CALIFORNIA STATE UNIVERSITY
SAN BERNARDINO
Facilities Services
Maintaining a Quality Campus Environment

California State University, San Bernardino

Electrical Safe Work Practice Document

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1.0 INTRODUCTION

Most incidents and injuries related to electrical systems can be avoided by following the safe work practices outlined in this document. Besides the personal pain of suffering an injury, incidents can result in lost time, medical costs, equipment damage, production loss, and legal costs.

2.0 SCOPE

This document provides the minimum safety knowledge and procedures that will allow individuals and facilities to work with, or in near proximity to, energized high and low voltage sources ("working on" or "working near" live parts). However, each individual, or facility shall be responsible for the details and activities specific to the affected facility.

The safety rules and safe work practices contained in this standard shall serve as minimum guidelines for the design, maintenance, and operation of systems and equipment throughout this facility. It is imperative that, at a minimum, these guidelines be met or exceeded to enhance employee safety.

If there are local governmental codes, accepted employee safety standards, design criteria, etc., that are more stringent than those identified within this document, then those shall be considered more appropriate, and shall be followed.

This standard shall apply to all employees, contractors, and visitors while in near proximity to energized conductors, energized exposed parts of electrical equipment, or such conductors and equipment that potentially may become energized.

This standard shall apply to new or modified high and low voltage installations. Existing installations need not be physically modified to comply with this document unless qualified personnel consider such modification necessary to protect affected persons from a recognized hazard.

For the purpose of this standard, low voltage means 600 volts nominal or less phase-to-phase or conductor-to-conductor, and high voltage means voltages above 600 volts A.C., phase-to-phase.

Knowledge of this standard does not make a person a qualified electrical worker. Guidelines shall be established by management concerning informal and formal training, as well as levels of experience needed for workers in the electrical field or other workers whose job function would expose them to a potential electrical hazard.

3.0 DEFINITIONS

The terms listed in this section are used throughout this document. Becoming familiar with them prior to reading this document will help clarify the material.

Affected Employee (or Affected Person)

An employee whose job requires him or her to operate or use a machine or equipment on which servicing or maintenance is being performed under lockout or tagout, or whose job requires him or her to work in an area in which such servicing or maintenance is being performed.

An employee whose job includes activities such as erecting, installing constructing, repairing, adjusting, inspecting, operating, or maintaining the equipment or process from a non-electrical perspective.

ANSI

American National Standards Institute

Approved

Methods, devices, tools, equipment or practices acceptable to the Company and/or regulatory body having jurisdiction.

Arc Flash Hazard

A dangerous condition associated with the possible release of energy caused by an electrical arc.

Arc Flash Hazard Analysis

A study investigating a worker's potential exposure to arc-flash energy, conducted for the purpose of injury prevention and the determination of safe work practices and the appropriate levels of PPE.

Arc Flash Protective Equipment

Equipment used to safeguard personnel from momentary electrical arcs. The equipment may include flame resistant clothing, arc flash suits, face protection, hand protection, and foot protection.

Arc Flash Suit

A complete FR clothing and equipment system that covers the entire body, except for the hands and feet. This includes pants, jackets, and bee-keeper-type hood fitted with a face shield.

Arc Rating

The maximum incident energy resistance demonstrated by a material (or layered system of materials) prior to breakopen or at the onset of a second-degree skin burn. Arc rating is normally expressed in cal/cm2.

Note: *"Breakopen" is a material response evidenced by the formation of one or more holes in the innermost layer of flame-resistant material that would allow flame to pass through the material.*

ASTM

American Society for Testing and Materials

Attendant

An employee assigned to remain immediately outside the entrance to an enclosed or other space to render assistance as needed to employees inside the space.

Authorized Employee (or Authorized Person)

An employee who locks out or tags out machines or equipment in order to perform servicing or maintenance on that machine or equipment. An "affected employee" becomes an "authorized employee" when that employee's duties include performing service or maintenance covered under this document.

An employee who has been given, by his or her employer, the training, authority, and responsibility to perform a specific assignment in an electrical area.

One who can demonstrate by experience and training (as stated in section 9.0 of this document) the ability to recognize potentially hazardous electrical energy.

Examples include electricians, mechanics, supervisors, operators, engineers, custodians, painters, etc.

Barricade

A physical obstruction such as tapes, ropes, cones, or A-frame type wood or metal structures intended to provide a warning about and to limit access to a hazardous area.

Barrier

A physical obstruction that is intended to prevent contact with equipment or live parts or to prevent unauthorized access to a work area.

Bond

The electrical interconnection of conductive parts designed to maintain a common electrical potential across the connection.

Boundary - Arc Flash Protection Boundary

An approach limit at a distance from an exposed live part within which a person could receive a second degree burn if an electrical arc flash were to occur.

Note: *Persons inside the arc flash protection boundary shall wear personal protective equipment appropriate for the potential arc flash energy for any part of the body that may be exposed.*

Boundary - Limited Approach Boundary

An approach limit at a distance from an exposed live part within which a shock hazard exists.

Note: *The limited approach boundary is a shock protection boundary to be crossed by qualified persons only. An unqualified person shall not cross the limited approach boundary unless escorted by a qualified person.*

Boundary – Restricted Approach Boundary

An approach limit at a distance from an exposed live part within which there is an increased risk of shock, due to electrical arc over combined with inadvertent movement, for personnel working in close proximity to the live part.

Note: *Unqualified persons shall not cross the restricted approach boundary whether or not they are escorted by a qualified person.*

Boundary – Prohibited Approach Boundary

An approach limit at a distance from an exposed live part within which work is considered the same as making contact with the live part.

Bus

A conductor or group of conductors that serves as a common connection for two or more circuits.

Bushing

An insulating structure, including a through conductor (or providing a passageway for such a conductor) with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

Cable

A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).

Cable Sheath

A conductive, protective covering applied to cables (may be multiple layers, of which one or more may be conductive).

Circuit

A conductor or system of conductors through which an electric current is intended to flow.

Clearance (Between Objects)

The clear distance between two objects measured surface to surface.

Clearance (For Work – "Access to Work Permit")

Authorization by the proper authority that a specified line or piece of equipment is safe to work on or in (i.e., de-energized, drained, purged, depressurized or whatever is necessary to make equipment safe to work on or in) and that the line or equipment is being turned over to the person in charge (PIC).

Clearance (From Hazard)

Separation from energized lines or equipment.

Close Proximity

Close enough to reach, fall in to, or otherwise accidentally contact.

Common Lockout System

A system which permits the use of locking devices that are not considered unique or uniquely controlled. (See Unique Lockout System).

Communications Lines (Lines, Communications)

The conductors and their supporting or containing structures that are 1) used for public or private signal or communication service and which 2) operate at potentials not exceeding 400 volts to ground or 750 volts between any two points of the circuit, and 3) the transmitted power of which does not exceed 150 watts. If the lines are operating at less than 150 volts, no limit is placed on the transmitted power of the system. Under certain conditions communication cables may include communication circuits exceeding these limitations, where such circuits are also used to supply power solely to communication equipment.

Competent Person

A person who through training or experience is capable of safely performing the work assigned.

Conductor

A material, usually in the form of a wire, cable, or bus bar, suitable for carrying electric current.

Covered Conductor

A conductor covered with a dielectric having no rated insulating strength or having a rated insulating strength less than the voltage of the circuit in which the conductor is used.

CPR

Cardiopulmonary Resuscitation

Current-Carrying Part

A conducting part intended to be connected in an electric circuit to a source of voltage. Non-current-carrying parts are those not intended to be so connected.

Deenergized

Free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the earth.

Designated Person

An employee who is designated by the employer to perform specific duties and who is knowledgeable in the construction and operation of the equipment and the hazards involved.

Dielectric Testing

A controlled method used to test the electrical safety integrity of personal protective and live-line equipment.

Disconnect

A device designed to connect or disconnect machines, equipment, and/or other installations from an electrical energy source.

Electric Utility

An organization responsible for the installation, operation, and maintenance of an electric supply system.

Electrically Safe Work Condition

A state in which the conductor or circuit part to be worked on or near has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded in accordance with section 5.10.

Employee

One employed by another, usually for wages or salary.

Enclosed Space

A working space, such as a manhole, vault, tunnel, or shaft, that has a limited means of egress or entry and that is designed for periodic employee entry under normal conditions, and it does not contain a hazardous atmosphere; but it may contain a hazardous atmosphere under abnormal conditions.

Note: Spaces that are enclosed but not designed for employee entry under normal operating conditions are not considered enclosed spaces for the purposes of this standard. Similarly, spaces that are enclosed and that are expected to contain a hazardous atmosphere are not considered to be enclosed spaces for the purposes of this standard.

Energized (Alive, Live)

Electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Energy Isolating Device

A physical device that prevents the transmission or release of energy, including, but not limited to, the following: a manually operated electric circuit breaker, a disconnect switch, a manually operated switch, a slide gate, a slip blind, a line valve, blocks, and any similar device with a visible indication of the position of the device. (Push buttons, selector switches, and other control-circuit-type devices are not energy isolating devices.)

Energy Source

Any electrical, mechanical, hydraulic, pneumatic, chemical, nuclear, thermal, or other energy source that could cause injury to personnel.

Equipotential Grounding (Earthing)

A grounding (earthing) scheme which places the worker in an envelope of equal potential. When everything that can be touched by the worker is of the same potential, no current can flow through the worker between two different touch points.

Equipment (Electrical)

A general term including material (fittings, devices, appliances, fixtures, and the like) used as part of, or in connection with, an electrical installation.

Escort

A qualified person accompanying non-qualified employees or visitors in the vicinity of electrical equipment or lines.

Exposed (as applied to live parts)

Capable of being inadvertently touched or approached nearer than a safe distance by a person. It applies to parts that are not suitably guarded, or isolated, or insulated.

Ground (Earth)

A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Grounded (Earthed)

Connected to earth or to some conducting body that serves in place of the earth.

Grounding (Earthing)

The act of providing an intentional connection to earth through a ground connection of sufficiently low impedance and having sufficient current carrying capacity to prevent build-up of voltage that could result in undue hazard to connected equipment or to persons.

Note: *For non North American installations, earthing is the common terminology.*

Guarded

Covered, shielded, fenced, enclosed, or otherwise protected, by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger.

Hazard Risk Analysis

The decision-making process required to determine the degree and extent of the hazard, the appropriate protective equipment, and the job planning necessary to complete a task safely.

Hazardous Atmosphere (As applied to confined/enclosed spaces, 29 CFR 1910.269)

An atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from an enclosed space), injury, or acute illness from one or more of the following causes:

1. Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL);
2. Airborne combustible dust at a concentration that meets or exceeds its LFL;
3. Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent;
4. Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in Subpart G, Occupational Health and Environmental Control, or in Subpart Z, Toxic and Hazardous Substances, of Part 1910 of Occupational Safety and Health Standards for General Industry, and which could result in employee exposure in excess of its dose or permissible exposure limit.
5. Any other atmospheric condition that is immediately dangerous to life or health.

High-Power Tests

Tests in which fault currents, load currents, magnetizing currents, and line-dropping currents are used to test equipment, either at the equipment's rated voltage or at lower voltages.

High Voltage

A.C. voltage above 600 volts, phase-to-phase, or conductor-to-conductor.

IEEE

Institute of Electrical and Electronic Engineers

Infrared Thermography

The measurement of radiant energy emitted by a source using a radiometric camera.
Immediately Dangerous to Life or Health
Any condition that poses an immediate threat to life or that is likely to result in acute or immediate severe health effects.

Insulated

Separated from other conducting surfaces by a dielectric substance (including air space) that offers a high resistance to the passage of current.

Insulated Conductor

A conductor covered with a dielectric material that has a rated insulating strength equal to or greater than the voltage of the circuit in which it is used.

Insulation (Cable)

That which is relied upon to insulate the conductor from other conductors, conducting parts, or ground.

ISO

International Standards Organization

Isolated

1. Any object that is not readily accessible to persons unless special means of access are used.
2. All sources of supply have been removed, that is, all isolation devices are locked open and any fuses associated with potential devices or other power supplies are removed.

Limited (hazardous) Work

Any work other than “prohibited” or “restricted” work that requires the approach to exposed, energized conductors or circuit parts by conductive objects or unguarded body parts closer than the "limited approach boundary".

Live-Line Tool

A live-line tool is a wooden or fiberglass rod, handle, or pole rated for the voltage involved and used to touch or come in close proximity to live parts.

Live Parts

Electric conductors, buses, terminals, or components that are uninsulated or exposed and a shock hazard exists.

Lockout

The placement of a lockout device on an energy-isolating device in accordance with an established procedure to ensure that the energy-isolating device and the equipment being controlled cannot be operated until the lockout device is removed. (See Unique Lockout System)

Lockout Device

A device that utilizes a positive means (such as a keyed lock) to hold an energy-isolating device in the safe position (to prevent the energizing of a machine or equipment).

Location Manager

Management supervisor.

Low Voltage

Any electrical circuit that normally operates at 600 volts nominal or less phase to phase or conductor to conductor.

Manhole

A subsurface enclosure which personnel may enter and which is used for the purpose of installing, operating, and maintaining submersible equipment or cable.

Manhole Steps

A series of steps individually attached to or set into the walls of a manhole structure.

Mobile Equipment

Includes but is not limited to cranes, bucket trucks, aerial lifts, and similar types of equipment.

Near Proximity

A minimum clearance of 10 feet (305 cm) to energized lines and equipment operating at 50 kV, or less. This distance increases 4 inches (10 cm) for every 10 kV over 50 kV.

Non-hazardous Work

Work that does not fit in the categories of "prohibited," "restricted," or "limited" work. An example is working on control circuits below 50 VAC or DC to ground.

Note: *Energized parts that operate at less than 50 volts are not required to be de-energized to satisfy an "electrically safe work condition." However, consideration should be given to the capacity of the source, any overcurrent protection between the energy source and the worker, and whether the work task related to the source operating at less than 50 volts increases exposure to electrical burns or to explosion from an electric arc.*

Non-Insulated Conductor

A conductor that has no insulating properties other than air.

Operating System Lock

A keyed lock placed on an electrical distribution system to prevent unintentional opening of a disconnect. Operating system locks may be unique or common lock systems. This is not a personal safety lock (see safety lock).

Person in Charge

A person in charge of work or employees, regardless of his or her title. Examples include a supervisor, foreman, lineman in charge, lead people, etc. or a qualified employee who has been authorized and designated to be locally in charge of Company work.

Potentially Energized

A non-insulated conductor or device that, by nature of design or location, may be energized by an adjacent energized conductor, switch closure, or back-feed.

Prohibited (live) Work

Work that requires intentional hand, body, or tool contact with exposed energized conductors or circuit parts operating at 50 VAC or DC or above, conductor-to-conductor or conductor-to-ground, or work that requires approach to exposed, energized

conductors or circuit parts by conductive objects or unguarded body parts closer than the “prohibited approach boundary”.

Qualified Employee (or Qualified Person)

One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training on the hazards involved.

Location management shall certify qualified personnel.

Restricted (proximity) work

Work that requires approach to exposed, energized (50 VAC or DC or above) conductors or circuit parts by conductive objects or unguarded body parts closer than the “restricted approach boundary”.

Rights-of-way (Power Lines)

The area under a power line within ten feet (305 cm) horizontal to the nearest conductor for lines rated 50 kV and below. This distance shall increase 4 inches (10cm) for each 10 kV above 50 kV.

Safety Lock

A lock that is a controlled keyed lock (intended for personnel protection only) that would be installed at each tagout/lockout location. This is a unique lock system.

Shall

In the context of this standard, always means “Mandatory.”

Shock Hazard

A dangerous condition associated with the possible release of energy caused by contact or approach to live parts.

Should

In this standard, means recommended.

Stand-by Person

A person whose sole responsibility is to observe the actions of the person performing the task and ensuring that he or she is aware of the associated potential hazards. The stand-by person shall be trained in how to recognize and avoid electrical hazards, emergency response techniques (such as CPR), and methods used to free a person from energized conductors or circuit parts.

Step Potential

A ground potential gradient difference that can cause current flow from foot to foot through the body.

Switch

A device for opening and closing or for changing the connection of a circuit. In this standard, a switch is understood to be manually operable, unless otherwise stated.

Switching Authority

A designated employee responsible for carrying out a switching operation on the electrical distribution system. This may be a crew electrician, the crew supervisor, or the utility supervisor.

Tagout

The placement of a tagout device on an energy-isolating device (in accordance with an established procedure) to indicate that the energy-isolating device and the equipment being controlled may not be operated until the tagout device is removed.

Tagout Device

A prominent warning device, such as a tag and a means of attachment, which can be securely fastened to an energy-isolating device in accordance with an established procedure, to indicate that the energy-isolating device and the equipment being controlled may not be operated until the tagout device is removed.

Ten (10) Foot Rule

An unqualified person must maintain a distance of 10 feet minimum from exposed live parts.

To prevent physical contact with energized or isolated ungrounded power lines, equipment or machines shall be operated as follows: The minimum clearance between the lines and every part of the equipment or machine or its load shall be 10 feet (305 cm) for lines rated 50 kV or below. This distance shall increase 4 inches (10 cm) for each 10 kV above 50 kV.

Touch Potential

A ground potential gradient difference that can cause current flow from hand to hand or hand to foot through the body.

Unique Lockout System

A controlled lockout system (unique lock/one key or unique lock group/one key) requiring special authorization for use. (Also see Lockout.)

Unqualified Person

A person who is not a qualified person.

Vault

An enclosure, above or below ground, which personnel may enter and which is used for the purpose of installing, operating, or maintaining equipment or cable.

Voltage

The effective (rms) potential difference between any two conductors or between a conductor and ground. Voltages are expressed in nominal values unless otherwise indicated. The nominal voltage of a system or circuit is the value assigned to a system or circuit of a given voltage class for the purpose of convenient designation. The operating voltage of the system may vary above or below this value.

Working Near (Live parts)

Any activity inside the “limited approach boundary”.

Working On (Live Parts)

Coming in contact with live parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment a person is wearing.

There are two categories of working. These are as follows:

- Diagnostic (testing) – The taking of readings or measurements of electrical equipment that does not require making any physical change to the equipment.
- Repair – Any physical alteration of electrical equipment such as making or tightening connections, removing or replacing components, etc.

Work Zone

The space required to safeguard personnel. An area temporarily marked off by rope, tape, or other barricading devices. Entry into this area is prohibited by all personnel other than those authorized by the person in charge of the work zone.

4.0 RESPONSIBILITIES

4.1 Facilities Manager

The location manager or his or her designee:

- May designate a qualified person for each functional or operational area to be responsible for meeting all administrative, design, construction, maintenance, and documentation requirements of this document. This responsibility includes system electrical planning, operation, and control. This person shall also be responsible for obtaining, reading, understanding/interpreting, implementing, and maintaining mandated (under law) governmental codes, policies and standards.
- Approves exceptions to the Live Part Work Policy.
- Approves Energized Electrical Work Permits.
- Approves PPE.
- Approves Test Equipment.
- Approves the decision to barricade and insulate instead of de-energize.

4.2 Task Supervisor or Person-in-Charge

This individual shall:

- Be a “qualified employee”.
- Adopt such precautions as are within the individual’s authority to prevent accidents, and to take positive action to obtain necessary precautions for those concerns not within the individual’s authority in order to insure employee safety.
- Ensure that the site safety rules, training requirements, and operating procedures as contained in this or other documents are observed by the employees under his or her direction.
- Prepare all necessary documentation as required. (i.e., Switching Procedures, Confined Space Procedures, Digging Permits, Welding Permits, etc.)
- Prevent unauthorized persons from approaching places where electrical work requiring qualification is being performed.
- Ensure that tools or devices used are suited for the work at hand, and that applicable tools have been inspected and tested, as required.
- Hold a job briefing before work begins.

4.3 Employee

The employee is the person most responsible for his or her own safety.

Qualified and Authorized employees shall remain knowledgeable in applicable electrical safety concerns as contained in this, or other documents.

Affected employees shall consider electrical hazards where electrical work is not the primary task, but, where the opportunity for contact exists (i.e. during lockout/tagout, working near open crane rails, motor control centers, and

switchgear, construction around cable ladders, and resetting devices and equipment).

4.4 Escort

The escort (a qualified person) shall safeguard the people in his or her care and shall ensure that safety regulations are observed.

4.5 Contractors and Visitors

Contractors and visitors shall follow, as a minimum, all safety regulations of this facility as contained in this, and other documents.

5.0 SAFE WORK PRACTICES

5.1 Live Part Work Policy

5.1.1 General Policies

It is the general policy that NO maintenance or construction/installation work is to be performed on any conductors and/or exposed circuit parts at 50 volts and above while they are energized. If a decision is made to work on exposed energized parts at 50 volts and above, then an Energized Electrical Work Permit is required before the start of this work. This permit shall be signed by the location manager or his or her designee.

The preferred work environment is to de-energize the line or equipment before a person works on or near them. The employee shall create an electrically safe work condition before start of work unless the employer can demonstrate that de-energizing introduces increased hazards or is infeasible.

Examples of increased or additional hazards include, but are not limited to, interrupting life support equipment, deactivation of emergency alarm systems, and shut down of hazardous location ventilation equipment.

Examples of work performed due to infeasibility include performing diagnostics and testing (i.e., start-up, troubleshooting, phasing) of electrical circuits that can only be performed with the circuits energized and work on circuits that form an integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.

Energized Electrical Work Permit - If exposed live parts at 50 volts and above are not placed in an electrically safe work condition (i.e. for reasons of increased or

additional hazards or infeasibility), work to be performed is considered energized electrical work and shall be performed by written permit only.

Note: *Energized parts that operate at less than 50 volts are not required to be de-energized to satisfy an "electrically safe work condition." However, consideration should be given to the capacity of the source, any overcurrent protection between the energy source and the worker, and whether the work task related to the source operating at less than 50 volts increases exposure to electrical burns or to explosion from an electric arc.*

The energized electrical work permit shall include, but not be limited to, the following items:

- Description of circuit and equipment to be worked on and their location
- Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage
- Detailed job description procedure to be used in performing the work
- Description of the safe work practices to be employed
- Results of the shock hazard analysis
- Determination of the shock protection boundaries
- Results of the arc flash hazard analysis
- Determination of the arc flash protection boundary
- Necessary personal protective equipment to safely perform the assigned task
- Means employed to restrict the access of unqualified persons from the work area
- Evidence of completion of a job briefing including a discussion of any job related hazards
- Signatures of electrically qualified person(s) performing the task
- Approval signatures from the following:
    - Location manager or his or her designee
    - Lead Electrician
    - Environmental Health & Safety Director

Energized Electrical Work Permits are to be reviewed and retained by the plant Safety Manager once the work is completed.

See Annex G for a sample of an energized electrical work permit.

Exemptions to requiring an Energized Electrical Work Permit - Work performed on or near live parts by qualified persons related to tasks such as testing, troubleshooting, voltage measurements, etc., shall be permitted to be performed without an energized electrical work permit, provided appropriate safe work practices and personal protective equipment are provided and used.

Working Near Exposed Live Parts

While working within reach of exposed live parts, the employee shall remove all jewelry and similar conductive apparel if such articles may inadvertently contact the exposed live parts. It is highly recommended that electricians and technicians

remove all conductive apparel and jewelry prior to entering the plant, production, or maintenance areas.

A hazard/risk evaluation procedure should be used before work is started on or near exposed live parts operating at 50 volts or more, or where an electrical hazard exists. For an example of such a procedure see Annex F of NFPA 70E-2009.

A shock hazard analysis should be performed to determine the voltage to which personnel will be exposed, the boundary requirements, and the PPE necessary to minimize the possibility of an electrical shock.

An arc flash hazard analysis is recommended before a person approaches exposed live parts that have not been placed in an electrically safe work condition in order to protect personnel from the possibility of being injured by an arc flash. The purpose of the arc flash analysis is to determine the arc flash protection boundary and the necessary PPE equipment for use while working within the arc flash protection boundary.

Non current-carrying metal parts, such as transformer cases or circuit breaker housings, should be considered energized to the highest voltage to which they are exposed until they are known by test to be free of voltage, or unless they are grounded by an equipment grounding conductor.

Load-rated switches, circuit breakers, or other disconnect devices specifically designed as disconnecting means shall be used for the opening, reversing, or closing of circuits under load conditions.

After a circuit is de-energized by a circuit protective device, the circuit shall not be manually reenergized until it has been determined that the equipment and circuit can be safely energized. The repetitive manual reclosing of circuit breakers or reenergizing circuits through replaced fuses is prohibited. When it is determined from the design of the circuit and the overcurrent devices involved that the automatic operation of a device was caused by an overload rather than a fault condition, examination of the circuit or connected equipment is not required before the circuit is reenergized.

All test equipment should be approved by location management.

All tools and/or handling equipment that might make contact with exposed live parts should be insulated and of approved design.

Employees shall not enter spaces containing exposed live parts unless illumination is provided that enables the employees to perform the work safely.

Employees shall not reach blindly into areas that might contain exposed live parts where an electrical hazard exists.

Employees shall not knowingly be permitted to work in areas containing exposed live parts operating at 50 volts or more or other electrical hazards while their alertness is recognizable impaired due to illness, fatigue, or other reasons.

5.1.2 Exceptions to General Policies

All exceptions, other than the ones listed below, should be approved by the location manager or his or her designee and require a written documented plan.

A qualified employee may perform the following tasks:

- Use non-contact (proximity) meters or other high voltage detectors.
- Attach grounds.
- Perform voltage phasing.
- Take voltage readings.
- Use Live line tools for switching operations.

Electrical servicing activities (maintenance trouble shooting and diagnostic testing) that require electrical equipment to be energized require the worker to take special precautions while he or she is performing these activities. Activities covered by this practice may include:

- Volltage phasing.
- Preventive maintenance observations and meter checks.
- System component adjustment.
- Volltage readings.
- Troubleshooting.
- Re-setting device overloads.

When these activities are performed and will place the worker in close proximity to exposed live parts, appropriate personal protective equipment (PPE) should be utilized. Such PPE in addition to the minimum basic requirements for electrical personnel may include:

- Arc-rated face shields or arc flash suite hood.
- Insulating gloves with leather protectors.
- Arc-rated flame resistant clothing or arc flash suit.

The location management is responsible for approving the PPE selection for such activities.

5.1.3 Requirements for Live Part Work

Before beginning any construction work or maintenance work that requires activities, other than the exceptions outlined in section 5.1.2, that will place the worker(s) in close proximity to exposed live parts, the electrical equipment shall be totally de-energized or the area of work shall be isolated and insulated.

The decision to isolate and insulate instead of de-energizing shall be made by the Task Supervisor or Person-in-Charge and approved by the location manager or his or her designee.

Only persons qualified in the techniques required to work on exposed live parts shall be utilized for this work. Safety conditions outlined in this document shall be utilized for all work on or near exposed live parts.

When persons qualified for exposed live part work must do work on or near exposed live parts, they should insulate and use barriers.

Barriers required to prevent qualified persons from contacting exposed live parts should be placed no closer to the exposed live part than the restricted approach boundary. While the barrier is being installed, the worker should not cross the restricted approach boundary or the equipment should be placed in an electrically safe work condition while the barrier is being installed.

To cross the prohibited approach boundary and enter the prohibited space is considered the same as making contact with the live parts. Any work on exposed live parts shall utilize the procedures defined under "working inside the prohibited approach boundary" (see Annex B).

5.2 Working On or Near Energized Equipment

5.2.1 Electrical Hazards

Two primary hazards to consider when working on or near energized equipment are:

- Shock Hazard
- Arc Flash Hazard

Examples of activities, which have the risk of creating an electrical arc flash are listed below:

- Performing switching with doors open on switchgear or motor starters.
- Installing or removing circuit breakers or motor starter contractors with the switchgear bus energized.
- Installing or removing combination circuit breaker and motor starter cubicles, commonly referred to as "buckets".
- Working on motor control centers with open doors (unless the power components at 480 or 600 volts are well guarded) or when removing or installing starters.
- Installing or removing safety grounds.
- Moving parts connected to energized wires.
- Taking voltage measurements.
- Working on exposed live parts.

5.2.2 Arc Flash Hazard Analysis, Arc Flash Protection Boundary, PPE

An arc flash hazard analysis is required before a person approaches any exposed electrical conductor or circuit part that has not been placed in an electrically safe work condition.

An arc flash hazard analysis shall be performed in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the arc flash protection boundary and the PPE that people within the arc flash protection boundary shall use.

As an alternative, the PPE requirements located in NFPA 70E section 130.7(C)(9) shall be permitted to be used in lieu of a detailed arc flash hazard analysis. One may also consider use of the "Simplified, Two-Category, Flame-Resistance (FR) Clothing System" outlined in Annex H of NFPA 70E.

Establish an arc flash protection boundary and require that all personnel crossing the boundary wear appropriate arc flash protective equipment. This will provide protection from vaporized metal, arc radiation, or hot gases should an arc flash occur on the equipment. The size of the arc flash protection boundary is determined by:

- The size of the source transformer or the available short circuit MVA
- The clearing time of the protective device (fuse or circuit breaker) upstream

Refer to NFPA 70E Section 130.3(A) to determine the arc flash protection boundary for a particular application (see Annex D of NFPA 70E and Annex D of this document for sample calculations of an arc flash protection boundary).

5.2.3 Shock Protection Boundaries – Approach Boundaries

The shock protection boundaries are identified as the Limited, Restricted, and Prohibited Approach Boundaries. These boundaries are fixed distances from exposed live parts based on voltage. The approach boundaries are listed in Table 130.2(C) of NFPA 70E (also see Annex A (Figure A-2 & Table A-6) and Annex B of this document).

Observing a safe approach distance from an exposed live part is an effective means of maintaining electrical safety. The potential for an electrical incident increases as the distance between a person and an exposed live part decreases. The safe approach distance to an exposed live part varies depending on the person's status:

Safe Approach Distance:

"Unqualified " or "Affected" persons (persons not "authorized" or "qualified") are not permitted to cross the limited approach boundary unless they are wearing appropriate PPE and are continuously escorted by a qualified person. Under no circumstance is the unqualified person(s) permitted to cross the restricted approach boundary.

"Authorized" persons, who are specifically trained for a task, may work inside the limited approach boundary but should never be allowed to work as close to exposed live parts as the restricted approach boundary.

"Qualified" persons may work up to the restricted approach boundary. If a person is working near the restricted approach boundary for an extended period of time, it is recommended that special precautions such as insulating and barricading be used.

To cross the restricted approach boundary and enter the restricted space, the qualified person shall:

- Have a plan that is documented and approved by management.
- Use personal protective equipment appropriate for working on exposed live parts, and rated for the voltage and energy level involved.
- Be certain that no part of the body enters the prohibited space.
- Minimize the risk due to inadvertent movement by keeping as much of the body out of the restricted space as possible, using only protected body parts in the space as necessary to accomplish the work. Crossing the prohibited approach boundary and entering the prohibited space is considered the same as making contact with the exposed live part. Only "Qualified" people are permitted to work on exposed live parts.

To cross the prohibited approach boundary and enter the prohibited space, the qualified person shall:

- Have specified training to work on exposed live parts.
- Have a documented plan justifying the need to work that close.
- Perform a risk analysis.
- Use personal protective equipment appropriate for working on exposed live parts, and rated for the voltage and energy level involved.

Note: The above items must be approved by management

5.2.4 Live Parts Operating at 50 Volts or More

Electrical lines and equipment shall be considered energized unless they have been put into an electrically safe work condition (i.e. isolated, locked out or tagged out, tested for the absence of voltage, and grounded as required in this document). The nominal voltage of lines and equipment shall be determined before work is performed on or near energized parts.

Only qualified employees may work on or near, or in an area of exposed live parts operating at 50 volts or more.

Where repair work (see definition of "Working On") is taking place inside the limited approach boundary and a shock hazard exists, two employees must be present. One employee must be a "qualified employee" and the other employee must be either a "qualified employee" or an "authorized employee".

Live Parts Operating at 600 Volts or More

Two employees shall be present to perform the following types of work:

- Installation, removal, or repair of lines that are energized at more than 600 volts.
- Installation, removal, or repair of de-energized lines if there is exposure to contact with other parts energized at more than 600 volts.
- IInstallation, removal, or repair of any other equipment if the employee is exposed to parts energized at more than 600 volts.
- Work using mechanical equipment (other than insulated aerial lifts) near parts energized at more than 600 volts.

Two qualified employees are not required to be present to perform the following work functions:

- Routine switching if employer verifies that site conditions allow this function to be performed safely.
- Work using live-line tools, as long as the employee cannot make contact with live parts.
- Emergency repairs to the extent necessary to safeguard the general public.

5.2.5 Approach to Exposed Live Parts Operating at 50 Volts or More

No qualified person shall approach or take any conductive object closer to live parts, operating at 50 volts or more, than the restricted approach boundary except when:

- The employee is insulated from the energized part (insulating gloves or insulating gloves and sleeves, rated for the voltage, are considered to be insulation of the employee only from the energized part upon which work is being performed): OR
- The energized part is insulated from the employee and any other conductive object at a different potential; OR
- The employee is insulated from any other exposed conductive objects at a different potential (as in live-line bare-hand work). If the employee is to be insulated from the exposed live parts by use of insulating gloves, insulating sleeves should also be used.

However, sleeves are not required for the following conditions:

- If the exposed live parts are insulated from the employee and these parts are not being worked upon; AND
- If the insulation is placed without exposure to the employee's upper arms or to other exposed parts.

5.2.6 Use of Insulated Tools and Insulated Gloves

The following applies to working on or near exposed live parts in installations not related to power generation, transmission, and distribution:

- Employees shall use insulated tools or handling equipment if the tool or handling equipment might make contact with exposed live parts.
- Tools used shall be rated for the voltage involved. Commercially available insulated hand tools (pliers, screwdrivers) are typically rated up to 1000 volts ac.
- Employees shall wear insulating rubber gloves with leather protectors.

Exceptions: If working on exposed live parts rated 50 through 300 volts (phase-to-phase), insulating rubber gloves are not required when all of the following conditions are satisfied:

- Fine dexterity is necessary for the task.
- Any insulated hand tools, test instruments and equipment, test probes, test clips, and test leads required for the task are visually inspected for external defects and damage prior to each use.
- The work on exposed live parts does not expose the worker to accidental contact with other exposed live parts in the vicinity of the task.
- Leather gloves are used if necessary for arc flash protection.

Note #1: This exception does not apply to working on 277 volt phase-to-neutral circuits, since the system phase-to-phase voltage rating is 480 volts (480Y/277 volts, three-phase, four-wire).

Note #2*: An Energized Electrical Work Permit is required for work on exposed live parts between 50 and 300 volts. The work permit must include the following:*

- *The Qualified person(s) must be specifically trained*
- *Wear Personal Protective Clothing and other PPE as needed*
- *Have a documented safety plan*
- *Justify the need*
- *Perform a risk analysis*
- *The safety plan and risk analysis shall be approved by Management*

5.2.7 Safety Procedures for Climbing Structures

Fall Prevention/Protection - Fall prevention/protection shall be used anytime an employee is working 6 feet or more above the ground. Follow the facility's fall protection program.

The following safety precautions shall be followed when raising or lowering Material/Equipment:

- All small equipment and tools to be used aloft shall be raised and lowered by means of a handline, a canvas bucket, or other suitable container.
- Employees working overhead shall take precautions to prevent tools or materials from dropping and falling.
- Employees on the ground shall stay clear of overhead work to reduce the potential of being struck by falling objects.

5.3 Equipment/Lines Status

5.3.1 Basic Rule

Electrical equipment and lines shall be considered energized until they have been put into an electrically safe work condition (i.e. isolated, tested, locked out and/or tagged out, and grounded if necessary in accordance with established practices).

5.3.2 Creating an Electrical Safe Work Condition

The following steps are required to achieve an electrically safe work condition:

- Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.
- After properly interrupting the load current, open the disconnecting device(s) for each source.
- Where it is possible, visually verify that all the blades of the disconnecting devices are fully open or that drawout type circuit breakers are withdrawn to the fully disconnected position.
- Apply lockout/tagout devices in accordance with a documented and established policy.
- Use an adequately rated voltage detector to test each phase conductor or circuit part to verify they are de-energized. Before and after each test, determine that the voltage detector is operating satisfactorily.
- Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them.
- Where it could be reasonably anticipated that the conductors or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, apply ground connecting devices rated for the available fault duty.
- Establish the boundary of the work area (work zone).

5.3.3 Testing and Verification Techniques for Isolation

Consider all circuits energized until a voltage test positively verifies them as de-energized. Use the “Test Before Touch” concept.

Recognize that once no voltage is verified, voltage can reappear on a de-energized system. For example:

- Backfeeds from voltage transformers or control power transformers.
- Undocumented alternate sources.
- Missed lockouts.
- Equipment not operating at the time of test.
- Lighting.
- Induced voltage.
- Energized line contacting a de-energized line.
- Insulation failure. The following testing and verification techniques are recommended when testing for the absence of voltage:

- Check for absence of voltage on molded-case circuit breakers (600 volts and less) since they cannot be visually verified.

+ Caution. Test for voltage both phase-to-phase and phase-to-ground.

- Purchase panel boards (600 volts and less) pre-equipped with locking devices and use these devices for lock out.
- Remove fuses from low-voltage switches that have covered blades, if applicable, after verifying there is no voltage.
- Withdraw draw-out circuit breakers to the farthest position in the cubicle (with the line and load stabs disconnected) and completely remove the circuit breaker if a ground-and-test device will be applied.
- Open isolation disconnects on circuit breakers within open-air switchyards. Remove any fuses for additional isolation.
- Do not rely on control circuit isolation for lock out purposes. Provide primary circuit isolation on circuit breakers and motor starters (i.e., withdraw, or "rack out," circuit breakers or open disconnect switches). Testing procedure for the absence of voltage should include the following:
- What voltage detector will be used and what will be done to verify proper operation of the voltage detector before and after testing for the absence of voltage.
- A requirement to define the boundary of the work area.
- A requirement to test before touching every exposed conductor or circuit part within the defined boundary of the work area.
- A requirement to retest for the absence of voltage when circuit conditions change or when the job location has been left unattended.
- Where there is no accessible exposed point to take a voltage measurement, planning considerations must include alternate methods of verification (example: use of a non-contact voltage tester).

5.3.4 Reenergizing Lines and Equipment

Prior to re-energizing the lines or equipment, the following steps shall be taken:
Remove all protective grounds.

+ Caution. Grounds left on equipment when re-energized present a short circuit hazard. A positive method of control shall be used to assure removal before re-energizing (tags, leaving doors or covers open, leaving the ground cables clearly visible, use of magnetic ground signs, etc.)

- Remove all protective safety locks and tags from points of disconnection.
- Release all associated electrical clearances.
- Ensure that all affected employees are clear of the lines and equipment covered under the lockout and/or electrical clearance and that they understand that the lines and equipment are being returned to service.
- Re-energize lines and equipment following the facility's procedures.

5.3.5 Switching Procedures for Power Systems

A written switching order is required before any switching can be performed on the high voltage distribution power system (this does not include switching of individual motors). The switching order shall be written by a qualified person and reviewed by at least one other qualified person. Both people shall sign and date the switching order before it may be used.

Before the start of any switching, a job briefing shall be held by the person in charge of the switching order. All employees that will be involved in the switching shall attend the job briefing. As a minimum the following items shall be reviewed:

- Reason switching is being performed. Review one line drawing and/or power system status board to assure that all involved understand what will occur.
- Discuss each step of the switching order.
- Make job assignments to all involved (who will do what).
- Discuss safety issues and required PPE.
- Review the following (if required).
    - Electrical clearance requirements and/or Lockout/tagout issues.
    - Location of safety grounds – to be installed or removed and by who.
    - Other issues (such as operational limitations).

During switching the switching order shall be followed in the order that it is written (step 1, 2, 3, etc.). Each switching step shall be checked off when completed. It is recommended that the time the switching step is completed be recorded. The following switching procedures and information items are recommended:

- The person receiving a switching command should repeat the switching command and have it confirmed by the person issuing the order before executing the command.
- If switching commands are given by radio, a unique switching channel should be used. Cross talk on the radio during switching could cause a switching error.
- When the switching is complete the status of the power system should be documented. Use of a status board or pin board is one method of accomplishing this issue.
- Information on abnormalities of the power system should be documented in order to inform off shift personnel who may be involved in responding to power system problems. It is recommended that this information be posted near a power system status board or pin board.
- It is recommended that open electrical clearances (or parts of the power system under lockout/tagout), the location of any safety grounds, and other power system safety issues be posted near the power system status board or pin board.
- A second person should stand clear and be a safety observer for the person doing the switching. The safety observer should ensure that each step the switch operator is about to perform is correct.

5.3.6 Switching Procedures for Low Voltage Systems

A written switching order is generally not required for low voltage systems. However, while low voltages do not typically require the formalized procedures and written switching instructions required for high voltage systems, a disciplined, through-through procedure should be followed.
If the work to be done is extensive and complex, a formal written switching order should be followed.

5.4 Job Briefings

5.4.1 General Requirements

The person-in-charge shall conduct a job briefing with all personnel involved in the work before starting each Job.

At least one job briefing shall be conducted before the start of each shift. Additional job briefings shall be held if changes occur during the course of the work that could affect personnel safety.

The job briefing shall cover at least the following subjects:

- Hazards associated with the job.
- Work procedures involved.
- Special precautions.
- Energy source controls.
- Personal protective equipment requirements.
- Work Zones (Barricades). During the job briefing, each person involved should be able to answer the following questions before start of work:
- Do I thoroughly understand the job?
- Do I thoroughly understand my role and everyone else's role in the job?
- Am I aware of all the hazards I may possibly encounter?
- Am I knowledgeable about all safety rules and required personal protective equipment applicable to this job?
- Do I have safeguards in place to protect me from unexpected events?

5.4.2 Repetitive or Similar Tasks

A brief discussion is satisfactory if the work involved is routine and if the employee, by virtue of training and experience, can reasonably be expected to recognize and avoid the hazards involved in the job.

A more extensive discussion shall be conducted:

- If the work is complicated or particularly hazardous, or
- If the employee (qualified or unqualified) cannot be expected to recognize and avoid the hazards involved in the job.

A person working alone shall plan their work as though a briefing is required. *Note: See Job Briefing Checklist in Annex F*

5.5 Multiemployer Relationship

5.5.1 Safe Work Practices

On multiemployer worksites (in all industry sectors), more than one employer may be responsible for hazardous conditions that violate safe work practices.

5.6 Personal Protective Equipment

The following basic personal protective equipment is recommended. Specific personal protective equipment requirements will be designated during the job briefing before start of each job.

5.6.1 Clothing/Apparel

Employees who work on or near live parts shall be trained in the hazards of arcs and flames of arcs.

An arc flash hazard analysis shall be done before a person approaches an exposed electrical conductor or circuit part that has not been placed in an electrically safe work condition.

It has been demonstrated that wearing arc-rated flame-resistant clothing (long sleeves and long pants) may reduce the severity of burns if an electrical arc flash occurs. No clothing made, either alone or in blends, of acetate, nylon, polyester, polypropylene, and spandex is permitted unless the fabric has been treated to withstand the conditions that may be encountered.

No clothing, including undergarments, may be worn that will increase the extent of an injury sustained from a flame or arc. Materials that melt as a result of arc flash exposure will aggravate the burn injury.

Garments worn as outer layers over flame-resistant (FR) clothing, such as jackets and rainwear, shall also be made from FR material.

5.6.2 Conductive Articles

Conductive articles shall not be worn in close proximity or within reaching distance of exposed live parts. This shall include such items as rings, metal watch bands, unrestrained metal-framed eyewear, metal dangling jewelry and key chains.

5.6.3 Head Protection

Class E hard hats shall be worn as required when working in near proximity to energized or potentially energized conductors or non-insulated, exposed equipment parts whenever there is a danger of head injury from electrical shock or burns due to contact with live parts. (See ANSI Z89.1)

Hard hats shall be kept clean and in good condition and shall not be altered in any manner except for the addition of company approved markings.

5.6.4 Eye Protection

Approved safety glasses, with non-conductive sideshields, shall be worn at all times when working with or in close proximity to potentially energized conductors or exposed non-insulated parts. (See ANSI Z87.1). Goggles and/or arc-rated face shields may also be required.

5.6.5 Hand Protection

Rubber insulating gloves with leather protectors shall be worn where there is a danger of hand injury from electrical shock due to contact with live parts. At no time shall the rating on the glove be exceeded.

INSULATING RUBBER GLOVES

Class	Maximum Use Voltage (AC)	Test Voltage (AC)
00	500 VOLTS	2,500 VOLTS
0	1,000 VOLTS	5,000 VOLTS
1	7,500 VOLTS	10,000 VOLTS
2	17,000 VOLTS	20,000 VOLTS
3	26,500 VOLTS	30,000 VOLTS
4	36,000 VOLTS	40,000 VOLTS

Rubber insulating gloves with protectors shall be worn as an added means of protection any time an employee is using live-line tools or test probes.

Rubber insulating gloves with protectors shall be worn during the installation or removal of safety grounds.

Only gloves dielectrically tested within the previous six (6) months shall be used. (ref. ASTM F496)

Gloves shall be inspected and air tested before each use and immediately following any incident that can reasonably be suspected as having caused damage. Air testing is performed by trapping air in the glove and examining for pin hole or other apparent leakage. (see Annex K)

Gloves shall be worn with approved protectors.

Gloves shall be stored in an approved glove bag or an equivalent protective location.

If possible, store gloves with the cuffs down.

5.7 Insulated Tools and Equipment

Employees shall use insulated hand tools and/or handling equipment when working inside the Limited Approach Boundary of exposed live parts where the tools or handling equipment might make contact with the exposed live part.

- Insulated tools shall be rated for the voltages on which they are to be used.
- Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.
- Ropes and Handlines used near exposed live parts operating at 50 volts or more, or used where an electrical hazard exists, shall be nonconductive.

5.7.1 Live-Line Tools

Store Live-line tools in a clean and dry location. Live-line tools should not be placed on the ground.

Each live-line tool shall be wiped clean and visually inspected for defects before use each day.

If, after wiping, the tool has contaminants which could affect its insulating qualities or if its mechanical integrity is questionable, remove the tool from service and have it repaired. After the tool has been repaired it shall be tested before it is returned to service.

Live-line tools shall be tested using the testing program procedures described below.

Testing Procedures

Each live-line tool shall be removed from service at least every two years and be given the following examination and tests:

- Thoroughly examined for defects.
- If defects or contaminants that could affect the insulating qualities or mechanical integrity of the tool are found, the tool may be repaired and refinished or permanently removed from service.
- If no defects are detected and no contaminants found, cleaned and wax the tool using only wax approved for live line tools.
- The test method shall test the entire working length of the tool.
- If the tool is made of fiberglass-reinforced plastic, it shall be tested under wet conditions over the entire working length of the tool.

- If the tool is made of fiberglass-reinforced plastic (FRP), the test shall consist of applying 100,000 volts per foot of length for 5 minutes. (ref. 29 CFR 1910.269 section j.1.i, IEEE 978)
- Other high voltage tests are acceptable if the employer can demonstrate that these are equivalent (such as IEEE Std. 978-1984).

5.7.2 Cord-connected Hand and Portable Power Tools

Ground fault circuit interrupters GFCI's) shall be used when using cord connected portable power tools or other cord connected equipment.

Visually inspect cord connected portable power tools, extension cords, and other cord connected equipment before each use. All extension cords shall be periodically inspected.

Observe the following precautions for any cord- and plug-connected equipment not supplied by premises wiring:

- Use tools equipped with a cord containing an equipment-grounding conductor connected to the tool frame and to a ground at the other end. (If the ground in the work environment increases the hazard, it may be omitted); OR
- Use a tool of the double-insulated type; OR
- Use a tool connected to the power supply through an isolating transformer with an ungrounded secondary.

Portable and vehicle-mounted generators being used to supply cord- and plug-connected equipment shall meet the following requirements:

- The generator frame should have a connection to ground (earth).
- The generator can supply only the equipment located on the generator or vehicle and cord- and plug-connected equipment through receptacles mounted on generator or vehicle.
- Bond the non-current-carrying metal parts of the equipment and the equipment-grounding conductor terminals of the receptacles to the generator frame.
- With vehicle-mounted generators, bond the frame of the generator to the vehicle frame.
- Bond any neutral conductor to the generator frame.

Note: *Portable generators may be used for temporary power to switchgear and/or motor control centers.*

5.7.3 Hydraulic and Pneumatic Tools

Ensure the following precautions are followed when hydraulic and pneumatic tools are used:

- Do not exceed safe operating pressures for hydraulic and pneumatic tools, hoses, valves, pipes, filters, and fittings.
- Where a hydraulic or pneumatic tool may contact exposed live parts, use a tool designed and maintained for such use.
- For a hydraulic system supplying a hydraulic tool that may contact exposed live parts, provide protection against loss of insulating value for the voltage involved due to formation of a partial vacuum in the hydraulic line. (35 feet or more elevation between reservoir and hose end, if there are no check valves, promotes formation of a partial vacuum.)
- Provide protection against the accumulation of moisture in the air supply when a pneumatic tool is used on energized lines or equipment or where it could contact exposed live parts.
- Assure that pressure is released before connections are broken, unless quick acting, self-closing connectors are used. Do not allow hoses to kink during use.
- Employees shall not use any part of their bodies to locate or attempt to stop a hydraulic leak.

5.7.4 Ladders and Platforms

Only use ladders and platforms that comply with Subpart D of 1910. Ladders and platforms shall:

- Be properly secured to prevent their becoming dislodged.
- Be used only in applications for which they were designed.
- Be capable of supporting without failure at least 2.5 times the maximum working load.
- They shall not be loaded in excess of the working load for which they were designed.
- Ladders and platforms used for electrical tasks shall be nonconductive. Ladders shall have nonconductive side rails if they are used where the employee or ladder may come in contact with exposed live parts or where an electrical hazard exists.

5.8 Work Zones – Alerting Techniques

Work Zones/Barricades may be required to safeguard personnel from potential hazards. Barricades in conjunction with safety signs shall be used to limit or prevent access to work areas where hazards may exist. Barricades shall be placed no closer to the live part than the limited approach boundary.

In some instances it will be necessary to barricade or otherwise identify a work area as containing electrical hazards not normally encountered during routine operation of the equipment and/or conductors located therein. This would normally be the case during maintenance, renovations to existing installations, and additions to installations where electrical equipment and/or conductors are located. Appropriate identification makes employees more aware of the hazards in their work areas.

5.8.1 Electrical Hazard Barricade Tape/Rope

Electrical hazard barricade tape/rope is used as a temporary hazard warning.

Temporary may be defined as the duration of any work assignment where there is an active effort to complete a permanent installation and employee safety is not compromised.

The recommended color is red.

The red tape should be imprinted with wording such as “Danger -- Do Not Enter”.

5.8.2 Area Protection Areas Accessible to Qualified Employees Only

Qualified employees should take the following action:

- Determine the size of the work zone.
- Consider the types and size of conductive materials and equipment to be used in the area.
- Determine the limited approach boundary and the arc flash protection boundary.
- If the work exposes energized or moving parts that are normally protected:
    - Display danger signs.
    - Erect suitable barricades to restrict other personnel from entering the area.

When working in a restricted section that adjoins other such sections (i.e., a portion of a substation, one section of switchgear, a row of transformers or breakers, or one panel of a switchboard), a qualified employee shall:

- Mark the work area conspicuously.
- Place barriers to prevent accidental contact with exposed live parts in adjacent sections.

Note: Use Designated Work Zones/Barricades Around “Look Alike” Equipment.

Areas Accessible to Vehicular and Pedestrian Traffic

Where vehicles and non-qualified pedestrian traffic may pass adjacent to electrical equipment that is under maintenance, operating, or construction activity and the safety of these vehicles and pedestrians could be compromised, appropriate warning signs and/or barricades shall be used.

5.8.3 Enclosed Spaces

These requirements apply only to enclosed spaces, such as manholes, unvented vaults, tunnels, etc. that can be entered by employees. All other confined spaces are covered by 29 CFR 1910.146.

The employer shall ensure that the employee uses safe work practices for entry into and work within enclosed spaces and for rescue of employees from such places. If hazards remain after the precautions taken for enclosed space are exercised or if the escape procedures cannot be met, then entry into enclosed spaces shall meet the requirements of permit-space or confined space requirements of 29 CFR 1910.146.

Employees who enter enclosed spaces or serve as attendants shall be trained in the following:

- The hazards of enclosed space entry.
- Enclosed space entry procedures.
- Enclosed space rescue procedures. Employees shall be provided equipment to ensure prompt and safe rescue. Before removal of any entrance cover to an enclosed space, the employer shall:
- Check for atmospheric pressure and temperature differences.
- Determine whether there is a hazardous atmosphere in the enclosed space.
- Eliminate any conditions that make it unsafe to remove the cover.

After the removal of a cover to an enclosed space, the opening shall be guarded by a railing or a temporary cover/barrier. Such precautions will help to prevent an employee from falling into the enclosed space and will help to prevent objects from falling into the enclosed space and causing injury to the employee.

Hazardous Atmosphere in an Enclosed Space

Before an employee enters the space, the following tests shall be performed:

- The internal atmosphere shall first be tested for oxygen deficiency.
- The internal atmosphere shall be tested for flammable gases and vapors.

Each test shall use a direct-reading meter that is capable of collection and immediate analysis of data samples, thus eliminating the need for off-site evaluation. Oxygen deficiency testing is not required if continuous forced air ventilation is provided.

+ Caution: *Test devices shall be approved as intrinsically safe and shall be kept in calibration.*

An employee cannot enter an enclosed space which contains a hazardous atmosphere (confined space hazardous atmosphere) unless the entry meets requirements of 29 CFR 1910.146.

If, while work is being performed in the space, there is reason to believe that a hazard may exist in the space or that traffic may cause a hazardous condition, an attendant with first aid training shall be immediately available to render emergency assistance. This attendant may perform tasks outside the enclosed space.

If flammable gases or vapors are found to be present or an oxygen deficiency exists, then forced air ventilation shall be used to maintain a safe level of oxygen and to prevent the accumulation of flammable gases or vapors from reaching a hazardous concentration.

If flammable gases or vapors are found to be at a safe level, forced ventilation may be waived, providing there is continuous monitoring to ensure that there is no increase of either.

If continuous forced air ventilation is used, it shall meet the following criteria:

- The supply for the continuous forced air ventilation shall be from a clean source and shall not contribute to the hazard in the enclosed space.
- It shall begin and be maintained long enough before workers are allowed to enter the enclosed space to ensure that a safe atmosphere exists.
- It shall be directed to the employees' immediate area.
- It shall continue until all employees have left the enclosed space.

If open flames are used in the enclosed space, a test for flammable gases or vapors shall be made immediately before the open flame device is used and at least once each hour while the device is being used in the enclosed space. More frequent tests shall be conducted if there is an indication that one hour periods are insufficient.

Note: L*ocal "Hot Work" procedures shall be used.*

5.8.4 Underground Electrical Facilities

The following requirements for work on underground electrical installations in manholes and/or vaults are required in addition to the work requirements for enclosed spaces listed in section 5.8.3:

- Ladders or other climbing devices shall be used to enter or exit manholes or subsurface vaults that exceed 4 feet (122cm) in depth.
- Employees shall not use cables or hangers as steps to climb in or out of manholes and vaults.
- Equipment used to lower materials and tools shall be capable of supporting the weight of the materials and tools and shall be checked for defects before use.
- Employees working in manholes and vaults shall stand clear of the area directly underneath openings while tools or materials are lowered or raised.
- While work is being performed in a manhole that contains energized electric cables or equipment:
    - All employees shall be in constant communication. This can consist of visual, voice, or signal-line communication.
    - An employee capable of rendering emergency assistance shall be on duty in the immediate vicinity of the manhole opening.
    - The attendant shall be trained in CPR, first aid, hazards of enclosed space entry, enclosed space entry procedures, and enclosed space rescue procedures.

- Rescue equipment shall be present at the worksite to ensure the prompt and safe rescue of employees from the enclosed space. The rescue equipment shall include a mechanical device to retrieve personnel, a full body harness (wristlets may be used in lieu of the harness), and a retrieval line.

An employee working alone may enter a manhole where energized cables or equipment are in service if the nature of the visit does not involve the energized cables or equipment but is for the purpose of housekeeping, inspection, meter reading, or similar activities. This is permitted only if it can be done safely.

If pulling tapes are to be used, pulling tapes shall be installed in the direction that presents the least amount of hazard to employees. An employee shall be stationed at the far end of the duct line to ensure that required minimum approach distances are maintained to protect employees.

An energized cable may be moved only under the direct supervision of a qualified employee and after management has approved a documented plan. Before the energized cable is moved it shall be inspected for defects.

- Cables may be defective when any of the following abnormalities are observed:
  - Oil or compound leaking from cable or joints.
  - Broken cable sheaths.
  - Broken joint sleeves.
  - Hot surface temperatures.
  - Joints swollen beyond normal tolerances.

When any one of these conditions occurs, no employees are permitted in the manhole while the cable is energized. However, if de-energizing the cable is not possible, employees shall be protected against effects of the failure by shields that are capable of containing the adverse effects of a fault in the joint.

When multiple cables are present, exact identification is required by electric means unless identification is obvious. All other cables not being worked on shall be protected against damage.

Cable cutting - Ground both ends where practical. Use a cable penetrator tool (such as A. B. Chance Company's catalog number C600-1625) to penetrate the insulation at the point of the cut if the cable cannot be visibly traced from the point of the cut to one of the two ends.

Sheath continuity shall be maintained while work is performed on buried cable or on cables in manholes, or the sheath shall be treated as energized.

5.8.5 Trenches and Excavation

Before the start of all trenching and excavation, notify others having underground installations in the affected location.

Normal trenches or excavations less than 4 feet deep do not require a protection system if a competent person has determined there is no cave-in potential.

Note: *All trenching and excavation operations shall comply with 29 CFR 1926.650, 1926.651 and 1926.652*.

5.9 Lockout/Tagout

This section applies to the servicing and maintenance of machines and equipment in which the unexpected startup of the equipment or the release of stored energy could cause injury to employees (reference 29 CFR1910.147).

Lockout/Tagout for electrical equipment is covered in NFPA 70E.

Conductors and parts of electrical equipment that have been de-energized but have not been locked out or tagged out in accordance with this document are to be treated as energized parts. For information on working on energized parts, see section 5.2.

5.9.1 General Industry Lockout/Tagout

Management shall establish a program of energy control procedures, training, and periodic inspections to ensure that before an employee services a machine or equipment all potentially hazardous energy sources are isolated and rendered inoperative.

If equipment is capable of being locked out, it shall be locked out unless the employer can demonstrate that tagout alone will provide full employee protection.

If equipment is not capable of being locked out, tagout only may be used. However, when that equipment is modified or undergoes major repair, it shall be retrofitted to accept a lockout device.

If tagout only is utilized, additional safety measures shall be used, such as removal of an isolating element, blocking of a control switch, or removal of a valve handle to reduce the likelihood of inadvertent energization. The employer shall also demonstrate compliance with all tagout related requirements.

5.9.2 Site Lockout/Tagout Procedures

Management shall ensure the development of lockout/tagout procedures that include:

- A specific statement of the intended use of the procedure.

- Specific procedural steps for shutting down, isolating, blocking, and securing machines or equipment.
- Specific procedural steps for the placement, removal, and transfer of lockout or tagout devices and the responsibility for them.
- Requirements for testing a machine or equipment to determine and verify the effectiveness of lockout devices, tagout devices, and other control measures.

When contractors are involved in lockout/tagout, the on-site employer and the contractor shall inform each other of their respective procedures.

Lockout/Tagout procedure shall be strictly adhered to by all personnel on the work site.

The procedure to follow during actual lockout/tagout is as follows:

- Only the authorized employees who will be servicing the machine or equipment may lockout/tagout the machine or equipment to be worked on.
- Notify all affected employees in advance of the applying or removing lockout or tagout devices.
- Shut down the machine or equipment in an orderly fashion using established procedures.
- Locate all energy isolating devices and operate them to isolate the equipment from the energy source.
- Install locks to hold the energy isolating device in a “safe” or an “off” position
- Install tags to indicate that movement of the energy isolating devices from the “safe” or “off” position is prohibited.
    - Where tagout devices are used with energy isolating devices not capable of being locked, affix the tag at the same point at which a lock would have been attached.
    - If the tag cannot be attached directly to the energy isolating device, locate it as close as possible to the device, in a position that will be immediately obvious to anyone trying to operate the device.
    - Once the locks and tags are in place, relieve all potentially hazardous sources of stored energy. If stored energy can re-accumulate, continue to verify the isolation as long as necessary.

Prior to servicing the machine, the authorized employee shall verify that the machine has been de-energized and put into an electrically safe work condition.

The lockout/tagout program should require each person to install their personal lock and tag before start of work and remove their personal lock and tag when they complete work. The use of “lockboxes” can be used for this purpose.

During shift changes, procedures shall be in place to ensure the continuity of lockout/tagout protection. There shall be an orderly transfer of lockout/tagout devices between off-going and on-coming employees.

Work on Equipment Performed by a Group of Employees

When servicing is performed by a group of employees, procedures shall ensure a level of protection equal to that of individual lockout/tagout devices.

Primary responsibility will be vested in one authorized employee for the group.

The designated authorized employee shall be able to ascertain the exposure status of individual group members.

When more than one crew is involved, one authorized employee shall be assigned responsibility to coordinate affected groups and ensure continuity of protection.

Each person shall install a personal lock and tag before start of work on a machine or equipment. Each person shall remove their personal lock and tag at the end of work on a machine or equipment.

5.9.3 Lockout/Tagout Materials

Management shall supply the lockout/tagout materials including locks, tags, chains, wedges, key locks, or other hardware for the isolating, securing, or blocking of equipment from energy sources.

Lockout/Tagout devices shall meet the following criteria:

- Be capable of withstanding the environment to which they are exposed.
- Be standardized in at least color, shape, or size.
- Be substantial enough to prevent removal without the use of excessive force.
- Lockout and tagout devices shall have provisions for the identification of the person applying the devices.
- Tagout devices shall be of a standardized print and format.
- Tags shall warn against the hazardous conditions if re-energized and shall include at least one of the following statements:
    - Do not start.
    - Do not open.
    - Do not close.
    - Do not energize.

5.9.4 Removing Lockout/Tagout Devices

Prior to removing lockout/tagout devices and re-energizing the equipment, the authorized employee shall do the following:

- Remove nonessential items from the work area.
- Ensure that all employees are safe.
- Notify affected employees that lockout/tagout devices are going to be removed.

Lockout/tagout devices shall be removed only by the employee who applied them.

Exception: If the employee who applied the lockout/tagout devices is not available to remove them, the devices may be removed under the direction of the employer by another employee if management:

- Verifies that the authorized employee who applied the devices is not at the facility; AND
- Makes reasonable efforts to contact the employee who applied the devices; AND
- Ensures that the authorized employee is informed of the device removal before the employee resumes work.

Temporary Removal of Lockout/Tagout Devices

When lockout/tagout devices must be temporarily removed from the machine or equipment for testing or positioning, the following precautions are required:

- Clear equipment or process of nonessentials items.
- Ensure that all employees are removed from the area or are safely positioned.
- Remove lockout/tagout devices.
- Energize and proceed with testing/positioning.
- De-energize equipment and re-apply lockout/tagout devices.

5.9.5 Annual Inspections of Specific Equipment Lockout/Tagout

Management shall conduct annual inspections of the lockout/tagout procedure used for locking and tagging specific equipment.

Where lockout and tagout procedures are used, the annual inspection should include a review between each authorized employee and the inspector responsible for monitoring the employee's responsibilities.

Authorized employees other than those applying the lockout/tagout devices shall conduct the inspections.

Management shall certify that the inspections have been performed and shall document the following:

- The identity of the machine,
- The date of inspection.
- Employees included in the inspection.
- The name of the inspector.

5.9.6 Lockout/Tagout Training

Management shall provide training to ensure that the purpose and function of the energy control program is understood and that personnel with knowledge and skill are available for safe application, usage, and removal of energy control as necessary.

Authorized employees shall be trained to recognize the applicable hazardous energy sources, the type and magnitude of energy sources, and the proper techniques for energy isolation and control.

Affected employees shall be instructed in the purpose and use of the energy control procedure.

Other employees whose work may be in areas where energy control is utilized shall be instructed about the procedure and the prohibition against restarting machines which have been locked/tagged out.

When tagout only is used, employees shall also be trained in the following limitations of tags:

- Tags are warning devices only and do not provide physical protection.
- A tag is not to be removed without the authorization of the person who applied it. It shall not be bypassed, ignored, or defeated.
- Tags shall be legible and capable of being understood by all in the area.

Authorized and affected employees shall be retrained when their assignment changes, when equipment changes, or when energy control procedures change. Retraining is also required when a periodic inspection reveals inadequacies in the program.

Management shall certify that training has been accomplished.

5.10 Grounding – Safety Grounds for Employee Protection

5.10.1 Installation of Protective Grounds

Use approved clothing that includes rubber gloves with protectors, hard hat, and eye protection when testing for voltage and placing/removing grounding devices.

Apply protective grounds as though the circuit was energized. Insulated cables can retain a capacitive charge and open wire lines can have induced voltage – both represent a shock hazard.

Protective grounds shall have an impedance to ground low enough to guarantee prompt operation of protective devices in case of accidental energization of the lines or equipment.

The protective grounds used shall be of adequate size to withstand the maximum fault current long enough for the upstream circuit breaker or fuse to clear the fault (ref. ASTM F855, also see Annex L of this document).

Before installing protective grounds, disconnect all capacitor banks and disconnect all auxiliary devices, such as voltage transformers, by removing all fuses (primary and secondary) or by removing the device (racking out).

Installing and Removing Protective Grounds

When installing protective grounds, first connect the protective ground to an effective ground, and then bring the protective ground into contact with the previously energized part using live-line tools. The protective ground should then be securely attached to the conductor.

When removing protective grounds, first remove the protective grounds from the de-energized parts using live-line tools, then, remove the connection to the ground. **Take extreme caution.** If the connection to the ground is removed first before the connection to the de-energized part, electric shock and injury may result.

Use visible protective grounds to assure that the conductors tested as de-energized remain safe. Inspect all temporary grounds for integrity prior to use (i.e., clamps, ferules, cables, etc.).

+ Caution: *Grounds left on equipment when re-energized present a short circuit hazard. A positive method of control shall be used to assure removal before re-energizing (tags, leaving doors or covers open, leaving the ground cables clearly visible, use of magnetic ground signs, etc.).*

5.10.2 What Requires Protective Grounds

Personal safety grounds shall be required as final protection against backfeeds on:

- All open wire lines.
- All feeders from substations.
- All switchgear buses.

Ground all motors equipped with power factor capacitors.

Ground all motor circuits above 600 volts before working on the motor. Use a switchgear “Ground and Test Device” or connect protective grounds at the load-side cable connections of the circuit breaker, fused disconnect switch, or starter.

5.10.3 Exceptions to the Use of Protective Grounds

Exceptions to the use of protective grounds:

- When grounding is impracticable.
- When grounds would present a greater hazard.
- When there is no possibility of contact with another energized source.
- When the hazard of induced voltage does not exist.

If the employee can demonstrate that the instillation of grounds is impractical or presents a greater hazard, the lines or equipment may be considered as de-energized if ALL of the following conditions are met:

- The lines or equipment have been put in an electrically safe work condition.
- There is no possibility of contact with another energized source.

- There is no possibility of induced voltage.

5.10.4 Traditional Grounding Methods

This section describes a procedure for grounding transmission and distribution lines and equipment.

For employees to work on lines or equipment designated as de-energized, an electrical clearance shall be issued or all isolating points locked and tagged and appropriate safety grounds, as detailed in this section, shall be installed.

Note: See *exceptions to the use of protective grounds in section 5.10.3.*

Before any ground is installed, the lines or equipment shall first be tested for absence of voltage unless a previously installed ground is present. Before installation of the grounds, the grounding equipment shall be visually inspected to confirm the equipment's integrity.

+ Caution: *Grounds left on equipment when re-energized present a short circuit hazard. A positive method of control shall be used to assure removal before re-energizing (tags, leaving doors or covers open, leaving the ground cables clearly visible, use of magnetic ground signs, etc.)*

Temporary protective grounding equipment shall be installed at the work location.

If installation of grounds at the work location is not feasible, grounds shall be installed on each side of the work location, as close to it as possible.

Single-point grounding (equipotential grounding) is an acceptable means of grounding.

Protective grounding equipment shall be capable of conducting the maximum ground-fault current that could flow for the time necessary to clear the fault. This equipment should have an ampacity greater than, or equal to, that of no. 2/0 AWG copper. A larger conductor size may be required for higher capacity systems (see ASTM F855).

Protective grounds shall have an impedance to ground low enough to guarantee prompt operation of protective devices in case of accidental energization of the lines or equipment.

Before grounding any previously energized part, the employee shall first connect one end of the grounding device to an effective ground. Then test the previously energized parts for voltage. If the parts are free from voltage, the grounding may be completed. The grounding device should next be brought into contact with the previously energized part using live-line tools and be securely attached. If the test indicates that the parts are not free from voltage, then the grounds must not be attached to the part. Determine the source of the voltage to ensure that the presence of this voltage does not prohibit completion of the grounding.

When removing grounds, first remove the grounding devices from the de-energized parts using live-line tools. Then, remove the connection to the ground.

Take extreme caution. If the connection to the ground is removed first before the connection to the de-energized part, electric shock and injury may result.

Approved clothing that includes rubber gloves with protectors, hard hat, and eye protection shall be worn when testing for voltage and placing/removing grounding devices.

Static capacitors (surge protection capacitors and power factor correction capacitors) shall be grounded (discharged) before work is done on them even if there is no possibility of their becoming energized. A five-minute waiting period is required between isolating the capacitor and applying the grounds.

Removing Grounds for Testing

Protective grounds may be removed temporarily for testing. During the test procedure, the previously grounded lines and equipment shall be considered as energized.

5.11 Mobile Equipment Operation

5.11.1 General Mobile Equipment Safety Precautions

Inspect the critical safety components of mechanical elevating and rotating equipment before use on each shift. Check the lower and upper controls to ensure they are functioning correctly. The inspection shall follow the manufacturer's recommended checklist.

No vehicular equipment with an obstructed view to the rear can be used on off-highway job sites unless one of the following provisions is met:

- The vehicle has a reverse signal alarm louder than the surrounding noise level OR
- A designated employee signals that it is safe to make movements.

Heavy equipment, with or without attachments, shall have roll-over protection that meets the requirements of 29CFR 1926, Subpart W.

Lifting equipment shall be used within its maximum load rating.

When a load that creates a hazard for any other employee is suspended, the operators of mobile equipment may not leave their position at the controls.

When potential exposure to electrical hazards can reasonably be anticipated before the start of a job assignment, the person assigning the job shall notify contractors and

location employees of the potential hazard before the mobile equipment is moved to the job site.

Any mobile equipment operators who notice that operation of their equipment may place that equipment to within 10 feet of energized or potentially energized exposed conductors or circuit parts of electrical equipment shall notify the appropriate location management and wait for further safety instructions.

5.11.2 Outrigger-equipped Vehicles

Outrigger-equipped vehicles shall be operated with outriggers extended and firmly set to provide stability for operation of the equipment.

Outriggers may not be retracted or extended beyond the clear view of the operator unless all employees are outside the range of possible equipment motion.

If the work area or terrain prohibits full use of outriggers, the equipment shall be operated according to the manufacturer's standards for operation without outriggers.

5.11.3 Operator Training

Mobile equipment operators who are not qualified in electrical work shall have the following training if their equipment has the potential of coming as close as 10 feet to energized lines or equipment.

Training in the potential electrical shock hazards associated with equipment operation under these conditions:

- Training in techniques for proper equipment grounding.
- Refresher training is recommended every two years.

5.11.3 Operating Zone for Mobile Equipment

A potential for electrical shock hazard exists when mobile equipment is operated within 10 feet of energized, non-insulated, high voltage conductors or to energized, exposed, high voltage current-carrying equipment parts (or to parts that have the potential for becoming energized).

To help eliminate this risk, follow the safety recommendations below:

Approach Distances

For lines and equipment energized at 50 kV or less, employees may not bring materials or equipment closer than 10 feet to exposed live parts (or to parts that have the potential for becoming energized). For more than 50 kV, the distance is 10 feet plus 4 inches for every 10 kV over 50 kV.

Whenever it is possible that any part of a vehicle or its load could violate the 10-Foot Rule by error, malfunctions, inadvertent operation, or any other cause, ground the vehicle or barricade around it.

If it is difficult for the operator to accurately determine the distance between the equipment and the energized parts, assign another person to observe the clearance and give timely warnings when the minimum clearance distance is approached.

It is the general policy that no equipment or material is to be hoisted over energized, non-insulated high voltage conductors or equipment. Any exception to this policy will require approval of the location manager or his or her designee. A documented plan will also be required.

Post minimum approach distances on a plate of durable non-conductive material so it is visible to the operator.

Exception: *An exception to this distance requirement is when lines have been de-energized and grounded or where barriers have been installed to prevent physical contact with the energized lines*.

Mobile Equipment in Transit

If mobile equipment is in transit with no load and the boom is lowered:

- Mobile equipment shall observe a minimum clearance of 4 feet for voltages less than 50 kV.
- For voltages higher than 50 kV, the clearance shall be increased 4 inches for every 10 kV over 50 kV.
- When visual conditions make it difficult for the operator to maintain the desired clearance, a person shall be designated to observe clearance for the operator.

Exception: *An exception to this distance requirement is when lines have been de-energized and grounded or where barriers have been installed to prevent physical contact with the energized lines*.

5.11.4 Grounding Mobile Equipment

Apply safety grounds to mobile equipment if the mobile equipment could inadvertently come closer than 10 feet to lines and equipment energized at 50 kV or less (or to parts that have the potential for becoming energized). For more than 50 kV, the distance is 10 feet plus 4 inches for every 10 kV over 50 kV.

Size and Materials Used for Mobile Equipment Grounding

Ground leads should not be less than 2/0 flexible stranded copper, rubber-covered cable to provide physical strength. The cable jacket is for mechanical protection of the conductor only.

Ground leads should be visually inspected for any type of damage or wear before installing.

Methods to Install and Remove Mobile Equipment Grounds

Only personnel trained in the proper grounding techniques are permitted to attach/detach grounding sets.

Install the ground to mobile equipment prior to raising a crane or derrick boom or similar equipment.

On a vehicle, trailer, or other mobile equipment (i.e., cranes, line trucks, and aerial lifts), make a connection from a suitable ground plate or stud on the vehicle to the best ground available in the immediate work area.

On distribution circuits, the "best ground" available is normally the common neutral or ground grid system. The second choice is a tower or other grounded structure. Only use a driven ground rod as a final alternative.

Note: *Instruct workers to stay clear of the driven ground location. Use other protective means, such as barricades, as necessary to avoid the "step potential" and "touch potential" hazards that may occur around the driven rod during a ground fault.*

The correct sequence to install and remove safety grounds is to:

- First attach the ground to the best available ground.
- Then attach the ground lead to the vehicle. When removing grounds:

Remove the ground lead from the vehicle only after the crane, derrick boom, or similar parts of the equipment have been removed from the vicinity of the potentially energized conductors or equipment.

- First detach the ground lead from the vehicle.
- Then detach the ground lead from the ground source.
-

5.12 Infrared Testing

Safety interlocks may only be bypassed by a qualified person. Upon completion of the testing, the interlocking system shall be restored to full operable condition.

Safety interlocks offer a high degree of personnel safety and should be utilized in all designs. Generally the interlock system should not be by-passed or otherwise rendered inoperative while the equipment is energized.

Employees performing infrared testing on open high and low voltage systems from outside the limited approach boundary should wear as a minimum:

- Approved clothing. If the employee is inside the arc flash protection boundary flame-resistant (FR) clothing appropriate for the task shall be worn.
- Approved hard hats.
- Safety glasses with side shields.
- Safety shoes.

When performing infrared testing on metal-clad, enclosed switchgear that requires the enclosure to be open (exposing energized high voltage parts), employees should wear as a minimum:

- Approved clothing. If the employee is inside the arc flash protection boundary flame-resistant (FR) clothing appropriate for the task shall be worn.
- Approved hard hats.
- Arc- rated protective hood or face shield as appropriate for the task.
- Safety glasses with side shields.
- Leather gloves or flame-resistant (FR) gloves.
- Safety shoes.

6.0 Design and Construction

6.1 Equipment Design Considerations

The following "Safety BY Design" issues should be considered for the design, operation, and maintenance of electrical systems:

- Separate low-energy circuits from circuits having a large arc flash hazard.
- Apply current-limiting fuses, where appropriate, to reduce the arc flash hazard.
- Purchase Motor Control Centers with guards covering exposed live parts above 120 volts.
- Use ground fault circuit interrupters on portable equipment to reduce shock hazards.
- The design should include fast protection that will clear faults as quickly as possible and reduce the arc exposure time.
- For 480 and 600 volt systems, transformer sizes should be limited to 1500 kVA and below to avoid excess arc flash energy.
- To keep the arc flash hazard on 208Y/120 volt systems to a minimum risk level, limit the size of supply transformers at this voltage to less than 125 kVA.
- For all circuit breakers operating over 1000 volts, specify "Remote Closing and Tripping" capability using either a plug-in cord and control or a supervisory control panel switch (for remote operation). This will enable the operator to be outside of the arc flash protection boundary while closing or opening a circuit breaker.
- Specify two tie breakers or disconnect switches between switchgear buses to improve the electrical isolation for busbar or switchgear maintenance. Workers could then work on or within a switchgear cubicle without the possibility of one set of circuit breaker stabs or disconnect switch bus being energized.
- Specify closed-door and remotely operated "racking" (insertion and removal) capability for switchgear breakers.
- Specify insulated bus for all electrical switchgear to help prevent arc propagation within the gear when a fault is initiated. Insulated bus can also reduce the arc flash hazard.
- Specify "grounding balls" (i.e., those manufactured by A.B. Chance Company) on the load-side terminals of high-voltage circuit breakers or disconnect switches to facilitate the connection of safety grounds.

- 120 volt supply circuits are recommended for lighting circuits to lower the shock hazard to personnel.
- Specify that all electrical disconnect devices have lockout capability.
- Provide “Mimic Bus” (single line diagram) on the front of switchgear.

6.2 Substation Design

Designed and construct all new substations in accordance with national and local codes and in such a manner as to afford maximum protection of the public, qualified persons, and non-qualified persons.

When modifying existing substations, all efforts shall be made to upgrade the station to current standards.

When designing, modifying, or constructing substations, follow these recommendations:

- Always provide and maintain sufficient access and working space.
- For all new or revised 600 volt to 34 kV distribution systems, consider designs that have no accessible conductors and use insulated cable and dead-front switchgear. (Generally this excludes the incoming power feeds.)
- Connect all equipment and structures to a common ground grid.
- Draw-out-type breakers shall be in the open position when removed or inserted. The control circuit should also be blocked or rendered inoperative if design permits.
- Locate all exposed live parts, including the energized racks of static capacitors, to provide personnel clearance in accordance with Appendix A, Table A-1.
- Substations that are not totally enclosed and that have exposed, energized parts shall be completely enclosed by fences at least seven (7) feet in height, with gates secured by suitable locks.
- Ground all conductive fences around substations.
- When fences are expanded or a section is removed, the grounding continuity shall be continued to prevent electrical discontinuity.
- Use bridging (bonding) conductors at all gates to ensure electrical continuity to the fence on each side of the gate and to the gate itself.
- Install substation auxiliary systems in such a fashion that they do not require maintenance personnel to approach in close proximity to any non-insulated or unguarded, energized parts.
- Lighting and other auxiliary systems should not be installed on poles or structures that would require maintenance personnel to approach non-insulated lines and equipment.

6.3 Guarding of Exposed Live Parts

During the design phase or during modifications, follow the recommendations below:

Guard all exposed live parts operating at 50 volts or more to prevent accidental contact by placing them in one of the following locations:

- In a cabinet or enclosure.
- In a room or vault accessible to only qualified people.
- On a balcony or platform. For systems exceeding 1000 volts, the above applies with the following additions:
- Control access to metal-enclosed equipment with a lock.

Exposed live parts shall be accessible to qualified persons only. The following recommendations should be followed for the guarding of all exposed live parts:

- Enclose energized parts installed in rooms and similar spaces with fences, screens, or walls.
- Lock all entrances not guarded by an attendant.
- Display signs at the entrance warning unqualified personnel to keep out.
- Unqualified persons may not enter these rooms and spaces while supply lines and equipment are energized.
- Place guards around all live parts that have voltages above 150 volts to ground and that have no insulation covering, unless the location of these parts gives enough horizontal and vertical clearance to prevent inadvertent contact.
- Covers or guards that must at any time be removed while the exposed parts are energized should be designed so that

6.4 Static Capacitor Banks

All new static capacitor banks should have a permanently installed grounding switch that is key or mechanically interlocked with the main line-disconnect switch connecting the capacitor bank to the system. The purpose of the interlock is to ensure that the line-disconnect and the grounding switches are not closed at the same time.

Place conspicuous signage on all sides of the support frame accessible to personnel indicating that the capacitor bank frame is energized.

6.5 Power Lines

Design and construct all new power lines in accordance with national and local codes. Installation of power lines should be constructed in such a manner as to afford maximum protection for the safety of the public, qualified personnel, and non-qualified personnel.

Give primary consideration to installing insulated cables for all new or relocated distribution power lines.

Do not locate non-electrical equipment on electrical structures that have non-insulated conductors closer than 10 feet to the non-insulated conductors.

Lighting and other auxiliary systems should not be installed on poles or structures that would require maintenance personnel to come in close proximity to high-voltage non-insulated lines and equipment.

When modifications are made to existing power lines, efforts should be made to upgrade the power lines to current design practices.

Refer to Annex A for spacing and dimensional clearances for power lines.

Installing and Removing Overhead Lines

Employees must confirm the structural capacity of elevated structures, such as poles and towers, before they are subjected to the stresses of climbing or the installation or removal of equipment. If the structural capacity is inadequate, brace or support the structure to prevent failure.

When poles are set, moved, or removed near overhead conductors, avoid direct contact between the pole and energized conductors. Wear protective equipment or use insulated devices to handle poles. Do not contact the pole with any uninsulated parts of their body.

Guard or place attendants at pole holes where employees are working.
Employ precautions during installation or removal of lines near energized conductors or energized equipment, such precautions include but are not limited to barriers or the tension stringing method.

Consider conductors, cables, pulling, and tensioning equipment energized if the conductor being installed is close enough to exposed energized conductors that any of the following failures could energize the equipment:

- Failure of the tensioning equipment.
- Failure of the wire or cable being pulled.
- Failure of previously installed lines or equipment.

Vehicles should be grounded to minimize touch potential and provide rapid protective relay action to de-energize the lines if a failure of equipment or other unexpected event causes the vehicle to come in contact with the exposed energized line.

Employees on poles or towers or in aerial lifts shall treat the newly installed conductors as energized unless safety grounds have been installed on the conductors at the work site.

Deactivate automatic reclosing devices for energized lines that are being worked on or near when the conductor being installed or removed crosses an energized conductor carrying over 600 volts.

When lines are installed parallel to existing energized lines, the employer is responsible for ensuring that employees determine whether or not the possibility of induced

hazardous voltage exists. This type of work shall proceed as if the lines are energized unless the following rules are applied:

- Grounds are placed on each bare conductor so that no point is more than two (2) miles (3.22km) from a ground.
- The grounds are left in place until the conductor installation is completed between dead-ends.
- Grounds are removed only during the last phase of aerial clean up.
- Grounds are installed at each location where employees are working on bare conductors and at all open dead-ends or catch off points or on the next adjacent structure.
- When two bare conductors are being spliced, both conductors are bonded and grounded.

When installing safety grounds to lines or equipment, the ground source connection is made first and the other end of the ground is then connected to the line or equipment by use of live-line tools and insulated gloves.

When removing safety grounds, use live-line tools and insulated gloves, remove the grounds from the line or equipment first, then remove the grounds from the ground connection.
Pulling and tensioning devices should be in safe operating condition and should be leveled and aligned.

Do not exceed the load rating of all associated equipment, such as stringing lines, pulling lines, conductor grips, rigging and hoists.

Replace or repair all defective pulling lines and accessories.

Do not use conductor grips on wire rope, unless the grip is specifically designed for this application.

Maintain reliable communications between the reel tender and the pulling rig operator. Only operate the pulling rig when it is safe to do so.

While a conductor or pulling line is in motion, employees are not permitted directly under overhead operations or on cross arms, except as necessary to guide the stringing block or board over or through the stringing sheave.

Observe the following requirements during tower and structure work:

No employee is allowed under the tower or structure while work is in progress, except to assist employees working aloft.

Use tag lines and other similar devices to position tower sections being assembled, unless these devices present a greater hazard

Keep load lines fully attached until loads are safely secured.

Except during emergency power restoration, discontinue work when adverse weather conditions make the work unusually hazardous.

6.6 Perimeter Fence Grounding

In order to minimize the shock hazard associated with induced or impressed voltages on perimeter fences, comply with the NESC Sections 92E and 93C6, as follows:

- Where high voltage power lines cross over fences, ground the fence at the point of crossing and at a distance not to exceed 150 feet (45m) on either side.
- When fences run under or are parallel to high voltage power lines, ground them at intervals not to exceed 150 feet (45m).
- In the condition described in the two points above, ensure that all gates or other opening are bonded to the fence with a bonding strap.

When armored high voltage cables are used, the grounding practices described in this section need not apply.

6.7 Pipelines, Conveyors, and Metal Structures

Where these items are parallel to, or pass under, high voltage power lines, proper grounding design shall be followed.

6.8 Signage

Signs are essential for conveying information regarding a potential electrical shock hazard. They are also used to convey information regarding arc flash hazards, the required PPE, and operation and/or maintenance issues.

This section of the document makes no attempt (except as noted below) to catalog types of signs, all locations where signs may be required, or lettering on signs. The listing references within this document should be used to obtain the necessary information for sign requirements at your location.

6.8.1 Design

Consider the following for signage requirements:

- **Material** -The sign should be made of a durable material that is appropriate for the anticipated environmental conditions and the expected length of exposure.
- **Colors and shapes** -The color and shape of the sign should be consistent with regulatory and consensus standards requirements.
- **Lettering** -Use large and highly visible lettering and anticipating dark or low-light situations.
- **International symbols** - Use internationally accepted symbols as much as practicable.

6.8.2 Location

As a minimum, place signs of warning/information as follows:

- On all doors, gates, and fence locations for substations.
- On doors to switchgear rooms; and on other similar compartments where potentially energized exposed electrical parts are located.
- On switchgear to indicate the nominal voltage.
- On all equipment and devices subject to operation or manipulation. Use large, prominent, and therefore easily read lettering.
- Where a low-voltage bus is supplied from two (2) or more sources and presents a back-feed opportunity to the high-voltage system, conspicuously display a sign that warns of this potential problem.
- If temporary alterations must be made to secondary load supply systems in order to maintain power supply continuity at the secondary voltage level (thus presenting a back-feed opportunity), then conspicuously display a sign warning of this potential problem until the need for the temporary alteration is abated.
- At roadways or railways where horizontal or vertical clearance from energized or potentially energized sources is minimal. (Refer to Annex A, Table A-2)
- At all low profile electrical equipment installations where physical distance requirements for employees and/or the requirements for handling of conductive material cannot be met or are is marginal.
- At all overhead pipes, bridges, etc. where adjacent energized electrical conductors and parts exhibit potential electrical shock hazards to maintenance or construction personnel.
- On all transmission and/or distribution structures where employee or public presence may be expected.
- In the case of multi-support structures, located signs on each supporting member.
- Where inadvertent electrical contact is possible.

6.9 Equipment Labeling, Marking, and Identification

6.9.1 Equipment Operating at Over 600 Volts, Nominal

Mark each cover or door behind which energized parts exist on switchgear, unit substations, transformers, pullboxes, covers for pullboxes, terminal and connection boxes, and motor starters with “DANGER HIGH VOLTAGE – KEEP OUT”

Mark building services over 600 volts with “DANGER HIGH VOLTAGE – KEEP OUT”

Mark the feeder or circuit number on the front and rear of permanent structure of the switchgear or equipment, but not on removable enclosure covers to the equipment

6.9.2 Equipment Operating at Over 600 Volts or Less, Nominal

Mark entrances to guarded rooms or locations with warning signs prohibiting entry by unqualified personnel

6.9.3 Other Equipment

Indicate the voltage of exposed parts at outdoor switchgear or transformer locations. Identify disconnects that have no load interrupting or fault closing rating with clear signs to prevent improper operation.

If a “backfeed” is possible, identify with a warning sign.

If there is an external or “foreign” voltage source, identify the source with a warning sign. Identify clearly all disconnect devices and the equipment with which they are associated. Identify clearly the rear doors of switchgear compartments

7.0 Operation and Maintenance

7.1 Substations

When entering an attended substation, employees other than those assigned to station work should report to the employee in charge. Upon reporting, these employees should receive special safety instructions and a job briefing.

7.1.1 Substation Enclosures

Keep substation enclosures locked at all times except while work is being performed.

7.1.2 Storage of Materials in Substations

Keep substation lots free of debris. Do not store materials and equipment not necessary for distribution and transmission system repair and maintenance (R & M) in substation lots.

Establish specific storage locations for distribution and transmission repair and maintenance (R & M) materials. Periodically inspect the storage location. Location management should approve the storage areas.

7.1.3 Substation Inspections and Maintenance

Substations shall be periodically inspected by qualified employees to determine the general condition of all equipment, including grounding systems (Ref. Annex I). Equipment maintenance is recommended every two to five years.

7.1.4 Servicing Substations and High Voltage Yard Auxiliary Equipment

When servicing existing equipment compromises worker safety, consideration should be given to relocating such equipment.

If the equipment cannot be relocated, employ alternate safety procedures, such as de-energizing and/or requiring appropriate personal safety equipment and clothing for work in close proximity to energized parts.

Note: *Auxiliary equipment and services (area lighting, P.A. systems, etc.) should not be mounted on, or in close proximity to substation/high-voltage yard structures if such positioning will breach dimensional clearance restrictions defined elsewhere in this document.*

7.2 Guarding of Live Parts During Operation and Maintenance

Provide guards around all live parts where the clearance requirements of Annex A, Table A-1 cannot be met. (Refer to NESC Section 124.)

When necessary to ensure reasonable safety, ensure that exposed live parts are guarded or provide clearances in excess of those specified in Annex A - Table A-1 and A-3. This requirement includes exposed live parts over or near passageways through which material may be carried and exposed live parts on or near spaces such as corridors, storerooms, and boiler rooms used for non-electrical work. Use substantial guards that completely shield or enclose the energized parts without openings.

Note: Guards for spaces accessible to unqualified personnel should be removable only by means of tools or keys.

Guard each portion of exposed live parts whose potential is unknown in the same manner as described above. Guarding should be based on the maximum voltage that may be present on the surface of that portion. Examples of such parts include telephone wires exposed to induction from high-voltage lines, ungrounded neutral connections, ungrounded frames, ungrounded parts of insulators or surge arresters, or ungrounded instrument cases connected directly to a high-voltage circuit.

Guards less than 4 inches outside the guard zone should completely enclose the parts from contact up to the heights listed Annex A, Table A-1 column 2. They should not be installed closer to the exposed live parts than the distance specified in Table A-1, column 4 except when suitable insulating material is used with circuits less than 2500 V to ground.

Covers or guards that must at any time be removed while the exposed live parts they guard are energized should be designed so that the guard cannot readily be brought into contact with the exposed energized parts.

7.3 Rights-of-Way

Maintain Rights-of-way in a clear and orderly condition, with trees and brush kept well clear of overhead lines.

Any vehicle that could inadvertently come within 10 feet of an energized line shall be prohibited from parking in this area. Examples would be aerial lifts, mobile cranes, dump trucks, dumpsters, and high lift fork trucks.

It is recommended that areas within a horizontal distance of 10 feet of an overhead non-insulated power line be “coned off” with appropriate barricades prior to any work near the overhead power lines.

Storage of Materials in Rights-of-Way

Material and equipment shall not be stored on rights-of-way under non-insulated high voltage lines closer than 10 feet horizontal for lines energized at 50 kV or less.

For lines energized at voltages above 50 kV add 4 inches for every 10 kV above 50 kV.

Do not store materials and equipment closer than the distances stated below in areas that are not restricted to entry by qualified employees only and that are located near exposed live parts:

For lines and equipment energized at 50 kV or less, the distance is 10 feet (305cm). (10 foot rule).

For lines and equipment energized at more than 50 kV, the distance is 10 feet (305cm) plus 4 inches (10cm) for every 10 kV over 50 kV. To these minimum clearances, enough distance shall be added to account for the following:

Maximum sag and side swing by conductors.

The space needed by the equipment used to handle the stored materials.

In areas restricted to qualified employees, do not store material within the working space around exposed energized lines or equipment.

8.0 Inspection and Testing of Insulating/Insulated Equipment

Inspection and Testing of Insulating Rubber Products, Insulated Tools, and Mechanized Equipment

8.1 Documentation

Maintain test records on all equipment, rubber goods, and insulated tools.

8.2 Insulating Rubber Products

8.2.1 Insulating Rubber Gloves

Electrically test insulating rubber gloves in accordance with the in-service care of insulating gloves and sleeves, per ASTM F496.

Ensure that Insulating rubber gloves are dielectrically tested as follows:

- Before their first use.
- Every 6 months during use.
- When the gloves might have been damaged, test before their next use.

Visually inspect and air test rubber insulating gloves before each use (see Annex K). Store insulating rubber gloves in canvas bags designed for that purpose.

8.2.2 Insulating Rubber Sleeves

Visually inspect rubber insulating sleeves at the start of each work day in which they will be used.

- Ensure that Insulating rubber sleeves are dielectrically tested as follows:
- Before their first use.
- Every 12 months thereafter.

Electrically test insulating rubber sleeves in accordance with the procedures for in-service care of insulating gloves and sleeves described in ASTM F496. Store insulating rubber sleeves in canvas bags designed for that purpose.

8.2.3 Insulating Blankets, Line Hose, and Covers

This equipment is not designed for permanent installation. Follow the manufacturer's specification for use, as exposure may result in ozone checking, corona cutting, or excessive weathering.

Test and inspect insulating blankets, line hose, and covers in accordance with ASTM F478 and F479.

Ensure that Insulating rubber blankets are dielectrically tested as follows:

- Before their first use.
- Every 12 months thereafter. Test line hoses and covers upon indication that the insulating value is suspect. Visually inspect this equipment for defects before use and installation on energized conductors, devices, or equipment, and at other times if damage is suspected. Don't use damaged or possibly damaged equipment until it has passed an electrical re-test.

8.3 Tools

8.3.1 Live-Line Tools

Visually inspect Live-line tools for defects and contamination before using the tool each day. Check the tool for defective hardware attachments, cracks, deformities, contamination, proper operation, and cleanliness.

Wax and then dielectrically test live-line tools at least every two years (24 months).

Fiberglass tools are dielectrically tested while wet. IEEE 978-1984 *"Guide For In-Service Maintenance and Electrical Testing of Live-Line Tools"* may be used for reference.

8.3.2 Insulated Hand Tools – Rated for 1000 Volts

Employees shall use insulated hand tools and/or handling equipment when working inside the limited approach boundary of exposed live parts where the tools or handling equipment might make accidental contact with exposed live parts.

Insulated gloves with leather protectors should also be used. Insulated tools shall be protected from damage to the insulating material.

Ensure that insulated tools meet the requirements of ASTM F1505 "Standard for Insulated Hand Tools".

8.4 Mechanized Equipment

Inspect the critical safety components of mechanical elevating and rotating equipment before use on each shift. Ensure that the lower and upper controls are functioning correctly. Follow the manufacturer's recommended checklist.

For insulated, extendible-boom aerial personnel devices, articulating-boom aerial personnel devices, and any combination thereof (such as line trucks):

- Dielectrically test and Inspect annually (every 12 months)
- Follow the inspection and test methods as outlined by the manufacturer, ANSI A92.2, and ASTM Standard Designation F914.

Whenever the equipment identified above is to be used to elevate an employee into close proximity of energized or potentially energized lines or equipment, a basket liner should be inserted in the basket. This liner should totally cover all surfaces exposed to the employee and should be dielectrically tested per ANSI A92.2 annually (every 12 months).

For non-insulated, digger-derrick, extensible-boom equipment, follow the inspection and test procedures reflected in ANSI A10.31.

8.5 Records/Documentation

9.0 Employee Training

9.1 Types of Training

The following types of training are recommended:

- Initial training
- Qualified employee
- Authorized employee
- Unqualified employee Refresher
- Lockout/Tagout Training on "Electrical Safe Work Practices"

All training should take place in a class room and/or on-the-job. It is recommended that both types of training take place. The degree of training provided should be based on the risk to the employee. Periodic refresher training may be computer- based.

9.2 Certification and Record Keeping

9.2.1 Certification

The employer should certify all personnel upon demonstration of the success of the training. Certification may include a dated record of successfully passing a test or an outline of the course or courses completed by the employee.

Location management should certify who are “qualified employees”, “authorized employees”, and who has the qualifications to work in each area.

For a person to be considered a qualified person they should:

- Understand the hazards related to the tasks they are requested to perform.
- Demonstrate that they can perform the tasks in a safe manner. A person can be considered qualified with respect to certain tasks and unqualified for others. For example:
    - Working on HVAC equipment
    - Working with 480 volt equipment
    - Working with 15,000 volt equipment

9.2.2 Record Keeping

Location management should ensure that all required training is completed and documented.

Establish and maintain records for each person considered a “qualified employee”. The records should include:

- The name and identification of the employee.
- The date and time of the training.
- The content of the training (e.g., course outline or on-the job demonstration of skills).
- Basis for acceptance as “qualified” (e.g., test grade, demonstration of skills, and work location).

9.3 Personal Responsibilities

The employer should verify, both through regular supervision and inspections conducted at least annually, that the employee is complying with the required safety-related work practices.
Supervisors should make sure that procedures are in place and that employees are trained in those procedures.

Employees shall follow safe work practice procedures, including using required PPE, and understand how an employee’s qualification status relates to the current task.

Note: *It is recommended that the facility conduct periodic audits of the required electrical safe work practice*s.

9.4 "Qualified Employee" (Qualified Person) Training

For a person to be considered a "qualified person", he or she shall:

- Be trained to identify and understand the relationship between electrical hazards and possible injury.
- Be trained in the safety-related work practices, safety procedures, and other personnel safety requirements as necessary to provide protection from the electrical hazards associated with the tasks they are required to perform.
- Be familiar with any other safety practices, including applicable emergency procedures related to their work and safety.
- Be trained in methods of release of victims from contact with live parts.
- Be able to perform cardiopulmonary resuscitation (CPR) and first aid.
- Be able to distinguish exposed energized parts.
- Be able to determine nominal voltage.
- Know and understand the minimum approach distances specified for voltages to which they may be exposed.
- Know the proper use of special precautionary techniques, personal protective equipment (PPE) including arc-flash protective equipment, insulating and shielding materials, test equipment, and insulating/insulated tools.
- Understand induced, static, and impressed voltages, grounding integrity, and the conditions of poles and structures.
- Have specialized knowledge regarding specific work methods.

9.5 "Authorized Employee" (Authorized Person) Training

For a person to be considered an "authorized person", he or she shall:

- Be trained to identify and understand the relationship between electrical hazards and possible injury.
- Be trained in the safety-related work practices, safety procedures, and other personnel safety requirements as necessary to provide protection from the electrical hazards associated with their job assignment and the tasks they are required to perform.
- Be familiar with any other safety practices, including applicable emergency procedures related to their work and safety. Recommended skills and knowledge in addition to those above include:
- Be able to distinguish exposed energized parts.
- Be able to determine nominal voltage.
- Know and understand the minimum approach distances specified for voltages to which they may be exposed.
- Know the proper use of special precautionary techniques, personal protective equipment (PPE) including arc-flash protective equipment, insulating and shielding materials, test equipment, and insulating/insulated tools.
- Be trained in methods of release of victims from contact with live parts.

9.6 "Unqualified Employee" (Unqualified Person) Training

Unqualified persons shall be trained in and be familiar with any of the electrical safety-related practices that are necessary for their safety.

9.7 Lockout/Tagout Training

Management shall provide training on lockout/tagout to ensure that the purpose and function of the energy program is understood. Training and periodic auditing of the lockout/tagout policy is required to ensure employees understand and follow the required procedures.

Authorized employees shall be trained to recognize applicable hazardous energy sources, type and magnitude of energy sources, and the proper techniques for energy isolation and control.

Affected employees shall be instructed in the purpose and use of the energy-control procedure.

All other employees whose work may be in the area where lockout/tagout is utilized shall be instructed about the procedure and the prohibition against restarting machines that have been locked/tagged out.

9.8 Refresher Training

Frequent training and reinforcement of electrical safety is essential. Establish schedules for refresher training, or retraining of personnel as follows:

- To keep abreast of technology, new types of equipment, and procedural changes.
- To maintain proficient skills.
- If the supervisor, periodic audits, or the annual inspection reveals that employees are not complying with required safety-related work practices.
- The employee does the task infrequently (Less often than once per year).

Refresher training should take place no less often than once every three years.

9.9 Retraining

Employees should be retrained when the following occurs:

- The work assignment changes.
- When new equipment is introduced.
- When energy control procedures change.
- When a periodic inspection reveals inadequacies in the safety program.

10.0 Administration Control

10.1 Location Management

10.1.1 Design Criteria

Location management shall ensure that design for all existing, modification, and new construction meet as a minimum or exceed, all safety regulated requirements of this document, along with required and consensus design and safety standards.

10.1.2 Vendor Control (System Design)

Location management shall ensure that vendor equipment and system design, as a minimum, shall meet or exceed all safety requirements for this document, and required regulated and consensus design and safety standards.

10.1.3 Construction/Maintenance Control

Location management shall ensure that all maintenance/ construction projects (electrical or otherwise) at the location be performed with all electrical safety concerns of this document followed.

10.2 Contractors

Contractor Personnel - Contractor personnel shall follow all applicable facility safety standards as a minimum.

Contractor Equipment - Contractor equipment shall meet all facility safety and health standards.

Knowledge of Rules - Key contractor personnel should be trained in Electrical Safe Work Practices. Contractors shall be informed of, and understand the potential electrical shock and arc flash hazards associated with their work.

10.2.1 Changing Work Conditions

Changing work conditions as they may relate to potential electric shock and/or arc flash hazards shall be communicated to the appropriate facility representative.

10.2.2 New (Replacement) Employees

As contractor employees are replaced or added, or contractor work is further sublet, the new contractor employees shall be advised of all electrical safety considerations that may apply to them as outlined in this document or other safety specifications/standards.

10.3 Escorting Non-Qualified and Non-Authorized Personnel

Any person who is not “qualified” or “authorized” requires an escort in order to enter areas where physical safe work distance clearances cannot be met (see Annex A, Tables A-1 and A-2). In generally, this includes all secured electrical installations and conductor/bus minimal clearances from buildings, rooftops, or other structures.

Examples of non-qualified and non-authorized personnel may include visitors, non-electrical maintenance employees (e.g., grass cutters, painters, roof repair personnel), potential contractor personnel, and equipment vendors.

Note: *Only a “Qualified Person” may act as an escort in areas where an electrical hazard might exist.*

10.4 Electrical System Safety for Operations

It is essential that general switching and controlling procedures for and between power generators and user locations, are well understood and documented.

10.5 Incident Investigation

All electrical incidents (including any contact with exposed live parts, near hits (near misses), and switching errors) shall be reported to management.

All electrical incidents shall be investigated. The incident report shall include recommendations, as may be necessary, to improve the electrical safety program. These recommendations should be sent to the corporate safety division and corporate business unit managers for further evaluation and distribution.

It is important that these incidents and near hits (misses) be evaluated from a fact-finding, versus a fault-finding approach and that the root cause(s) of the incident be documented.

10.6 Periodic Electrical Safety Reviews (Assessments)

It is recommended that a periodic review (assessment) of electrical systems, maintenance procedures, and operating practices be performed at least once every two (2) years.

Electrical safety reviews should be performed more often if changes occur that are likely to increase the potential for an electrical shock or arc flash hazard (i.e., an increase in the frequency of electrical accidents, changes in the work force, renovation of the current system, or new construction).

This review (assessment) shall be provided by qualified personnel and/or an outside consulting service knowledgeable in the electrical safety concerns of the review.

11.0 Power System and Electrical Installation Security (Locking)

The following locations that contain exposed live parts should be locked:

- Substations.
- Switchgear rooms and electric control rooms.
- Other locations that have energized, or potentially energized high voltage conductors and exposed parts of electrical equipment.

11.1 Safety Lock

A safety lock is a controlled lock with unique lock/key or unique lock group/one key

Its function is to protect personnel, and should be installed on each lockout/tagout location.

Use of a safety lock on high and low voltage distribution systems is recommended to prevent a switch or breaker from being operated. This is important for protecting workers.

11.2 Operation System Lock

The function of an operation system lock is to prevent unintentional operation of a high voltage line switch. Unique one lock/one key are not required but are strongly recommended for operation system locks.

11.3 Preferred Lock System

In the interest of overall employee safety, a one lock/one key system offers the highest degree of safety in any locking situation.

11.4 Equipment Access Interlock System (Safety Interlocks)

Safety interlocks offer a high degree of personnel safety and should be utilized in all designs. Generally the interlock system should not be by-passed or otherwise rendered inoperative while the equipment is energized.
Safety interlocks may only be bypassed by a qualified person. Upon completion of the testing, the interlocking system shall be restored to full operable condition.

11.5 Remote/Other Utility Operations (Clearance Lockout/Tagout)

Where generating and switching locations are influenced by distance, personnel safety shall not be compromised by lack of a positive locking or rendering inoperable procedure.

It is recommended that a formal written agreement be made between the parties outlining the agreed upon clearance or lockout/tagout procedure.

All clearances ("Access to Work Permits") shall be in writing.

The clearance or lockout/tagout system associated with the remote location may be used but in no way compromise the safety of the facility clearance or lockout/tagout policy.

12.0 References

12.1 ANSI (American National Standards Institute)

- A10.31 Digger Derricks-Safety Requirements, Definitions, and Specifications
- A92.5 Boom-Supported Elevated Work Platforms
- B30.5 Mobile and Locomotive Cranes
- Z87.1 Practice for Occupational and Educational Eye and Face Protection
- Z89.1 Requirements for Protective Headwear for Industrial Workers
- Z41 Safety-Toe Footwear

12.2 ASTM (American Society for Testing and Materials)

Standard on Electrical Protective Equipment for Workers

- D120 Standard Specification for Rubber Insulating Gloves
- F496 Standard Specification for the In-Service Care of Insulating Gloves and Sleeves
- F479 Standard Specification for the In-Service Care of Insulating Blankets
- F478 Specifications for In-Service Care of Insulating Line Hose and Covers
- F914 Standard Test Method for Acoustic Emission Insulated Aerial Personnel Devices
- F855 Specifications for Temporary Grounding Systems to be Used on De-energized Electric Power Lines and Equipment
- F1506 Standard Performance Specification for Textile Materials for Protective Wearing Apparel for use by Electrical workers When Exposed to Momentary Electric Arcs
- F1891 Standard Specification for Arc and Flame Resistant Rainwear
- F2178 Standard Test

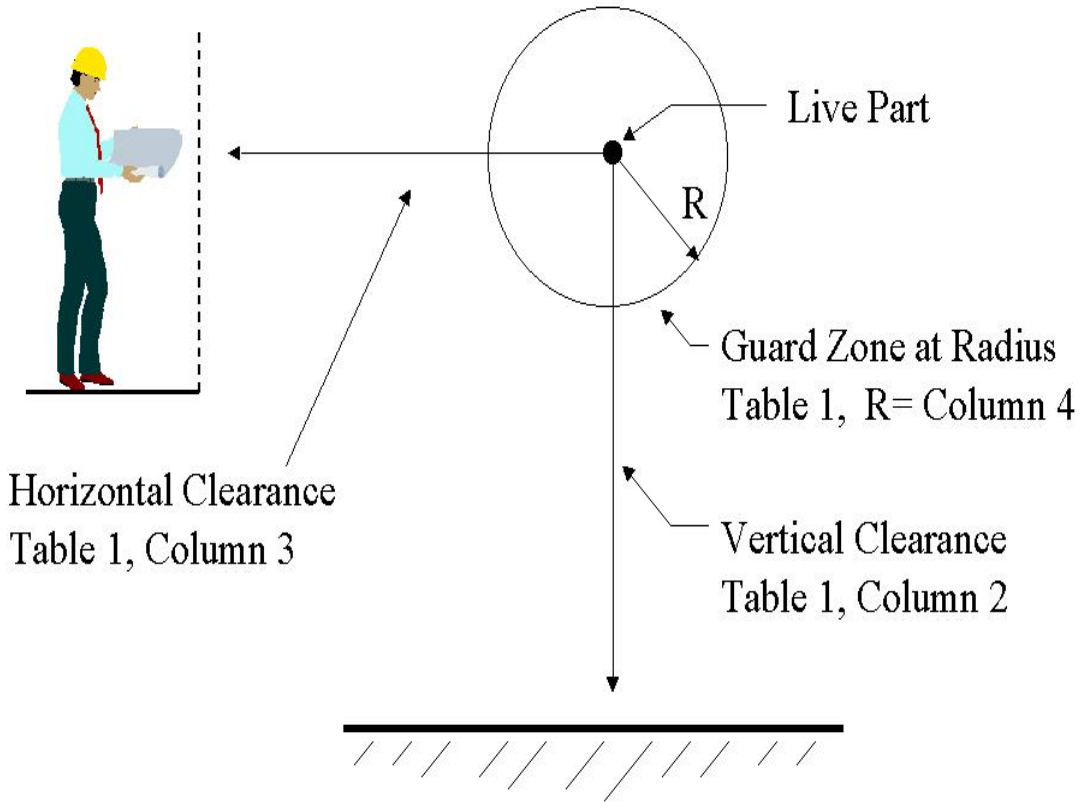
12.3 CFR (Code of Federal Regulations)

- 29CFR (Title 29 - Labor) Subpart I
- 1910.137 Personal Protective Equipment, Electrical Protective Devices Subpart J
- 1910.146 Permit-required Confined Spaces Subpart J
- 1910.147 The control of hazardous energy (lockout/tagout) Subpart R
- 1910.268 Telecommunications Subpart R
- 1910.269 Electrical Power Generation, Transmission, and Distribution Subpart S
- 1910.301 - 399 Electrical - General Subpart K
- 1926.400 – 449 Construction Electrical Subpart E 1926 Fall Protection Subpart P
- 1926 Excavations
- 12.4 IEEE (Institute of Electrical and Electronic Engineers)
- IEEE 978 Guide for In-Service Maintenance and Electrical Testing of Live-Line Tools.
- IEEE 1584 IEEE Guide for Performing Arc-Flash Hazard Calculations ANSI/IEEE C2 National Electric Safety Code
- 12.5 NFPA (National Fire Protection Association)
- NFPA 70 National Electrical Code
- NFPA 70B Electrical Equipment Maintenance
- NFPA 70E Standard for Electrical Safety in the Workplace

12.6 Applicable State and Local Codes

All facilities shall meet or exceed the above referenced guidelines, codes and regulations.

CLEARANCE FROM LIVE PARTS



Annex A Clearances and Approach Boundaries Figures and Tables

Table A-1 Clearance From Exposed Live Parts

NOMINAL VOLTAGE PHASE TO PHASE	VERTICAL CLEARANCE OF UNGUARDED PARTS			HORIZONTAL CLEARANCE OF UNGUARDED PARTS			CLEARANCE GUARD TO EXPOSED LIVE PARTS		
kV	Feet	In.	m	Feet	In.	m	Feet	In.	m/cm
.151 to 2.4	8	9	2.67	3	4	1.02	0	3	7.6 cm
7.2	8	10	2.69	3	4	1.02	0	4	10.1 cm
13.8	9	0	2.74	3	6	1.07	0	6	15.2 cm
23.0	9	3	2.82	3	9	1.14	0	9	22.8 cm
34.5	9	6	2.90	4	0	1.22	1	0	30.4 cm
46.0	9	10	3.00	4	4	1.32	1	4	40.6 cm
69.0	10	5	3.18	4	11	1.50	1	11	58.4 cm
115.0	11	7	3.53	6	1	1.85	3	1	93.9 cm
138.0	12	2	3.71	6	8	2.03	3	8	1.12 m
161.0	12	10	3.91	7	4	2.24	4	4	1.32 m
230.0	14	10	4.52	9	4	2.84	6	4	1.93 m
362.0	20	2	6.1	14	8	4.5	11	8	3.6 m
550.0	28	4	8.6	22	10	7.0	19	10	6.0 m

Figure A-1 Clearances from exposed live parts

(Based on Figure 124-1 NESC C2-2002. From IEEE Std. C2-2002. Copyright 2001

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- Table A-2 MINIMUM BASIC VERTICAL CLEARANCE OF WIRES, CONDUCTORS, AND CABLES ABOVE GROUND, RAILS, OR WATER[1,2]

Clearance Categories Where wires, conductors, or cables cross over or overhang	Neutrals and Grounded Guys		(Open Conductors) 0 to 750V (phase-to-gnd)		 751V – 22kV [3] (phase-to-gnd)	
	Feet	Meters	Feet	Meters	Feet	Meters
1. Railroad tracks	23.5	7.2	24.5	7.5	26.5	8.1
2. Roads and other areas subject to truck traffic	15.5	4.7	16.5	5.0	18.5	5.6
3. Residential driveways	15.5	4.7	16.5	5.0	18.5	5.6
4. Other land traversed by vehicles	15.5	4.7	16.5	5.0	18.5	5.6
5. Spaces or ways accessible to pedestrians only	9.5	2.9	12.5	3.8	14.5	4.4
6. Water areas not subject to sailboating	14.0	4.3	15	4.6	17	5.2
7. Water areas subject to sailboating a. Less than 20 acres b. 20 to 200 acres c. 200 to 2,000 acres d. Over 2,000 acres	17.5 25.5 31.5 37.5	5.3 7.8 9.6 11.4	18.5 26.5 32.5 38.5	5.6 8.1 9.9 11.7	20.5 28.5 34.5 40.5	6.2 8.7 10.5 12.4
8. Areas subject to sailboat launching	Clearances above ground shall be 5 feet (1.5 meters) greater than Item 7 above.					
Where wires, conductors, or cables run along and within the limits of highway or other road right-of-way, but do not overhang the roadway						
9. Roads in urban districts	15.5	4.9	16.5	5.0	18.5	5.6
10. Roads in rural districts where it is unlikely that vehicles will cross under the line	13.5	4.3	14.5	4.4	16.5	5.0

(Note: Voltages are phase-to-ground for effectively grounded circuits.)

1. For unguarded live parts (bus, cutouts, pole transformer bushing, etc.) clearance refer to NESC Table 232-2.

2. For clearances of insulated conductors see Table 232-1 NESC C2-2002.

3. Distances shall increase 4 in. (10cm) for each 10 kV over 22 kV phase to ground.

(Table is based on Table 232-1 NESC C2-2002. From IEEE Std. C2-2002. Copyright 2001 IEEE. All rights reserved.)

Table A-3 CLEARANCE OF EXPOSED/NON-INSULATED WIRES, CONDUCTORS, CABLES AND UNGUARDED LIVE PARTS ADJACENT BUT NOT ATTACHED TO BUILDINGS AND OTHER INSTALLATIONS EXCEPT BRIDGES

4 Table A-4 VERTICAL CLEARANCE BETWEEN CONDUCTORS AT SUPPORTS ON SAME STRUCTURE

1.

(DISTANCE IN INCHES & CM)

(Voltages are phase-to-ground for effectively grounded circuits.)

Upper Level Conductors	Open Supply Cables						Minimum Clearance 751 V – 22 kV 1. Phase to Ground	
Lower Level Conductors or cables	0 -8.7 kV		8.7 – 50 kV				Feet	Meters
Application	Same Utility				Different Utilities			
	in.	cm	In.		Cm	in.		cm
A. Buildings								
1. Horizontal 2. Vertical							7.5	2.3
a. Over or under roofs of projections not accessible to pedestrians.							12.4	3.8
Communication Conductors	40	100	40		100	40	13.4	100 4.1
b. Over or under balconies and roofs accessible to pedestrians							Plus "A"	
c. Over roofs accessible to mobile equipment but not subject to truck traffic							13.4	4.1
Triplex & Quadplex 0-750 V Supply Cable	16 1.	41 1	16		41	40	Plus "A"	100
d. Over roofs accessible to truck traffic **B. Signs, chimneys billboards, radio and television antennas, tanks, and other installations not classified as buildings or bridges**							18.3	5.6
750V – 8.7 kV Supply Cable	16 1	41 1	16		41	40	Plus "A"	100
1. Horizontal Over or under catwalks and							7.5	2.30
8.7 kV–22 kV Supply Cable	16		41		16 2.3.		13.4	41 2,3 4.1
2. Vertical other surfaces upon which personnel walk			Plus "A"				Plus "A"	
>22 kV–50kV Supply Cable	16		41		16		7.5	41 2.30
3. Vertical: Over or under other portions of such installations			Plus "A"				Plus "A"	

Distances shall increase 4 in. (10 cm) for each 10 kV over 22 kV phase to ground.

(Table is based on Table 234-1 NESC C2-2002. From IEEE Std. C2-2002. Copyright 2001 IEEE. All rights reserved.)

"A" = 0.4 inches (1.0 cm) per kV over 8.7 kV

1 Increase to 40" (100 cm) if conductors are operated by different utilities.

2 Increase to 40” (100 cm) if live line maintenance is performed and adjacent circuits are neither de-energized nor covered.
3 Example: Different utilities, other utility does live line maintenance 26.6 kV circuit above a 13.9 kV circuit. Phases may be displaced by 180 degrees, therefore voltage difference is considered to be 26.6 + 13.9 = 40.5 kV A = 0.4 (40.5 – 8.7) = 12.72” (32 cm) Clearance = 40 + 13 = 53” (133 cm)

(Table is based on Table 235-5 NESC C2-2002. From IEEE Std. C2-2002. Copyright 2001 IEEE. All rights reserved.)

1. Rules 230C1,C2,and C3 cover cables supported on effectively grounded bare messengers or neutral conductors, cables having effectively grounded sheathes or shields, or 5 kV non-shielded cables supported and cabled together on effectively grounded bare messengers.
2. This clearance may be reduced to 4 ft. (1.2 m) where supply conductors of 750 V to
8.7 kV cross a communication line more than 6 ft. (1.8 m) horizontally from a communications structure.
3. This type crossing is not recommended.
4. Trolley and electrified railroad contact conductors of more than 750 V should have at least 6 ft. of clearance.

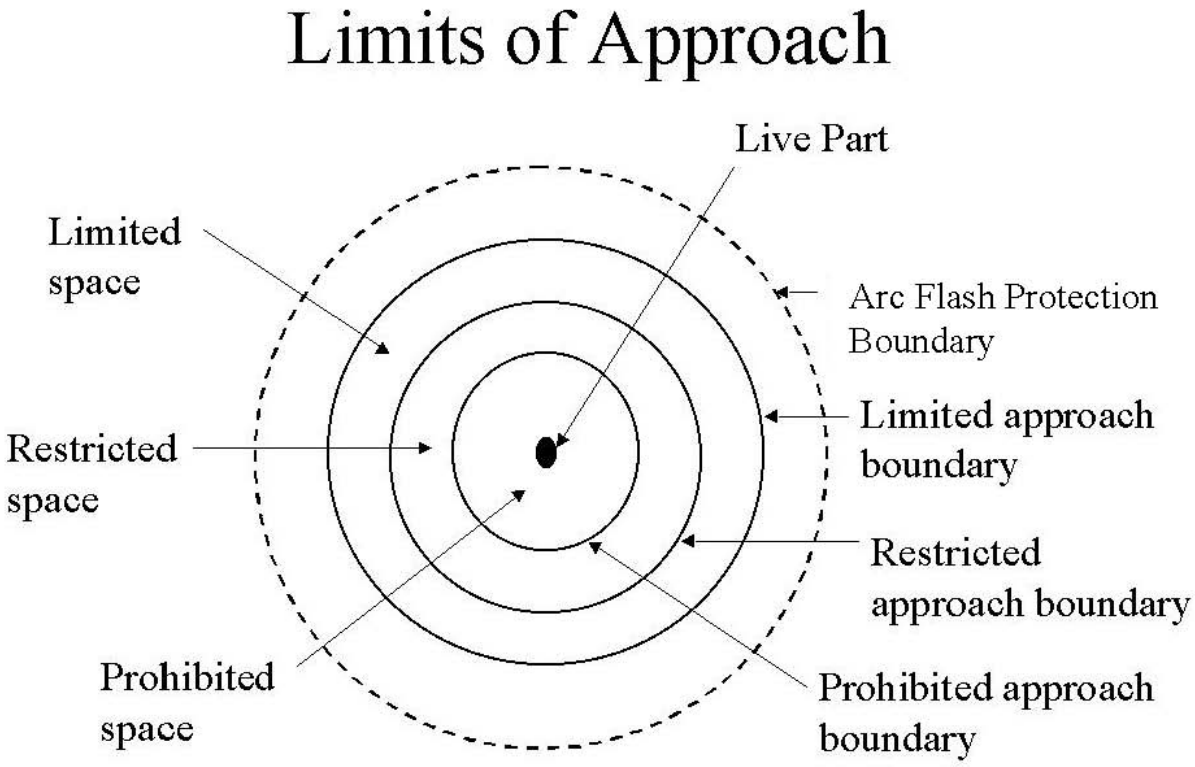
(Table is based on Table 233-1 NESC C2-2002. See the NESC table and

Upper Level Conductors	Open Supply Conductors			
Lower Level Conductors	**Cables meeting rule 230C1 and 0 to 750V meeting rule 230C2 or 230C3[1]**		**751 V to 22 kV**	
	Feet	**Meters**	**Feet**	**Meters**
Communication Conductors, Cables and Messengers	2	.6	5[2]	1.5
Open Supply Conductors 0-750 V; meeting rule 230C1, 230C2, or 230C3	2	.6	2	.6
Open Supply Conductors 750V – 22 kV	2[3]	.6	2	.6
Trolley and Electrified Railroad Conductors	4[4]	1.8	6	2.1
Guys, span wires, neutral conductors and surge protection wires	2	.6	2	.6

Table A-5 BASIC VERTICAL CLEARANCE OF WIRES, CONDUCTORS AND CABLES CARRIED ON DIFFERENT SUPPORTING STRUCTURES

(Voltages are phase-to-ground for effectively grounded circuits.)

Figure A-2 Limits of Approach



Note: The Limited, Restricted, and Prohibited Approach Boundaries are based on voltage. The Arc Flash Protection Boundary is based on the available incident energy equal to 1.2 cal/cm^2 (the onset of a second degree burn). The Arc Flash Protection Boundary may be less than or greater than the Limited Approach Boundary.

Table A-6 Approach Boundaries

Nominal System Voltage Range	Limited Approach Boundary		Restricted Approach Boundary	Prohibited Approach Boundary
Phase to Phase	Exposed Moveable Conductor	Exposed Fixed Circuit Part	Includes Inadvertent Movement Adder	
0 - 50	Not specified	Not specified	Not specified	Not specified
51 - 300	10 ft. 0 in.	3 ft.6 in.	Avoid contact	Avoid contact
301 - 750	10 ft. 0 in.	3 ft.6 in.	1 ft. O in.	0 ft. 1 in.
751 V – 15 kV	10 ft. 0 in.	5 ft.0 in.	2 ft. 2 in.	0 ft. 7 in.
15.1 – 36 kV	10 ft. 0 in.	6 ft.0 in.	2 ft. 7 in.	0 ft. 10 in.
36.1 –46 kV	10 ft. 0 in.	8 ft.0 in.	2 ft. 1O in.	1 ft. 5 in.
46.1 – 72.5 kV	10 ft. 0 in.	8 ft.0 in.	3 ft. 3 in.	2 ft. 1 in.
72.6 – 121 kV	10 ft. 8 in.	8 ft.0 in.	3 ft. 3 in.	2 ft. 8 in.
138 – 145 kV	11 ft. 0 in.	10 ft.0 in.	3 ft. 7 in.	3 ft. 1 in.
161 – 169 kV	11 ft. 8 in.	11 ft.8 in.	4 ft. 0 in.	3 ft. 6 in.
230 – 242 kV	13 ft. 0 in.	13 ft.0 in.	5 ft. 3 in.	4 ft. 9 in.
345 –362 kV	15 ft. 4 in.	15 ft.4 in.	8 ft. 6 in.	8 ft. 0 in.
500 – 550 kV	19 ft. 0 in.	19 ft.0 in.	11 ft. 3 in.	10 ft. 9 in.
765 – 800 kV	23 ft. 9 in.	23 ft. 9 in.	14 ft. 11 in.	14 ft. 5 in.

Note: This table is based on NFPA 70E 2009 Approach Distances Table.

Notes:

1. Affected Persons, persons who are not authorized or qualified cannot cross the limited approach boundary unless escorted by a qualified person.
2. Authorized Persons, specifically task trained, may work inside the limited approach boundary. However, in no case shall an authorized person be allowed to work as close to live parts as the restricted approach boundary allowed for a qualified person.
3. Qualified persons may work up to the restricted approach boundary. For a qualified person to cross the restricted approach boundary he/she shall follow the rules outlined in section
5.2 of this document.
4. Qualified Persons who cross the prohibited approach boundary shall follow work procedures required to make contact with live parts. To cross the prohibited approach boundary is considered the same as making contact with live parts (see section 5.2.3).

Annex B Limits of Approach

A. Preparation for Approach

Observing a safe approach distance from live parts is an effective means of maintaining electrical safety. As the distance between a person and the live parts is decreased, the potential for electrical accident increases.

B. Safe Approach Distance

Unqualified Persons

Unqualified persons are safe when they maintain a distance from the live parts, including the longest conductive object being handled, so that they cannot contact or enter a specified air insulation distance to the live parts.

The safe approach distance for an unqualified person is the limited approach boundary. Further, persons shall not cross the arc flash protection boundary unless they are wearing appropriate personal protective clothing and are under the close supervision of a qualified person.

Note: The arc flash protection boundary may be greater than the limited approach boundary for higher capacity systems.

Qualified Persons

Determine the arc flash protection boundary and, if the boundary is to be crossed, appropriate arc-flash protection equipment shall be utilized.

To cross the limited approach boundary and enter the limited space the person must be a “qualified person”. An exception to this is that an “authorized person” is permitted to cross the limited approach boundary if he or she has been specifically trained for the task to be performed.

To cross the restricted approach boundary and enter the restricted space, the qualified person shall:

- Have a documented plan that has been approved by authorized management.
- Use personal protective equipment appropriate for working on live parts, and rated for the voltage and energy level involved.
- Be certain that no part of the body enters the prohibited space.
- Minimize the risk due to inadvertent movement by keeping as much of the body out of the restricted space, using only protected body parts in the space as necessary to accomplish the work. To cross the prohibited approach boundary and enter the prohibited space is considered the same as making contact with live parts, the qualified person shall:
- Have specified training to work on live parts and be approved by authorized management.
- Have a documented plan justifying the need to work that close. The plan must be approved by authorized management.
- Perform a risk analysis.
- Use personal protective equipment appropriate for working on live parts, and rated for the voltage and energy level involved.

Annex C Flame Resistant Clothing Recommendations

Arc Flash Hazard Analysis

An arc flash hazard analysis shall be done before a person approaches any exposed electrical conductor or circuit part that has not been placed in an electrically safe work condition.

The arc flash protection boundary shall be utilized to initiate the need for personal protective equipment. Refer to chapter 1, section 130.3 and Annex D of NFPA 70E2004 for formulas and other information needed to establish the arc flash protection boundary. Chapter 1, section 130.7 and Annex H in NFPA 70E also contain information and recommendations that address personal protective equipment required for personnel to cross inside the arc flash protection boundary.

Flame Resistant (FR) Clothing and Personal Protective Equipment (PPE) shall be used by the employee based upon the incident energy exposure associated with the specific task. As an alternative, the PPE requirements outlined chapter 1, section 130.7 of NFPA 70E may be used.

For systems which are 600 volts and below, the arc flash protection boundary shall be 4.0 feet or the arc flash protection boundary may alternatively be calculated using information and formulas outlined in NFPA 70E-2009.

At voltage levels above 600 volts, the arc flash protection boundary is the distance at which the incident energy level equals 1.2 cal/cm2. For situations where fault clearing time is 0.1 second (or faster), the arc flash protection boundary is the distance at which the incident energy level equals 1.5 cal/cm2.

Existing knowledge about arc flash exposure at voltage levels above 600 volts is limited. Other methods of calculating such exposure exist and may be used. Commercial and shareware programs are available for calculating these values. It is important to investigate the limitations of any programs to be used. It should be noted that all present methods of calculating incident energy at higher voltage levels have limitations.

Equations for calculating the incident energy produced by a three phase arc on systems rated 600 volts and below for an “Arc in Open Air” (Ema) and an “Arc in a Cubic Box” (Emb - arc flashes emanating from within switchgear, motor control centers, or other electrical equipment enclosures) may be calculated by using the formulas derived in the IEEE paper by R.L. Doughty, T.E. Neal, and H. L. Floyd, “Predicting Incident Energy to Better Manage the Electric Arc Hazard on 600 Volt Power Distribution Systems,” IEEE Sept 30, 1998.

NOTE: *See Annex D for Sample Calculation of the Arc Flash ProtectionBoundary Dc, Arc in Open Air Ema, and Arc in Cubic Box Emb (formulas hold for current range from 16 kA to 50 kA only).*

Annex D Sample Calculations of Incident Energy

Sample Calculation of Arc Flash Protection Boundary D_c, Arc in Open Air E_{ma}, and Arc in Cubic Box E_{mb}

Note: Dc = distance in feet of person from arc source for a just curable burn

For systems which are 600 volts and below, the arc flash protection boundary is 4.0 feet, based on the product of clearing times of 0.1 seconds and the available fault currents of 50 kA or any combination not to exceed 300 kA cycles (5,000 ampere seconds).

At voltage levels above 600 volts, the arc flash protection boundary is the distance at which the incident energy level equals 1.2 cal/cm^2.

The arc flash protection boundary shall alternatively be permitted to be calculated as shown below.

A. Sample Calculation -Arc Flash Protection Boundary D_c (just curable burn distance)

1 Calculation is on a 4,160-volt bus.

2 Transformer MVA (and base MVA) = 10 MVA.

3 Transformer impedance on 10 MVA base = 5.5%.

4 Circuit breaker clearing time = 6 cycles. Note: Required formulas are located in NFPA 70E-2004, Annex D.6 Calculate the short-circuit current:

I_{sc} = {[MVA Base x 10^6] / [1.732 x V]} x {100 / %Z}

= {[10 x 10^6] / [1.732 x 4,160]} x {100 / 5.5} = 25,000 Calculate the power in the arc:

P = 1.732 x 4,160 x 25,000 x 10^{-6} x $.707^2$ P =

90 MW

Calculate the curable burn distance D_c

D_c = {2.65 x [1.732 x 4,160 x 25,000 x 10^{-6}] x 0.1}$^{1/2}$ = 6.8 or 7 feet Or, calculate the curable burn distance D_c using an alternative method:

D_c = [53 x 10 x .1]$^{1/2}$ **=**

7.28 feet

B. Sample Calculation - Arc in Open Air E_{ma}

Incident Energy produced by a three phase arc on systems rated 600 volts and below:

$E_{ma} = (5271)(D_A)^{-1.9593}(t_A)[0.0016(I_{sc})^2 - 0.0076(I_{sc}) + 0.8938] = E_{ma}$ in cal/cm^2

For I_{sc} = 25 kA, t_A = 0.1 seconds, D_A = 18 inches $E_{ma} = (5271)(18)^{-1.9593}$ $(0.1)[0.0016(25)^2 - 0.0076(25) + 0.8938] = 3.12$ cal/cm^2 Note: This would require a Category 1 clothing system For I_{sc} = 50 kA, t_A = 0.1 seconds, D_A = 18 inches $E_{ma} =$ $(5271)(18)^{-1.9593}(0.1)[0.0016(50)^2 - 0.0076(50) + 0.8938] = 8.62$ cal/cm^2 Note: This would require a Category 3 clothing system

C. Sample Calculation - Arc in Cubic Box E_{mb}

Incident Energy produced by a three phase arc on systems rated 600 volts and below:

$E_{mb} = (1038.7)(D_B)^{-1.4738}(t_A)[0.0093(I_{sc})^2 - 0.3453(I_{sc}) + 5.9675] = E_{mb}$ in cal/cm^2

For I_{sc} = 25 kA, t_A = 0.1 seconds, D_B = 18 inches $E_{mb} = (1038.7)(18)^{-1.4738}$ $(0.1)[0.0093(25)^2 - 0.3453(25) + 5.9675] = 4.62$ cal/cm^2 Note: This would require a Category 2 clothing system For I_{sc} = 50 kA, t_A = 0.1 seconds, D_B = 18 inches $E_{mb} =$ $(1038.7)(18)^{-1.4738}(0.1)[0.0093(50)^2 - 0.3453(50) + 5.9675] = 17.54$ cal/cm^2 Note: This would require a Category 3 clothing system

Annex E Work Area Protection

A. Introduction

Work area protection is the adequate safeguarding or protecting of pedestrians, motorists, workers and equipment by the use of adequate barriers, warning signs, lights, flags, high visibility vests, traffic cones, high-level standards, barricade rope or flagpersons on approaches and in the vicinity of work areas, excavations, open

manholes or parked equipment.

Work area protection is accomplished by the use of good informative and protective devices keeping in mind that a safe installation requires the use of these devices in relation to the location of the employees and the equipment involved. The use of these devices must be coupled with proper planning, design, installation, inspection, maintenance and the use of good common sense and will greatly minimize the possibility of accidents. It is of the utmost importance that the work area be properly identified and that warning devices say what they mean, to convey the message to the employees well in advance of arrival at the work area.

The employee must be warned in advance, then regulated and guided safely through or around the work area. Proper work area protection shall be planned to insure the safety and protection of the public and the equipment.

High visibility vests or their equivalent should be worn by employees whenever working in or around vehicular traffic areas. If work is to be done at night, reflectorized material should be worn.

B. Equipment and Devices to be Used

Only those signs, standards, barricades, flags and cones that conform to federal, state or local codes should be used.

All state and local traffic codes should be followed when providing work area protection.

During night operations or in periods of reduced visibility, special precautions should be taken. Adequate warning equipment, which may include flashing lights, flares or area illumination, should be used.

Warning devices and equipment should be removed as soon as the hazard is eliminated.

Warning devices and equipment not in use should be removed from the work area and stored in a proper manner.

C. Flagperson

Flagpersons or other appropriate traffic controls shall be used whenever there is any doubt that effective protection can be provided by signs, signals and barricades and where state or local standards dictate their use.

Flagpersons should:

- Wear a blaze orange warning vest or other high visibility garment. Warning garments worn at night should be of a reflectorized material.
- Place themselves in a protected position to reduce possibility of injury from traffic.
- Insure they can fully observe the operation and guide vehicular traffic in such a manner as to minimize the possibility of accidents or injury.
- Face traffic when giving signals.
- Give positive, direct signals that leave no doubt as to their meaning. Flagpersons using hand signaling equipment should insure that signals provide sufficient warning to protect themselves and the work site. The following rules apply:
- Use signal flags only in an emergency. The flags should be red and at least 24 inches square.
- Sign paddles (stop and slow) should be on a 6-foot staff.
- In periods of darkness or reduced visibility red lights should be used. Flashlights may be used in emergencies.

When flagpersons are used at both ends of a job site, reliable communications or prearranged signals shall be used to insure proper traffic flow.

Annex F Job Briefing and Planning Checklist

Identify

- ☐ What are the hazards?
- ☐ What voltage levels are involved?
- ☐ What skills are required?
- ☐ "Foreign" voltage source present?
- ☐ Potential for arc flash
- ☐ Unuusal work conditions
- ☐ Is this a multiple-person job?

Ask

- ☐ Can the equipment be de-energized?
- ☐ Are there possible backfeeds of the circuits to be worked on?
- ☐ Is a "standby person" required?

Check

- ☐ Job plans
- ☐ One lines and vendor prints
- ☐ Status board
- ☐ Individuals familiar with facility?
- ☐ Safety procedures
- ☐ Vendor information
- ☐ For up-to-date information on plant and vendor resources

Know

- ☐ What is the job?
- ☐ Who is in charge?
- ☐ Who else needs to know? Communicate!

Think

- ☐ About the extra event? What if?
- ☐ Lock – Tag – Test – Try
- ☐ Test for voltage – FIRST
- ☐ Install and remove grounds
- ☐ Use the right tools and equipment, including PPE
- ☐ Install barriers and barricades
- ☐ What else??

Prepare for an emergency

- ☐ Standby person CPR trained?
- ☐ Telephone location?
- ☐ Fire alarm locations?
- ☐ Confined space rescue available if required?
- ☐ Emergency phone numbers?
- ☐ Extinguisher?
- ☐ What is the exact work location?
- ☐ How is the equipment shut off in an emergency?
- ☐ Where is the emergency equipment?
- ☐ Is the required emergency equipment available?
- ☐ Radio communications available?

Annex G Sample Energized Electrical Work Permit

Extracted from NFPA 70E-2004. Used by permission.

PART I: TO BE COMPLETED BY THE REQUESTER:

	Job/Work Order Number:
1. Description of circuit/equipment location:	
2. Description of work to be done:	
3. Justification of why circuit/equipment can not be de-energized or the work deferred until the next scheduled outage:	
Requester/Title:	Date:

PART II: TO BE COMPLETED BY THE ELECTRICALLY QUALIFIED PERSONS *DOING* THE WORK:

	Check when complete
1. Detailed job description procedure to be used in performing the above described work:	
2. Description of the Safe Work Practices to be employed:	
3. Results of the Shock Hazard Analysis:	
4. Determination of Shock Protection Boundaries:	
5. Results of the Arc Flash Hazard Analysis:	
6. Determination of the Arc Flash Protection Boundary:	
7. personal protective equipment to safely perform the assigned task:	
8. Means employed to restrict the access of unqualified persons from the work area:	
9. Evidence of completion of a Job Briefing including discussion of any job-specific hazards:	
10. Do you agree the above described work can be done safety? Yes____ No___ (If no, return to requester.)	
Electrically Qualified Person(s)	Date
Electrically Qualified Person(s)	Date

PART III: APPROVAL(S) TO PERFORM THE WORK WHILE ELECTRICALLY ENERGIZED:

Manufacturing Manger:	Maintenance/Engineering Manager:
Safety Manager:	Electrically Knowledgeable Person:
General Manager:	Date:

Note: Once the work is complete, forword this form to the site Safety Department for review and retention.

Annex H Substation Project Inspection Safety Assessment Checklist

Project Title:	Date:
Auditor:	Time:
Contractor:	Supervisor:
Project Progression:	

Item		Yes	No	N/A	Comments
1.	Employees wearing proper PPE as required for job being performed (eye protection, hard hat, boots,etc)?				
2.	All wearing protective clothing where necessary?				
3.	All completed electrical safe work practices safety orientation?				
4.	All Hot Work/Confined space Entry/ Digging permits posted and conditions followed?				
5.	Aerial device/crane communication procedures followed, operators/crew trained?				
6.	Electrical equipment in good repair, grounded, utilizing GFCI?				
7.	Lockout & tagout, procedures followed, training completed?				
8.	Excavations/Trenches shored, sloped, set-up properly (OSHA 1926.650-652)?				
9.	Training of electrical safe work practices is provided.				
10.	Are safe work practice rules readily available to all personnel?				
11.	Enforcement of electrical safe work practices is consistent.				
12.	All qualified and authorized personnel understand that "*Electrical equipment and lines shall be considered energized until isolated, tested or otherwise determined to be de-energized, and grounded."* as stated in electrical safety standard.				
13.	All steps outlined in electrical safety standards to establish a zero-potential work area are followed.				
14.	Grounds are installed as per electrical safety standard and applied in the proper manner.				
15.	Documented Plans exist for all repetitive high voltage work and all switching is done from written switching orders. Clearance and/or lockout/tagout procedures are adequate.				
16.	Pre-work briefings are held to discuss Job Plans (switching orders, clearance procedures, lock/tag requirements, PPE requirements, job hazards).				

Item		Yes	No	N/A	Comments
17.	Documentation shows that equipment, live line tools, and gloves are tested with appropriate frequency, maintained, and stored correctly.				
18.	Live line tools are used for all high voltage work.				
19.	Safety awareness/behavior meets expectations?				
20.	Safe approach distances are understood and adhered to by authorized, qualified, and unqualified personnel.				
21.	All mobile equipment operators understand 10-foot rule.				
22.	Critical safety components of mechanical elevation and rotating equipment are inspected before use on each shift using the manufacturers recommended checklist.				
23.	Electrical hazards are taken into consideration when mobile equipment is in transit. Escorts are used when required.				
24.	Safe work zones are established.				
25.	Mobile equipment that could potentially enter the 10 foot restricted zone is properly grounded and or barricaded.				
26.	Materials, equipment, and temporary structures are not stored on right-of-ways under non-insulated high voltage lines closer than 10 feet horizontal.				
27.	Unnecessary materials and equipment are not stored in substation yard.				
28.	Guards are provided around live parts when electrical safety hazards may exist.				
29.	A fall prevention survey specific to high-voltage electrical has been completed.				
30.	Fall arrest equipment is used when appropriate and inspected before each use.				
31.	Cranes/Heavy Equipment/Vehicles inspected, safe, set-up properly?				
32.	Rigging correct, and in good condition?				
33.	Roads, walkways properly blocked and flagged where necessary? Fire access clear?				
34.	Scaffolding properly installed/inspected/tagged?				
35.	Ladders used Properly				
36.	Tools used properly? In good condition?				
37.	Proper lifting methods/material handling?				
38.	Retaining pins on air hose/tool connections?				
39.	Welding/cutting equipment used properly and in good repair?				
40.	Compressed gas cylinder secured upright and in proper location?				
41.	Good housekeeping, environmental conditions safe?				
42.	Hazardous corners, protrusions, pinch points guarded?				
43.	Special warning signage posted as necessary?				

Annex I Substation Inspection Checklist

Plant	Electrical Control Room	Inspection Date	Inspector

Item		Yes	No	N/A	Comments
1.	Signage - Substation Identification, Entry Requirements, Electrical Hazard Warning				
2.	Gates Locked				
3.	Fence Secure				
4.	Debris or unauthorized Material In Substation Lot				
5.	Vegetation in Substation Lot				
6.	Fence, Gate, Other Metal Surfaces Bonded Grounded				
7.	Guarding and hazard warning – Low Profile Equipment, Dimensional Clearances, Potential Safety Items				
8.	Equipment Identification/labels - Switches, Transformers, Breakers				
9.	Operation Locks on Switches to Prevent Unintentional Operartion				
10.	Bushings and Insulators in Good Condition				
11.	Indications of Burning, Arcing or Heat Buildup In Electrical Joints				
12.	Evidence of Oil Leaks				
13.	Substation Lighting, Emergency Lighting				
14.	Single Line Diagram of Power System, Posted in Area, Drawing up to date				

BATTERY CHARGER	NAME OF EQUIPMENT			
Volts				
TRANSFORMER				
Name on transformer				
Top Oil Temperature				
Oil Level				
Tank Pressure, psi				
Fan operation				
Pump operation				
Oil leaks?				
Abnormal noises?				
Condition of :				
Sign of corrosion or heating?				
Cabinet grounded				
Nominal voltage posted on equipment				
Radiators				
CIRCUIT BREAKER				
Name on circuit breaker				
Oil leaks?				
Condition of :				
Paint				
Bushings				
Terminals, bushing studs, other electrical connections – evidence of corrosion or heating?				
SWITCHES				
Name on switch				
Switch operating handle and operating pipe bonded to ground?				
Switching ground mat available and bonded to ground?				
Switch cubicle doors closed?				
Evidence of corrosion or heating?				
STATION BATTERIES				
Condition of batteries and terminals				
Volts				
Battery Station Ventilation				

ENCLOSED SWITCHGEAR	NAME OF EQUIPMENT			
Name on switches				
"Feed to", Fed From" information on switch				
Condition of cabinet:				
Paint				
Doors closed				
Bushings				
Terminals, bushing studs, other electrical connections – evidence of corrosion or heating?				
"Mimic Bus" on front of switchgear				
SPARE CIRCUIT BREAKERS, GROUNDING AND TEST DEVICES				
Clean and ready for use?				
Identification of voltage, ampere, and breaker rating				
OTHER EQUIPMENT				
SINGLE LINE DIAGRAM OF POWER SYSTEM				
Posted in area?				
Drawing up to date?				

General Comments:

Annex J Electrical Control Room Inspection Checklist

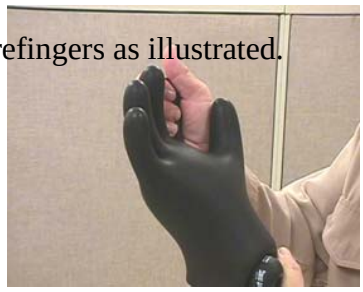
Plant	Electrical Control Room	Inspection Date	Inspector

Item		Yes	No	N/A	Comments
1.	Signage – Identification of Control Room or Area, Entry Requirements, Electrical Hazard Warning				
2.	Entry Doors Locked, Control of Unauthorized				
3.	Storage of Material in Electrical Control Room				
4.	Items Stored in front of Switchgear or MCCs				
5.	Debris In Electrical Control Room (Housekeeping items)				
6.	Single Line Diagram of Power System, Switchgear, and MCC's Posted in Area, Drawing up to date				
7.	Equipment Identification (labels) – Switchgear, Transformers, Switches, Breakers				
8.	Metal Surfaces of Transformers, Switchgear, or MCCs Bonded and Grounded				
9.	Switchgear or MCC Doors Open, Covers Missing on Electrical Equipment Enclosures				
10.	Guarding and Hazard Warning – Live parts, Low Profile Equipment, Dimensional Clearances, Potential Safety Items				
11.	Evidence of Abnormalities in Electrical Equipment, Indications of Burning, Arcing or Heat Buildup, Physical Damage, Abnormal Noises				
12.	STATION BATTERIES – Condtion of Batteries and Terminals, Volts, Battery Station Ventilation				
13.	BATTERY CHARGER – Volts, Condition of Eyewash Station				
14.	Electrical Control Room lighting, Emergency Lighting				

General Comments:

Annex K Test Procedure for Inspection of Rubber Gloves

1. Hold each glove with the thumb and forefingers as illustrated.



2. Twirl the glove around quickly to fill with air.

3. Trap the air by squeezing the gauntlet with one hand. Use the other hand to squeeze the palm, fingers and

Calculated Short Circuit Properties[1]			
Grounding Cable Size, AWG	Withstand Rating Symmetrical kA RMS 60 Hz	Ultimate Capacity[2,3] Symmetrical kA RMS 60 Hz	Continuous Current Rating, A RMS 60 Hz
Copper Aluminum	15 cycles (250 MS) 30 cycles (500 MS) 6 cycles (100 MS) 15 cycles (250 MS) 30 cycles (500 MS) 60 cycles (1 s)		
#2 1/0 2/0 3/0 4/0 250 MCM 350 MCM 1/0 3/0 4/0 250 MCM 300 MCM 350 MCM 500 MCM	14.5 21 27 36 43 54 74 10 15 20 25 30 39 54 29 47 59 74 94 120 150 18 30 37 47 60 70 98 13 21 26 33 42 49 69 9 14 18 23 29 35 49		200 250 300 350 400 450 550

4. Hold the glove to the face to detect air leakage or hold it to the ear and listen for escaping air.

Annex L Grounding Cable and Jumper Ratings

Grounding Cable and Jumper Ratings

1. Withstand and ultimate short circuit properties are based on performance with surges not exceeding 20% asymmetry factor.
2. Utilimate capacity represents a calculated symmetrical current which the cable or jumper is capable of conducting for the specified time.
3. These currents are based upon the fusing (melting) current-time values for copper, derived from I. M. Onderdonk's equation with an ambient temperature of 40^{0} C

Annex M Principals of Electrical Safety

You must understand, accept, and practice all of the following safety principles:

Maintain Distance

An effective way to maintain safety is to keep a safe distance from live parts.

Test Before Touch

Consider every electrical conductor or circuit part energized until proven otherwise.

De-energize if Possible

De-energize all equipment before you work "on" or "near" exposed electrical conductors or circuit parts.

Recognize potential hazard

Installing barriers, barricades, and de-energizing (switching) are potentially hazardous tasks.

Plan Every Job

Plan every job carefully, regardless of size.

Anticipate Unexpected Events

Before beginning work, ask "What if..?" and decide what you will do if something goes wrong.

Use the Right Tool for the Job

Identify the tools required and do not perform the task until you have the correct tool.

Use Procedures as Tools

Establish and adhere to procedures to accomplish a job safely.

Isolate the Equipment

Lock, Tag, Try and Test.

Identify the Hazard

Identify and address each hazard.

Minimize the Hazard

Use insulating barriers, safety grounds, and safe work practices.

Protect the Person

Avoid exposure to electrical hazards wherever possible. Use appropriate personal protective equipment (PPE) for each potential hazard.

Assess People's Abilities

Evaluate each person's qualifications, capabilities, and physical and mental state at the time a potentially hazardous task is to be done.

Audit These Principles

Audit the principles frequently to verify that they reflect current practices.

Isolate the Equipment

Lock, Tag, Try and Test

Indentify the Hazard

Identify and address each hazard.

Minimize the Hazard

Use insulating barriers, safety grounds, and safe work practices.

Protect the Person

Avoid exposure to electrical hazards wherever possible. Use appropriate personal protective equipment (PPE) for each potential hazard.

Assess People's Abilities

Evaluate each person's qualifications, capabilities, and physical and mental state at the time a potentially hazardous task is to be done.

Audit These Principles

Audit the principles frequently to verify that they reflect current practices.