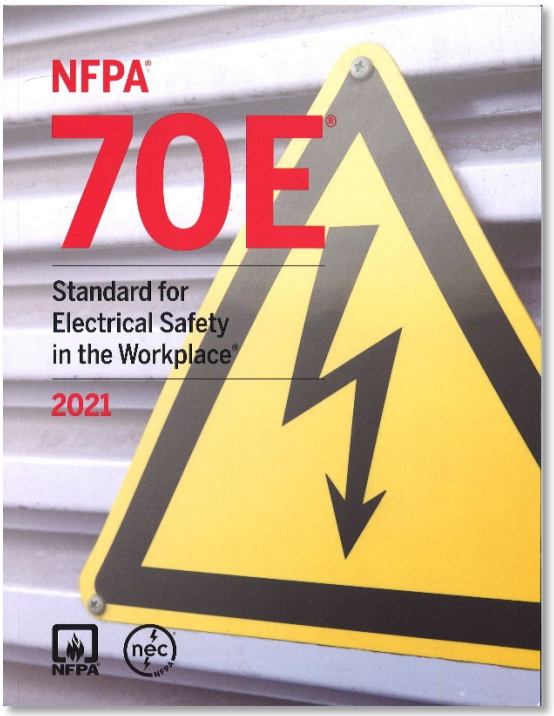
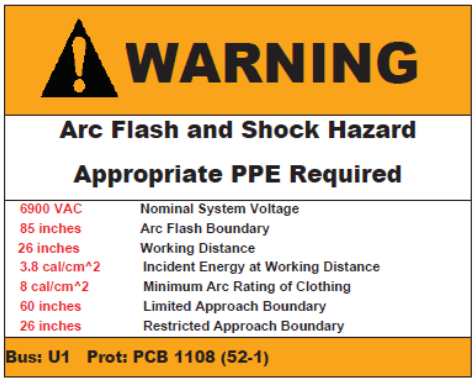
Central Arizona Project
ELECTRICAL SAFETY PROGRAM





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1 INTRODUCTION

This program establishes minimum standards to prevent hazardous electrical exposures to personnel and ensure compliance with regulatory requirements applicable to electrical systems (OSHA 1910.331-335, 1910.269, NFPA 70E, NEC). This program is designed to ensure that energized electrical work at CAP facilities is performed safely by qualified electrical workers who are trained and provided with the appropriate safe work procedures, personal protective equipment (PPE), and other controls. This program is designed to protect employees against electrical shock, arc flash burns, and arc blast.

1.1 Scope

This program applies to all CAP facilities and work performed by its employees regardless of job site location.

All contractors providing services for CAP shall have their own Electrical Safety Program that is equal to CAP's or adopt CAPs program for their own usage.

1.2 Purpose

To implement and document an overall safety program that directs activity appropriate for the voltage, energy level, and circuit conditions.

This program has been established in order to:

a) Ensure the safety of employees who may work on or near electrical equipment.
b) Ensure that employees understand and comply with adopted safety standards related to electrical work.
c) Comply with OSHA 1910, NFPA 70E, and the National Electric Code as applicable to the work performed at CAP.
d) Provide and demonstrate an electrical safety program with defined responsibilities.
e) Determine the degree of arc flash hazard encountered by CAP personnel and notification through the use of current warning labels on equipment.
f) Provide personal protective equipment (PPE) for all workers exposed to electrical hazards that is in accordance with current standards.
g) Provide documented training and notification to workers of CAP electrical safety standards.
h) Provide appropriate tools for safe work on and around electrical equipment
i) Provide a standard for which CAP will audit the program usage and determine that all users are in compliance.

2 ROLES AND RESPONSIBILITIES

2.1 Electrical Safety Committee

The Electrical Safety Committee shall audit the electrical safety program to verify the principles and procedures of the program are in compliance with the current NFPA 70E standard. The audits shall be done every 3 years, coinciding with the issuance of the latest revision of the standard. The Committee shall update the program as required within the first year of the latest NFPA 70E standard issuance. The review shall be

documented by the revision number and issue date of the program. The Committee membership shall be composed from the following positions:

a. Operational Technology Manager.
b. Safety Manager.
c. West and South Maintenance Managers.
d. Electrical Safety Program Administrator
e. Electrical Reliability Engineering Supervisor
f. Electrical Systems Engineering Supervisor

2.2 Electrical Safety Program Administrator

a. Evaluate work being performed and determine compliance with this program.
b. Provide electrical training specified in this program.

2.3 Safety Department

a. Evaluate the overall effectiveness of the electrical safety program.
b. Training recordkeeping.
c. Provide or coordinate general training for CPR/AED requirements of this program.
d. Review and approve Contractor safety programs.

2.4 Supervisors

a. Promote electrical safety awareness to all employees.
b. Ensure employees comply with ALL provisions of the electrical safety program.
c. Evaluate employees' compliance with this program, and their skills and knowledge appropriate to their assigned electrical tasks.
d. Ensure employees are provided with and use appropriate protective equipment.
e. Ensure job briefings are performed prior to work execution.

2.5 Employees

a. Comply with work practices described in this document, including the use of appropriate protective equipment and tools.
b. Attend all training required relative to this program.
c. Immediately report any concerns related to electrical safety to supervision.

2.6 Engineering (Systems and Reliability)

a. Complete arc flash analyses required by this program as needed and during equipment replacement or upgrading.
b. Emphasize controlling electrical hazards through the application of engineering and design controls.
c. Promote consistency in how electrical tasks are completed within the various facilities.
d. Assure newly installed or modified electrical equipment and systems comply with applicable codes and standards prior to being placed into service.

2.7 Training Adminstrator

a. Maintains list of qualified electrical workers.
b. Maintains records of training required by this program.

3 DEFINITIONS

Arc Flash Hazard. A source of possible injury or damage to health associated with the release of energy caused by an electric arc. See Table 130.5(C) for examples of tasks that increase the likelihood of an arc flash incident occurring.

Arc Flash Suit. A complete arc-rated clothing and equipment system that covers the entire body, except for the hands and feet.

Arc Rated Clothing. Arc Rated (AR) clothing or equipment indicates that it has been tested for exposure to an electric arc. Flame Resistant (FR) clothing without an arc rating has not been tested for exposure to an electric arc. All arc-rated clothing is also flame-resistant.

Arc Rating. The value attributed to materials that describes their performance to exposure to an electrical arc discharge. The arc rating is expressed in cal/cm^2 and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakopen threshold (E_{BT}) (should a material system exhibit a breakopen response below the ATPV value). Arc rating is reported as either ATPV or E_{BT}, whichever is the lower value.

Area Supervisor. A maintenance supervisor who is the asset owner of the equipment and systems in his area of responsibility.

Authorized Employee. A person who has completed the required hazardous energy control training and is authorized to lockout or tagout a specific machine or equipment to perform service or maintenance. A person must have knowledge of the equipment and systems within their area of responsibility and be approved by their supervisor and the area supervisor as an Authorized Employee in order to apply a lock or tag to control hazardous energy. All Authorized Employees must be trained in:

- Electrical Safety Program / NFPA 70E.
- Hazardous Energy Control Program.
- Equipment specific procedures (SECP's) in their assigned work areas.

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

Barrier. A physical obstruction that is intended to prevent contact with equipment or energized electrical conductors and circuit parts.

Bonded (Bonding). Connected to establish electrical continuity and conductivity.

Bonding Conductor or Jumper. A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.

Boundary, Arc Flash. When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm^2. According to the Stoll skin burn injury

model, the onset of a second degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm^2 for one second.

Boundary, Limited Approach. An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists. Unqualified personnel may not cross this boundary.

Boundary, Restricted Approach. An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement. Insulated tools and PPE are required inside the restricted approach boundary.

CAP Minimum Arc-Rated (AR) Clothing. CAP provides arc-rated shirts and pants to Qualified Electrical Workers, who are to wear the clothing anytime they are in a facility or site interacting with electrical equipment.

De-energized. Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth. De-energized does not describe an electrically safe work condition; e.g. a circuit that has been disconnected but not controlled and verified.

Disconnecting (or Isolating) Switch. A mechanical switching device used for isolating a circuit or equipment from a source of power.

Electrical Hazard. A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn or arc blast injury.

Electrical Safety. Identifying hazards associated with the use of electrical energy and taking precautions to reduce the risk associated with those hazards.

Electrically Safe Work Condition. A state in which the conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with the Hazardous Energy Control Program, tested to verify the absence of voltage, and if necessary, temporarily grounded for personnel protection.

Energized. Electrically connected to, or is, a source of voltage.

Energized Electrical Work. Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment (PPE) a person is wearing. There are two categories of energized electrical work: ***Diagnostic (testing)*** is taking readings or measurements of electrical equipment, conductors or circuit parts with approved test equipment that does not require making any physical change to the electrical equipment, conductors or circuit parts; ***repair*** is any physical alteration of electrical electrical equipment, conductors or circuit parts (such as making or tightening connections, removing or replacing components, etc.).

Energized Electrical Work Permit. A document required to perform repairs within the restricted approach boundary when it is infeasible to put the equipment into an electrically

safe work condition. The work permit includes a description of the circuit and equipment, shock and arc flash risk assessments, the work to be performed, a justification for why the work must be performed in an energized condition, a job plan and job briefing, and authorization from management.

Exposed (as applied to energized electrical conductors or circuit parts). Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated, or insulated.

Fault Current. The amount of current delivered at a point on the system during a short circuit condition.

Fault Current, Available. The largest amount of current capable of being delivered at a point on the system during a short circuit condition.

Ground. The earth.

Ground Fault. An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non-current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth.

Grounded (Grounding). Connected (connecting) to ground or to a conductive body that extends the ground connection.

Grounded, Solidly. Connected to ground without inserting any resistor or impedance device.

Grounded Conductor. A system or circuit conductor that is intentionally grounded.

Ground-Fault Circuit Interrupt (GFCI). A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a class A device (when a fault current to ground exceeds 6mA and does not trip below 4mA).

Grounding Conductor, Equipment (EGC). The conductive path(s) that provides a ground fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both.

Grounding Electrode. A conducting object through which a direct connection to earth is established.

Grounding Electrode Conductor. A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

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

Hazard. A source of possible injury or damage to health.

Hazardous. Involving exposure to at least one hazard.

Incident Energy. The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. Incident energy is typically expressed in calories per square centimeter (cal/cm^2).

Incident Energy Analysis. A component of an arc flash risk assessment used to predict the incident energy of an arc flash for a specified set of conditions.

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

Interlock. An electrical, mechanical, or key-locked device intended to prevent an undesired sequence of operations.

Interrupter Switch. A switch capable of making, carrying, and interrupting specified currents.

Interrupting Rating. The highest current at rated voltage that a device is identified to interrupt under standard test conditions.

Isolated (as applied to location). Not readily accessible to persons unless special means of access are used.

Maintenance, Condition of. The state of the electrical equipment considering the manufacturer's instructions, manufacturer's recommendations, and applicable industry codes, standards and recommended practices.

Qualified Person. One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.

Qualified, Limited Person. A Qualified person limited to working on specific systems or equipment that is energized or potentially energized.

Risk. A combination of the likelihood of occurrence of injury or damage to health and the severity of injury or damage to health that results from a hazard.

Risk Assessment. An overall process that identifies hazards, estimates the likelihood of occurrence of injury or damage to health, estimates the potential severity of injury or damage to health, and determines if protective measures are required.

Service Entrance Switchgear. The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the entrance of supply conductors to the building and intended to constitute the main control and means of cutoff of the supply.

Service Point. The point of connection (point of demarcation) between the facilities of the serving utility and the premises wiring.

Shock Hazard. A source of possible injury or damage to health associated with current through the body caused by contact or approach to exposed energized electrical conductors or circuit parts.

Short-Circuit Current Rating. The prospective symmetrical fault current at a nominal voltage which an apparatus or system is able to be connected without sustaining damage exceeding defined acceptance criteria.

Single-Line Diagram. A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used in the circuit or system.

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

Switching Device. A device designed to close, open, or both, one or more electric circuits.

Touch Potential. A ground potential gradient difference that can cause current flow from hand to hand, hand to foot, or another path, other than foot to foot, through the body.

Ungrounded. Not connected to ground or a conductive body that extends the ground connection.

Unqualified Person. A person who is not a Qualified person.

Voltage (of a circuit). The greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned.

Voltage, Nominal. A value assigned to a circuit or system for the purpose of conveniently designating its voltage class, e.g., 120/240, 480Y/277, and 600 volts. The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Working Distance. The distance between a person's face and chest area and a prospective arc source. Note: working distance is used to calculate incident energy. CAP uses the restricted approach boundary or the minimum approach distance, whichever is further, for the working distance in the arc flash analyses.

Working On (energized electrical conductors or circuit parts). See Energized Electrical Work.

4 EMPLOYEE TYPES

4.1 Qualified Electrical Workers

Qualified personnel that have successfully completed all training requirements are considered Qualified Electrical Workers. Qualified electrical workers are the only workers that are allowed to work within the Limited Approach Boundary of exposed energized electrical conductors and circuit parts operating at greater than 50 volts.

A **qualified electrical worker** is defined as one who has demonstrated skills and knowledge in the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk. Specifically the qualified electrical worker will have the following:

a) Familiarity with the proper use of special precautionary techniques, personal protective equipment including arc-flash suit, insulating and shielding materials, insulated tools and test equipment.
b) The skills and techniques necessary to distinguish exposed energized electrical conductors and circuit parts from other parts of electrical equipment.
c) The skills and techniques necessary to determine the nominal voltage of exposed energized electrical conductors and circuit parts.
d) Understanding of approach distances and the corresponding voltages to which qualified persons will be exposed as specified in NFPA 70E Table 130.4(D)(a) and (b) in Appendix B of this program.
e) The decision making process necessary to determine the degree and extent of the hazard and the personal protective equipment and job planning necessary to perform the task safely.
f) Specified training to work on energized conductors or circuit parts which includes selecting an appropriate voltage detector/s to verify the absence or presence of voltage and has demonstrated that usage.
g) An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a qualified person is considered to be a qualified person for the performance of those duties.

Note: *A person can be considered qualified with respect to certain equipment and methods but still be unqualified for others. For this reason, we define certain positions as Limited Qualified with the boundaries of their responsibilities defined. The following is a list of positions at CAP that are considered qualified electrical workers or limited qualified.*

4.1.1 Electrician (Plant, Meter/Relay, Headquarters, I&C)

a) Qualified electrical worker.
b) Interacts with plant, switchyard and substation equipment.
c) PPE issued CAP minimum clothing up to Arc Flash PPE Category 4 and class 0 voltage rated gloves.

4.1.2 Electrical Engineer

a) Qualified electrical worker.
b) Interacts with plant, switchyard and substation equipment.
c) PPE issued CAP minimum clothing and class 0 voltage rated gloves.

4.1.3 Communication Engineer

a) Limited qualified electrical worker.
b) Works with and on plant and communications site equipment consisting of circuits under 600 volts.
c) PPE issued CAP minimum clothing and class 0 voltage rated gloves.

4.1.4 Engineering Construction Inspector (Electrical)

a) Qualified electrical worker.
b) Interacts with cathodic protection systems.
c) PPE issued CAP minimum clothing and class 0 voltage rated gloves.

4.1.5 HVAC and Fire ProtectionTechnician

a) Limited qualified electrical worker.
b) Works on HVAC and fire control systems consisting of circuits under 600 volts.
c) PPE issued CAP minimum clothing up to Arc Flash PPE Category 2 and class 0 voltage rated gloves.

4.1.6 Apprentice Electrician

a) Limited qualified electrical worker, who is undergoing on-the-job training.
b) PPE issued CAP minimum clothing, class 0 voltage rated gloves and additional arc flash PPE appropriate to their training level.

4.1.7 ATP Employees with Electrical Training

a) Includes supervisors, managers, planners, etc. with training and experience defined above.
b) PPE issued CAP minimum clothing and class 0 voltage rated gloves.

4.2 Unqualified Persons working on and around electrical installations

4.2.1 Unqualified Persons

a) Are not permitted closer to exposed energized conductors than the Limited Approach Boundary.
b) Are not permitted to open doors or remove panels that expose them to any voltages in excess of 50 volts.
c) Are allowed to work on or within any electrical equipment after such equipment has been placed in an Electrically Safe Work Condition.

4.2.2 Unqualified positions at CAP

a) Plant Mechanic
b) Plant Maintenance Worker
c) Overhaul Mechanic
d) Industrial Coater/Painter
e) Machinist
f) Aqueduct Maintenance Worker (all classes)
g) Universal (crane) Operators
h) Aqueduct Heavy Equipment Operator and Equipment Operator
i) Water Operators
j) Construction Inspectors (non-electrical)
k) Non-electrical ATP employees

5 TRAINING REQUIREMENTS (110.6)

5.1 General Training Requirements

All CAP employees shall be trained in and be familiar with general safety procedures and electrical safety. Employees shall be trained in safety-related work practices and procedural requirements, as necessary, to provide protection from the electrical hazards associated with their respective job or task assignments.

5.2 Training Requirements for Qualified Electrical Workers

5.2.1 Electrician (Plant and Headquarters)

a) NFPA 70E Electrical Hazard Training (retrain every 3 years).
b) Hazardous Energy Control Program (Authorized, retrain every 3 years).
c) CPR/AED Training every 2 years.

5.2.2 Electrician (Relay and I&C and Apprentices)

a) NFPA 70E Electrical Hazard Training (retrain every 3 years).
b) Hazardous Energy Control Program (Authorized, retrain every 3 years).
c) CPR/AED Training every 2 years

5.2.3 Technician (HVAC, Fire Protection)

a) NFPA 70E Electrical Hazard Training (retrain every 3 years).
b) Hazardous Energy Control Program (Authorized, retrain every 3 years).
c) CPR/AED Training every 2 years.

5.2.4 Engineering Construction Inspector and Technician (Electrical)

a) NFPA 70E Electrical Hazard Training (retrain every 3 years).
b) Hazardous Energy Control Program (Authorized, retrain every 3 years).
c) CPR/AED Training every 3 years.

5.2.5 Communication Engineer

a) NFPA 70E Electrical Hazard Training (retrain every 3 years).
b) Hazardous Energy Control Program (Authorized, retrain every 3 years).
c) CPR/AED Training every 3 years.

5.2.6 Electrical Engineer

a) NFPA 70E Electrical Hazard Training (retrain every 3 years).
b) Hazardous Energy Control Program (Affected, retrain every 3 years).
c) CPR/AED Training every 3 years

5.2.7 Supervisors (Qualified Electrical or Pumping Plant)

a) NFPA 70E Electrical Hazard Training (retrain every 3 years).
b) Hazardous Energy Control Program (Authorized, retrain every 3 years).
c) CPR/AED Training every 2 years.

5.2.8 Managers (Staff interacts with electrical equipment)

a) NFPA 70E Electrical Hazard Training (retrain every 3 years).
b) Hazardous Energy Control Program (Affected, retrain every 3 years).
c) CPR/AED Training every 2 years.

5.3 Training Requirements for Electrically Unqualified Workers

5.3.1 Work in and around electrical installations

5.3.1.1 Mechanic (Plant, Overhaul, Machinist, Apprentice)

a) NFPA 70E Unqualified Training (retrain every 3 years).
b) Hazardous Energy Control Program (Authorized, retrain every 3 years).
c) CPR/AED Training every 3 years.

5.3.1.2 Plant Maintenance Workers

a) NFPA 70E Unqualified Training (retrain every 3 years).
b) Hazardous Energy Control Program (Authorized, retrain every 3 years).
c) CPR/AED Training every 3 years.

5.3.1.3 Universal Operators (Crane Operators)

a) NFPA 70E Unqualified Training (retrain every 3 years).
b) Electrical Safety Program Overview (HECP affected,retrain every 3 years)
c) CPR/AED Training every 3 years.

5.3.1.4 Aqueduct Maintenance Worker (All Classes)

a) NFPA 70E Unqualified Training (retrain every 3 years).
b) Electrical Safety Program Overview (HECP affected,retrain every 3 years)
c) CPR/AED Training every 3 years.

5.3.1.5 Aqueduct Heavy Equipment Operator and Equipment Operator

a) NFPA 70E Unqualified Training (retrain every 3 years).
b) Electrical Safety Program Overview (HECP affected,retrain every 3 years)
c) CPR/AED Training every 3 years.

5.3.1.6 Industrial Coater / Painter

a) NFPA 70E Unqualified Training (retrain every 3 years).
b) Electrical Safety Program Overview (HECP affected,retrain every 3 years)
c) CPR/AED Training every 3 years.

5.3.1.7 Non-Electrical Supervisors and Managers with Staff that do not work around electrical installations

a) NFPA 70E Unqualified Training (retrain every 3 years).
b) Electrical Safety Program Overview (HECP affected,retrain every 3 years)
c) CPR/AED Training every 3 years.

5.3.1.8 Construction Inspectors (non-electrical)

a) NFPA 70E Electrical Hazard Training (retrain every 3 years).
b) Hazardous Energy Control Program (Authorized, retrain every 3 years).
c) CPR/AED Training every 3 years.

5.3.2 Workers whose job does not expose them to electrical hazards.

1) Electrical Safety General Awareness (one time, new employee orientation).
2) Electrical Safety Program Overview (HECP affected, retrain every 3 years)
3) CPR/AED Training every 3 years.

5.4 Retraining

Additional training and retraining in safety-related work practices and applicable changes to this program shall be performed at intervals not to exceed 3 years. An employee shall receive additional training or retraining under any of the following conditions:

a) If the supervision or annual inspections indicate that the employee is not complying with the safety-related work practices.
b) If new technology, new types of equipment, or changes in procedures necessitate the use of safety-related work practices that are different from those that the employee would normally use.
c) The employee needs to review tasks that are performed less often than once per year.
d) If the employee must employ safety-related work practices that are not normally used during his or her regular job duties.
e) The employee's job duties change.

6 ELECTRICAL SAFETY AUDITING (110.5(M))

6.1 Electrical Safety Program

The electrical safety program shall be audited by the Electrical Safety Committee to verify the principles and procedures of the program are in compliance with the current NFPA 70E standard. The audits shall be done every 3 years, coinciding with the issuance of the latest revision of the standard. The program will be updated as required within the first year of the latest NFPA 70E standard issuance. The review shall be documented on the revision number and issue date of the program.

6.2 Field Work

Field work audits are performed by field supervisors annually as part of the Qualified Electrical Worker's performance evaluation. Compliance with this program is a required competency for those employees, and is documented on their annual performance evaluation.

6.3 Hazardous Energy Control Program

The hazardous energy control program (LO/TO) is audited annually by the Electrical Safety Administrators to verify the principles and procedures of the program are in compliance with the current NFPA 70E standard. The audit covers at least one lockout / tagout procedure in progress and is documented to identify and correct deficiencies in the procedures and training.

6.4 Incident Investigations (110.5(J))

Electrical incidents include events or occurrences that result in, or could have resulted in, a fatality, an injury, or damage to health. Such incidents will be investigated to identify causes contributing to the incident. Causes shall be addressed to prevent re-occurrance. Incidents that do not result in fatality, an injury, or damage to health are commonly referred to as "close call" or "near miss". Close Call Report Form

7 RISK ASSESSMENT CONSIDERATIONS FOR ENERGIZED WORK (110.5(H))

A risk assessment uses the information in the Arc Flash Hazard Analysis Report as related to the tasks to be performed. If an electrical hazard exists, the risk assessment includes a procedure to carry out the following:

a) Identify hazards.
b) Assess risks.
c) Implement risk control strategies utilizing the hierarchy of controls listed in 7.4.

7.1 Hazard Identification

a) A job hazard analysis must identify the electrical hazards associated with each energized electrical task to be performed.
b) The equipment electrical hazard label should be referenced to identify potential incident energy exposure for each task associated with an arc flash hazard. If the incident energy has not been analyzed, refer to Appendix D for arc flash hazard information.
c) Either the equipment electrical hazard label or Appendix B should be referenced to identify shock hazards.

7.2 Risk Assessment

a) For tasks identified with arc flash hazards, refer to Appendix E to assess the likelihood of an arc flash incident and the equipment electrical hazard label or Appendix D to assess the severity of incident energy exposure.
b) For tasks identified with shock hazards, determine which approach boundaries will be crossed, if any.

7.3 Human Error

Tasks should be evaluated for the potential for human error and the negative consequences on people, processes, the work environment, and equipment relative to the electrical hazards in the workplace. Human performance addresses managing human error as a unique control that is complementary to the hierarchy of risk control methods.

7.4 Risk Control Strategies

Control strategies must be considered and documented in descending order of effectiveness to reduce hazards to the maximum extent possible. The purpose of these controls is to either reduce the likelihood of an incident occurring or to prevent or mitigate the severity of consequence if an incident occurs. No control is infallible. All of the controls are subject to errors in human performance, whether at the design, implementation, or use phase.

7.4.1 Elimination

De-energizing and establishing an electrically safe work condition is the ideal method of eliminating injuries due to shock or arc flash hazards. By following hazardous energy controls, the risks have been eliminated and the potential inherent electrical hazards have been effectively eliminated. It should be noted that the hazard elimination process, e.g. placing the equipment in an electrically safe work condition, could require interaction with energized equipment and the hazards can only be considered eliminated once the electrically safe work condition is established.

7.4.2 Substitution

Replacing equipment or changing procedures and processes may effectively eliminate or reduce the hazards to a tolerable level of risk or to a lower risk where a combination of controls can be implemented to reduce the risk and potential hazards to the employee.

7.4.3 Engineering Controls

(1) Modifying or adding protection controls such as the use of zone selective interlocking.

(2) Replacing older breakers with breakers that have adjustable trip elements.

(3) Differential relaying.

(4) Energy-reducing maintenance switch systems.

(5) Energy-reducing active arc flash mitigation systems.

(6) Arc flash relay.

(7) High-resistance grounding coils.

(8) Current-limiting devices.

7.4.4 Awareness

The use of warning labels, signs, equipment labeling, and alerting techniques. (NFPA 70E Art. 130.5(H) and 130.7(E)).

7.4.5 Administrative Controls

(1) Emergency procedures.

(2) Employee training.

(3) Risk assessment.

(4) Pre-Job briefing.

(5) Increasing working distances (including remote racking and operating).

(6) Reviewing Lockout/tagout procedures.

(7) Use of Energized Electrical Work Permits.

(8) Approach boundaries.

(9) Arc flash boundaries.

(10) Arc Flash Hazard Analysis Report.

7.4.6 PPE

(1) Considered the least effective of the safety controls.

(2) Last line of defense before an event happens.

(3) Properly arc rated (AR) for the exposure.

(4) Most appropriate PPE for the tasks to be performed determined and used.

(5) Adequately maintained and inspected.

(6) Does not protect against hazards such as concussion, flying debris, or foreign objects.

8 JOB SAFETY PLANNING AND PRE-JOB BRIEFING (110.5(I))

Before starting each job that involves exposure to electrical hazards, the employee in charge shall complete a job safety plan and conduct a job briefing with the employees involved. If working alone, no job briefing is required.

8.1 Job Safety Planning

The job safety plan shall be in accordance with the following:

a) Be completed by a Qualified Electrical Worker.
b) Be documented using the Job Hazard Analysis/Pre-Job Brief form.
c) Include the following information:
    1. Description of the job and individual tasks.
    2. Identification of the electrical hazards associated with each task.
    3. A shock risk assessment in accordance with NFPA 70E 130.4 for tasks involving a shock hazard. Refer to the electrical hazard label or Appendix B for shock boundaries.
    4. An arc flash risk assessment in accordance with NFPA 70E 130.5 for tasks involving an arc flash hazard. Refer to Appendix E for arc flash incident likelihood and the electrical hazard label for arc flash severity (incident energy).
    5. Work procedures involved, special precautions, and energy source controls.

8.2 Pre-Job Briefing

The job briefing shall cover the job safety plan and the information on the energized electrical work permit, if a permit is required. If the work or operations to be performed during the work day or shift are repetitive and similar, at least one job briefing shall be conducted before the start of the first job of the day or shift.

8.3 Change in Scope

Additional job safety planning and job briefings shall be held if changes occur during the course of the work that might affect the safety of employees.

9 ESTABLISHING AN ELECTRICALLY SAFE WORK CONDITION (120)

Establishing an electrically safe work condition is the preferred method for working on electrical equipment or circuit parts. An electrically safe work condition is a state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with Hazardous Energy Control Program, tested to verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection. It should be noted that de-energizing an electrical conductor or circuit part and making it safe to work on is, in itself, a potentially hazardous task.

9.1 Establishing an electrically safe work condition includes (120.5):

a) Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.
b) After performing a normal shutdown on the load equipment, open the disconnecting device(s) for each source.
c) Visually verify that all blades of the disconnecting devices are fully open or that drawout-type circuit breakers are withdrawn to the fully disconnected position.
d) Block or relieve stored nonelectrical energy, where applicable, in devices to the extent the circuit parts cannot be unintentionally energized by such devices.
e) Apply lockout/tagout devices in accordance with the CAP Hazardous Energy Control Program .
f) Use an adequately rated voltage detector to test each phase conductor or circuit part for the absence of voltage. Test each phase conductor or circuit part both

phase-to-phase and phase-to-ground. Before and after each test, determine that the voltage detector is operating satisfactorily.

g) Verify any stored electrical energy is released.

h) If exposed normally current-carrying parts on equipment having a nominal voltage rating over 600 volts are to be contacted or approached within the restricted approach boundary, personal protective grounding shall be applied.

9.2 Personal Protective Grounding Installation

The primary purpose of personal protective grounding is to provide adequate protection against electrical shock causing death or injury to personnel working on deenergized lines or equipment. This is accomplished by grounding and bonding lines and equipment to limit the body contact or exposure voltages at the worksite from induced voltages or accidental energization, to a safe value until protective relays can operate to isolate the source of energy. Refer to USBR FIST 5-1 for more information.

a) Personal protective grounding is required when approaching nearer than the restricted approach boundary for equipment rated 600V and above.

b) The shock hazard remains until PPG are applied to the circuit for equipment rated 600V and above. Use live-line tools to apply grounds.

c) Personal protective grounds shall be capable of conducting the maximum fault current that could flow at any point of grounding for the time necessary to clear a fault. Personal protective grounds shall have an impedance low enough to cause immediate operation of protective devices in case of unintentional energizing of the electric conductors or circuit parts.

d) In applying grounds, care must be exercised to stay clear of the grounding cables. The practice of holding the cable near the base of the hot stick to lighten the load on the head of the stick is strictly prohibited. A co-worker should assist in applying heavy grounds by holding the cable with another hot stick, or by using a shepherd hook with a pulley and nonconductive rope to hoist the ground cable into position.

e) Grounds are placed on circuits or conductors that have been disconnected from energized parts and locked/tagged as described in the HECP manual.

f) Grounds are connected directly to the equipment, bus, or conductor to be grounded. No impedance or device (circuit breaker, disconnect switch, transformer, line trap, etc.) shall be permitted in series between the point of connection of the protective grounds and location of contact by the workers.

g) Ground cable assemblies shall be visually and mechanically inspected before each use.

h) The clamp jaws should be wire brushed immediately before attachment, and the surface of the object to be clamped should be cleaned before the clamp is attached. De-energized conductors must be cleaned with a wire brush attached to a hot stick.

i) Ground end clamps are applied first to a grounding point as close as practical to the location where workers are likely to simultaneously contact grounded objects (metal equipment enclosures, circuit breaker and transformer tanks, etc.) and exposed parts of temporary grounded equipment at the worksite.

j) Circuit-end or the working end clamps of ground cable assemblies shall be applied after the ground-end clamps are connected. The circuit or working end clamps shall always be connected and disconnected by means of hot sticks of adequate length to stay outside of the restricted approach boundary. If feasible,

use a hotstick of sufficient length to remain outside the arc flash boundary also, so that no additional arc flash PPE will be needed.

k) Slack in installed cables should also be minimal to reduce possible cable failure or injury to workers due to whipping action from fault currents.

l) Placement of personal protective grounds is documented on the clearance form and by Water Operations.

Precautions to consider when placing grounds:

m) Placing grounds on the wrong equipment and other human errors create deadly consequences.

n) Exposed equipment that is not locked/tagged per HECP may be present in the work area and could be contacted by grounds, tools or body parts creating deadly consequences.

10 INTERACTION WITH ENERGIZED ELECTRICAL EQUIPMENT (130.1)

Interaction is defined as affecting or changing the state or condition of energized electrical equipment or circuits.

10.1 Equipment Operating at Less Than 50 Volts (110.4(C))

Energized electrical conductors and circuit parts that operate at less than 50 volts shall not be required to be de-energized where the capacity of the source and any overcurrent protection between the energy source and the worker are considered and it is determined that there will be no increased exposure to electrical burns or to explosion due to electric arcs.

10.2 Normal Operation (110.4(D))

Normal operation of electric equipment shall be permitted where a normal operating condition exists. A normal operating condition exists when all of the following conditions are satisfied:

a) Equipment is properly installed.

b) Equipment is properly maintained.

c) Equipment is used in accordance with instructions included in the listing and labeling and in accordance with manufacturer's instructions.

d) Equipment doors are closed and secured or open as required by the equipment design for the operation being performed.

e) All equipment covers are in place and secured.

f) There is no evidence of impending failure.

g) All protection devices, protective relays, and trip elements protecting the equipment or device have been properly maintained and are in service.

10.3 Energized Electrical Work Permit (110.4; 130.2)

10.3.1 When Required

An energized electrical work permit is required and documented if:

a) It is infeasible to put the equipment in an electrically safe work condition due to equipment design or operational limitations; OR

b) When it is determined that de-energizing introduces additional hazards or increased risk; AND

c) Work is performed within the restricted approach boundary; OR

d) The employee interacts with the equipment when conductors or circuit parts are not exposed, but an increased likelihood of injury from an exposure to an arc flash hazard exists.

10.3.2 When Energized Electrical Work Permit is Not Required (130.2(C))

Electrical work shall be permitted without an energized electrical work permit if a qualified electrical worker is provided with and uses appropriate safe work practices and PPE in accordance with the following conditions:

a) Testing, troubleshooting or voltage measuring.
b) Lifting wires to isolate portions of plant control circuits as defined in 10.3.3.
c) Thermography, ultrasound, or visual inspections if the restricted approach boundary is not crossed.
d) Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed.
e) General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed.

10.3.3 Working behind (downstream) of lifted wires or conductors

Occasions may arise where it may be necessary to isolate a portion of a plant control circuit without taking the entire circuit out of service. This only involves circuits of 125VDC, 120VAC or less. Most common is the situation where the protection circuit of equipment must be kept energized as in a protective relay scheme but a device must be removed or re-wired.

a) Lift the wire(s) to isolate the portion of the circuit to be worked on.
b) Assure the lifted wires are insulated to prevent inadvertent contact with energized circuits.
c) Tag each one with a Lifted Wire tag.
d) Document in the plant green log book or create a lifted wire list in the work package.

11 EQUIPMENT LABELING AND ELECTRICAL HAZARD ANALYSIS (130.4, 5)

11.1 Electrical Hazard Warning Labels

CAP will label all electrical equipment enclosures that will indicate the electrical hazards that may be encountered when accessing the equipment. Refer to Appendix A for examples. Any equipment that has not had an incident energy analysis performed and does not have an electrical hazard label, refer to Appendix B for shock hazard and Appendix D for arc flash hazard information. There are three groups of information on the electrical hazard warning labels:

11.1.1 Arc Flash Hazards

An incident energy analysis will be performed that determines the incident energy a person could potentially be exposed to when performing work on the energized equipment. The label will indicate the following information related to arc flash hazards:

a) **Arc flash boundary**. Arc-rated PPE is required to cross this boundary.
b) **Working distance**.
c) **Incident energy at the working distance**.

d) **Minimum arc rating of clothing**. Up to 40 cal/cm^2 for Warning labels. Arc flash PPE rated at or greater must be worn to cross the arc flash boundary or to perform tasks where an arc flash hazard exists. Where the incident energy is above 40 cal/cm^2, the label will indicate Danger and N/A for the minimum arc rating of clothing. For tasks involving an arc flash hazard, equipment with a Danger label must not be accessed until de-energized.

11.1.2 Shock Hazards

The label will indicate the following information related to shock hazards:

a) **Nominal system voltage**.
b) **Limited approach boundary**. Only qualified electrical workers may cross.
c) **Restricted approach boundary**. Requires insulated tools and/or insulating PPE to cross.

11.1.3 General Information

The label will indicate the following general information:

a) Panel or equipment designation.
b) Upstream protective device that interrupts the fault and/or isolates the equipment.

11.2 Incident Energy Analysis

The Incident Energy Analysis determines the severity of potential arc flash hazards by identifying the arc flash boundary, the incident energy at the minimum working distance, and the required PPE to be used within an arc flash boundary. This analysis provides the information and tools that can be used to reduce the potential incident energy exposure. The assumptions, calculations, methodology, findings, and recommendations made while performing the Incident Energy Analysis of these circuits must be documented in the facility Arc Flash Hazard Analysis Report. The Incident Energy Analysis must be performed in tandem with an equipment duty evaluation and a protective device coordination study.

The Incident Energy Analysis shall be updated when changes occur in the electrical distribution system that could effect the results of the analysis. The Incident Energy Analysis shall also be reviewed for accuracy at intervals not to exceed 5 years.

12 GENERAL SAFE WORK PRACTICES (130.8)

12.1 Employee Working Alone

a) An employee working alone need not conduct a job briefing. However, the employee shall complete the JHA / PJB form and ensure that the tasks to be performed are reviewed as if a job briefing were required.
b) Routine high voltage switching of circuits does not require two employees be present.
c) Employees may request a second qualified person be present if the work is particularly hazardous or complicated.

12.2 Alertness

a) Employees are to remain alert at all times while working within the Limited Approach Boundary of any energized equipment or in situations where any electrical hazards may exist.
b) Employees that are recognizably impaired shall not be permitted to work within the Limited Approach Boundary of any energized equipment. Impairment may be due to illness, fatigue, prescription drug use, or any other reasons.
c) Changes in scope or plan of a job or task that may impose hazards to the work that were not originally planned for require an additional "on the spot" job briefing with all employees involved in the work. If these hazards cannot be worked safely then the work shall stop until a new plan can be initiated.
d) Employees are not to reach blindly into areas that may contain exposed energized conductors or where an electrical hazard may exist.
e) Employees working on electrical equipment are to remain alert of others that may enter the area and keep all unqualified individuals out of the Limited Approach Boundary.

12.3 Illumination

a) Employees shall not enter spaces containing electrical hazards unless illumination is provided that enables the employee to perform the work safely. This illumination may be in the form of hand held lights or portable work lights.
b) Where lack of illumination or an obstruction precludes observation of the work to be performed, employees shall not perform any task where an electrical hazard exists.

12.4 Conductive Articles Being Worn

a) Conductive articles of jewelry and clothing (watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive threads, metal headgear, or metal frame glasses) shall not be worn within the restricted approach boundary or where they present an electrical contact hazard with energized conductors or circuit parts.
b) Over glasses made of insulated materials may be worn over wire frame prescription glasses and are stocked in the CAP warehouse.
c) Face shields made of non-conductive materials may be worn over wire frame prescription glasses and are stocked in the CAP warehouse.

12.5 Conductive Materials, Tools, and Equipment Handling

a) Conductive materials that are in contact with any part of an employee's body shall be handled in a manner that prevents accidental contact with energized conductors or circuit parts. Such materials include but are not limited to pipes, tubing, conduits, metal tape measures, scaffold parts, ladders, steel tapes, and conductive hoses.
b) When approaching or working around energized electrical conductors while carrying or handling conductive materials special precautions must be taken to prevent the conductive material from coming within the Restricted Approach Boundary.

12.6 Doors and Hinged Panels

Doors, hinged panels, and similar installations shall be secured to prevent them from swinging into an employee and causing the employee to contact exposed energized

electrical conductors or circuit parts where an electrical hazard exists if movement of the door, hinged panel, and the like is likely to create a hazard. While working in panels with hinged doors with energized conductors, the workers body shall be protected from the conductors with insulating shields or blankets.

12.7 Clear Spaces

Working space required by other codes and standards shall not be used for storage. This space shall be kept clear to permit safe operation and maintenance of electrical equipment.

12.8 Housekeeping Duties Around Energized Equipment

Employees shall not perform housekeeping duties inside the Limited Approach Boundary where there is a possibility of contact with energized electrical conductors or circuit parts, unless adequate safeguards such as insulating blankets or barriers are installed to prevent contact. Electrically conductive cleaning materials such as steel wool and metal brushes shall not be used within the Limited Approach Boundary unless procedures to prevent electrical contact are followed.

12.9 Anticipating Failure

When there is evidence that electrical equipment could fail and injure employees or damage equipment, the electrical equipment shall be de-energized unless de-energizing will introduce additional hazards or increased risk or is infeasible because of equipment design or operational limitations. Until the equipment is de-energized or repaired, employees shall be protected from hazards associated with the impending failure of the equipment by suitable barricades and other alerting techniques necessary for safety of the employees.

12.10 Routine Opening and Closing of Circuits

Load-rated switches, circuit breakers, or other devices specifically designed as disconnecting means shall be used for opening, reversing, and closing of circuits under load conditions. Cable connectors not of load-break type, fuses, terminal lugs, and cable splice connections shall not be used for such purposes, except in an emergency.

12.11 Draw-Out-Type Circuit Breakers

When draw-out-type circuit breakers are removed or inserted, the breaker shall be: In the Open position and the doors are closed where design permits.

12.12 Re-energizing Circuits After Protective Device Operation

a) After a circuit is de-energized by a circuit protective device, the circuit shall not be manually re-energized until it has been determined (by qualified persons) that the equipment can be safely energized.
b) Equipment protected by a lockout relay must not be re-energized until the cause has been determined and proper authorization obtained. Refer to Resetting Lockout Relays and Re-energizing Equipment .
c) Re-energization shall be performed by qualified personnel in accordance with CAP Standing Operating Procedures.

12.13 Safety Interlocks of Safety Switches, Combination Starters and Like Equipment

a) Only qualified electrical workers following the requirements for working within the Restricted Approach Boundary shall be permitted to defeat or bypass an electrical

safety interlock over which the person has sole control, and then only temporarily while the qualified person is working on the equipment. The safety interlock system shall be returned to its operable condition when the work is completed.

b) Switching Keyed Interlocks (Kirk Key type interlocks) that are interlocks used for operational purposes and are interlocked to prevent access into equipment or switch operation without certain conditions being met are not allowed to be defeated or bypassed in any fashion unless the effected circuits have been put into an Electrically Safe Work Condition. These types of interlocks are not to be used for personal protection or lockout/tagout purposes.

12.14 Excavation, Coring and Confined Space Permits (130.11)

Coring permits are required prior to drilling of walls or floors more than 3". Digging permits are required prior to excavation, penetration, or digging into the earth in excess of 6". The permitting process is administered by the Engineering Department. Entering a confined space with exposed, energized circuit parts or conductors requires a confined space permit, administered by the Safety department.

12.15 Cutting, Removing or Rerouting of Conductors (130.12)

Where conductors are de-energized, in order to cut, remove, or reroute them and the conductor terminations are not within sight of the point of work, such as where the conductors are remote from the source of supply in a junction or pull box, additional steps to verify the absence of voltage or identify the conductors shall be taken prior to cutting, removing, or rerouting the conductors.

12.16 Safe Work Practices for Specific Equipment

12.16.1 Capacitors and Surge Arrestors (360.5)

a) Before employees work on capacitors, the capacitors shall be disconnected from energized sources and, after a wait of at least 5 minutes from the time of disconnection, grounded and short-circuited.

b) Before the units are handled, each unit shall be short-circuited between all terminals and the capacitor case or its rack. If the cases of capacitors are on ungrounded substation racks, the racks shall be bonded to ground.

c) Any line to which capacitors are connected shall be short-circuited (grounded) before it is considered de-energized.

12.16.2 Current Transformers

a) The secondary circuit of a current transformer may not be opened while the transformer is energized. Opening the secondary circuit of an energized current transformer will result in extremely high voltages on the secondary circuit. This creates an electrocution hazard to employees and will cause major electrical wiring and equipment failures. If the primary of the current transformer cannot be de-energized before work is performed on an instrument, relay, or other section of a current transformer secondary circuit, the circuit shall be bridged so that the current transformer secondary will not be opened.

b) Most current transformer circuits have shorting bars or links located on terminal blocks at some point in the circuit to aid in the bridging of the secondary circuit. NOTE: Not all current transformer terminations

have these shorting bars, therefore in such cases the current transformer must be de-energized. When lifting wires on any circuit extreme care must be taken to not inadvertently open the wrong circuit. Before lifting wires, wiring diagrams and schematics should be consulted to avoid this error.

c) Typically current transformer secondary circuits have a "Q" as one of the letters designating the circuit. (Examples 1TQ1A = Transformer 1 CT circuit phase A, 1MQB = Unit 1 motor CT circuit phase B, 1GQ0 = Unit 1 Generator CT circuit neutral).

12.16.3 Battery and DC Systems

a) Proper goggles and face shields will be worn while servicing batteries
b) Chemical-resistant gloves will be worn while servicing batteries.
c) Portable or stationary eyewash stations and shower shall be available.
d) All tools used while working on energized DC systems or while servicing batteries shall be of the insulated type to prevent any sparking.
e) No other conductive tools or materials shall be used where they may make circuit contact while servicing batteries (ie, tape measures, or other hand tools).

12.17 Performing Tests on Equipment in an Electrically Safe Work Condition

a) When performing field testing that involves high voltages, the area shall be barricaded to prevent unauthorized persons from entering.
b) Test equipment that operates at high voltages (hipot, insulation resistance, Doble testing, etc.) shall be used in accordance with manufacturer's instructions. Equipment under test must be grounded to place or remove leads.
c) The conductive part of the equipment being tested shall be kept grounded while the testing is not in process.
d) Following completion of DC hipot or insulation resistance tests, the test specimen must be grounded for four times the duration of the test to bleed off absorbed charge.

13 WORK WITHIN ENERGIZED SWITCHYARDS AND SUBSTATIONS (130.9)

13.1 Personnel Working Within Switchyard

When working within a switchyard or substation, employees must not go nearer to uninsulated energized power lines, nor take any conductive objects nearer than the limited approach boundary, with the exception that a qualified electrical worker may cross the limited approach boundary only when placing the lines in an electrically safe working condition.

Where the work to be performed is within the limited approach boundary, such as erecting scaffolding, the lines shall be put into an electrically safe work condition, including visible grounds near the work site. The safe work area shall be clearly marked and energized areas flagged off.

Scaffolding shall be bonded to the equipment being accessed to create an equipotential zone.

Unqualified persons or are allowed into switchyards and substations under the following rules and circumstances:

a) A qualified person has reviewed the work that the unqualified person is performing and assures that it will be outside of the Limited Approach Boundary of overhead lines. A job briefing is required for the unqualified employee. This may be done once with an individual for repetitive work such as routine inspections and the employee will then be allowed to perform it in the future without briefing.
b) For work that is not repetitive or is performed by individuals not familiar with the hazards or performed by contractors, the qualified person will escort the worker(s) while the work is being performed.

13.2 Mobile Equipment within Switchyards

Mobile equipment used for work within the switchyards and substations includes but is not limited to, aerial devices, passenger trucks, earthmoving equipment and cranes.

13.2.1 Bonding Mobile Equipment Used in Electrically Safe Work Zones

This paragraph applies to mobile equipment used to access conductors and apparatus that have been placed in an electrically safe work condition. The equipment is normally stationary while the work is being done. The purpose of bonding mobile equipment to the worksite grounding system (during de-energized work), is to control and minimize transferred touch potentials between the structure, equipment, and vehicle during an accidental energization of the line. Vehicle and equipment grounds are to be used in conjunction with properly installed personal protective grounds. In no instance shall vehicle and equipment grounds be used in place of personal protective grounds. Ground cables used for equipment and vehicle grounding shall be no smaller than #1/0 copper and shall be tested in accordance with CAP personal protective ground testing procedure Pumping Plant Tool Ground Electrical Annual Test Procedure. Ground cables on reels or looped on the vehicle shall be completely unwound to allow thorough inspection of the cable prior to use as well as eliminate destructive forces resulting from induction in the event of a fault at the worksite. Refer to USBR FIST 5-1 Personal Protective Grounding for Electric Power Facilities for more information.

13.2.2 Mobile Equipment Used in Transit Near Energized Lines

This paragraph applies to mobile equipment used in energized yards or near energized lines. The equipment will commonly be in motion much of the time while the work is being done and is not encroaching the limited approach boundary. In this application, the equipment will not be bonded to the ground system, therefore the following rules apply:

a) No part of the mobile equipment may cross the limited approach boundary as it is used on the job.
b) Any parts of the equipment that are capable of being moved into the limited approach boundary, such as a boom or bucket, must be restrained to prevent this from happening.

c) The equipment operator must remain in the cab while in the switchyard, and only enter or exit the vehicle outside the switchyard.
d) Personnel on the ground must avoid contact with the vehicle while in the switchyard.

14 TEST INSTRUMENTS AND EQUIPMENT (110.8)

14.1 Diagnostic Testing

Only qualified electrical workers shall perform tasks such as testing, troubleshooting, and voltage measuring on electrical equipment where an electrical hazard exists.

14.2 Test Instruments Requirements

All test instruments, and their accessories shall be rated for circuits and equipment to which they will be exposed. Personal tools and test instruments shall not be used on CAP equipment.

a) All hand held multi-meters and accessories (including test leads) for field use shall meet the IEC (International Electrotechnical Commission) CAT IV safety rating standard.
b) All hand-held scopemeters and accessories (including test leads) for field use shall meet the IEC (International Electrotechnical Commission) CAT III safety rating standard.
c) Test instruments for bench use, and for field use in the communications, electronics, and SCADA may be rated CAT I through IV depending upon the application.
d) All test instruments, equipment, leads, cable, power cords, probes, and connectors shall be visually inspected for external defects and damage before each use.
e) When test instruments are used for testing the absence of voltage on conductors or circuit parts operating above 50 volts, the operation of the test equipment shall be verified before and after an absence of voltage test is performed. This test must be performed on a known energized circuit or a live-dead-live tester.

14.3 Portable Cord- and Plug- Connected Electrical Equipment (110.9)

a) Portable equipment shall be handled in a manner that will not cause damage.
b) Power cords shall not be used for raising or lowering equipment.
c) Extension cords shall not be fastened with staples or hung in a fashion that may cause damage to the outer jacket or insulation.
d) Power cords and extension cords shall be inspected before each use and if damage is found to the outer jacket, insulation, or plug connectors it shall be removed from service for replacement or repairs.
e) Extension cords used with grounding-type utilization equipment shall contain an equipment grounding conductor.
f) Attachment plugs and receptacles on power cord equipment or extension cords shall not be connected or altered in a manner that would interrupt continuity of the grounding conductor. Additionally, these devices shall not be altered in order to allow use in a manner that was not intended by the manufacturer.
g) Adapters that interrupt the continuity of the equipment grounding conductor shall not be used.

h) All plug and receptacle equipment shall be used only with proper mating equipment.
i) All locking-type plug and connector equipment shall be secured (locked) after connection.

14.4 Conductive or Wet locations

a) Portable cord and plug connected electric equipment used in conductive or wet work locations shall be approved for use in those locations. In work locations where employees are likely to contact or be drenched with water or conductive liquids, ground-fault-circuit-interrupter (GFCI) protection for personnel shall be used.
b) GFCI protection devices shall be tested in accordance with manufacturer's instructions or before each use.
c) Employee's hands or plug and receptacle equipment shall not be wet when plugging and unplugging power or extension cords into a live receptacle.

14.5 Ground Fault Circuit Interrupter Protection (110.10)

a) GFCI protection shall be provided where required by applicable state, federal or local codes and standards. Listed cord sets or devices incorporating listed GFCI protection shall be permitted.
b) GFCI protection or an assured grounding program shall be employed for maintenance and construction activities using 120 volt, 15-, 20- or 30- ampere circuits.
c) GFCI receptacles shall be tested as part of the facility safety maintenance program and prior to use.

14.6 Overcurrent Protection Devices

The following requirements apply to overcurrent protection of circuits rated 600 volts, nominal, or less.

a) Conductors and equipment must be protected from overcurrent in accordance with their ability to safely conduct current and the conductors must have sufficient current-carrying capacity to carry the load.
b) Overcurrent devices must not interrupt the continuity of the grounded conductor unless all conductors of the circuit are opened simultaneously, except for motor-running overload protection.
c) Overcurrent devices must be readily accessible and not located where they could create an employee safety hazard by being exposed to physical damage or located in the vicinity of easily ignitable material.
d) Fuses and circuit breakers must be so located or shielded that employees will not be burned or otherwise injured by their operation, e.g., arcing.
e) Overcurrent protection of circuits and conductors shall not be modified, even on a temporary basis, beyond the ampacity of what is permitted by applicable portions of electrical codes and standards dealing with overcurrent protection.

14.7 Requirements for use of Portable/Vehicle Mounted Generators

14.7.1 General Requirements

a) The generator may only supply equipment located on the generator or the vehicle and cord- and plug-connected equipment through receptacles mounted on the generator or the vehicle.

b) The non-current-carrying metal parts of the equipment and the equipment grounding conductor terminals of the receptacles shall be bonded to the generator frame.
c) In the case of vehicle mounted generators, the frame of the generator shall be bonded to the vehicle frame.
d) Any neutral conductor shall be bonded to the generator frame.

14.7.2 Earthing Requirements for Portable and Vehicle-mounted Generators

Under the conditions listed above in General Requirements, the frame of a portable generator need not be connected to earth and the frame may serve as the ground (in place of the earth).

14.7.3 When a Ground Rod is Required

If the portable generator is providing temporary electric power to a structure (home, office, shop, trailer, or similar) the structure service entrance must be connected to a grounding electrode system, such as a driven ground rod.

If the generator neutral is directly connected to the system neutral, no ground rod is required. If the neutral is switched through a transfer switch, then a ground rod is required.

Grounding requirements for generators connected via transfer switches are covered by Article 250 of the National Electrical Code

15 PERSONAL AND OTHER PROTECTIVE EQUIPMENT (130.7)

15.1 General

PPE includes protective clothing and equipment to protect personnel from exposure to arc flash hazards and shock hazards identified by the risk analysis. When a qualified electrical worker is working within the restricted approach boundary, the worker shall wear shock protection equipment consisting of shock protective gloves, insulating tools and/or insulating blankets as necessary. When an employee is working within the arc flash boundary, he or she shall wear arc rated clothing and other personal protective equipment as listed in Appendix C, rated for the incident energy determined by the risk analysis. All parts of the body inside the arc flash boundary shall be protected. All qualified electrical workers shall wear Electrical Hazard rated footwear. All employees shall wear proper hardhats. All employees working on exposed energized electrical circuits at any voltage level shall wear proper eye protection.

15.2 Care of Personal Equipment

a) It is the responsibility of the employee to provide care for his PPE.
b) CAP provided protective equipment shall be visually inspected per manufacturer's recommendations before each use.
c) Protective equipment shall be stored in a manner to prevent damage from moisture, dust, physical damage, or other types of deterioration.

15.3 Body Protection

All qualified electrical workers shall wear CAP provided 8 cal/cm^2 arc-rated shirts and pants when in field areas or CAP facilities. Qualified electrical workers shall wear arc-rated PPE as specified in Appendix C anytime they are within an arc flash boundary.

15.3.1 Arc Flash PPE Categories

There are four categories of arc flash PPE defined by NFPA 70E Table 130.7(C)(15)(c), see Appendix C. Each category defines clothing and protective equipment to be worn for protection against increasingly higher incident energies. CAP issues arc flash PPE kits equal to category 2 and category 4 to every qualified electrical worker whose job duties require it.

15.4 Eye Protection

Employees shall wear approved eye protection while working on all energized equipment. This rule also includes electrical equipment energized below 50 volts which includes battery systems. Additionally, eye protection is required whenever there is any danger of injury from electric arcs, flashes, or from flying objects resulting from electrical explosion.

15.5 Hearing Protection

Employees shall wear hearing protection whenever working within the arc flash boundary.

15.6 Hand Protection

15.6.1 Shock Protection

a) Qualified electrical workers shall wear insulating gloves with leather protectors for shock protection anytime the worker's hand(s) cross a restricted approach boundary.
b) Class 0 insulating gloves with leather protectors are the standard gloves issued to and used by CAP qualified electrical workers since the highest voltages where the restricted approach boundary may be crossed by the worker's hands will be 600V class gear (typically 600V class gear is energized at 480 volts nominal). Class 0 insulating gloves with leather protectors are rated for use at up to 1000 VAC and 1500 VDC. The top of the cuff of the protector glove shall be shorter than the rolled top of the cuff of the insulating glove by at least 0.5 inch.
c) Insulating gloves will be issued only to qualified electrical workers and shall be replaced or tested at intervals not exceeding 6 months.
d) Insulating gloves shall be stored and carried cuff down in a bag, box, or container that is designed for this purpose. Insulating gloves may be kept inside of the leather protectors.
e) Insulating gloves shall be visually inspected inside and out, and field air-tested before use each day and at shorter intervals if there is cause to suspect damage, and immediately following any incident that can reasonably be suspected of having caused damage. Any damage such as holes, tears, punctures, cuts, cracking, swelling, texture changes, hardening, becoming sticky or inelastic, contamination with chemicals, embedded foreign objects, shall render the glove unusable and the pair shall be returned to the warehouse for return and testing by the vendor.

f) Insulating gloves should be uniquely identified (i.e., serial number or other marking).
g) Insulating gloves shall be wiped clean of any oil, grease, or other damaging substances as soon as possible.
h) Heat, light, sunlight, oil, petroleum products, and distortion are natural enemies of rubber and insulating gloves should be guarded from these as much as possible.

15.6.2 Arc Flash Protection

Hand protection shall be worn where there is a possible exposure to arc flash burn. The apparel described in Appendix C shall be required for protection of hands from burns.

15.7 Foot Protection

All qualified electrical workers are required to wear ASTM F2413-05 approved footware with electrical hazard (EH) rating.

15.8 Factors in Selection of Protective Clothing

a) Outer Layers – Garments worn as outer layers over arc-rated clothing, such as jackets, high-visibility apparel, or rainwear, shall also be made from arc-rated material when worn inside an arc flash boundary. Non arc-rated outerwear may not be worn inside an arc flash boundary. The arc rating of outer layers worn over arc-rated clothing as protection from the elements or for other safety purposes, and that are not used as part of a layered system, shall not be required to be equal to or greater than the estimated incident energy exposure.
b) Underlayers – Meltable fibers such as acetate, nylon, polyester, polypropylene and spandex shall not be permitted in fabric underlayers. *Exception: an incidental amount of elastic used on non-melting fabric underwear or socks shall be permitted.*
c) Coverage – Clothing shall cover potentially exposed areas as completely as possible. Shirt and coverall sleeves shall be fastened at the wrists, shirts shall be tucked into pants, and shirts, coveralls, and jackets shall be closed at the neck.

15.9 Care and Maintenance of Arc-Rated Clothing

a) Inspection – Arc-rated apparel shall be inspected before each use. Work clothing or arc flash suits that are contaminated or damaged to the extent that their protective qualities are impaired shall not be used. Protective items that become contaminated with grease, oil, or flammable liquids or combustible materials shall not be used.
b) Manufacturer's instructions for the care and maintenance of arc-rated apparel shall be followed.
c) Storage – arc-rated apparel shall be stored in a manner that prevents physical damage; damage from moisture, dust, or other deteriorating agents; or contamination from flammable or combustible materials.
d) Cleaning, repairing, and affixing items – When arc-rated clothing is cleaned, manufacturer's instuctions shall be followed. When arc-rated clothing is repaired, the same arc-rated materials used to manufacture the arc-rated clothing shall be used to provide repairs.

15.10 Insulated Tools and Equipment (130.7(D)(1))

Qualified electrical workers shall use insulated tools or handling equipment, or both, when working inside the restricted approach boundary. Insulated tools shall be protected from damage to the insulating material.

15.10.1 Requirements for insulated tools.

a) Insulated tools shall be rated for the voltages on which they are used.
b) Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.
c) Insulated tools and equipment shall be inspected prior to each use.

15.10.2 Live-line Tools

Fiberglass-reinforced plastic (FRP) live-line tools shall be designed and constructed to withstand the following minimum test:

100,000 volts per foot of length for 5 minutes.

a) Each live-line tool shall be wiped clean and visually inspected for defects before use each day.
b) If any defect or contamination that could adversely affect the insulating qualities or mechanical integrity of the live-line tool is present after wiping, the tool shall be removed from service and examined and tested.
c) Live-line tools used at CAP shall be tested annually. Pumping Plant Tool Ground Electrical Annual Test Procedure

15.10.3 Fuse or Fuseholder Handling Equipment

Fuse or fuseholder handling equipment, insulated for the circuit voltage, shall be used to remove or install a fuse if the fuse terminals are energized.

15.10.4 Grounding Sticks (360.6)

Grounding sticks shall be provided for qualified persons to safely discharge any residual stored energy or to hold potential at zero volts on capacitors or other electrical apparatus with capacitive characteristics such as motor and transformer windings.

a) Ground sticks shall be visually inspected for defects that could adversely affect the insulating quality or mechanical integrity before each use. Defective ground sticks shall be removed from service until repaired or replaced and tested.
b) Ground stick cable shall be tested annually to verify the impedance is less than 0.1 ohm. Pumping Plant Tool Ground Electrical Annual Test Procedure

15.10.5 Ropes and Handlines

Ropes and handlines used within the limited approach boundary shall be nonconductive.

15.10.6 Portable Ladders

Portable ladders shall have nonconductive side rails when used within the limited approach boundary or where the employee or ladder could contact exposed energized electrical conductors or circuit parts.

15.11 Barriers

Exposed energized electrical conductors or circuit parts operating at 50 volts or more shall be guarded by a barrier to prevent unintentional contact while an employee is working within the restricted approach boundary of those conductors or circuit parts. Barriers shall be supported to remain in place and shall prevent unintentional contact by a person, tool, or equipment.

a) Insulating Rubber or Plastic Equipment used for protection from unintentional contact with energized conductors or circuit parts shall be rated for the voltage and meet the requirements of applicable state, federal or local codes and standards.
b) Physical or Mechanical Barriers (field-fabricated) shall be installed no closer than the restricted approach boundary distance. While the barrier is being installed, the restricted approach boundary distance shall be maintained, or the energized conductors or circuit parts shall be placed in an electrically safe work condition.

15.12 Alerting Techniques around energized work (130.7(E), (F))

When working with exposed energized electrical circuits, panels, conductors, or when racking out or removing breakers from energized gear, the qualified electrical worker shall barricade the area off to prevent personnel from inadvertently entering either the arc flash or limited approach boundaries, whichever is further. If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees.

Where work performed on equipment in an electrically safe work condition is in an area with other energized equipment that is similar in size, shape and construction, signs or barricades shall be employed to prevent the employee from entering look-alike equipment.

15.13 Personal Protective Grounds (USBR FIST 5-1)

15.13.1 Purpose

The primary purpose of personal protective grounding is to provide adequate protection against electrical shock causing death or injury to personnel while working on de-energized lines or equipment. This is accomplished by grounding and bonding lines and equipment to limit the body contact or exposure voltages at the worksite to a safe value if the lines or equipment are accidentally energized from any source of hazardous energy. The greatest source of hazardous energy in most cases is direct energization of lines or equipment from the power system. Other sources of hazardous energy may include:

a) Stored energy (capacitors)
b) Electromagnetic coupling
c) Static charge build-up
d) High-voltage testing
e) Faulted equipment
f) Instrument transformer backfeed

15.13.2 Uses Permitted

a) Over 600 volts (required).
   Lines and equipment with a nominal voltage rating over 600 volts must have personal protective grounds applied as part of the process

of creating an electrically safe work condition if the work requires crossing the restricted approach boundary. Other nearby exposed parts of any electrical equipment rated over 600 volts which are not associated with the work, but may be approached within the restricted approach boundary during the work activities, shall either be de-energized and grounded or
suitably isolated to prevent contact.

b) Less than 600 volts (optional).
Grounding of equipment and circuits rated 600 volts or less is optional. Equipment and circuits operating below 600 volts can be just as deadly under the right conditions as higher voltage equipment. However, application of personal protective grounds on circuits below 600 volts may create unnecessary hazards due to limited approach distances and close proximity between conductors and grounded parts of equipment.

15.13.3 Uses not Permitted

a) Lightning.
For de-energized, grounded work on transmission lines, switchyards and
substations, personal protective grounds cannot be relied upon to provide
adequate safety from a direct or indirect lightning strike within the line of sight. Therefore, work shall not be performed while there is any indication of lightning in the area.

b) Over 50,000 Amperes Available Fault Current.
Extreme electromechanical separation forces are developed in ground cables for currents exceeding 50,000 amperes, symmetrical. Mechanical failure of the ground cable assembly is likely. The method of double-isolation grounding is recommended in lieu of conventional direct application of protective grounds. Refer to HECP manual.

c) Non-Temporary Installations.
Personal protective grounding is intended for temporary grounding during
installation, maintenance, and repair or modification of lines and equipment. It is not intended to substitute for a prolonged or permanent plant or station equipment grounding connection which should be provided by permanent grounding and wiring methods.

15.13.4 Requirements for Personal Protective Grounds

Protective ground cables and associated grounding equipment shall meet the following requirements:

a) Capable of conducting the maximum fault current which could occur at the grounded worksite if the de-energized line or equipment becomes energized from any source and for the fault clearing times below:
1) Thirty cycles (1/2 second) for transmission and distribution lines;
2) Fifteen cycles (1/4 second) for switchyards and substations; or
3) Fifteen cycles (1/4 second) for power and pumping plants.

CAP utilizes 4/0 AWG grounding cable sets for all applications to prevent an employee from utilizing an undersized grounding cable. *Exception: Grounding sets used in underground rural distribution equipment (load-break elbows).*

b) Capable of withstanding a second energization within 30 cycles after a first inadvertent energization.
c) Each single point ground is tagged at both ends with a unique identifier and its length. Multi-point grounds have a unique identifier and length tag at the clamp end of each leg.
d) Single and multi-point grounds (ground clusters) are tested annually as an assembled unit. A grounding assembly that has been modified (e.g.; a clamp replaced) must be retested before use. A record of the tests is filed under the facility plant safety/protective equipment folder in Content Server. Pumping Plant Tool Ground Electrical Annual Test Procedure .

16 RELATIONSHIPS WITH CONTRACT EMPLOYERS (CONTRACTORS) (110.7)

16.1 CAP Responsibilities to Contract Employers

The department hiring the contractor is responsible for the following:

a) Shall inform the contractor of all known hazards that are related to the contractor's work.
b) Shall report to the contractor information about the installation necessary for the contractor to make proper safety assessments.
c) Shall report to the contractor all observed contract-employee violations of this program.
d) Where lockout/tagout protection is provided, a Special Work Permit shall be prepared that documents the protection and is issued to the contractor.

16.2 Contract Employer Responsibilities

a) The contractor shall ensure that each of their employees is instructed in the hazards communicated to the contractor by the responsible CAP department.
b) The contractor shall ensure that all of their employees have had the required training with respect to job function they will be performing.
c) The contract employer shall ensure that each of their employees follow the work practices required by their program and CAP Electrical Safety Program.
d) The contract employer shall keep CAP advised of:
    1) Any unique hazards presented by the contractor's work.
    2) Any hazards found during the contractor's work that were not communicated by CAP.
    3) The measures that the contractor takes to correct any violations reported to them by CAP and how similar violations are prevented from re-occurring.

16.3 Pre-Job Safety Meeting

CAP will communicate job related hazards to the contractor prior to work beginning.

17 ARC FLASH HAZARD ANALYSIS

17.1 Arc Flash Hazard Analysis Report

a) CAP Engineering Resources will perform an arc-flash incident energy analysis of all electrical equipment rated above 50 volts. The incident energy analysis determines the severity of potential arc flash hazards by identifying the arc flash boundary, the incident energy at the minimum working distance, and the required PPE to be used within an arc flash boundary. This analysis provides the information and tools that can be used to reduce the potential incident energy exposure. The assumptions, calculations, methodology, findings, and recommendations made while performing the incident energy analysis of these circuits must be documented in the facility Arc Flash Hazard Analysis Report. The incident energy analysis must be performed in tandem with an equipment duty evaluation and a protective device coordination study.

b) Maintenance test data such as breaker and relay trip times should be used in the incident energy analysis as opposed to performance assumptions based on manufacturer specifications.

c) The engineer performing the analysis will make recommendations identified in the Report to reduce hazards, improve coordination or correct equipment deficiencies. The recommendations must be documented in the CMMS or the asset modification process.

d) The Arc Flash Hazard Analysis Report must be updated when a major modification or renovation takes place, including external system/utility changes.

e) The Arc Flash Hazard Analysis Report must be reviewed at least once every 5 years by Engineering Resources and updated to account for changes in the electrical systems that could affect the results of the analysis, updated arc flash hazard information or guidance, and revised industry standards.

f) The Arc Flash Hazard Analysis Report shall be maintained in Content Server under the facility reports and studies folder.

17.2 Electrical Hazard Warning Labels – Editing, Printing and Applying

a) The Arc Flash Hazard Analysis Report shall produce a set of electrical hazard warning labels in pdf format. The warning label file will be sent to Electrical Safety Administration for review.

b) Electrical Safety Administration will review the label file, comparing to the facility equipment, and report any missing equipment, or label errors back to the engineer. Engineering will generate additional labels as needed to correct deficiencies.

c) Electrical Safety Administration will edit the file as required to make label copies (where there are multiple access panels on the same equipment); or change panel or protective device designations, where the incident energy analysis designations do not always match equipment designations.

d) Electrical Safety Administration will print labels from the final approved label file and apply them on the equipment at the facility.

e) The facility electrical hazard warning label file will be stored in Content Server in the Electrical Safety Program\ Arc Flash Labels folder .

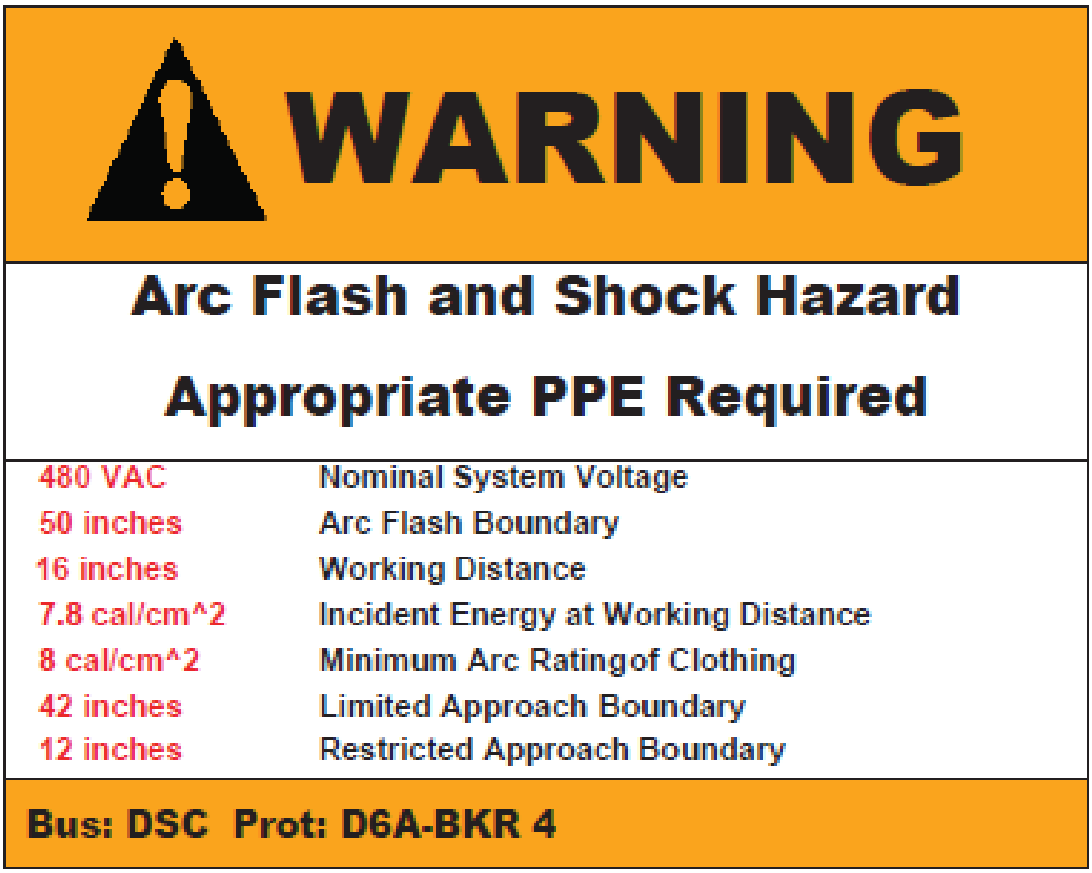
18 REFERENCES

- NFPA 70E Standard for Electrical Safety in the Workplace 2021

- NFPA 70 National Electrical Code
- USBR FIST Vol. 5-1 Personal Protective Grounding for Power Facilities and Power Lines
- USBR FIST Vol. 1-1 Hazardous Energy Control Program
- USBR FIST Vol. 5-14 Electrical Safety Program
- CAP Hazardous Energy Control Program (HECP)

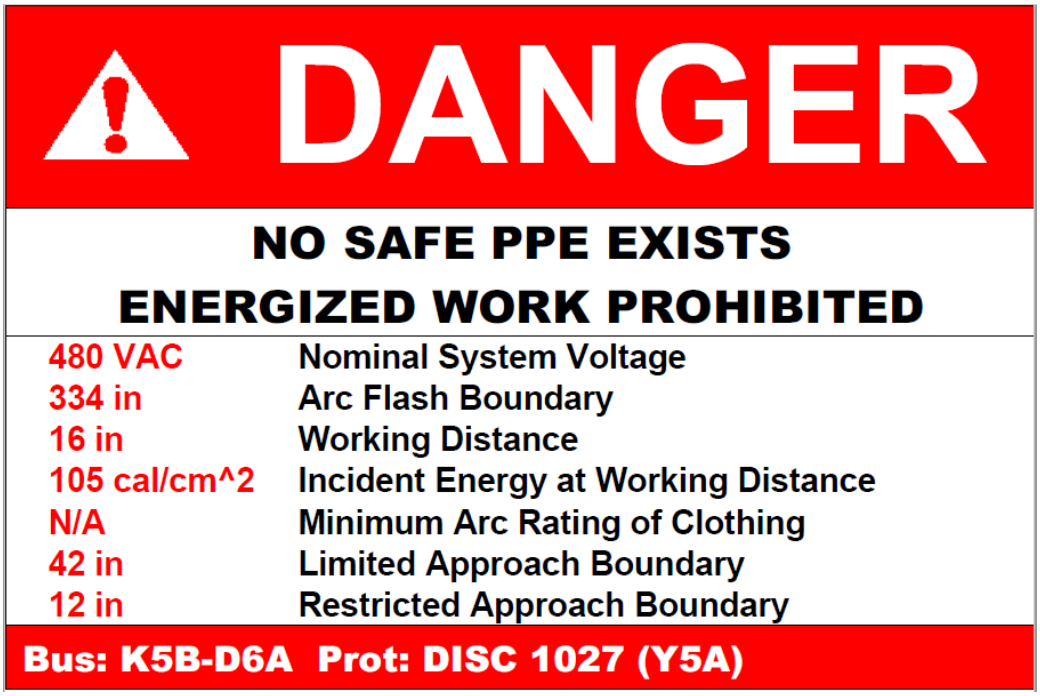
APPENDIX A: EQUIPMENT LABELING

All electrical equipment greater than 50 volts at CAP that has had an Arc Flash Hazard Analysis performed shall be labeled with standard electrical hazard labels.

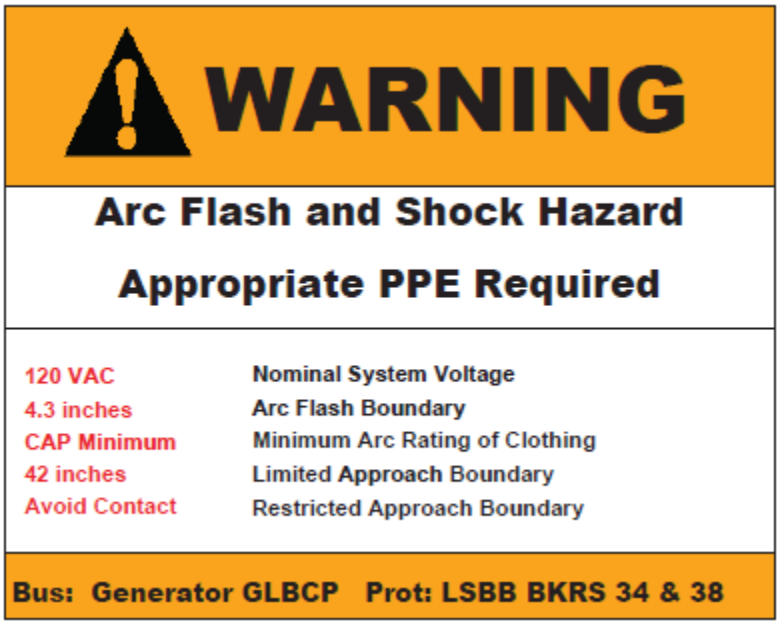


(1) Voltage level of the circuit.
(2) Distance from exposed, energized parts at which arc flash PPE is required.
(3) Minimum distance a worker's face or chest is allowed to approach for energized work.
(4) Energy a person at the working distance would be exposed to if an arc flash event occurred.
(5) Minimum arc rating of clothing used in arc flash PPE to cross the arc flash boundary.
(6) Minimum allowable approach distance for unqualified workers.
(7) Distance at which insulating PPE must be worn or insulated tools employed.
(8) Equipment designation and overcurrent interrupting device protecting that equipment.

Example of a Danger Label (incident energy exceeds PPE arc rating). Tasks involving an arc flash hazard must not be performed when energized (including placing equipment in an electrically safe work condition). Upstream source must be de-energized before approaching exposed parts.

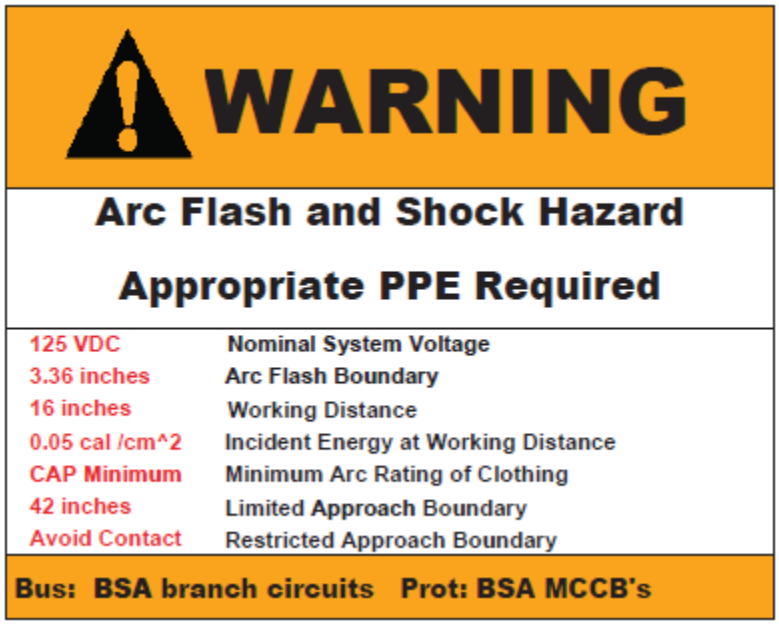


Example of a label for a single phase AC circuit. The analysis calculates the arc flash boundary using equation D.2.1d from NFPA 70E and assuming a bolted fault current just under the instantaneous trip setting of the overcurrent protective device to obtain the worst-case.

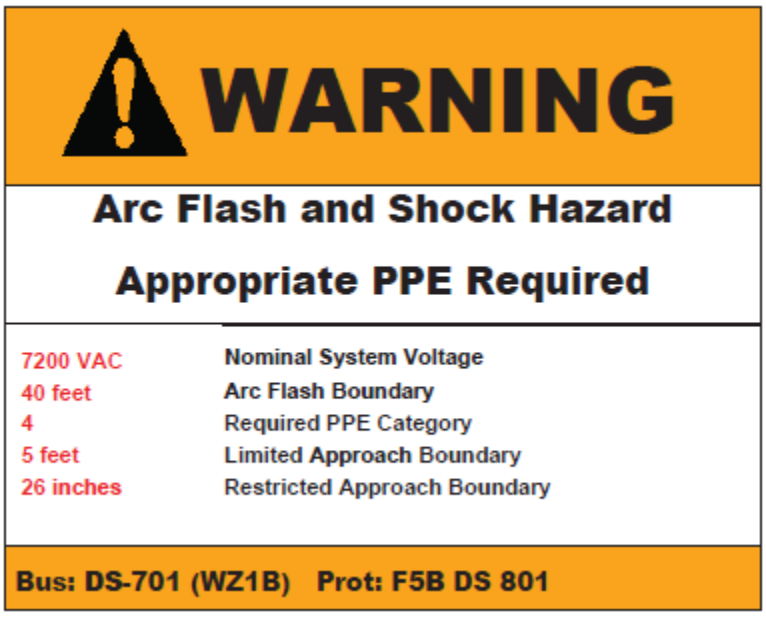


CAP minimum refers to the shirt and pants rated for 8 cal/cm^2 provided to all qualified electrical workers.

Example of a label for a direct current circuit fed from the DC distribution panel. The analysis calculates the arc flash boundary using equation D.2.1d from NFPA 70E and the battery fault current.



Example of an electrical hazard label on equipment that has not had an incident energy analysis performed. Arc flash boundary and PPE requirements determined from NFPA 70E Tables 130.7(C)(15)(a) and (b). See Appendix D



APPENDIX B: SHOCK PROTECTION BOUNDARIES

NFPA 70E Table 130.4(E)(a) Alternating Current Systems

(1)	(2)	(3)	(4)
	Limited Approach Boundary[b]		Restricted Approach Boundary[b]; Includes Inadvertent Movement Adder
Nominal System Voltage Range, Phase to Phase[a]	Exposed Movable Conductor[c]	Exposed Fixed Circuit Part	
Less than 50 V	Not specified	Not specified	Not specified
50 V–150 V[d]	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
151 V–750 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)
751 V–15 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.7 m (2 ft 2 in.)
15.1 kV–36 kV	3.0 m (10 ft 0 in.)	1.8 m (6 ft 0 in.)	0.8 m (2 ft 9 in.)
36.1 kV–46 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.8 m (2 ft 9 in.)
46.1 kV–72.5 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
72.6 kV–121 kV	3.3 m (10 ft 8 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
138 kV–145 kV	3.4 m (11 ft 0 in.)	3.0 m (10 ft 0 in.)	1.2 m (3 ft 10 in.)
161 kV–169 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	1.3 m (4 ft 3 in.)
230 kV–242 kV	4.0 m (13 ft 0 in.)	4.0 m (13 ft 0 in.)	1.7 m (5 ft 8 in.)
345 kV–362 kV	4.7 m (15 ft 4 in.)	4.7 m (15 ft 4 in.)	2.8 m (9 ft 2 in.)
500 kV–550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.6 m (11 ft 8 in.)
765 kV–800 kV	7.2 m (23 ft 9 in.)	7.2 m (23 ft 9 in.)	4.9 m (15 ft 11 in.)

Notes:

All dimensions are distance from exposed energized electrical conductors or circuit parts to employee.

[a]For single-phase systems above 250 volts, select the range that is equal to the system's maximum phase-to-ground voltage multiplied by 1.732.

[b]See definition in Article 100 and text in 130.4(D)(2) and Informative Annex C for elaboration.

[c]*Exposed movable conductors* describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

[d]This includes circuits where the exposure does not exceed 120 volts nominal.

NFPA70E Table 130.4(E)(b) Direct Current Voltage Systems

(1)	(2)	(3)	(4)
	Limited Approach Boundary		Restricted Approach Boundary[b]; Includes Inadvertent Movement Adder
Nominal Potential Difference	Exposed Movable Conductor[c]	Exposed Fixed Circuit Part	
Less than 50 V	Not specified	Not specified	Not specified
50 V–300 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
301 V–1 kV	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)
1.1 kV–5 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.5 m (1 ft 5 in.)
5 kV–15 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.7 m (2 ft 2 in.)
15.1 kV–45 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.8 m (2 ft 9 in.)
45.1 kV– 75 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
75.1 kV–150 kV	3.3 m (10 ft 8 in.)	3.0 m (10 ft 0 in.)	1.2 m (3 ft 10 in.)
150.1 kV–250 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	1.6 m (5 ft 3 in.)
250.1 kV–500 kV	6.0 m (20 ft 0 in.)	6.0 m (20 ft 0 in.)	3.5 m (11 ft 6 in.)
500.1 kV–800 kV	8.0 m (26 ft 0 in.)	8.0 m (26 ft 0 in.)	5.0 m (16 ft 5 in.)

Note:

[a]All dimensions are distance from exposed energized electrical conductors or circuit parts to worker.

[b]*Exposed movable conductors* describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles

APPENDIX C: PERSONAL PROTECTIVE EQUIPMENT PPE

NFPA 70E Table 130.7(C)(15)(c)

Arc-Flash PPE Category	PPE
1	**Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm^2** [a] Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated face shield [b] or arc flash suit hood Arc-rated jacket, parka, rainwear, or hard hat liner (AN) [f] **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) [c] Heavy duty leather gloves [d] Leather footwear (AN) [e]
2	**Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm^2** [a] Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield [b] and arc-rated balaclava Arc-rated jacket, parka, rainwear, or hard hat liner (AN) [f] **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) [c] Heavy duty leather gloves [d] Leather footwear [e]
3	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm^2** [a] Arc-rated long-sleeve shirt (AR) Arc-rated pants (AR) Arc-rated coverall (AR) Arc-rated arc flash suit jacket (AR) Arc-rated arc flash suit pants (AR Arc-rated arc flash suit hood Arc-rated gloves [d] Arc-rated jacket, parka, rainwear, or hard hat liner (AN) [f] **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) [c] Leather footwear [e]
4	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40 cal/cm^2** [a] Arc-rated long-sleeve shirt (AR) Arc-rated pants (AR) Arc-rated coverall (AR) Arc-rated arc flash suit jacket (AR) Arc-rated arc flash suit pants (AR) Arc-rated arc flash suit hood Arc-rated gloves [d] Arc-rated jacket, parka, rainwear, or hard hat liner (AN) [f] **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) [c] Leather footwear [e]

AN: as needed (optional). AR: as required. SR: selection required.

Notes:

[a] *Arc rating* is defined in Section 3.

[b] Face shields are to have wrap-around guarding to protect not only the face, but also the forehead, ears, and neck, or, alternatively, an arc-rated arc flash suit hood is required to be worn.

[c] Other types of hearing protection are permitted to be used in lieu of or in addition to ear canal inserts provided they are worn under an arc-rated arc flash suit hood.

[d] Rubber insulating gloves with leather protectors provide arc flash protection in addition to shock protection. Higher class rubber insulating gloves with leather protectors , due to their increased material thickness, provide increased arc flash protection.

[e] Footwear other than leather or dielectric shall be permitted to be used provided it has been tested to demonstrate no ignition, melting, or dripping at the estimated incident energy exposure or the minimum arc rating for the respective arc flash PPE category.

[f] The arc rating of outer layers worn over arc-rated clothing as protection from the elements or for other safety purposes, and that are not used as part of a layered system, shall not be required to be equal to or greater than the estimated incident energy exposure.

APPENDIX D: ARC FLASH PPE CATEGORIES FOR AC AND DC SYSTEMS

NFPA 70E Table 130.7(C)(15)(a) Alternating Current (ac) Systems

Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Panelboards or other equipment rated 240 V and below Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycle) fault clearing time; minimum 18 in. working distance	1	19 in
Panelboards or other equipment rated greater than 240 V and up to 600 V Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycle) fault clearing time; minimum 18 in. working distance	2	3 ft
600 v class motor control centers (MCCs) Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycle) fault clearing time; minimum 18 in. working distance	2	5 ft
600 v class motor control centers (MCCs) Parameters: Maximum of 42 kA available fault current; maximum of 0.33 sec (20 cycle) fault clearing time; minimum 18 in. working distance	4	14 ft
600 V class switchgear (with power circuit breakers or fused switches) and 600 V class switchboards Parameters: Maximum of 35 kA available fault current; maximum of 0.5 sec (30 cycle) fault clearing time; minimum 18 in. working distance	4	20 ft
Other 600 V class (277 V through 600 V, nominal) equipment Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycle) fault clearing time; minimum 18 in. working distance	2	5 ft
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2kV Parameters: Maximum of 35 kA available fault current; maximum of 0.24 sec (15 cycle) fault clearing time; minimum 36 in. working distance	4	40 ft
Metal clad switchgear, 1 kV through 15kV Parameters: Maximum of 35 kA available fault current; maximum of 0.24 sec (15 cycle) fault clearing time; minimum 36 in. working distance	4	40 ft
Metal enclosed interrupter switchgear, fused or unfused type construction, 1 kV through 15kV Parameters: Maximum of 35 kA available fault current; maximum of 0.24 sec (15 cycle) fault clearing time; minimum 36 in. working distance	4	40 ft

Other equipment 1 kV through 15kV Parameters: Maximum of 35 kA available fault current; maximum of 0.24 sec (15 cycle) fault clearing time; minimum 36 in. working distance	4	40 ft
Arc-resistant equipment up to 600-volt class Parameters: DOORS CLOSED and SECURED; with an available fault current and a fault clearing time that does not exceed the arc resistant rating of the equipment*	N/A	N/A
Arc-resistant equipment 1 kV through 15kV Parameters: DOORS CLOSED and SECURED; with an available fault current and a fault clearing time that does not exceed the arc resistant rating of the equipment*	N/A	N/A

N/A: Not applicable
Note: For equipment rated 600 volts and below and protected by upstream current-limiting fuses or current-limiting molded case circuit breakers sized at 200 amperes or less, the arc flash PPE category can be reduced by one number but not below arc flash PPE category 1.
*For DOORS OPEN refer to the corresponding non-arc resistant equipment section of this table.

Informational Note No. 1 to Table 130.7(C)(15)(a): The following are typical fault clearing times of overcurrent protective devices:

1) 0.5 cycle fault clearing time is typical for current-limiting fuses and current-limiting molded case circuit breakers when the fault current is within the current limiting range.
2) 1.5 cycle fault clearing time is typical for molded case circuit breakers rated less than 1000 volts with an instantaneous integral trip.
3) 3.0 cycle fault clearing time is typical for insulated case circuit breakers rated less than 1000 volts with an instantaneous integral trip or relay operated trip.
4) 5.0 cycle fault clearing time is typical forrelay operated circuit breakers rated 1 kV to 35 kV when the relay operates in the instantaneous range (i.e., “no intentional delay”).
5) 20 cycle fault clearing time is typical for low-voltage power and insulated case circuit breakers with a short time fault clearing delay for motor inrush.
6) 30 cycle fault clearing time is typical for low-voltage power and insulated case circuit breakers with a short time fault clearing delay without instantaneous trip.

NFPA 70E Table 130.7(C)(15)(b) Direct Current (dc) Systems

Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Storage batteries, dc switchboards and other dc supply sources Parameters: Greater than or equal to 100 V and less than or equal to 250 volts Maximum arc duration and minimum working distance: 2 sec @ 18 in.		
Available fault current less than 4 kA	2	3 ft
Available fault current greater than or equal to 4 kA and less than 7 kA	2	4 ft
Available fault current greater than or equal to 7 kA and less than 15 kA	3	6 ft
Storage batteries, dc switchboards and other dc supply sources Parameters: Greater than or equal to 250 V and less than or equal to 600 volts Maximum arc duration and minimum working distance: 2 sec @ 18 in.		
Available fault current less than 1.5 kA	2	3 ft
Available fault current greater than or equal to 1.5 kA and less than 3 kA	2	4 ft
Available fault current greater than or equal to 3 kA and less than 7 kA	3	6 ft
Available fault current greater than or equal to 7 kA and less than 10 kA	4	8 ft

Notes:

1) Apparel that can be expected to be exposed to electrolyte must meet both of the following conditions:
   a. Be evaluated for electrolyte protection
   b. Be arc rated

2) A two-second arc duration is assumed if there is no overcurrent protective device (OCPD) or if the fault clearing time is not known. If the fault clearing time is known and is less than 2 seconds, an incident energy analysis could provide a more representative result

APPENDIX E: ESTIMATE OF THE LIKELIHOOD OF OCCURRENCE OF AN ARC-FLASH INCIDENT FOR AC AND DC SYSTEMS

NFPA 70E Table 130.5(C)

Task	Equipment Condition[a]	Likelihood of Occurrence[b]
Reading a panel meter while operating a meter switch Performing infrared thermography and other non-contact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers. Working on control circuits with exposed energized electrical conductors and circuit parts nominal 125 volts ac or dc, or below, without any other exposed energized equipment over nominal 125 volts ac or dc, including opening of hinged covers to gain access. Examination of insulated cable with no manipulation of cable. For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack.	Any	No
For ac systems, work on energized electrical conductors and circuit parts, including electrical testing. Operation of a CB or switch the first time after installation or completion of maintenance in the equipment. For dc systems, working on energized electrical conductors and circuit parts of series-connected battery cells, including electrical testing. Removal or installation of CB's or switches Opening hinged door(s) or cover(s) or removal of bolted covers (to expose bare, energized electrical conductors and circuit parts). For dc systems, this includes bolted covers, such as battery terminal covers Application of temporary protective grounding equipment, after voltage test. Working on control circuits with exposed energized electrical conductors and circuit parts, greater than 120 volts. Insertion or removal of individual starter buckets from motor control center (MCC). Insertion or removal (racking) of circuit breakers (CB's) or starters from cubicles, doors open or closed. Insertion or removal of plug-in devices into or from busways. Examination of insulated cable with manipulation of cable. Working on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panelboard or motor control center. Insertion or removal of revenue meters (kW-hour, at primary voltage and current). Insertion or removal of covers for battery intercell connector(s). For dc systems, working on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source. Opening voltage transformer or control power transformer compartments.	Any	Yes

Operation of outdoor disconnect switch (hookstick operated) at 1 kV through 15 kV. Operation of outdoor disconnect switch (gang-operated, from grade) at 1 kV through 15 kV.	Any	Yes
Operation of a CB, switch, contactor or starter. Voltage testing on individual battery cells or individual multi-cell units. Removal or installation of covers for equipment such as wireways, junction boxes, and cable trays that does not expose bare, energized electrical conductors and circuit parts. Opening a panelboard hinged door or cover to access dead front overcurrent devices. Removal of battery nonconductive intercell connector covers.	Normal	No
Maintenance and testing on individual battery cells or individual multi-cell units in an open rack. Insertion or removal of individual cells or multi-cell units of a battery system in an open rack. Arc-resistant equipment with the DOORS CLOSED and SECURED, and where the available fault current and fault clearing time does not exceed that of the arc-resistant rating of the equipment in one of the following conditions:. (1) Insertion or removal of individual starter buckets (2) Insertion or removal (racking) of CB's from cubicles (3) Insertion or removal (racking) of ground and test device (4) Insertion or removal (racking) of voltage transformers on or off the bus.	Abnormal	Yes

[a]Equipment is considered to be in a "normal operating condition" if all the conditions in Paragraph 10.2 (110.4(D)) are satisfied.

[b]As defined in this standard, the two components of risk are the likelihood of occurrence of injury or damage to health and the severity of injury or damage to health that results from a hazard. Risk assessment is an overall process that involves estimating both the likelihood of occurrence and severity to determine if additional protective measures are required. The estimate of the likelihood of occurrence contained in this table does not cover every possible condition or situation, nor does it address severity of injury or damage to health. Where this table identifies "No" as an estimate of likelihood of occurrence, it means that an arc flash incident is not likely to occur. Where this table identifies "Yes" as an estimate of likelihood of occurrence, it means an arc flash incident should be considered likely to occur. The liklihood of occurrence must be combined with the potential severity of the arcing incident to determine if additional protective measures are required to be selected and implemented according to the hierarchy of risk control identified in Paragraph 7.4 (110.5(H)(3)).

Informational Note No. 1: An example of a standard that provides information for arc-resistant equipment referred to in table 130.5(C) is IEEE C37.20.7 *Guide for Testing Switchgear Rated Up To 52 kV for internal arcing faults*

Informational Note No. 2: Improper or inadequate maintenance can result in increased fault clearing time of the overcurrent protective device, thus increasing the incident energy. Where equipment is not properly installed or maintained, PPE selection based on incident energy analysis or the PPE category method might not provide adequate protection from arc flash hazards.

Informational Note No. 3: Both larger and smaller available fault currents could result in higher incident energy. If the available fault current increases without a decrease in fault clearing time of the overcurrent protective device, the incident energy will increase. If the available fault current decreases, resulting in a longer fault clearing time for the overcurrent protective device, incident energy could also increase.

Informational Note No. 4: The occurrence of an arcing fault inside an enclosure produces a variety of physical phenomena very different from a bolted fault. For example, the arc energy resulting from an arc developed in the air will cause a sudden pressur increase and localized overheating. Equipment and design practices are available to minimize the energy levels and the number of procedures that could expose an employee to high levels of incident energy. Proven designs such as arc-resistant switchgear, remote racking (insertion or removal), remote opening and closing of switching devices, high-resistance grouinding of low voltage and 5000-volt (nominal) systems, current limitation, and specification of covered bus or covered conductors within equipment are available to reduce the risk associated with an arc flash incident. See Informative Annex O for safety related design requirements.

Informational Note No. 5: For additional direction for performing maintenance on overcurrent protective devices, see Chapter 2, Safety-related Maintenance Requirements.

Informational Note No. 6: See IEEE 1584, *Guide for Performing Arc Flash Hazard Calculations,* for more information regarding incident energy and the arc flash boundary for three-phase systems.

APPENDIX F: LIFTED WIRE TAG