lightly jab the gaff into the pole to a distance of approximately 1/4 inch (6 millimeters).
Intermediate action. Keeping enough pressure on the stirrup to keep the gaff in the pole but not so much as to cause the gaff to penetrate any deeper, push the climber and the hand toward the pole by moving the knee until the strap loop of the sleeve is against the pole.
Full pressure. Making certain that the strap loop is held against the pole with pressure from the leg, gradually exert full pressure of the foot straight down on the stirrup without raising the other foot off the ground (to maintain balance if the gaff does not hold).

(4) Restrictions on Pole Climbing. Do not climb a pole unless you are sure it can safely hold your weight. Be sure to inspect for rotted areas, knots, and nails. Check for proper pole support. Discontinue work during adverse weather conditions such as thunderstorms, rain, high winds, and icy conditions. In bad weather, do not climb poles except for emergency restoration work.

b. Fall Protection. Use of fall protection equipment is required in all instances while climbing or changing positions on poles or towers. Four types of fall protection are used to handle various fall situations as shown in *Figure 4-2.* Fall arrest equipment is effective only if adequate anchoring has been identified by a qualified person.

(1) Positioning, Retrieval, and Suspension Fall Protection. Must support worker's weight plus any additional load. Does not provide fall arrest. Fall arrest must be added if it is determined that there is a fall arrest anchor point capable of meeting fall arrest requirements.

(2) Fall Arrest Protection. Requires an anchor point capable of supporting 5,000 pounds (2,250 kilograms) plus a connection device. Protection must provide an adequate free fall distance of 6 feet (1.8 meters) or with a deceleration unit a fall distance of 9.5 feet (2.8 meters).

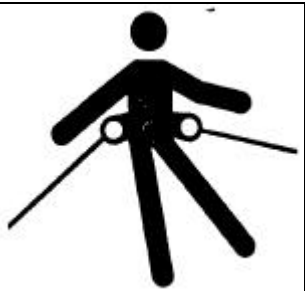
			
Positioning Rings on Full Body Harness	Retrieval	Suspension	Fall arrest
Leaves hands free while positioning a worker.	Allows emergency retrieval from a confined space.	Leaves hands free and supports a worker.	For arresting a fall from an elevated position.
Use on wood pole.	Use in a manhole.	Use on structures.	With anchor points.

Figure 4-2
Fall protection types

CHAPTER 5. WORK AREA PROTECTIVE EQUIPMENT

5-1. Temporary Protective Electrical Insulation. The qualified worker must be protected from electrical energy exposure while either de-energizing (isolating and grounding) the line or working on a live line. Temporary protective insulation is provided by using the insulating properties of rubber goods, plastic guard equipment, and live-line tools. Platforms and aerial lift trucks provide insulated supports for positioning a worker.

a. Rubber Protective Equipment. Equipment consists of gloves, sleeves, blankets, covers, and line hose. All items must meet or exceed requirements of the applicable *ASTM F 18* series specification and be suitable for the working voltage level *(Table 5-1).* Rubber goods should be visually inspected before use.

(1) Air Tests and Visual Inspections. An air test of gloves is also required. Workers should periodically review *ASTM F 1236 (Guide for Visual Inspection of Protective Rubber Products).*

(2) Electrical Retesting. Electrically retest rubber goods issued for service based on work practice and test experience intervals. Retesting intervals shall not exceed 6 months for rubber gloves and 12 months for rubber sleeves and blankets. Retest any rubber goods where there may be a reason to suspect the electrical integrity of the equipment. Electrically retest items that have been removed from storage for issue or service, unless they were electrically tested at the time of placement into storage and storage time does not exceed 12 months.

Table 5-1. ASTM F 18 rubber goods[1]

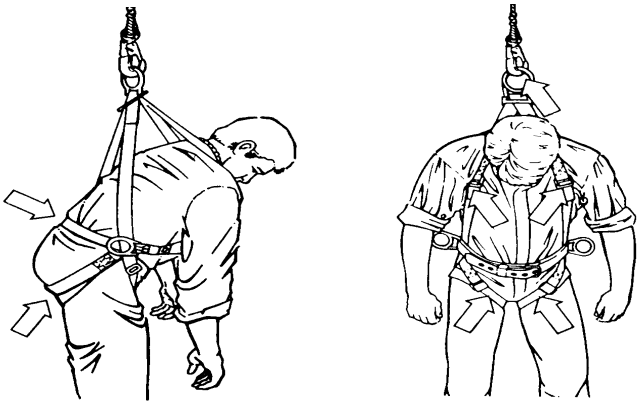
Maximum use, ac volts	Class	Color label	Proof test ac volts	Minimum distance[2] inches(millimeters)
1,000	0	Red	5,000	1 (25)
7,500	1	White	10,000	1 (25)
17,000	2	Yellow	20,000	2 (50)
26,500	3	Green	30,000	3 (75)
36,000	4	Orange	40,000	4 (100)

[1]Wear leather protectors over rubber gloves.
[2]Minimum length of exposed rubber glove above the leather protector.

b. Plastic Guard Equipment. This equipment is rated for momentary (brush) contact protection (see *Table 8-4*). Guards include conductor guards; connecting covers used over lines, insulators, buses, and structures; and apparatus guards used over poles, crossarms, cutouts, and switchblades. Electrically retest plastic guard equipment based on work practice and test experience. Electrically retest items where there may be a reason to suspect the electrical integrity of the equipment.

c. Live-Line Tools. *ANSI/IEEE 935 (Guide on Terminology for Tools and Equipment to be Used in Live-Line Working)* covers the live-line tools used to hold, move, operate, and test equipment. Tools are only as safe as their continued care and inspection make them. Try to always use a fiberglass tool as it is impervious to oil-borne materials and solvents, is stronger, and is a better insulator than wood. Live-line tools will be wiped clean and visually inspected before use each day. Do not use tools in rain or heavy fog, except in an emergency where directed by your foreman/lead electrician. In any case, never use tools when weather conditions allow formation of rivulets of water along the tool. Hang tools on hand lines or approved tool hangers, never on conductors or ground (bond) wires. See paragraph 8-3 for further information.

d. Equipment for Positioning a Worker. Body harnesses, platforms, and aerial lift buckets are used to position workers performing elevated electrical maintenance. See *Figure 5-1* for the advantages of body harnesses. Always use fiberglass ladders and platforms *(See Table 5-2, Ladder inspections, Table 5-3, Proper care and storage of ladders, and Table 5-4, Proper setup and use of ladders).* Review the safety rules given in the manufactures' operating manual when using aerial lifts (insulated buckets), vehicle-mounted elevating and rotating work platforms, manually-propelled mobile work platforms, and scaffolds (towers). Body harnesses must be worn with a lanyard attached to the boom or bucket. Climbers will not be worn by workers when in an aerial lift bucket. Only one energized conductor may be worked at a time regardless of the number of workers on the pole and/or in the bucket.



FULL BODY HARNESS
Forces distributed over the body. Sliding back rings keep body upright.

Figure 5-1

Support Points of Full Body Harness

WARNING: FAILURE TO FOLLOW SAFETY PRECAUTIONS WHILE USING LADDERS MAY RESULT IN SERIOUS INJURY.

Table 5-2. Ladder inspections

1.	Inspect ladder for damage or missing parts before each use.
2.	Never use ladder that is damaged or has missing parts.
3.	Check all parts for good condition. Lightly lubricate moving parts occasionally.
4.	Never repair damaged ladder without manufacturer's instruction.
5.	Replace ladder if exposed to excessive heat or corrosive agent.

Table 5-3. Proper care and storage of ladders

1.	Always keep ladders clean of foreign materials.
2.	Never store materials on ladders.
3.	Properly support and restrain ladders while in transit or storage.

Table 5-4. Proper setup and use of ladders

1.	Only use ladders made of non-conductive material around sources of electricity.
2.	Never use a ladder if you are not in good physical condition.
3.	A ladder is designed to support the weight of one person and materials. Do not exceed the maximum weight duty rating of a ladder.
4.	Do not use a ladder in front of unlocked doors.
5.	Place ladder feet on firm level ground. Avoid slippery surfaces.
6.	Never place anything under or attach anything to a ladder to gain height or adjust for uneven surfaces.
7.	Extend a ladder only from the ground. When using for roof access, extend ladder 3 feet above roof edge.
8.	Check that all 4 ends of the ladder are firmly supported to prevent excessive movement.
9.	The distance from ladder base to base of support wall must be ¼ the working length of the ladder.
10.	Securely engage ladder locks before climbing.

Table 5-4 Proper setup and use of ladders. (Con't)

11.	Use extreme caution when getting on or off ladder
12.	When possible, have someone hold ladder. If not, tie off ladder to a secure support.
13.	Always face ladder and have a firm grip while on it.
14.	Never walk, bounce, or move ladder while on it.
15.	Do not over reach-always keep belt buckle between side rails when climbing or working from ladder. You may lose your balance and/or tip the ladder.
16.	Use extreme caution when pushing or pulling anything while on ladder. You may lose your balance and/or tip the ladder.
17.	Windy conditions require extra caution.
18.	Never climb or stand higher than 3 feet from the top of the ladder.
19.	Never use a ladder as a platform, plank, or brace.
20.	Do not use any components not supplied by the manufacturer to repair a ladder.

5-2. Energy Hazard Detection. Potential differences, induced voltages on lines, accidental short circuiting, leakage current across insulated protective equipment, and combustible gas accumulation can create safety hazards if not detected by the use of proper test devices. Typical test devices include:

a. Potential Differences. 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. Direct-contact type detectors may not be effective on circuits not connected to ground, and proximity-type detectors may not be effective where magnetic fields can cancel (such as cable potheads). Proximity-type detectors cannot detect nonalternating (dc) voltages. Never use portable multimeters for measurements on medium- and high-voltage systems. Always check a voltage detector for proper operation using the “hot-dead-hot” method: first, check the detector on a known energized circuit, then check the desired line or device for voltage, and last, check the detector on a known energized circuit.

b. Phasing Testers. Phasing testers are used to determine the phase relationship of energized lines. Short circuits occur when different phases are tied together. A phasing tester can use two high-resistance units on hot sticks connected by a phasing-out voltmeter. Where voltage transformers are available, a voltmeter can be connected between one side to the other side. If lines are in phase, the voltmeter will register zero. If performing a phasing check at a generator disconnect, the maximum voltage rating of the phasing tester must be at least two times the nominal rated voltage of the circuit to be tested.

c. Combustible Gas/Oxygen Detectors. Portable monitors provide visual and audible warnings of explosive atmospheres and/or low oxygen levels which often occur in confined spaces. A continuous reading is given of any gas concentration ranging from 0 to 100 percent of the lower explosive level (LEL) and 0 to 25 percent of the oxygen level. A detector can be used to check battery rooms where ventilation is suspect. Determine if a hazardous atmosphere exists before entering a confined space. Hazardous atmospheres include: a contaminant concentration 10 percent or more of its lower flammability limit; oxygen concentration less than 19.5 percent by volume; contaminant concentrations exceeding specific OSHA standards (lead, asbestos, cadmium, and like substances); and oxygen concentration more than 23 percent by volume, particularly if oil mist or other combustible materials are present. (*OPNAVINST 5100.23, (Respiratory Protection Program*, and *Confined Space Entry Program (Non-maritime)).*

d. Aerial-Lift Leakage-Current Monitoring. Leakage current flows along the surface of tools or equipment due to the properties of the device's surface and surface deposits. The permissible leakage current on aerial lifts is one microampere per kilovolt ac or 0.5 microamperes per kilovolt dc. Adverse weather conditions derate the normal dielectric quality of air which results in a greater leakage current. Periodic testing is required. The use of a monitor on an aerial lift providing a continuous display of leakage current is recommended. The monitor should sound an alarm at a pre-set leakage current level to alert workers to danger.

CHAPTER 6. DE-ENERGIZED LINE CLEARANCE

6-1. Safe Clearance Procedures. General lockout/tagout/tryout policy and procedures for isolating machines or equipment from energy sources are given *in OPNAVINST 5100.23, (Energy Control Program (Lockout/Tagout/Tryout)),*along with examples of suitable tags to accompany lockout devices.

a. Safe Clearance Provisions. A Safe Clearance provides lockout/tagout/tryout directions for the safe blocking, tagging, and grounding of electrical switching and controlling devices to clear lines and equipment for the safe accomplishment of work in the de-energized condition.

b. Preparation Responsibility. A lockout/tagout/tryout procedure will be developed by certified individuals authorized to do so.

c. Standardization/Strength. Lockout/tagout devices shall be standardized within each facility based on at least one of the following ways: Color, shape, or size. They shall be strong enough to prevent removal except in cases of excessive force, such as the use of bolt cutters.

d. Tag Recognition. In the process of lockout/tagout/tryout, tags defining the hazard and the control measure to be used must be filled in, including the names of the individual responsible for the tag and the functional manager. The tags must warn against hazardous conditions if the machine or equipment is energized and shall include a legend such as the following:

DO NOT START, DO NOT OPEN, DO NOT CLOSE,

DO NOT ENERGIZE, DO NOT OPERATE.

6-2. Lockout/tagout/tryout Instructions. Each lockout/tagout/tryout instruction for a specific job must cover all the steps given in *Table 6-1.*

Table 6-1. Sequence of lockout/tagout/tryout steps

De-energizing steps
1. Notify all affected workers as to the hazard source, its control, and its possible stored energy. (See *Table 6-2.)*
2. Shut down the system by isolation of energy sources. System is rendered inoperative.
3. Secure all energy source shutdowns by lockout/tagout/tryout of controls.
4. Release all stored energy and verify such release. *(See Table 6-2.)*
5. Verify by testing there is no voltage.
6. Provide temporary grounding *(Chapter 7).*
Re-energizing steps
1. Inspect the work area for an operationally intact system and remove nonessential items.
2. Notify all affected workers that the system is to be re-energized and warn them to stand clear.
3. Remove temporary grounding *(Chapter 7).*
4. Remove the lockout/tagout/tryout devices.
5. Visually determine that all affected workers are clear of the circuit.
6. Proceed with restoring service.

6-3. Hazardous Energy Elimination. Eliminate any source of hazardous energy affecting the work by controlling electrical and nonelectrical energy hazards as shown *in Table 6-2.*

Table 6-2. Hazardous energy control

Electrical systems/equipment
1. Isolating by control operation: • Open switching devices; lockout if possible • Pull plugs or fuses • Block interlock feedbacks
2. Stored or other energy release: • Disconnect and discharge capacitors, choke coils, and surge arresters. • Discharge static electricity. • Temporarily short to ground induced voltage from adjacent lines, static charges, accidental connections, and incorrect disconnections. • Provide shielding for possible contact with energized parts
3. Verify by testing there is no voltage on de-energized system/equipment.
Nonelectric energy hazards
1. Check for chemical, electromagnetic, mechanical, pneumatic, thermal, and ultraviolet energy.
2. Isolate by blocking valve operations or other control operations for the above systems.
3. Discharge trapped energy by releasing pressure or by draining/purging lines and verify lack of rotation or dangerous temperatures.

CHAPTER 7. DE-ENERGIZED LINE GROUNDING

7-1. Grounding Provision. Grounding is used to limit dangerous potentials. Permanent grounding is provided as a part of any electrical system to meet safety and design requirements. A ground system consists of a grounding connection, a grounding conductor, a grounding electrode, and the earth (soil) that surrounds the electrode or some conductive body which serves instead of the earth (a ship hull/aircraft frame). A jumper connects conductors so that continuity is maintained. Bonding is the joining of metallic parts to form a conductive path. Temporary grounds are used so that work may be safely done on parts of the system that are temporarily isolated and cleared (de-energized).

7-2. Why Temporary Grounds Are Necessary. Energized lines over 50 volts which have been opened and checked as showing no voltage must be considered as hot if they have not been grounded. Potential differences can occur on de-energized lines from any of the factors described in *Table 7-1*. Temporary grounding is essential for safety.

Table 7-1. Causes of hazardous induced potential differences

1.	Potential differences caused by various line effects (such as induced voltages from adjacent energized lines and electrostatic build-up from wind action).
2.	Lightning strikes anywhere in the circuit.
3.	Fault-current feed-over from adjacent energized lines.
4.	Connection to an energized source through switching equipment, either by equipment malfunction or human error.
5.	Accidental contact of the de-energized line with adjacent energized lines.
6.	Residual charge from power-factor correction capacitors or surge arresters.

7-3. Equipotential (Single Point) Grounding. Whenever possible install temporary grounding to provide an equipotential zone at the work site. An equipotential zone provides a zero ground potential gradient across a worker's body, thus preventing a harmful electrical current through the worker. *Figure 1-1* shows the voltage gradient around a grounded energized object when a ground fault occurs. *Figure 1-2* shows the current path across the worker's body which flows when there is a potential difference between two different points or an individual's contact with the ground or a grounded structure. *Table 6-1* indicates where grounds are provided in the sequence of de-energized lockout/tagout/tryout steps.

7-4. Placement of Grounds. Grounds will be installed as close as possible to the work. Temporary grounding connection/removal procedures will be in accordance with *Table 7-2*. Never approach closer than working distances given in *Table 3-7 and Table 3-8* until after the line/equipment has been isolated, de-energized, tested, and properly grounded. Afterwards, avoid coming closer than 10 feet (3 meters) to minimize the hazard from step and touch potentials. This minimizes step and touch potential differences. Such potential differences occur from items such as down guys, ground rods, maintenance vehicles, and structure legs or ground wires during the period in which they are bonded to temporary grounds. When it is absolutely necessary to work on or near these features, workers should use bonded conductive or insulated platforms, or approved insulated shoes to minimize the hazard from step and touch potentials. Bond separately grounded systems together if they can be simultaneously contacted.

Table 7-2. Temporary grounding connection/removal procedures

1.	Select a ground electrode using either an established ground at the structure or a temporarily driven ground rod. The selection should minimize impedance and not introduce a hazardous potential difference.
2.	Test the de-energized line/equipment for voltage by an approved tester, verified immediately before and after use as to its good working condition
3.	Visually inspect ground equipment. Check mechanical connections for tightness. Clean clamp jaws and conductor surfaces. Clean not earlier than 5 minutes before connection using a wire brush attached to a hot-line tool. Use of self-cleaning equipment is also acceptable.
4.	The ground end clamp of each grounding cable should always be the first connection made and the last to be removed. Hot sticks will be used if the grounded system and worker are at different potentials.
5.	The conductor-end clamps of each grounding cable will always be connected last and removed first by hot sticks. Apply to the nearest conductor first and proceed outward and/or upward until all phases have been connected. Remove in reverse order. The practice of holding the cable near the base of the hot stick to lighten the load on the head of the stick is strictly prohibited. Instead, a co-worker should assist in installing heavy cables by holding the cable with another hot stick, or by using a “shepherd hook” with a pulley and a nonconductive rope to hoist the grounding cable into position.

7-5. Temporary Grounding System Components. Use system application (overhead, underground, substation) sets with *ASTM F 855 (Temporary Grounding Systems to be Used on De-Energized Electric Power Lines and Equipment)* grounding jumpers (clamps, ferrules, and clear 600-volt jacketed elastomer flexible cable) to the maximum possible extent.

a. Clamps. Use the alloy (copper or aluminum) matching the conductor or device to which it is attached and meeting or exceeding the current-carrying capacity of the associated cable. Use smooth jaw clamps on buses to avoid surface marring. Use serrated clamp jaws to bite through corrosion products for attachment to conductors or metal products. Self-cleaning jaws are recommended for use on aluminum. Never use hot-line clamps for grounding.

b. Cable. Cables will be preferably *ASTM F 855, Type I* of a minimum 2/0 AWG copper selected to meet the fault current necessary as given for 15-cycle substation duty and 30-cycle line use. See *Table 7-3*.

(1) Derating. Derate the fault current by 10 percent when using multiple ground cables (which must all be of the same size and length).

(2) Handling. Handle cables to avoid conductor strand breakage from sharp bends or excessive continuous flexing. Avoid excessive cable length because an increased resistance can elevate potential differences and twisting or coiling reduces their current-carrying capacity. Avoid very low temperatures; the clear jacket which allows checking for strand breakage will stiffen at low temperatures and split or shatter.

(3) Facility-Prepared Cable. Cables prepared by facility personnel for grounding applications should be highly flexible but rugged. (Specialty wires intended for electric welders or for railroad locomotives are typically used.)

Table 7-3. Maximum fault current capability for grounding cables[1]

Cable size (AWG)	Fault time (cycles)	RMS amperes (copper)
2/0	15	27,000
	30	20,000
3/0	15	36,000
	30	25,000
4/0	15	43,000
	30	30,000

[1]These current values are the "withstand rating" currents for grounding cables and cables as per *ASTM F 855*. These values are about 70 percent of the fusing (melting) currents for new copper conductors. They represent a current that a cable should be capable of conducting without being damaged sufficiently to prevent reuse.

c. Ferrules. Use *ASTM F 855*, Type IV (threaded stud copper base compression type) when installed on grounding cables by facility personnel. Ferrules should have the filler compound vent hole at the bottom of the cable so that employees can visually check that the cable is fully inserted into the ferrule. Heat shrink or springs should be installed over a portion of the ferrule to minimize strand breakage caused by bending. In all cases, the manufacturer's recommendations should be followed. Do not use aluminum alloy ferrules as they will not provide a lasting snug fit. Check for tightness periodically.

d. Grounding Cluster Bars. Use to connect phase and neutral conductor jumper cables to the selected method of providing a ground electrode (pole ground wire, temporary ground rods, substation ground grid). Cluster bars must have an attached bonding lead. Provide temporary ground rods as given in *Table 7-4*.

Table 7-4. Temporary ground rod minimum requirements

1. Single rod installed to a depth of 5 feet (1.5 meters) below grade.
   - A minimum 5/8-inch (16-millimeter) diameter bronze, copper, or copper-weld rod at least 6 feet (1.8 meters) long.
   - A 6-foot (1.8-meter), screw-type ground rod, consisting of a minimum 5/8-inch (16-millimeter) diameter copper-weld shaft with a bronze auger bit and bronze T-handle, tightly connected to the rod.
2. Additional rods to provide a total of 5 feet (1.5 meters) below grade where required.
   - Install 6 to 8 feet (1.8 to 2.4 meters) apart while maintaining the 10-foot (3-meter) step and touch potential clearance.
   - Bond all rods together prior to installing other electrode connections.

7-6. Temporary Grounding of Aerial Lines. Ground by installing an overhead distribution grounding set. The grounding set provides a parallel low-level (milliohm) resistance path which limits the current flow through the worker to a very low (safe) value (milliamperes) thus limiting the potential across the worker to a safe value. If the ground resistance were in series with the worker life-endangering currents could flow through the worker under fault conditions. Avoid any ground connection which could provide violent whipping from wind action. Double-point grounds are sometimes utilized but single-point (equipotential) grounding is the preferred method. If double-point grounding is necessary, install the temporary grounds at least one span away from the work site because the grounding cables may violently move during a fault condition.

7-7. Temporary Grounding of Substation Current-Carrying Equipment Components. Ground de-energized current-carrying components of substation equipment before approaching them within working clearance distances given in *Tables 3-7 and Tables 3-8.* Grounds should be placed as close to the equipment as practical *(see distance D_1 on Figure 7-1)* to minimize the inductive voltage loop (*see distance D_2 on Figure 7-1)* formed by the ground cable and the worker. See *Tables 7-5* and *7-6*. Special precautions are needed during oil handling *(Table7-7).*

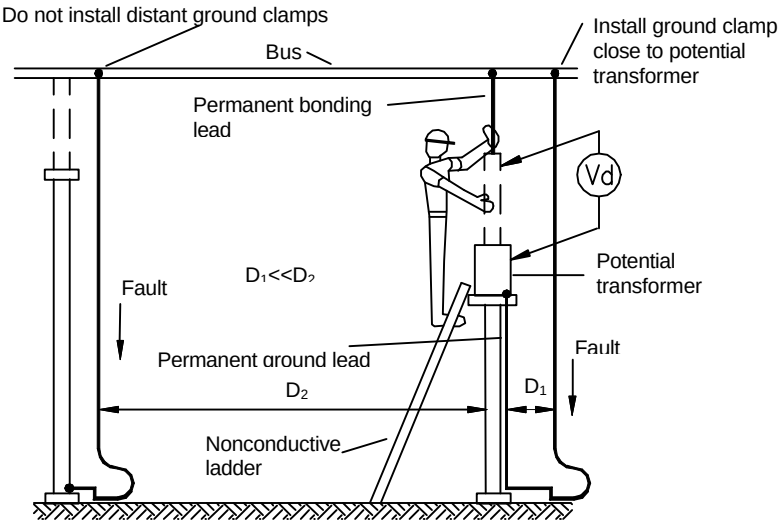


Figure 7-1
Substation temporary grounding

Table 7-5. Substation protective grounding procedures

1.	Check validity of permanent equipment grounds.
2.	Install a protective ground cable and bond to a grounded structure member or to a common copper equipment bushing lead for equipment being worked on.
3.	Apply personal protective grounds before working within *Table 3-2* clearance distances on substation equipment including: • Bushings • Buses • Capacitors • Circuit breakers • Instrument transformers • Power transformers • Switches • Surge arrestors

Table 7-6. Grounding of substation equipment

1. Grounds must be in place (see Table 7-7) before a tank is opened and the insulating medium (oil/gas) is changed. This does not apply to sampling.

2. No type of switch may be used to maintain personal ground continuity.

3. Allow at least 5 minutes between opening of the capacitor switching devices and the closing of the ground switch on a fully charged capacitor bank. At least 5 minutes will be allowed after the ground switch is closed before installing protective grounds. A capacitor bank will remain de-energized for at least 5 minutes before it is re-energized. The time required for these maneuvers will be explicitly expressed in switching orders involving capacitor banks.

4. Surge arrestors will be disconnected and discharged using grounding cables.

5. Grounding transformers will not be worked on unless de-energized and properly grounded. Phase reactors will be isolated from all energized sources and grounded before being worked on.

6. Bushing leads may be disconnected from bushing terminals as necessary to permit equipment testing that requires the equipment to be ungrounded. Use a hot stick to connect test equipment and re-establish the ground as soon as the test is completed. Following an applied potential test (“Hi-Pot”), ensure the ground remains in place for a period at least two times the duration of the test period. Work clearances and grounding instructions for the test equipment will be in accordance with the manufacturer’s recommendations.

7. Install separate grounds for each isolated section of the de-energized circuit if a hazard exists when working in a de-energized area of a substation where there are one or more physical breaks in the electrical circuit.

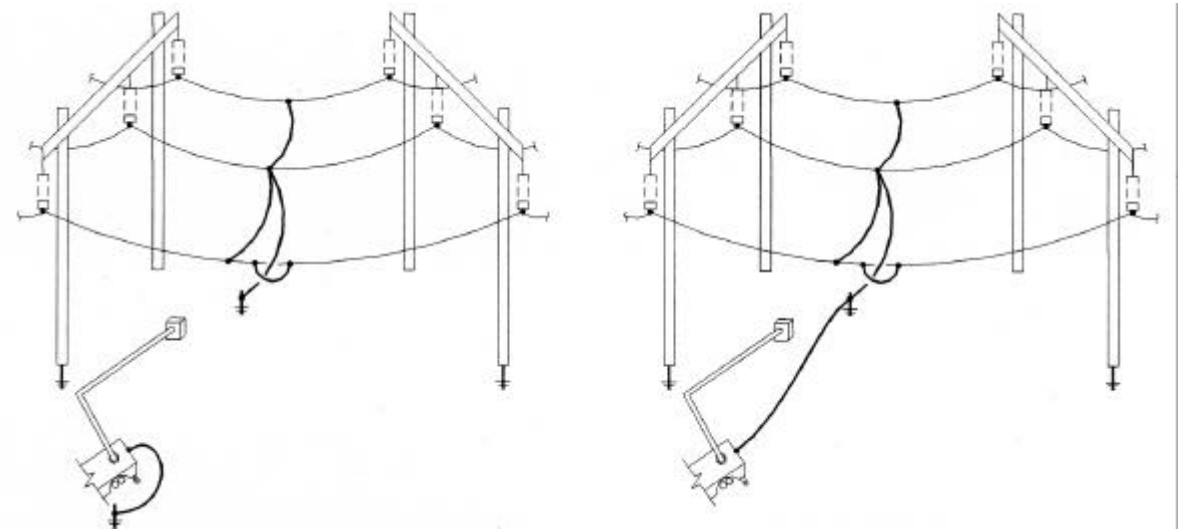
Table 7-7. Grounding of equipment during oil handling

Observe the following precautions to prevent the buildup of a hazardous electrical charge:
1. Bond apparatus tanks, conductive hoses, pumping or filtering equipment, drums, tank cars, trucks, and portable storage tanks to the station ground mat. Connect the vehicle end first and disconnect it last to prevent possible arcs near the vehicle.
2. Bond exposed conductors, such as transformer or circuit breaker bushings, or coil ends or transformers where bushings have been physically removed, to the same grounding point.

7-8. Aerial Lift Truck Vehicle Grounding. Ground vehicles prior to conductor bonding, if at all possible. If not, use a hot stick to remove or install vehicle grounds on a grounded system bonded to the conductor. Ground in accordance with *Table 7-8* and *Figure 7-2.*

Table 7-8. Procedures for grounding insulated and uninsulated aerial lift trucks

Grounding	Procedure
Insulated boom vehicles	Bond the vehicle to a separate driven ground rod located about midway on one side and as close to the vehicle as practical. If possible, keep insulated vehicles and their ground rods at least 10 feet (3 meters) away from the structure grounding system to minimize step and touch potentials. If workers can simultaneously contact two or more separately grounded systems, the systems will be bonded together.
Uninsulated boom and other electrical work vehicles	Bond the uninsulated boom and all other vehicles directly involved in electrical work to the grounded system using a grounding cable rated for the maximum available fault current.
Tensioning vehicles	Vehicles used to pull and hold tension on the conductor or overhead ground wire must be properly bonded to a structure ground or a temporary ground rod. Stay on the vehicle or at least 10 feet (3 meters) away from the vehicle ground when possible.



Insulated aerial lift Uninsulated aerial lift

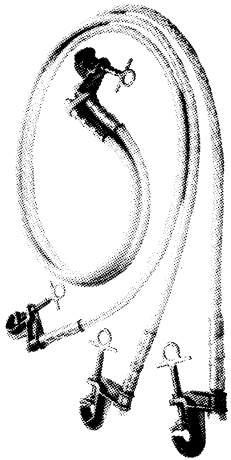
Figure 7-2

Insulated and uninsulated aerial lift vehicle grounding connections

7-9. Temporary Grounding of Underground Lines. Ground all possible sources of power (including transformer backfeed). Omission of grounds will be permitted only if their application decreases the work hazard. Install protective grounds at equipment terminations or ground by spiking cable (using an approved tool) prior to work on the cable. Use approved ground sets of the type shown on *Figure 7-3.*

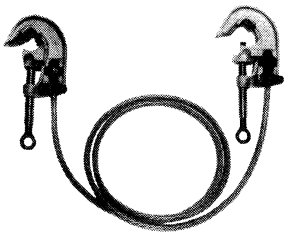
7-10. Opening or Splicing De-Energized Conductors. Conductors may be spliced at ground level, from aerial lift equipment utilizing ground mats (uninsulated aerial lifts), or from insulating platforms (insulated aerial lifts). Grounding for conductive or insulating platforms is shown on *Figure 7-4.* Install all grounding jumpers with hot sticks. Steps in providing safe grounds are given in *Table 7-2.* Remove in reverse order as installed. Ground any mobile equipment. Stay 10 feet (3 meters) away from grounded items and step onto equipment or platforms as quickly as possible to minimize any adverse step and touch potentials.

7-11. Grounding for Stringing and Removing Lines. Locate grounds to meet requirements of *Table 7-9* and *Figure 7-5*. After conductor pulling, locate grounds in accordance with *Table 7-10.*

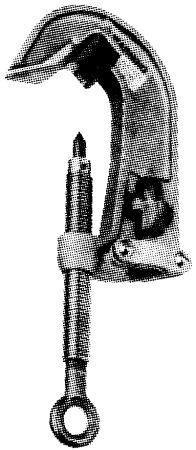


Live-front pad-mount equipment grounding set

Elbow grounding set



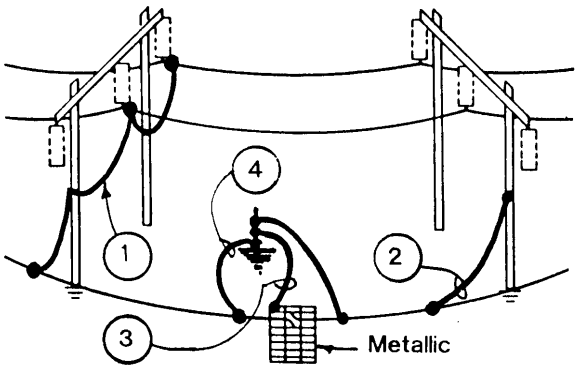
Cable spiking grounding jumper



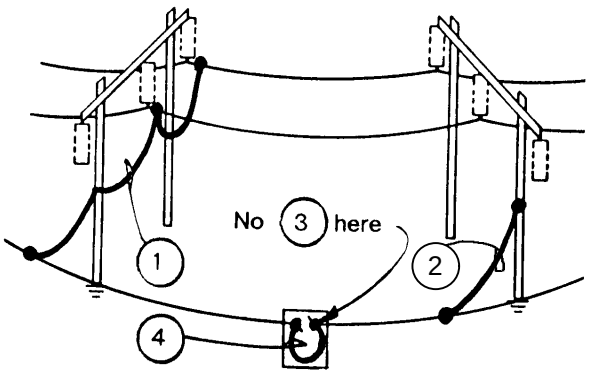
Cable clamps with a penetrating grounding spike

Figure 7-3

Underground system grounding sets



Conductive platform



Insulating platform

1. Three-phase ground all conductors and structure on one side of the work.
2. Single-phase ground work on conductor and structure on the other side of the work.
3. Ground conductive platform but not insulating platform.
4. Maintain integrity of conductor connection.

Figure 7-4

Using a conductive or insulating platform for opening/closing de-energized overhead conductors

Table 7-9. Stringing/removing conductor ground locations

1. Ground all stringing equipment such as reel stands, pullers, tensioners, and other devices.
2. Provide a safety barrier around the equipment.
3. Install a running ground between pulling and tensioning equipment and their adjacent structures.
4. Ground stringing blocks at first and last structures, and at least every 2 miles (3.2 kilometers) in between.
5. Ground stringing blocks at each structure on both sides of an energized circuit being crossed. If the design of the circuit interrupting devices protecting the lines so permits, the automated reclosing feature of those devices shall be made inoperative.

Table 7-10. Conductor ground location after pulling

1. Ground at each structure next to intermediate deadends of the stringing operation.
2. Ground at each structure where and while work (including clipping-in) is being performed on or near the conductor.
3. Remove grounds as the last phase of finished aerial installation.

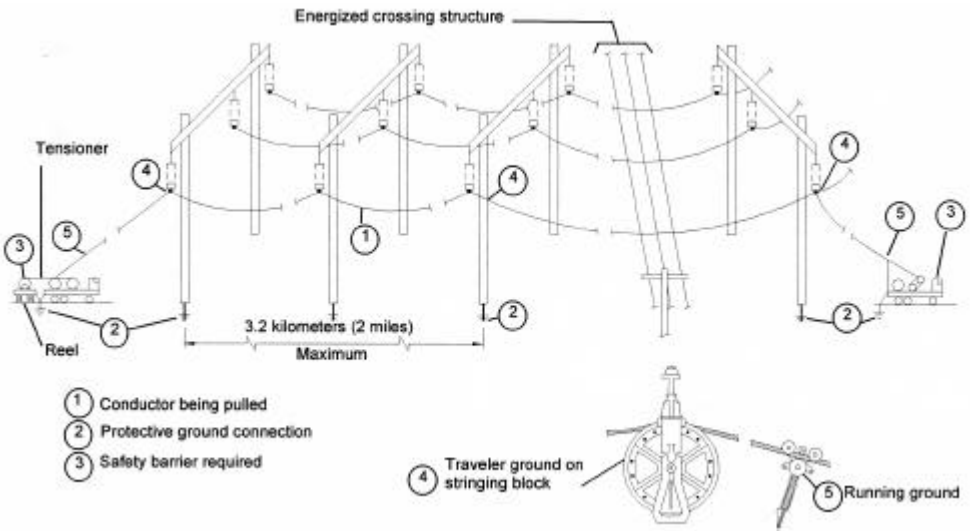


Figure 7-5
Composite stringing/removing the temporary protective grounds on overhead conductor lines

CHAPTER 8. ENERGIZED LINE WORK

8-1. Normal Work Methods. Lines will be worked de-energized, except where energized line maintenance has been approved by the Commanding Officer and considered necessary to support a critical mission, prevent human injury, or protect property. Observe approved work methods, equipment prework procedures, and general job-in-progress procedures. No work may be performed during adverse weather conditions (ice storms, high winds, electric storms) unless there is an emergency and the work has been approved. See *Tables 3-8, 3-9,* and *3-10* for number of qualified workers. All energized line work will require written, job specific procedures that are approved by the Public Works Officer (PWO).

8-2. Permitted Energized Line Work Methods. Only the approved methods given in *Table 8-1* can be used by facility workers in performing energized line maintenance.

Table 8-1. Categories of energized line maintenance work

Line potential	Worker insulation	Energized line clearances	Approved for use
Ground	None	Use lockout/tagout/tryout and temporary grounding	Always
Intermediate	Isolated by aerial lifts/ Insulating supports	Use insulated equipment and tools on energized lines	Requires specific approval
Line	Insulated from ground	Bonded to energized line for barehand work	Prohibited

8-3. Voltage Levels and Approved Work Methods and Equipment. Use the approved energized work methods given in *Table 8-2* while maintaining the working distance requirements given in *Table 3-8.* Use insulating (rubber) goods meeting the requirements of *ASTM F 18* standards with color coding meeting the requirements of *Table 5-1*. Use leather protectors over rubber gloves. Use insulating tools meeting the requirements of *Table 8-3* and insulating plastic guard equipment meeting the requirements of *Table 8-4*. Use approved gloves and rubber insulating sleeves with hot-line tools. The use of hot-line tools without gloves to detect tool deterioration is discouraged. Complete instructions and regulations detailing correct use and maintenance of such tools/equipment should be available and reviewed as a part of the work procedures. At least two workers, fully qualified for the voltage range (including other conductors within reach), must be available.

Table 8-2. Approved energized work methods by voltage class

Nominal ac voltage level	Work method
Up to 600 volts	Gloving by conventional work position or by structure mounting (ground potential)
0.601 to 7.5 kilovolts	Gloving from structure mounting or in an aerial lift bucket (ground potential)
7.6 to 15 kilovolts	Gloving from electrically insulated aerial lift bucket or platform (intermediate protection) or gloving and use of live-line tools from structure mounting or an aerial lift bucket (ground potential)
15.1 to 36 kilovolts	Gloving and use of live-line tools from an electrically insulated aerial lift bucket (intermediate potential)

Table 8-3. Insulating tools for electrical workers

Standards			
ASTM F711, Specification for Fiberglass Reinforced Plastic (FRP) Rod and Tube Used in Live-Line Tools.			
IEEE Std 978, Guide for In-Service Maintenance and Electrical Testing of Live-Line Tools.			
Minimum test values			
Tool material	OSHA acceptance[1]	IEEE in-service[2]	Use
Fiberglass reinforced plastic (FRP)	100 kV/foot (0.3 meters)	75 kV/foot (0.3 meters)	Preferred[3]
Wood	75 kV/foot (0.3 meters)	50 kV/foot (0.3 meters)	Phase-out[4]

[1]Test values manufacturers must certify for acceptance by buyer.
[2]Test values required after acceptance and tested after use in the field. Electrically test at intervals of not more than 6 months for tools in frequent use. Electrically test at intervals of not more than one year for tools stored for long periods of time.
[3]All new tools will be FRP.
[4]Replace wood hot line tools with FRP tools.

Table 8-4. Insulating plastic guards/platforms for electrical workers

Standards			
ASTM F 712, Test Methods for Electrically Insulating Plastic Guard Equipment for Protection of Workers			
ASTM F 968, Specification for Electrically Insulating Plastic Guard Equipment for Protection of Workers			
ASTM F 1564, Specification for Structure Mounted Insulating Work Platforms for Electrical Workers			
Common classifications for plastic guards			
Installation	Conductors	Structure/apparatus	Special
✐ Attached hot stick ✐ Eye for removable hot stick ✐ Rope loop or equivalent for gloving or hot stick	✐ Line guards ✐ Line guard connectors ✐ Insulator covers ✐ Deadend covers ✐ Bus guards ✐ Bus “T” guards	✐ Pole guards ✐ Ridge pin covers ✐ Switchblade covers ✐ Arm guards ✐ Cutout covers ✐ Crossarm guards	✐ Shape ✐ Size ✐ Attachment ✐ More stringent electrical requirements

Table 8-4. Insulating plastic guards/platforms for electrical workers (cont.)

Guard rating for accidental brush contact						
Class	Maximum use rating kV (60 Hz)		Proof test withstand voltage (in-service testing)			Criteria
	Phase-to-phase[1]	Phase-to-ground	Phase-to-ground kV 60 Hz	dc	Duration, minutes	
2	14.6	8.4	13.0	18	1	No flashover other than momentary as a result of too close spacing of electrode
3	26.4	15.3	24.0	34	1	
4	36.6	21.1	32.0	45	1	
5	48.3	27.0	42.0	60	0.5	
6	72.5	41.8	64.0	91	0.25	

[1]Cover-up materials are tested at values greater than the 60 Hz use maximum phase-to-ground values. The maximum use phase-to-phase values relate to guarded-phase-to-guarded-phase. The units are not rated for bare-phase-to-guarded-phase potentials.

8-4. Prework Procedures. Do not start work until the requirements of *Table 8-5* have been completed.

Table 8-5. Prework procedures

1. Obtain energized work approval.
2. Determine existing conditions and complete a job hazard analysis (see *Chapter 2)*.
3. Determine the voltage rating of circuits to be worked on, distances to other energized lines, and location of work. Evaluate the following:
   a. If aerial lift equipment can be used.
   b. What personnel qualifications are needed for the work.
   c. If special equipment, tools, or hazard protection are needed.
4. Prepare a written work procedure.
5. Review work and safety precautions with the crew before work begins (including tailgate briefing).
6. Inspect tools/equipment before starting work.

8-5. General Job-in-Progress Procedures. Observe the precautions given in *Table 8-6* before proceeding with the procedures given in *Table 8-7*.

Table 8-6. Energized work precautions

1. Check that circuit automatic reclosing devices have been made inoperative while work is being performed.
2. All items of a voltage class lower than required for the work should not be available to the workers at the work site.
3. Exercise special care when working in the proximity of equipment such as fuses, surge arresters, and similar equipment, or where conductor checks indicate burns or other defects in conductors, tie wires, and insulators. Procedures may require that some equipment be bypassed for the duration of the work.
4. Comply with adverse weather and number of qualified worker requirements.

Table 8-7. Voltage level work procedures

Voltage levels, 600 volts and below
1. Ground vehicles and aerial lifts in the vicinity of the work site.
2. Cover with approved protective equipment, or isolate with suitable barriers, energized phase and neutral wires, ground wires, messengers, and guy wires in the vicinity of the work. Apply covering to the nearest and lowest conductor first and remove in reverse order. See *Tables 7-5, 7-6*, and *7-7*.
3. See *Table 8-2* for work methods. Rubber gloves with leather protectors will be worn when entering a glove-required area and removed only after leaving that area.
4. Observe the working distance requirements of *Table 3-8*.
5. Protective equipment and vehicle grounds will be removed at the end of each workday.
6. Perform work on only one conductor at a time.
7. Tape or otherwise protect splices. Secure loose ends of conductors.

Table 8-7. Voltage level work procedures (cont.)

Voltage levels, 601 to 15,000 volts
1. Ground vehicles and aerial lifts in the vicinity of the work site.
2. Cover with approved protective equipment, or isolate with suitable barriers, energized phase and neutral wires, ground wires, messengers, and guy wires in the vicinity of the work. Apply covering to the nearest and lowest conductor first and remove in reverse order. See *Tables 7-5, 7-6*, and *7-7*.
3. Use approved live-line tools where required by *Table 8-2*. Rubber will be worn when entering a glove-required area and removed only after leaving that area.
4. Observe the working distance requirements of *Table 3-8*.
5. Protective equipment and vehicle grounds will be removed at the end of each workday.
6. Work performed must be under the direct supervision of a qualified work leader devoting full time and attention to the workers and the safety of their work.
7. Perform work on only one conductor at a time, although it is recognized that three-phase lifting tools may be used.
8. When moving an energized conductor with live-line tools, stay below the conductor until it is firmly secured in a safe working position
9. Do not raise, move, or lower conductors more than 1.5 feet (0.45 meters) when energized at 7,500 to 15,000 volts. Do not move conductors energized at more than 15,000 volts.

Table 8-7. Voltage level work procedures (cont.)

Voltage levels, above 15,000 volts
1. Except for the replacement of fuses and switching, work on energized lines or apparatus at this voltage range should be performed by qualified contract personnel. Follow the requirements of *Table 8-2*.
2. Do not move conductors energized at more than 15,000 volts.
3. Live-line work above 36,000 volts will be done by qualified contract personnel.

CHAPTER 9. SUBSTATIONS AND SWITCHGEAR

9-1. Safety Precautions. Review the applicable safety rules given in *MIL-HDBK 1025/10* for outdoor substations and interior medium-voltage systems for the specific safety rules applying to the work which you will be doing. Ensure that everyone is alerted to possible job hazards and is aware of their responsibilities. Discuss any question you have at your tailgate briefing before the job is started (See *Table 2-4*).

9-2. Major Equipment Hazards and Safety Precautions. Each type of equipment has its own safety rules. *Table 9-1* summarizes safety reminders. Essential to all safe operations is the use of proper protective equipment, knowledge of the manufacturer's safety instructions, and correct identification of the devices worked on.

Table 9-1. Major device important safety reminders

Testing
1. Provide a written switching order sequence.
2. Determine interrupting capability for opening loads.
3. Lock out switches.
4. Check procedures for opening/closing oil switches.
5. Check fuses for partial melting and do not bypass, except with plainly visible jumpers.
Energy storing devices
1. Positively disconnect surge arresters and choke coils. Discharge and ground them.
2. Provide the correct discharge period for disconnected capacitors. Wait at least 5 minutes after de-energizing a capacitor bank before grounding its terminals. Use hot-line tools and install grounding equipment to dissipate residual charges.
Instrument transformers
1. Ground case and one secondary winding of voltage (potential) transformers (PT). Remove secondary fuses before replacing primary fuses.
2. Short secondary leads and ground them if the primary of a current transformer (CT) is energized. Use a CT short-circuiting type terminal block, if provided.

Table 9-1. Major device important safety reminders (cont.)

Power transformers and regulators
1. Disconnect all primary wires and disconnect or ground all secondary wires on power transformers.
2. After de-energizing the transformer, verify there is a good transformer tank ground.
3. Set regulators in the neutral position before opening or closing their bypass switch.
Metalclad switchgear and network protectors
1. Prior to racking out a metalclad switchgear circuit breaker, trip the circuit breaker, and then de-energize and ground the switchgear. De-energize heater circuits if necessary for the work. Caution: Stand-alone circuit breakers may use a capacitive trip device that retains a charge (up to 500 volts). The device does not contain a built-in discharge resistor. If available use the manufacturer's procedure to discharge the trip device. Otherwise, discharge the trip device using a minimum 10-kilohm, 1-watt resistor. Do not use a jumper.
2. Shutters in medium-voltage metal clad switchgear are not intended to prevent electric shock. When working near the rear of the switchgear, use lockout/tagout/tryout procedures and temporary grounding.
3. Do not use circuit breaker grounding and test devices unless specifically qualified on this specialty item.
4. Do not work on network protectors unless specifically qualified on this specialty item. Always wear flash-resistant clothing when operating network protectors and keep unnecessary personnel clear.

Table 9-1. Major device important safety reminders (cont.)

Batteries
1. Verify the type of battery being handled (NICAD, Lead Acid, etc.). Storage batteries emit hydrogen and oxygen gas, especially when being charged. If contained in a room, these gases can create an explosive atmosphere. • Lead Acid batteries contain sulfuric acid; a highly corrosive acid. • NICAD Batteries contain Cadmium, Cadmium hydroxide, Nickel, Nickel Hydroxide and Potassium Hydroxide in varying proportions. Cadmium and Nickel are listed as carcinogens. Avoid contact with the liquids contained inside NICAD batteries. • Nickel Metal Hydride Batteries contain Nickel and small amounts of Manganese, Potassium Hydroxide, Lanthanum and Neodymium. Nickel is a listed carcinogen. The liquids contained in these batteries are irritating to the skin. Avoid Contact. For more information on these materials, consult the MSDS.
2. Do not smoke or use an open flame.
3. Do not use brushes or devices which can short out a battery cell.
4. Ensure and verify there is a working eye wash, fixed or portable, near the battery bank.
5. When working with or around electrolytes, ensure there is a solution of baking soda and water available to neutralize any spilt acid.
6. When adding electrolyte solution, always pour acid into water. The reverse can cause an explosion.
7. Wear acid proof gloves, sleeves, apron, and goggles when opening battery caps.

Phasing
1. Check correct phase relationship. For two buses (1 and 2) correctly in-phase, expect to measure: a. Rated line-to-line voltage: 1A-1B, 1A-1C, 1B-1C, 2A-2B, 2A-2C, 2B-2C. b. Rated line-to-line voltage: 1A-2B, 1A-2C, 1B-2A, 1B-2C, 1C-2A, 1C-2B. c. Zero (or near zero) voltage: 1A-2A, 1B-2B, 1C-2C.
Rotating equipment
1. Rotating equipment (such as engine- and motor-generators and many motors) is often automatically started or remotely started. Ensure all means of manual and automatic operation are locked out and tagged, both locally and remotely. 2. Ensure approvals are obtained before shutdown of critical, emergency, or standby equipment.

CHAPTER 10. AERIAL LINES

10-1. Safety Precautions. Review the applicable safety rules given in *MIL-HDBK 1025/10* for overhead lines and associated electrical components. Ensure presite job requirements *(Table 2-4)* are completed. Discuss any question at the tailgate briefing before the job is started.

a. On-Ground Work. On-ground work is not covered in this handbook. See *MIL-HDBK 1025/10* for information on pole handling and installation, and conductor stringing and removal.

b. Above-Ground Work. Above-ground work may be accomplished from an aerial lift truck or by climbing the pole. Consider street lighting circuits as possibly energized to the highest voltage of conductors occupying the same poles. See *Subparagraph 5-1d* for equipment for positioning a worker. See *Subparagraph 4-2a* for climbing protection and training. *Figure 4-2* covers fall protection.

10-2. Climbing and Working on Poles. Precautions for equipment such as surge arresters, switches, fuses, capacitors and power transformers are discussed in *Table 9-1*.

Table 10-1. Pole climbing and working precautions

1.	Determine that the pole is safe to climb and the best climbing space.
2.	The safety strap should not be attached to the pole while climbing or descending the pole except in conditions of high winds or severely inclement weather.
3.	Never depend on crossarm assemblies for support nor attach your safety strap close enough to the top of the pole where it could slip off. Always carry a safety handline.
4.	Where there are two workers on the same pole, one must be in a working position or on the ground before the other ascends or descends. Never work directly under another worker on the pole or on the ground, except in an emergency.
5.	Take special care when crossing pole-mounted structures from one side the other.

10-3. Aerial Rope Use. Always use polypropylene synthetic rope in good condition and of the proper strength. Rope must be dry, and of the necessary length. Do not allow the rope to be damaged by contamination or abraded by pulling methods.

CHAPTER 11. UNDERGROUND LINES

11-1. Safety Precautions. Review the applicable safety rules given in *MIL-HDBK 1025/10* for underground cables, structures, and associated electrical components. Ensure presite job requirements *(Table 2-4)* are completed. Develop specific rules for each task based on equipment condition and reliability. Discuss any questions at the tailgate briefing before the job is started.

a. Worker Protection. Experience proves the importance of following safety precautions for electrical work in confined spaces. In one incidence in a confined space, five Navy civilian workers were injured, one fatally and two seriously, when the electrical system they were repairing failed catastrophically. Treat underground structures such as manholes and unvented vaults as confined spaces and conform to the requirements of *OPNAVINST 5100.23, (Confined Space Entry Program)*. Treat these structures as Permit-required confined spaces and conform to the requirements for testing/monitoring, ventilation, attendants, respiratory protection, personal protective equipment, and training. Provide the number of workers required by *Tables 3-10 and 3-11* as a minimum. Illumination will not be less than the minimums given in *Table 3-1*.

b. Public Safety. Protect the public around the work area in accordance with *Subparagraph 3-1b*.

c. Existing Utility Protection. Locate and mark existing utilities in work areas where excavations are to be made. Digging restrictions may apply. Coordinate with the appropriate maintenance group or the fire department for unexpected hazards.

11-2. Underground Structure Precautions. Work in underground structures must conform to the confined space entry permit requirements. *Table 11-1* summarizes the major steps in determining that structures can be safely entered.

Table 11-1. Precautions before entering underground structures

1. Secure the work area.
2. Use the probes of an atmospheric tester to check air. First check for moisture on the end of the probe. If none found, test for air.
3. If air is acceptable, remove manhole cover.
4. Inspect the structure interior for the presence of water, oil, gasoline, or other contaminants which must be removed before work can proceed. Then check the structure by lowering the probe as far as possible .
5. If air is acceptable, set up the lifting A-frame on the manhole.
6. Enter (and leave) the structure by means of a ladder or climbing device for structures more than 4 feet (1.2 meters) deep. Never climb in or out by stepping on cables or their supports.
7. Test the air at each corner of the structure and at each of the duct entrances.
8. Provide additional ventilation as necessary. Continuous monitoring of air quality should be performed for work taking longer than 15 minutes. Whenever the cover has been replaced, repeat air testing.
9. Lower tools using a handline. Use the A-frame for heavy tools and parts, or when a manhole rescue must be made.

11-3. Work in Underground Structures. All work on separable connector or other equipment parts of energized cables will be handled with live-line tools and/or rubber gloves as appropriate to the voltage level. Work on equipment will be done in the same manner as given in *Table 9-1* with particular consideration given to the dangers of working in locations with limited access. Comply with the precautions given in *Table 11-2* for work in underground structures. Observe the safety precautions of *Table 11-3* when working on cables in structures underground.

Table 11-2. Precautions when working on underground structures

1. Use only flashlights or facility approved lighting units for illumination. In hazardous locations, use a light certified for NEMA Class 1, Division 1, Groups C and D locations (heat, spark, and impact resistant).
2. Never have open flames inside the structure and avoid spark producing connections/ disconnections.
3. Move energized cables only when specifically approved. Never change energized cable bends.
4. Splicing and terminating of cable must be done by qualified cable splicers/terminators.
5. Equipment for heating cable splicing materials will be operated only by workers trained in such use.

Table 11-3. Underground structure cable work precautions

1. Identify cables to be worked on and examine them for any damage.
2. Protect the work space by covering all live parts and cables with temporary insulation.
3. De-energize a cable and test for no voltage after waiting long enough for the dissipation of any static or capacitive charges. This period will be at least 5 minutes for capacitors with internal discharge resistors and at least twice the duration of an applied voltage test (“Hi-Pot”).
4. Ground the de-energized cable downstream from all sources of electric power and on both sides of the work location as hazardous potential differences may occur on de-energized (but not grounded) cables (see *Table 7-1)*.
5. Proceed with cable work (such as cutting, resplicing, other reconnections, and fireproofing) in accordance with standard work procedures.

CHAPTER 12 SHORE-TO-SHIP ELECTRICAL POWER CONNECTIONS

12-1 Safety Precautions. Review the applicable safety rules given in *MIL-HDBK 1025/10 Handbook For Electrical Transmission And Distribution Safety (Chapter 13, Shore-To-Ship Electrical Power Connections)* for specific safety rules applying to the work you will be doing. Ensure that everyone is alert to possible job hazards and is aware of their responsibilities. Discuss any questions you have at your tailgate briefing before the job is started (*See Table 2-4).*

12-2 Responsibilities. The Shore's Electrical Supervisor (SHORES ES) is responsible for the power provisions of cables connected to shore receptacles in pier electrical outlet assemblies and rigged to the ship. Ship's Electrical Officer (SHIP EO) is responsible for providing cable connections to the ship's electrical bus fed by the ship's generators and dictating when shore electrical power is energized or de-energized to supply this bus.

Table 12-1. Shore to ship electrical connect responsibilities.

SHIP EO:	Provide ship's logistic requirements prior to docking. **(12-8.a)**
	Transfer from ship's generators to shore electrical power after docking. (**12-8.f**)
SHORES ES:	Ensure shore provision prior to ship docking.
	Lay, inspect, and test cable assemblies on dock. (**12-8.a**)
	Check shore receptacles. (**12-8.d**)
	Insert cable plugs into shore receptacles. (**12-8.e)**
	Rig shore to ship cable after ship docks. (**12-8.f**)

Table 12-2 Shore to ship electrical disconnect responsibilities.

SHIPS EO:	Transfer ship from shore electrical power back to ship's generator. (**12-8.g**)
SHORE ES:	Disconnect cable plugs, un-rig and remove cables. (**12-8.h**)

a. Split personnel responsibilities: Standard Operating Procedures (SOPs) shall be in-place for shore-to-ship connections. SOPs shall define specific responsibilities between shore and ship.

b. Standard Operating Procedures; SOPs. Requirements for SOPs shall be as follows with specific guidelines for the activity's operating procedure. SOPs should be used for day-to-day pre-job briefings.

Table 12-3. Specific SOP requirements

Organization Requirements 1. Name of shore personnel and area of responsibility. 2. Name of ship. 3. Docking location.
Ship Specific Requirements 1. Voltage of estimated ampere load requirements including supershore electrical power. 2. Number of ship-to-shore power cables. 3. Type of cable termination, in-line connections, jumpers. 4. Identification of any interface problems. 5. Special paralleling requirements if longer than 10 seconds.

c. Preparation responsibility. The activity responsible for shore-to-ship electrical service shall prepare general SOPs with a section for individual organization requirements. Requirements are to be correctly filled in for each specific ship's service and service period. Distribution is to be to all personnel involved.

12-3 Distribution Systems. Specific safety requirements given apply to the cable assemblies from pier's electrical outlet assemblies (turtlebacks) to ship's electrical bus.

a. Shore medium-voltage distribution system. Pier primary electrical distribution systems normally operate in the medium-voltage range of 5 kV and 35 kV. *Figure 12-1* provides an example of an electrical connection outlet assembly with a 15-kV receptacle. For permanent pier service, dual primary feeders are preferred. Pier systems may be furnished with single feeders. The feeders serve substations which stepdown the distribution system's primary voltage to the secondary voltage for ship service of 480 volts or 4.16 kV *(See Figures 12-4 and 12-5).*

b. Low voltage distribution system. *(See Figure 12-4).*

Figure 12-1
Electrical connection outlet assembly with a 15-kV receptacle

12-4 Substation Assemblies. There are two types of substations; nonfixed, which are installed on the top of the pier, and fixed which are installed in vaults under the pier.

a. Nonfixed pier substations: *(See Figure 12-2)* are skid mounted and fed from a shore installation substation consisting of a medium voltage disconnect assembly. They are supplied by primary cable assemblies installed on the pier and connected to the electrical distribution system source and the substation by primary voltage pier coupler plugs and receptacles in electrical connection outlet assemblies.

b. Fixed pier substations: *(See Figure 12-3)* are fed by primary cables installed in duct lines. Both types of substations contain primary switch(es), a step-down transformer, and secondary circuit breakers supplying the pier electrical outlet assemblies.

Figure 12-2
A skid-mounted substation

Figure 12-3
A substation inside a pier vault housing

c. Working Space. NEC Definitions:

1. Underground Vaults: equipment in underground vaults is not readily assessable and may not meet current NEC work space requirements. Workers in vaults need to meet confined space requirements of *OPNAVINST 5100.23 (Confined Space Entry Program), 29 CFR 1910.146 (Permit Required Confined Spaces), and/or 29 CFR 1910.269(t) (Electric Power Generation, Transmission, and Distribution: Enclosed Space).*

2. Readily Accessible: equipment that is capable of being reached quickly for operation, without requiring climbing over obstacles, using portable ladders, chairs, or other devices to reach the equipment.

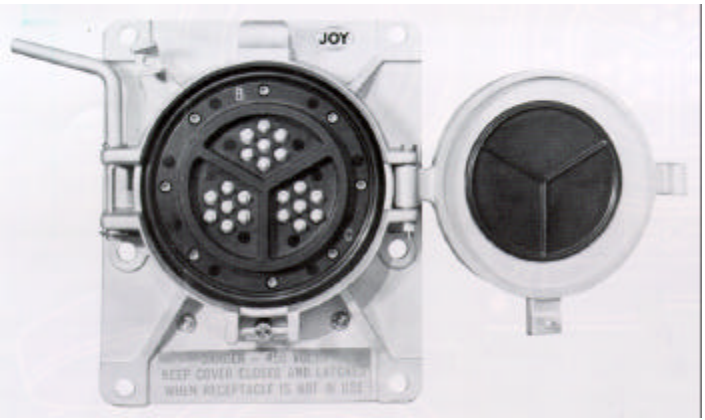
3. Working Space: sufficient access provided and maintained about all electric equipment to permit ready and safe operation and maintenance. Working space in vaults is provided in accordance with NEC requirements at time of construction. Vaults built pervious to NEC requirements do not fall into current requirements. Each activity shall evaluate these spaces for their effect on worker safety and provide SOPs as necessary to assure safe working conditions.

12-5 Outlet Assemblies. Ships service from pier electrical outlet assemblies contain multiples of three-pole, 500 ampere receptacles rated for either 480 volts or 4.16 kV *(See Figures 12-4 and 12-5)*. Receptacles are interlocked with substation secondary circuit breaker for safety *(See Figure 12-7).*

Figure 12-4
A 480-volt pier electrical outlet assembly without cable connections

Figure 12-5
A 4.16 kV pier electrical outlet assembly and outlets

a. Low-voltage (480-volts), Type 1: three pole, 500 ampere, 480-volt receptacle with matching plug *(See Figure 12-6)*.



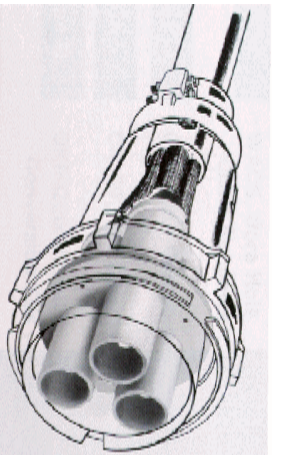
Male receptacle Female Plug

Figure 12-6

Low-voltage shore receptacle

b. Medium-Voltage (4160-volts): three pole, 500-ampere, 4160-volt receptacle with matching plug *(See Figure 12-7)*.

Male Plug



Female Socket

Figure 12-7
Medium-voltage shore receptacle

c. Low-voltage (480-volt) Receptacle Protective Circuit Breaker: low-voltage, metal enclosed drawout type power circuit breaker. Air-magnetic, electrically operated with 120-volt ac closed, 48-volt dc trip. Equipped with current limiting fuses. Circuit breakers are interlocked with respective receptacles. Circuit breaker will trip automatically if: (1) an attempt is made to remove the assembly plug, or (2) the receptacle cover is opened. Remote close/trip provided at receptacle assembly.

d. Medium-voltage (4160-volt) Receptacle Protective Circuit Breaker: Air or vacuum type have long time trip; setting at 400 amperes. Key interlocked with respective receptacles to prevent insertion/removal of connector unless circuit breaker is open.

12-6 Cables: Ship's electrical input cables provide an ungrounded correctly-phased, system with sufficient number of cables to service the ship's load.

a. Grounding: Ship's hull serves as ground for ship's electrical service. A ground between ship and shore can result in damaging circulating current.

b. Improper matching of phase rotation: Will cause ships motors to operate in the wrong direction. Connection of two or more cables together requires all the same phase cables be connected together.

c. Number of cables: The number shall meet SHIP EO request based on activity in port. When more than one feeder cable is required, all cables shall be of the same length (+/- 10%) to minimize unequal load distribution.

Low voltage receptacles: power supply capability of 386 kVa.

Medium voltage outlets: power supply capability of 2075 kVa.

(Per NEC Table 310-17, 75 ^{0}C for 500 kcm at 450 volts for continuos service. 620 amps X 450 v X 1.732 X 0.80 / 1000 =386 kVa 360 amps X 4160 v X 1.732 X 0.8 / 1000 = 2075 kVa)

d. Cable rating:. Portable shore-to-ship power cables are rated for operating at: (1) Medium voltage (601 to 5000 volts), three phase, three-wire, ac. (2)Low voltage (480 volts), three phase, three-wire, ac. All shore-to-ship power circuits operate ungrounded between shore enclosure and the ship. Splices are not allowed in 4.16 kV power cables.

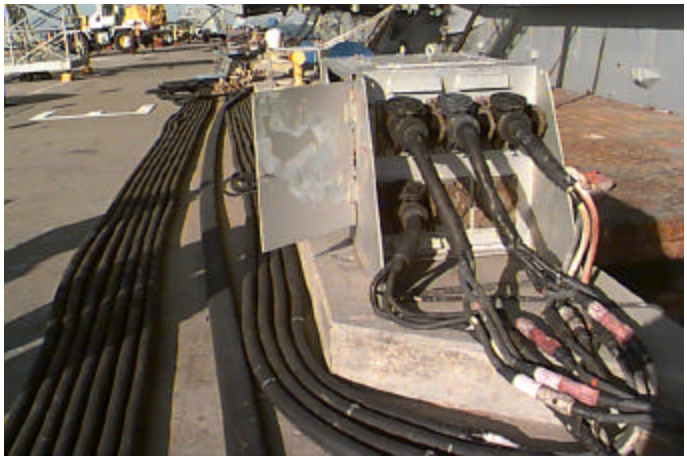


Figure 12-8
A 480-volt shore-cable to ship-cable plug and receptacle connection in place

Figure 12-9
A 480-volt shore-cable to ship-cable with camlock connection

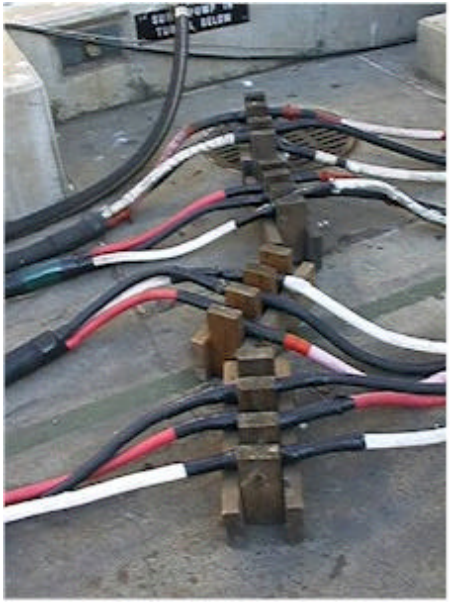


Figure 12-10

A 480-volt shore-cable to ship-cable splice connection in place

Table 12-4. Power cable specifications

Cable Power Rating	Specifications
Low-voltage: 480 volts	Three-conductor, 600-volt. Flexible, unshielded. Single-conductor cables may be used-but not recommended.
Medium-voltage: 4160 volts	Three -conductor, 8000-volt, 360 amperes. Overall propylene jacket .

Table 12-5. Portable cable and outlet safety concerns

Installation Type	Safety Concerns
Permanent Installations	Exposure to harsh environments: salt spray, high humidity, cold temperatures. Subject to rapid deterioration.
Portable Power Cables	Deterioration from wheels of vehicles, dragging on hard surfaces. Need to barricade whenever possible.
Personnel In Area	Civilians, military personnel, and contractors working on piers who are not familiar with electrical energized power cables which are installed in an accessible position.

12-7 Circuit Arrangements

a. Service Component Diagrams. (*See Figure 12-11: diagram of the physical relation of ship and power connections to the pier electrical power service*). Ships may have 1, 2, or 3 service ports requiring connections. Power cables provided must be of equal length (within + or - 10%) and without sharp bends. Power cables may need additional protection; (*See Table 12-9).*

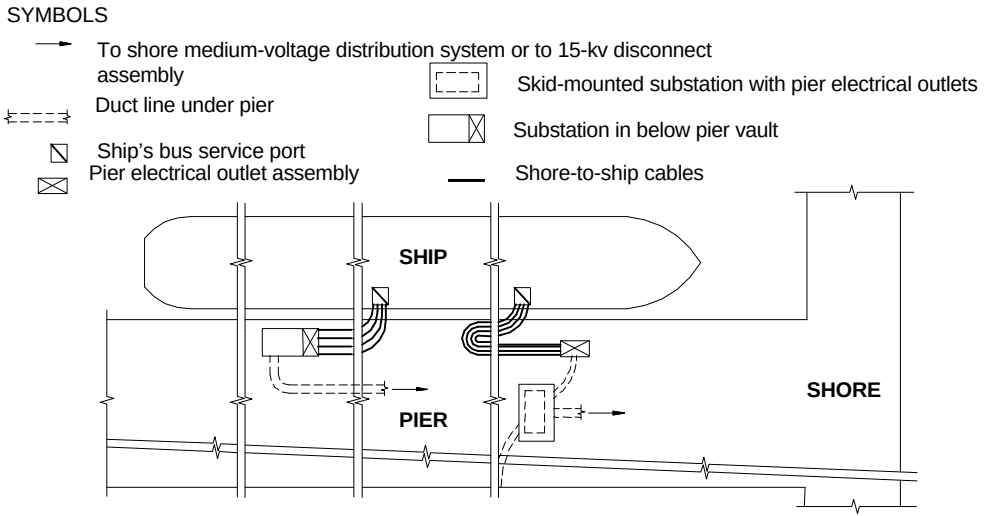
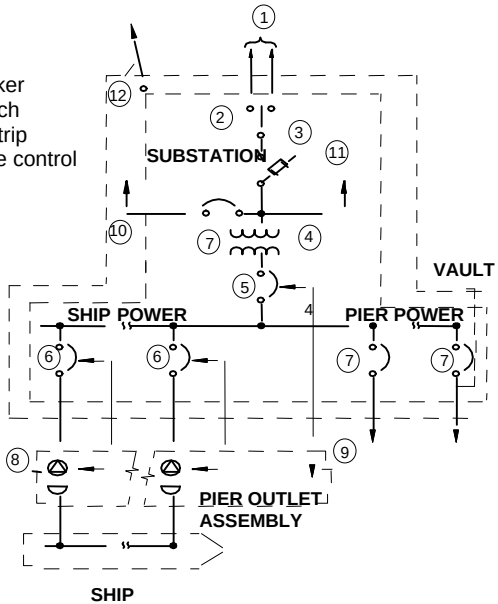


Figure 12-11

Shore-to-ship portable power cable location diagram

b. Preferred ship-to-shore circuit arrangement. (*See Figure 12-12: Simplified one-line diagram of ship's main electrical service components*). Note Chapters 9 and 11 for safety requirements. This circuit diagram is similar for skid-mounted substations *except* without vault requirements. Pier outlet assemblies may be part of a skid-mount substation.

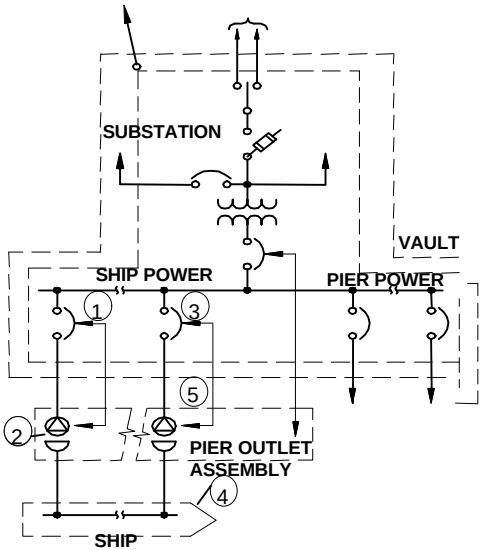
Abbreviations:
CB Circuit breaker
CS Control switch
ET Emergency trip
LR Local remote control



1. To shore medium-voltage distribution system
2. Primary selector switch
3. Fused Primary disconnect
4. Transformer
5. Main CB with CS and ET pushbutton
6. Feeder CB with CS and LR
7. Feeder CB with CS only
8. Pier receptacle and plug with remote CB control
9. ET pushbutton
10. To vault power
11. To meters and control power
12. Vault alarm circuits

Figure 12-12
Preferred ship-to-shore circuit arrangement

c. Ship energizing safety procedures: (*See Figure 12-13: Procedures in safely energizing a ship from a shore electrical circuit*), are to be followed to assure that energizing the ship is done in a safe manner. Responsibilities for the connection of portable power cables to shore electrical receptacles and ship electrical buses are covered in section 12-2.



Notes on order of

1. Switch to local control when working at the substation and when plugging in shore-to-ship cable plugs
2. After receiving clearance from the ship's electrical officer, seat plug correctly to close ground connection first and then twist, clamp, or pull to lockout microswitch which would prevent closing to the shore-to-ship circuit.
3. Switch circuits to remote control at the pier outlet assembly.
4. This connection will be made by ship's personnel with the circuit breaker open.
5. Do not close circuit breaker by remote control unless directed by the ship's electrical officer.

Figure 12-13

Procedures in safely energizing a ship from a shore electrical circuit

d. Parallel Operation: Parallel operation of ship's generators and shore power system is prohibited except to allow load transfer to or from shore power. Transfer time should not exceed 10 seconds. Paralleling shore transformers through ship's electrical bus without prior activity approval is a violation of safety practices and may result in circulating currents, overheated cables, unbalanced loads, and excessive shore circuit current. This could result in property damage and injury to personnel.

12-8 Connection/Disconnection Procedures

Priorities: Prior to rigging cables, consideration of the following shall be given:

1. Verify that there are no unusual job hazards present.
2. Verify that boom trucks, cranes, and forklifts are properly rigged.
3. Verify that the location has been given structural approval by the facility engineer.
4. Verify that construction work will not interfere with power cable placement and rigging.

Special safety provisions:

1. Barricades: required to protect cables from damage. Consider events such as contractor work which may have vehicles, equipment placement in area, and welcoming crowds at ship's homecoming. Maintain safe distance, *Table 3-8.* Note safety hazard information on all cables in conformance with activity requirements.

2. Pier vault access: if possibility of vault access is required, have emergency rescue equipment readily available *(See Figure 12-14)*.

Figure 12-14
Effective vault rescue

a. Prior to ship's arrival: Logistics Requirements (LOGREQ) message received by waterfront operations from ship prior to arrival in port, will contain power and general berthing requirements.

Table 12-6. Logistics requirements

1. Laying power cable assemblies: move power cables from storage to pier.
2. Authorized vehicles to move power cables are: Shop Mule, Reel Truck, Line Truck, Boom Truck.*
3. Perform vehicle use checkout following Standard Operating Procedure; SOP.
4 Inspect Pier Area, Check for obstructions that could prevent power set up.
5 Position Vehicle; Use second person to assist in backing up or positioning in tight places.

Operators shall have approved state commercial drivers license (CDL), current medical examination, and be physically and mentally fit to operate vehicle. **Additionally,** *Boom Truck operators shall have a valid category 4 crane operator's license.

Table 12-7. Unloading/loading equipment precautions

1. Vehicle is operated safely.	4. Barriers are set to proper distance.
2. Wheel chocks are down.	5. Sets of cables are connected together.
3. No unauthorized personnel in work area.	

Table 12-8. Rigging truck precautions

Boom Truck Outriggers	1. Not blocked by any obstruction.
	2. Not set on top of vault, steam, or manhole covers.
	3. Boom shall not swing forward of outriggers.
Reel Trucks	1. Stabilizer jacks are set.

b. Moving power cable assemblies on pier:

Table 12-9. Power cable setup precautions

1. Move cables as a single unit.	5. Arrange cables neatly.
2. Do not allow cables to rest on sharp edges. Place in saddles.	6. Raise splices and connectors to protect from water contamination.
3. Verify that cables are long enough to account for tidal conditions.	7. Do not allow cables to become wedged between ship and pier.
4. Barricade cables to protect from vehicle traffic.	8. Do not connect cable ends to any shore or vehicle device.

c. Inspecting and testing power cable assemblies: To be performed under the direct supervision of SHIP EO, leading electrician's mate, or SHORES ES.

Table 12-10. Power cable assemblies inspection

1. Test with voltage meter. Ensure de-energized prior to handling. 2. Lay out and perform visual inspection for defects. 3. Clean/inspect shore power cable assembly covers.	4. Measure insulation resistance between assembly, conductors and grounds with megohmeter. Record lowest acceptable value on ship's connect/disconnect form. 5. Verify phase identification marking with megohmeter. 6. Place **"DANGER**-HIGH VOLTAGE**"** tag and barricade work area.

d. Checking shore receptacles: Tag out shore power receptacles circuit breakers in accordance with the following procedure or local activity prepared procedures:

Table 12-11. Tagout procedure for shore power receptacles circuit breakers

1. Test multimeter to a known source. 2. Remove indicator lights and phase meter fuses. 3. Ensure shore power receptacle(s) are de-energized. 4. Inspect covers for tears, cracks, deformation.	5. Operate receptacle interlock switch manually. 6. Test insulation resistance with megohmeter: 1 megohm for 480-volt 5 megohm for 4160-volt. 7. Reinstall indicator lights. 8. Remove **“DANGER”** tags. Replace with “CAUTION” tags.

Table 12-11 Tagout procedure for shore power receptacles circuit breakers (cont)

9. Test cover interlock switches and indicator lights : • Close shore power receptacle circuit breaker. • Shore power receptacle should be energized. • Ensure indicating light is ‘ON’. • Open cover. Receptacle circuit breaker should trip and lights extinguish.	10. Test shore power receptacle terminal with approved, tested, potential difference tester. 11. Test shore power receptacle. Ensure it is de-energized. 12. Close access cover. 13. Open shore power receptacle breaker(s). 14. Remove ‘CAUTION’ tag. Attach **“DANGER”** tag.

e. Inserting cable plugs into receptacles: Connections are to be made from the ship's electrical bus toward the shore power receptacle. **Note**: If distance to bus requires splicing of two or more cables, splicing shall take place prior to making any ship or shore power receptacle connections (See *Section 12-6.d)*.

Table 12-12. Inserting cable plugs into receptacles

1. Test shore power receptacle terminal with approved, tested, potential difference tester.	3. Ensure terminals are de-energized with potential difference tester.
2. Open access covers.	4. Insert plug(s) into shore power receptacle.

f. Shore-to-ship power cable rigging after ship docks: Upon arrival contact SHIP EO. Establish cable connection time, receive ship connect/disconnect form, and provide personnel.

Table-12-13. Power cable rigging after ship docks

1. Check all cable assemblies for proper phase rotation. 2. Check all assemblies for proper orientation. 3. Check all cables. Ensure they are de-energized.	4. Load cable assemblies from shore to ship for extension by ship's personnel to ship's bus connection. 5. SHIP EO shall give permission to SHORE EC to energize power at stated time. 6. SHIP EO shall transfer electrical load within 10 seconds of shore power input.

After transfer of power is complete, remove **"DANGER"** tags. Complete and sign forms.

g. Ship's transfer back to ship's generators: De-energizing and disconnecting shore power cable assemblies should be under direct supervision of SHIP EO, leading electrician's mate, and shore activity personnel.

Table 12-14. Transfer back to ship's generators

1. Establish time for transfer of power to ships generators. 2. Have ship's generators running and synchronized without load.	3. Parallel ship's generators to shore power within 10 seconds. 4. Open shore power receptacle circuit breakers. 5. Attach **"DANGER"** tags to shore receptacle circuit breakers.

h. Shores disconnection of cable plugs and removal of cable assemblies: Prior to start of procedure, ensure the following:

1. Shore power receptacle circuit breakers are open and tagged.
2. Shore power energized indication lights are extinguished.
3. Shore power cable assemblies are disconnected at the source.

Table 12-15. Disconnection and removal of cable assemblies

1. Disconnect cable assemblies. Remove plug from shore power receptacle(s). 2. Close cover. 3. Remove **"DANGER"** signs.	4. Lower cable assemblies from ship onto pier and reel for transport to storage area. 5. Notify ship when all connections are removed. 6. Complete all necessary forms. Sign all forms.

CHAPTER 13. ELECTRICAL WORKER RESCUE

13-1. Rescue Needs. Electrical workers on poles and in underground structures require certification in cardiopulmonary resuscitation as well as annual training and practice in rescue methods in addition to the required standard first aid training. *(See Section 1-3 for mishap handling).*

13-2. Pole-Top Rescue. Apply first aid on the pole as necessary to prevent loss of life or minimize further injuries. Lower the victim from the pole as soon as practical and obtain medical assistance.

a. Pole-Top First Aid. Artificial respiration can be applied to a victim on a pole with victim in an unusual position like the one shown in *Figure 13-1.* If no aerial lift device is available for rescue, then a qualified climber (rescuer) should climb the pole. Free the victim from the energized line if the victim is still in contact with the line**. Use great care to ensure you are not electrocuted**. Use rubber gloves, rubber sleeves, hot-line tools, and other personnel protective devices as necessary for your safety. Mouth-to-mouth resuscitation can be applied to a victim on a pole and the best position will be slightly above the victim. See *Figure 13-2.* When the victim begins breathing naturally, keep the victim in position and under control until the victim can be lowered to the ground. If CPR is required, lower the victim as quickly as possible and then administer CPR.

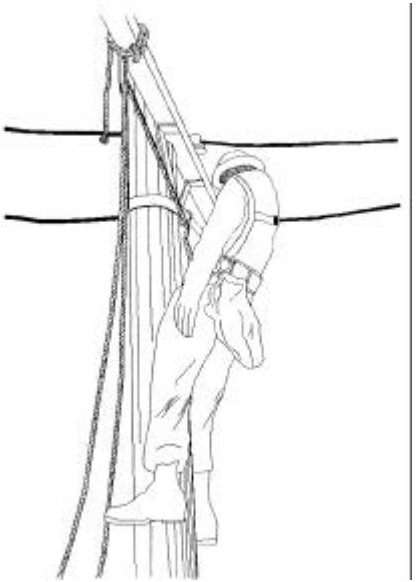


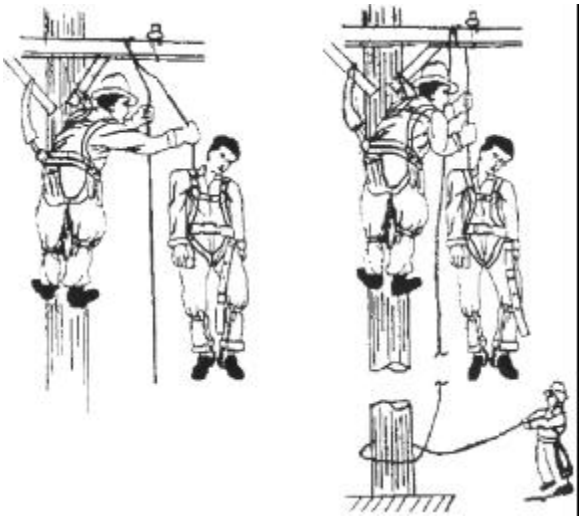
Figure 13-1
Unconscious victim on a pole

Figure 13-2
Mouth-to-mouth resuscitation on a pole

b. Lowering the Victim from the Pole. Use the handline method given in *Table 13-1* and as shown in *Figure 13-3.* After reaching the ground, summon help by whatever means available without delaying CPR (if required).

Table 13-1. Method for lowering a victim

1. Place a handline on the crossarm, preferably 2 or 3 feet (0.6 to 0.9 meters) from the pole.
2. With only one rescuer, it is necessary to add friction to the handline to control the rate of descent of the victim. This may be done by making two full wraps of the handline around the crossarm or other solid support before tying the handline to the victim. See *Figure 13-3*.
3. Pass the handline under the victim's armpits.
4. Tie three half-hitches in the handline.
5. Cinch the handline tightly around the victim.
6. Remove the slack in the handline.
7. Cut the victim's safety strap.
8. With one rescuer, lower the victim by guiding the load line with one hand and controlling the rate of descent with the other hand. See *Figure 13-3.*
9. With two rescuers, the worker on the ground should make one full wrap of the handline around the base of the pole to add sufficient friction to control the rate of descent of the victim. See *Figure 13-3*.



1. One person 2. Two people

Figure 13-3

Control of a handline

13-3. Rescue from a Manhole. Even though normal precautions are observed, there is always a possibility that personnel will be overcome by gas or injured, and rescue from a manhole is necessary.

a. Protect Yourself. Immediate rescue is important, but workers engaged in rescue attempts must protect themselves. In cases of asphyxiation or gas poisoning, it is advisable to ventilate with a blower or other methods while preparing the rescue.

b. Safety Observance. All measures of safety should be observed. If at all possible, there should be another worker present to help with the rescue before you go into a manhole. If no other worker is available, you may proceed with the rescue if you are absolutely certain you will not become a second victim. Otherwise, obtain assistance from the fire department or other personnel trained in confined space rescue. There are many ways in which a rescue can be done.

13-4. Aerial Lift Rescue. Aerial lifts will be equipped to lower victims.

Appendix A

Guide For Qualifying Personnel For Work On Or Near High Voltage Electrical Distribution Apparatus

The following is a sample listing of electrical trades with the applicable reference to OSHA 29 CFR 1910.269 sections, which must be successfully completed.

29 CFR 1910.	*.269(a)* General Information	*.269(b)* Medical Services and First Aid	*.269(c)* Job Safety Briefing	*.269(d)* Lockout/Tagout	*.269(e)* Enclosed Spaces	*.269(f)* Excavations	*.269(g)* Personal Protective Equipment	*.269(h)* Working Surfaces	*.269(i)* Hand and Portable Power Tools	*.269(j)* Live-Line Tools	*.269(k)* Materials Handing and Storage	*.269(l)* Exposed Energized Parts	*.269(m)* Deenergizing Lines and Equipment	*.269(n)* Personal Grounding Protection	*.269(o)* Testing and Test Facilities	*.269(p)* Mechanical Equipment	*.269(q)* Overhead Lines	*.269(r)* Tree-trimming Clearance	*.269(s)* Communication Facilities	*.269(t)* Underground Electric Installations	*.269(u)* Substations	*.269(v)* Power Generation	*.269(w)* Special Conditions
High Voltage Electrician	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Electrician	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X
Electrical Power Controller	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X			X	X	X	X
Electronics Technician	X	X	X	X	X		X	X	X		X	X		X	X	X	X		X	X	X	X	X
HVAC Mechanic	X	X	X	X	X		X	X	X		X	X		X	X	X	X		X	X			
Crane Operator	X	X	X				X					X				X	X		X				
Rigger	X	X	X				X					X				X	X		X				
Painter	X	X	X				X	X				X				X	X		X				
Roofer	X	X	X				X	X	X			X	X			X	X		X				
Welder	X	X	X	X	X	X	X	X	X		X	X	X			X	X		X	X			

NOTE: Activities which have separated the responsibilities of their High Voltage Electricians into specialty groups, i.e., overhead/underground lineman, substation/breaker/relay electrician, etc., must determine individually those sections which directly apply to their employees.

Definitions applicable to this guide:

- **Qualified Workers.** Persons who by training and demonstration are familiar with the skills and techniques for: (1) distinguishing exposed live parts from other parts of electric equipment; (2) determining the nominal voltage of exposed live parts; and (3) maintaining minimum clearance distances corresponding to the voltages to which that person will be exposed.
- **Unqualified Workers**. Persons not meeting the requirements for Qualified Worker. However, to be on the job these persons must be trained in all electrically related practices that are necessary for their safety.
- **Complete Working Knowledge**. At a minimum, the employee must demonstrate to their supervisor or designated representative, his/her ability, knowledge and skill to understand and apply the controls required by their exposures, and that they can safely complete their assigned work using the tools, procedures and safety precautions established or referenced by the appropriate sections in this guide. Each employee's possession of the necessary skills, knowledge and abilities should be determined by written or verbal tests, in conjunction with functional tests.

Method of Accomplishment: Develop and use lesson plans or Standard Operating Procedures. Training may also be contracted from outside sources, which include certified training facilities or Utility Companies.
Only certified instructors can provide CPR and First Aid training.

29 CFR Reference Description

General Information [1910.269(a)]
Understand the applicability of the electrical standard, the associated training requirements and recognize preexisting electrical safety hazards.

Medical Services and First Aid [1910.269(b)]
Understand the requirement for trained first aid personnel, when they are required to be on-site, and the availability and packaging requirements of first aid supplies and kits.

Job Safety Briefing [1910.269(c)]
Understand the requirements of the job safety briefing including; its content, when it is to be scheduled, and who is to deliver the briefing.

Lockout/Tagout [1910.269(d)]
Understand the purpose and function of the lockout/tagout program and display the knowledge and skills required for the safe application, usage, and removal of energy controls.

Enclosed Spaces [1910.269(e)]
Understand the hazards of enclosed space entry, enclosed space entry procedures, and in enclosed space rescue procedures.

Excavations [1910.269(f)]
Understand the hazards of working in excavations and the basics requirements of 29 CFR 1926 Subpart P.

Personal Protective Equipment [1910.269(g)]
Demonstrate the proper procedures required for selecting, donning and wearing personal protective equipment to include fall arrest protective gear.

Working Surfaces [1910.269(h)]
Understand the hazards and safe use of ladders, platforms, step bolts, and manhole steps.

Hand and Portable Power Tools [1910.269(i)]
Understand the hazards, pre-use inspection requirements and safe operation of hand and portable power tools.

Live-Line Tools [1910.269(j)]
Understand the hazards, pre-use inspection requirements and safe operation of live-line tools.

Materials Handling and Storage [1910.269(k)]
Understand the general material handling and storage requirements of 20 CFR 1910 Subpart N and the safe clearance requirements for storage of materials near energized lines and equipment.

Exposed Energized Parts [1910.269(l)]
Understand the requirements for working on or around energized lines and equipment.

Deenergizing Lines and Equipment [1910.269(m)]
Understand the requirements for deenergizing lines and equipment for employee protection.

Personal Grounding Protection [1910.269(n)]
Understand the requirements of grounding of transmission and distribution lines and equipment for the protection of employees.

Testing and Test Facilities [1910.269(o)]
Understand the safe working practices for high-voltage and high-power testing performed in laboratories, shops, substations, and in the field on electric transmission and distribution lines and equipment.

Mechanical Equipment [1910.269(p)]
Understand the pre-use inspection requirements and safe operation of mechanical elevating and rotating equipment.

Overhead Lines [1910.269(q)]
Understand the requirements for working on or near overhead lines and equipment.

Tree-trimming Line Clearance [1910.269(r)]
Understand the safe work practices for line-clearance tree trimming operations and for equipment used in these operations.

Communication Facilities [1910.269(s)]

Understand the safe work practices for working around an energized open waveguide or antenna or where electromagnetic radiation could exceed the radiation protection guide.

Underground Electric Installations [1910.269(t)]

Understand the safe work practices for performing work on underground electrical installations.

Substations [1910.269(u)]

Understand the safe work practices for working on or in electrical substations.

Power Generation [1910.269(v)]

Understand the safe work practices for working in an electric power generating plant.

Special Conditions [1910.269(w)]

Understand the safe work practices for working on special equipment or under hazardous conditions such as working over water or in public work areas.