



WESTERN CONNECTICUT STATE UNIVERSITY

ENERGIZED ELECTRICAL SAFETY AND ARC FLASH
PROGRAM

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Please direct any questions or comments about the applicability of this document to David Serino, Director of
Environmental Health & Safety

Western Connecticut State
University

Energized Electrical Safety and Arc Flash Program

OSHA 29 CFR 1910 Subpart S, 1926 Subpart K, and NFPA 70E

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1. INTRODUCTION

Electricity is a serious workplace hazard that is capable of causing both employee injury and property damage. It is the policy of Western Connecticut State University to protect all employees, students, and other personnel from potential electrical hazards. This will be accomplished through compliance with the electrical safety related work practices described in this policy along with effective application of engineering controls, administrative controls, and the use of personal protective equipment.

This Electrical Safety and Arc Flash Program is based upon the principle of avoiding energized work when feasible. Live parts will be de-energized before an employee performs work on or near the equipment unless one of the conditions applies:

- De-energizing introduces additional or increased hazards. Examples of additional or increased hazards may include deactivation of emergency alarm systems or shutdown of hazardous location ventilation systems.
- De-energizing is not possible due to equipment design or operational limitations. Examples of this situation may include testing and troubleshooting of electrical circuits that can only be performed with the circuit energized and performing work on circuits that form an integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.
- Energized parts are operating at less than 50 volts to ground and there is no increased exposure to electrical burns or to explosion due to electrical arcs.

2. PURPOSE

This program serves the purpose to ensure:

- the safety of employees who may work on or near electrical systems.
- qualified employees understand how to comply with safety standards related to electrical safety.
- qualified employees follow uniform practices during the completion of electrical work.

3. SCOPE

The Electrical Safety and Arc Flash Program applies to personnel (including WCSU employees, contractors, and others) who are exposed to, work with, or supervise operations involving work with hazardous electrical energies at the WCSU midtown campus, WCSU westside campus, and related WCSU facilities. To work on energized equipment the individual must be a qualified worker. The scope of the Electrical Safety and Arc Flash Program covers work on live electrical equipment.

4. DEFINITIONS

Arc Flash Hazard- A source of possible injury or damage to health associated with the release of energy caused by an electric arc.

Arc Flash Risk Assessment- A study investigating a worker's potential exposure to arc flash

energy, conducted for the purpose of injury prevention and the determination of safe work practices, arc flash boundary and the appropriate level of personal protective equipment.

AR apparel — Arc Rated Apparel; Fabrics that are Arc Thermal Performance Value (ATPA) tested, which predicts whether a second-degree burn would result, and calculates the energy likely to cause a second-degree burn through that fabric fifty percent of the time. This number is expressed in calories.

Arc Flash Suit — A complete AR clothing and equipment system that covers the entire body, except for the hands and feet. Such a suit typically includes pants, jacket, coveralls, balaclava and a “bee-keeper” style hood or properly rated face shield.

Arc Rating — The maximum incident energy resistance demonstrated by a material (or a layered system of materials) prior to “breaking open” or at the onset of a second-degree skin burn. This rating is assigned to electrical protective clothing and is normally expressed in calories per square centimeter (cal/cm²). Arc-rated 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.

Boundary, Arc Flash- When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm². The onset of a second degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm² 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.

Boundary, Restricted Approach — An approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.

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.

Electrically safe work condition — A state in which the conductor or circuit part to be worked on or near has been disconnected from energized parts, locked/tagged in accordance with the WCSU Control of Hazardous Energy (Lockout/Tagout) Program, tested to verify the absence of voltage, and grounded if determined necessary.

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

Exposed (as applied to live parts) — Capable of being inadvertently touched or not suitably guarded, isolated, or insulated.

Incident energy — The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. One of the units used to measure incident energy is calories per square centimeter (cal/cm²).

PPE — Personal Protective Equipment

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

Unqualified person — Any person who does not meet the definition of a qualified person.

Working near (Energized electrical conductors or circuit parts) — Any activity within a Limited Approach Boundary.

Working on (Energized electrical conductors or circuit parts) — 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 “working on”: *Diagnostic (testing)* is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment; *repair* is any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, ect.)

5. ROLES AND RESPONSIBILITIES

5.1 WCSU Administration

The WCSU Administration is responsible for assuring the University is in compliance with applicable Federal and State Occupational Safety and Health regulations regarding the Electrical Safety Standards as stated in 29 CFR 1910 Subpart S, 29 CFR 1926 Subpart K, NFPA 70 E, and for providing necessary resources to assure the implementation and continuance of this program.

5.2 WCSU Department Directors/Managers/Supervisors

Deans, Directors, Managers, and Supervisors have primary responsibility for the management and enforcement of the Electrical Safety and Arc Flash Program in their areas. They are responsible for:

- Actively supporting the funding for this program as part of the work unit’s overall safety effort.
- Ensuring that responsibilities assigned within this program are carried out within their administrative work unit.
- Designating individuals responsible for the implementation of this program within their work unit.
- Developing and maintaining a list of qualified electrical workers under their supervision.
- Ensuring that employees are trained to their assigned electrical tasks and maintaining documentation of such training.
- Ensuring that the electrical equipment is labeled appropriately.
- Ensuring that energized electrical work permits are utilized per this program.
- Ensuring that employees exposed to live electrical hazards are provided with appropriate protective equipment.
- Ensuring that the electrical safety equipment and personal protective equipment are performance tested per the manufacturer’s recommendations.
- Assisting in the investigation of all injuries and incidents involving electrical work.
- Attending all required training.
- Ensuring employees comply with all provisions of this program.

5.3 WCSU Project Managers/WCSU Personnel Who Hire External Contractors

WCSU Project Managers or individuals responsible for external contractors or vendors that will be conducting electrical work are responsible for:

- Understanding the roles and responsibilities of the contractors or vendors per Section 5.6 of this program and communicating the requirements to the contractors or vendors.
- Communicating electrical energy hazards that may not be evident to the contractor or vendor.
- Where electrical activities conducted by contractors or vendors may or have the potential to create an exposure for WCSU employees and students, assuring:
 - WCSU affected employees are clearly notified of the hazards, the intended electrical operations of the contractor or vendor, methods to minimize exposures, and the equipment or processes that will be impacted during the electrical activities.
 - That all involved WCSU Project Managers, qualified employees, contractors and vendors participate in a pre-planning meeting prior to performing the electrical work.
 - WCSU qualified employees working with or alongside contractors must follow the requirements of this program.
 - Coordination between WCSU Project Managers, contractors and vendors on all electrical projects.

5.4 Environmental Health and Safety (EHS)

- Develop and provide overall administrative support for this program, including interpretation of the regulations.
- Review and update this written program at least every three years or as needed.
- Assist WCSU department personnel with selecting appropriate PPE and electrical testing equipment when requested.
- Provide or coordinate general training for work units on the content of this program.
- Evaluate the overall effectiveness of the electrical safety program on a periodic basis.
- Maintain training records associated with this program.
- Verify that all equipment and PPE have been tested on an annual basis according to the manufacturer's recommendations.

5.5 Qualified Employees

- Follow the electrical safety work practices described in this program, including the use and inspection of PPE.
- Filling out energized electrical work permits when required.
- Participate in all training required by this program.
- Immediately report electrical safety concerns to supervision.

5.6 Contractors and Vendors

Contractors are responsible for ensuring their employees are instructed in the hazards of the job. They must also ensure that:

- They comply with all local, state and federal safety requirements.
- All of their employees and sub-contractors who perform work on WCSU property have been suitably trained to perform the tasks that they have been assigned.

- They provide all necessary tools, personal protective equipment, and electrical safety equipment for their employees to perform the tasks that they have been assigned.
- After the work has been completed, their employees perform a walkthrough of any affected areas with a WCSU representative and remove all tools and equipment.

6. TRAINING

6.1 Classroom Training: Initial and Periodic

- Employees who have the potential to be exposed to an electrical hazard that is not reduced to a safe level by the installation must receive training.
- The level of electrical safety training provided is dependent on whether the employee is classified as a “qualified person” or “unqualified person”.
- A “qualified person” shall be trained and knowledgeable in all of the following topics:
 - Construction and operation of equipment on which work is assigned
 - Skills and techniques necessary to distinguish exposed energized parts from other parts of electrical equipment.
 - Skills and techniques necessary to determine the normal voltage of exposed live parts.
 - The approach distances specified in this program and the corresponding voltages to which the qualified employee may be exposed.
 - The process necessary to determine the degree and extent of electrical hazards along with the PPE and job planning necessary to perform the task safely.
 - Methods of safe release of victims from contact with exposed energized electrical conductors or circuit parts.
- A person can be considered qualified with respect to certain equipment and methods but unqualified for others.
- Employees who perform electrical work on electrical equipment that is 50 volts or higher are encouraged to receive cardiopulmonary resuscitation (CPR) and automatic external defibrillator (AED) training.
- An “unqualified person” shall be trained in the inherent hazards of electricity and any related work practices that are necessary for their safety.
- Training must be provided before the employee is assigned duties that involve work on or near electrical systems.
- EHS shall maintain a record of all electrical safety training provided to University employees.

6.2 Employee Retraining

- Re-training pertaining to NFPA 70E shall occur every three years.
- Additional training (or re-training) is required if any of the following conditions exists:
 - The supervision determines that the employee is not complying with the electrical safety-related work practices.
 - 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.
 - The employee needs to review tasks that are performed less often than once per year.
 - The employee needs to review safety-related work practices not normally used by the employee during regular job duties.

- The employee experiences a change in job duties.

7. WORK INVOLVING ELECTRICAL HAZARDS

7.1 General

This program covers the following:

- (1) When an electrically safe work condition must be established
- (2) Requirements for work involving electrical hazards such as the electrical safety-related work practices, assessments, precautions, and procedures when an electrically safe work condition cannot be established.

All requirements of this program shall apply whether an incident energy analysis is completed or if **Appendix D**, **Appendix E**, and **Appendix G** are used in lieu of an incident energy analysis.

7.2 Electrically Safe Work Conditions

Energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts shall be put into an electrically safe work condition before an employee performs work if any of the following conditions exists:

- (1) The employee is within the limited approach boundary.
- (2) The employee interacts with equipment where conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.

7.2.1 Energized Work

- (1) **Additional Hazards or Increased Risk.** Energized work shall be permitted where the employer can demonstrate that de-energizing introduces additional hazards or increases risk.
- (2) **Infeasibility.** Energized work shall be permitted where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations.
- (3) **Equipment Operating at Less Than 50 Volts.** 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.
- (4) **Normal Operating Condition.** 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. The equipment is properly installed.
 - b. The equipment is properly maintained.

- c. The equipment is used in accordance with instructions included in the listing and labeling and in accordance with manufacturer's instructions.
- d. The equipment doors are closed and secured.
- e. All equipment covers are in place and secured.
- f. There is no evidence of impending failure.

7.2.2 Energized Electrical Work Permit

(1) When Required. When energized electrical work is permitted, an energized electrical work permit shall be required and documented under any of the following conditions:

- a. When work is performed within the restricted approach boundary
- b. When the employee interacts with equipment when conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.

(2) Elements of a Work Permit. According to **Appendix B**, the work permit shall include, but not be limited to, the following items:

- a. Description of the circuit and equipment to be worked on and the job location.
- b. Description of work performed.
- c. Justification for why the work must be performed in an energized condition.
- d. Description of the safe work practices to be employed.
- e. Results of the shock risk assessment.
 - Voltage to which personnel will be exposed
 - Limited approach boundary
 - Restricted approach boundary
 - Personal and other protective equipment required to safely perform the assigned task and to protect against the shock hazard
- g. Results of the arc flash risk assessment.
 - Available incident energy at the working distance of arc flash PPE category
 - Personal and other protective equipment required to protect against the arc flash hazard
 - Arc flash boundary
- h. Means to restrict the access of unqualified persons from the work area
- i. Evidence of completion of the job briefing, including a discussion of any job specific hazards.
- j. Energized work approval signatures.

All Energized Electrical Work Permits are required to be maintained by individual department that perform service or maintenance that require a permit.

(3) Exemptions to Work Permits. Electrical work shall be permitted without an energized electrical work permit if a qualified person is provided with and uses appropriate safe work practices and PPE under any of the following conditions:

- a. Testing, troubleshooting, or voltage measuring
- b. Thermography, ultrasound, or visual inspections if the restricted approach boundary is not crossed
- c. 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
- d. General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed

7.3 Working While Exposed to Electrical Hazards

Safety-related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from electrical conductors or circuit parts that are or can become energized. The specific safety-related work practices shall be consistent with the electrical hazards and the associated risk. Appropriate safety-related work practices shall be determined before any person is exposed to the electrical hazards involved by using both shock risk assessment and arc flash assessment. Only qualified persons shall be permitted to work on or near electrical conductors or circuit parts that have not been put into an electrically safe work condition.

7.4 Shock Risk Assessment

7.4.1 General

A shock risk assessment shall be performed:

- (1)** To identify shock hazards,
- (2)** To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health, and
- (3)** To determine if additional protective measures such as the use of PPE are required.

7.4.2 Additional Protective Measures

If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls. When additional protective measures include the use of PPE, the following shall be determined:

- (1)** The voltage to which personnel will be exposed,
- (2)** The boundary and other protective equipment required, and
- (3)** The personnel and other protective equipment required by this standard to protect against the shock hazard.

7.4.3 Documentation

The results of the shock risk assessment shall be documented.

7.4.4 Shock Protection Boundaries

The shock protection boundaries identified as limited approach boundary and restricted approach boundary shall be applicable where personnel are approaching exposed energized electrical conductors or circuit parts. **Appendix C** shall be used for the distances associated with various AC and DC systems voltages.

Note: In certain instances, the arc flash boundary might be a greater distance from the energized electrical conductors or circuit parts than the limited approach boundary. The shock protection boundaries and the arc flash boundary are independent of each other.

7.4.5 Limited Approach Boundary

(1) Approach by Unqualified Persons. No unqualified person shall be permitted to approach nearer than the limited approach boundary of energized conductors and circuit parts.

(2) Working at or Close to the Limited Approach Boundary. Where one or more unqualified persons are working at or close to the limited approach boundary, the designated person in charge of the work space where the electrical hazard exists shall advise the unqualified person(s) of the electrical hazard and warn him or her to stay outside of the limited approach boundary.

(3) Entering the Limited Approach Boundary. Where there is a need for an unqualified person to cross the limited approach boundary, a qualified person shall advise the unqualified person of the possible hazards and continuously escort the unqualified person while inside the limited approach boundary. Under no circumstance shall unqualified persons be permitted to cross the restricted approach boundary.

7.4.6 Restricted Approach Boundary

No qualified person shall approach or take any conductive object closer to exposed energized electrical conductors or circuit parts than the restricted approach boundary set forth in **Appendix C**, unless one of the following conditions applies:

(1) The qualified person is insulated or guarded from energized electrical conductors or circuit parts operating at 50 volts or more. Insulating gloves and sleeves are considered insulation only with regards to the energized parts upon which work is performed.

(2) The energized electrical conductors or circuit parts are insulated from the qualified person and from any other conductive object at a different potential.

7.5 Arc Flash Risk Assessment

7.5.1 General

An arc flash risk assessment shall be performed:

- (1)** To identify arc flash hazards,
- (2)** To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health, and
- (3)** To determine if additional protective measures are required, including the use of PPE.

7.5.2 Estimate of Likelihood and Severity

The estimate of the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health shall take into consideration the following:

- (1)** The design of the electrical equipment, including its overcurrent protective device and its operating time, and
- (2)** The electrical equipment operating condition and condition of maintenance.

7.5.3 Additional Protective Measures

If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls. When the additional protective measures include the use of PPE, the following shall be determined:

- (1)** Appropriate safety-related work practices,
- (2)** The arc flash boundary, and
- (3)** The PPE to be used within the arc flash boundary.

7.5.4 Documentation

The results of the arc flash risk assessment shall be documented.

7.5.5 Arc Flash Boundary

- (1)** The arc flash boundary shall be the distance at which the incident energy equals 1.2 cal/cm².
- (2)** The arc flash boundary shall be permitted to be determined by **Appendix D** or **Appendix E** when the requirements of these tables apply.

7.5.6 Arc Flash PPE

One of the following methods shall be used for selection of arc flash PPE:

- (1) The incident energy analysis method in accordance with **Appendix F, or**
- (2) The arc flash PPE category method in accordance with **Appendices D, E, and G.**

Either, but not both, methods shall be permitted to be used on the same piece of equipment. Utilize the results of an incident energy analysis to specify the arc flash PPE category in **Appendix G.**

7.5.7 Incident Energy Analysis Method

The incident energy exposure level shall be based on the working distance of the face and chest areas of the employee from a prospective arc source for the specific task to be performed. Arc-rated clothing and other PPE shall be used by the employee based on the incident energy exposure associated with the specific task. Recognizing that incident energy increases as the distance from the arc flash decreases, additional PPE shall be used for any parts of the body that are closer than the working distance at which the incident energy was determined.

The incident energy analysis shall take into consideration the characteristics of the overcurrent protective device and its fault clearing time, including its condition of maintenance.

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

Appendix F identifies the arc-rated clothing and other PPE required of Article 130 and shall be permitted to be used with the incident energy analysis method of selecting arc flash PPE.

7.5.8 Equipment Labeling

Electrical equipment such as switch boards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are found in spaces other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be marked with a label containing all the following information:

- (1) Nominal system voltage
- (2) Arc flash boundary
- (3) At least one of the following:
 - a. Available incident energy and the corresponding working distance, **or** the arc flash PPE category in **Appendix D** or **Appendix E** for the equipment, but not both

- b. Minimum arc rating of clothing
- c. Site-specific level of PPE

The method of calculating and the data to support the information for the label shall be documented. The data shall be reviewed for accuracy at intervals not to exceed 5 years. Where the review of the data identifies a change that renders the label inaccurate, the label shall be updated.

The owner of the electrical equipment shall be responsible for the documentation, installation, and maintenance of the marked label.

7.6 Other Precautions for Personnel Activities

7.6.1 Alertness

(1) When Electrical Hazards Might Exist. Employees shall be instructed to be alert at all time when they are working within the limited approach boundary of energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts and in work situations when electrical hazards might exist.

(2) When Impaired. Employees shall not be permitted to work within the limited approach boundary of energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts, or where other electrical hazards exist, while their alertness is recognizably impaired due to illness, fatigue, or other reasons.

(3) Changes in Scope. Employees shall be instructed to be alert for changes in the job or tasks that could lead the person outside of the electrically safe work condition or expose the person to additional hazards that were not part of the original plan.

7.6.2 Blind Reaching

Employees shall be instructed not to reach blindly into areas that might contain exposed energized electrical conductors or circuit parts where an electrical hazard exists.

7.6.3 Illumination

(1) General. Employees shall not enter spaces where electrical hazards exist unless illumination is provided that enables the employees to perform the work safely.

(2) Obstructed View of Work Area. Where lack of illumination or an obstruction precludes observation of the work to be performed, employees shall not perform any task within the limited approach boundary of energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts or where an electrical hazard exists.

7.6.4 Conductive Articles Being Worn

Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear, or metal framed glasses) shall not be worn within the restricted approach boundary or where they present an electrical contact hazard with exposed energized electrical conductors or circuit parts.

7.6.5 Conductive Materials, Tools, and Equipment Being Handled

(1) General. Conductive materials, tools, and equipment that are in contact with any part of an employee's body shall be handled in a manner that prevents unintentional contact with energized electrical conductors or circuit parts, such as materials and equipment shall include, but not limited to, long conductive objects, such as ducts, pipes and tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, bull floats, and chains.

(2) Approach to Energized Electrical Conductors and Circuit Part. Means shall be employed to ensure that conductive materials do not approach exposed energized electrical conductors or circuit parts any closer than that permitted by electrically safe work conditions.

7.6.6 Confined or Enclosed Work Spaces

When an employee works in a confined or enclosed space (such as manhole or vault) that contains exposed energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts or where an electrical hazard exists, the employer shall provide, and the employee shall use, protective shields, protective barriers, or insulating materials as necessary to avoid inadvertent contact with these parts and the effects of the electrical hazards.

7.6.7 Doors and Hinged Panels

Doors, hinged panels, and the like shall be secured to prevent swinging into an employee and causing the employee to contact exposed energized electrical conductors or circuit parts operating at voltages equal to or greater than 50 volts or where an electrical hazard exists if movement of the door, hinged panel, and the like is likely to create a hazard.

7.6.8 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.

7.6.9 Housekeeping Duties

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 equipment or barriers) are provided to prevent conductive solids such as steel wool, metalized cloth, and silicon carbide, as well as, conductive liquid solutions) shall not be used inside the limited approach boundary unless procedures to prevent electrical contact are followed.

7.6.10 Occasional Use of Flammable Materials

Where flammable materials are present only occasionally, electrical equipment capable of igniting them shall not be permitted to be used, unless measures are taken to prevent hazardous conditions from developing. Such flammable materials shall include, but are not limited to, flammable gases, vapors, or liquids, combustible dust, and ignitable fibers or flyings.

7.6.11 Anticipating Failure

When there is evidence that electric equipment could fail and injure employees, the electric equipment shall be de-energized unless the employer can demonstrate that de-energizing introduces additional hazards or increased risk or is infeasible because of equipment design or operational limitation. Until 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 the safety of the employees.

7.6.12 Routine Opening and Closing of Circuits

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

7.6.13 Reclosing Circuits After Protective Device Operation

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

7.6.14 Safety Interlocks

Only qualified persons following the requirements for working inside the restricted approach boundary as covered by shock protection boundary (**Appendix C**) 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.

8. PERSONAL AND OTHER PROTECTIVE EQUIPMENT

8.1 General

Employees exposed to electrical hazards when the risk associated with the hazard is not adequately reduced by the applicable electrical installation requirements shall be provided with, and shall use, protective equipment that is designed and constructed for the specific part of the body to be protected and for the work to be performed.

8.2 Care of Equipment

Protective equipment shall be maintained in a safe, clean, and reliable condition and in accordance with manufacturers' instructions. The protective equipment shall be visually inspected before each use. Protective equipment shall be stored in a manner to prevent damage from physically damaging conditions and from moisture, dust, or other deteriorating agents.

8.3 Personal Protective Equipment

(1) General. When an employee is working within the restricted approach boundary, he or she shall wear protective clothing and other PPE in accordance with the Arc Flash Risk Assessment. All parts of the body inside the arc flash boundary shall be protected.

(2) Movement and Visibility. When arc-rated clothing is worn to protect an employee, it shall cover all ignitable clothing and shall allow for movement and visibility.

(3) Head, Face, Neck and Chin (Head Area) Protection. Employees shall wear nonconductive head protection wherever there is a danger of head injury from electrical shock or burns due to contact with energized electrical conductors or circuit parts or from flying objects resulting from electrical explosion. Employees shall wear nonconductive protective equipment for face, neck, and chin whenever there is a danger of injury from exposure to electrical explosion. If employees use hairnets or beard nets, or both, these items must be arc rated.

(4) Eye Protection. Employees shall wear protective equipment for the eyes whenever there is danger of injury from electric arcs, flashes, or from flying objects resulting from electrical explosion.

(5) Hearing Protection. Employees shall wear hearing protection whenever working within the arc flash boundary.

(6) Body Protection. Employees shall wear arc-rated clothing wherever there is possible exposure to an electrical arc flash above the threshold incident energy level for a second degree burn (1.2 cal/cm²).

(7) Hand and Arm Protection.

(a) Shock Protection. Employees shall wear rubber insulating gloves with leather protectors where there is a danger of hand injury from electrical shock due to contact with exposed energized electrical conductors or circuit parts. Employees shall wear rubber insulating gloves with leather protectors and rubber insulating sleeves where there is a danger of hand and arm injury from electric shock due to contact with exposed energized electrical conductors or circuit parts. Rubber insulating gloves shall be rated for voltage for which the gloves will be exposed. Rubber insulating gloves shall be permitted to be used without leather protectors, under the following conditions:

- There shall be no activity performed that risks cutting or damaging the glove.
- The rubber insulating gloves shall be electrically retested before reuse.
- The voltage rating of the rubber insulating gloves shall be reduced by 50 percent for class 00 and by one whole class for classes 0 through 4.

(b) Arc Flash Protection. Hand and arm protection shall be worn where there is possible exposure to arc flash burn.

(c) Maintenance and Use. Electrical protective equipment shall be maintained in a safe, reliable condition. Insulating equipment shall be inspected for damage before each day's use and immediately following any incident that can reasonably be suspected of having caused damage. Insulating gloves shall be given an air test, along with the inspection. Electrical protective equipment shall be subjected to periodic electrical tests. Test voltages shall be in accordance with applicable state, federal, or local codes and standards. The maximum intervals between tests shall not exceed the specified schedule in **Appendix H**.

(8) Foot Protection. Where insulated footwear is used as protection against step and touch potential, dielectric footwear shall be required. Insulated soles shall not be used as primary electrical protection.

(9) Factors in Selection of Protective Clothing. Clothing and equipment that provide worker protection from shock and arc flash hazards shall be used. If arc-rated clothing is required, it shall cover associated parts of the body, as well as, all flammable apparel while allowing movement and visibility.

Clothing and equipment required for the degree of exposure shall be permitted to be worn alone or integrated with flammable, nonmelting apparel. Garments that are not arc rated shall not be permitted to be used to increase the arc rating of a garment or of a clothing system.

(a) Layering. Nonmelting, flammable fiber garments shall be permitted to be used as underlayers in conjunction with arc-rated garments in a layered system. If nonmelting, flammable fiber garments are used as underlayers, the system arc rating shall be

sufficient to prevent breakopen of the innermost arc-rated layer at the expected arc exposure incident energy level to prevent ignition of flammable underlayers. Garments that are not arc rated shall not be permitted to be used to increase the arc rating of a garment or of a clothing system.

- (b) **Outer Layers.** Garments worn as outer layers over arc-rated clothing, such as jackets or rainwear, shall also be made from arc-rated materials.
- (c) **Underlayers.** Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric underlayers.
- (d) **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.
- (e) **Fit.** Tight-fitting clothing shall be avoided. Loose-fitting clothing provides additional thermal insulation because of air spaces. Arc-rated apparel shall fit properly such that it does not interfere with the work task.
- (f) **Interference.** The garment selected shall result in the least interference with the task but still provide the necessary protection. The work method, location, and task could influence the protective equipment selected.

(10) Arc Flash Protective Equipment.

- (a) *Arc Flash Suits.* Arc Flash suit design shall permit easy and rapid removal by the wearer. The entire arc flash suit, including the hood's face shield, shall have an arc rating that is suitable for the arc flash exposure. When exterior air is supplied into the hood, the air hoses and pump housing shall be either covered by arc-rated materials or constructed of nonmelting and nonflammable materials.
- (b) *Head Protection.*
 - (1) An arc-rated hood or an arc-rated balaclava with an arc-rated face shield shall be used when the back of the head is within the arc flash boundary.
 - (2) An arc-rated hood shall be used when the anticipated incident energy exposure exceeds 12 cal/cm².
- (c) *Face Protection.* Face shields shall have an arc rating suitable for the arc flash exposure. Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area shall be used. Face shields without an arc rating shall not be used. Eye protection (safety glasses or goggles) shall always be worn under face shields or hoods.
- (d) *Hand Protection.*
 - (1) Heavy-duty leather gloves or arc-rated gloves shall be worn where required for arc flash protection.
 - (2) Where insulating rubber gloves are used for shock protection, leather protectors shall be worn over the rubber gloves.

(e) *Foot Protection.* Heavy-duty leather footwear or dielectric footwear or both provide some arc flash protection to the feet and shall be used in all exposures greater than 4 cal/cm².

(11) Clothing Material Characteristics.

Clothing consisting of fabrics, zipper tapes, and findings made from flammable synthetic materials that melt at temperatures below 600°F, such as acetate, acrylic, nylon, polyester, polyethylene, and spandex, either alone or in blends, shall not be worn.

(12) Clothing and Other Apparel Not Permitted. Clothing and other apparel (such as hard hat liners and hair nets) made from materials that do not meet the requirements of the clothing material characteristics regarding melting or made from materials that do not meet the flammability requirements shall not be worn.

(13) Care and Maintenance of Arc-rated Clothing and Arc-rated Arc Flash Suits.

(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.* The garment manufacturer's instructions for 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 instructions shall be followed to avoid loss of protection. 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) Arc Flash Category Method. The below requirements shall apply when the arc flash PPE category method is used for the selection of the arc flash PPE.

(a) *Alternating Current (AC) Equipment.* When the arc flash risk assessment indicates that arc flash PPE is required and the arc flash PPE category method is used for the selection of PPE for AC systems in lieu of the incident energy analysis of **Appendix F, Appendix D** shall be used to determine the arc flash PPE category. The estimated maximum available fault current, maximum fault-clearing times, and minimum working distances for various AC equipment types or classifications are listed in **Appendix D**. An incident energy analysis shall be required in accordance with an Arc Flash Risk Assessment for the following:

(1) Power systems with greater than the estimated maximum available fault current,

(2) Power systems with longer than the maximum fault clearing times, and

(3) Less than the minimum working distance.

(b) *Direct Current (DC) Equipment.* When the arc flash risk arc flash PPE is required and the arc flash PPE category method is used for the selection of PPE for DC systems in lieu of the incident energy analysis of **Appendix F, Appendix E** shall be used to determine the arc flash PPE category. The estimated maximum available fault current, maximum arc duration, and working distances for DC equipment are listed in **Appendix E**. An incident energy analysis shall be required in accordance with arc flash risk assessment for the following:

(1) Power systems with greater than the estimated maximum available fault current,

(2) Power systems with longer than the maximum fault clearing times, and

(3) Less than the minimum working distance.

(c) *Protective Clothing and PPE.* Once the arc flash PPE category has been identified from **Appendix D or Appendix E, Appendix G** shall be used to determine the required PPE for the task. **Appendix G** lists the requirements for PPE based on arc flash PPE categories 1 through 4. This clothing and equipment shall be used when working within the arc flash boundary.

8.4 Other Protective Equipment

(1) Insulated Tools and Equipment. Employees shall use insulated tools or handling equipment, or both, when working inside the restricted approach boundary of exposed energized electrical conductors or circuit parts where tools or handling equipment might make unintentional contact. Insulated tools shall be protected from damage to the insulating material.

The following requirements shall apply to insulated tools:

(a) Insulated tools shall be rated for 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. The inspection shall look for damage to the insulation or damage that can limit the tool from performing its intended function or could increase the potential for an incident.

(2) 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 of circuit parts. Nonconductive ladders shall meet the requirements of applicable state, federal, or local codes and standards.

8.5 Alerting Techniques

(1) Safety Signs and Tags. Safety signs, safety symbols, or tags shall be used where necessary to warn employees about electrical hazards that might endanger them.

(2) Barricades. Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas containing energized conductors or circuit parts. Conductive barricades shall not be used where it might increase the likelihood of exposure to an electrical hazard. Barricades shall be placed no closer than the limited approach boundary. Where the arc flash boundary is greater than the limited approach boundary, barricades shall not be placed closer than the arc flash boundary.

(3) Attendants. If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees. The primary duty and responsibility of an attendant providing manual signaling and alerting shall be to keep unqualified employees outside a work area where the potential to be exposed to electrical hazards exists. An attendant shall remain in the area while there is a potential for employees to be exposed to the electrical hazards.

(4) Cutting, Removing, or Rerouting of Conductors. Where conductors are de-energized in order to cut, remove, or reroute them and conductor terminations are not within sight, such as where they are in a junction or pull box, additional steps to verify absence of voltage or identify the conductors shall be taken prior to cutting, removing, or rerouting the conductors.

9. RECORDKEEPING

- Records shall be maintained by individual departments that perform electrical service or maintenance within the scope of this program.
- Records must be kept in a location that is secure and accessible to individuals who manage the records for the department.
- Records must be made available to EHS, internal auditors, and external agencies.
- Record that must be kept include:

Records to Maintain	Retention	Department
Departmental qualified employee training <ul style="list-style-type: none">• Classroom	Current active qualified employees for length of employment plus 3 years	Individual department and EHS
Departmental qualified employee training <ul style="list-style-type: none">• On-The-Job Training	Current active qualified employees for length of employment plus 3 years	Individual department
List of qualified employees	N/A ^a	Individual department
Energized Electrical Work Permit	1 year	Individual department

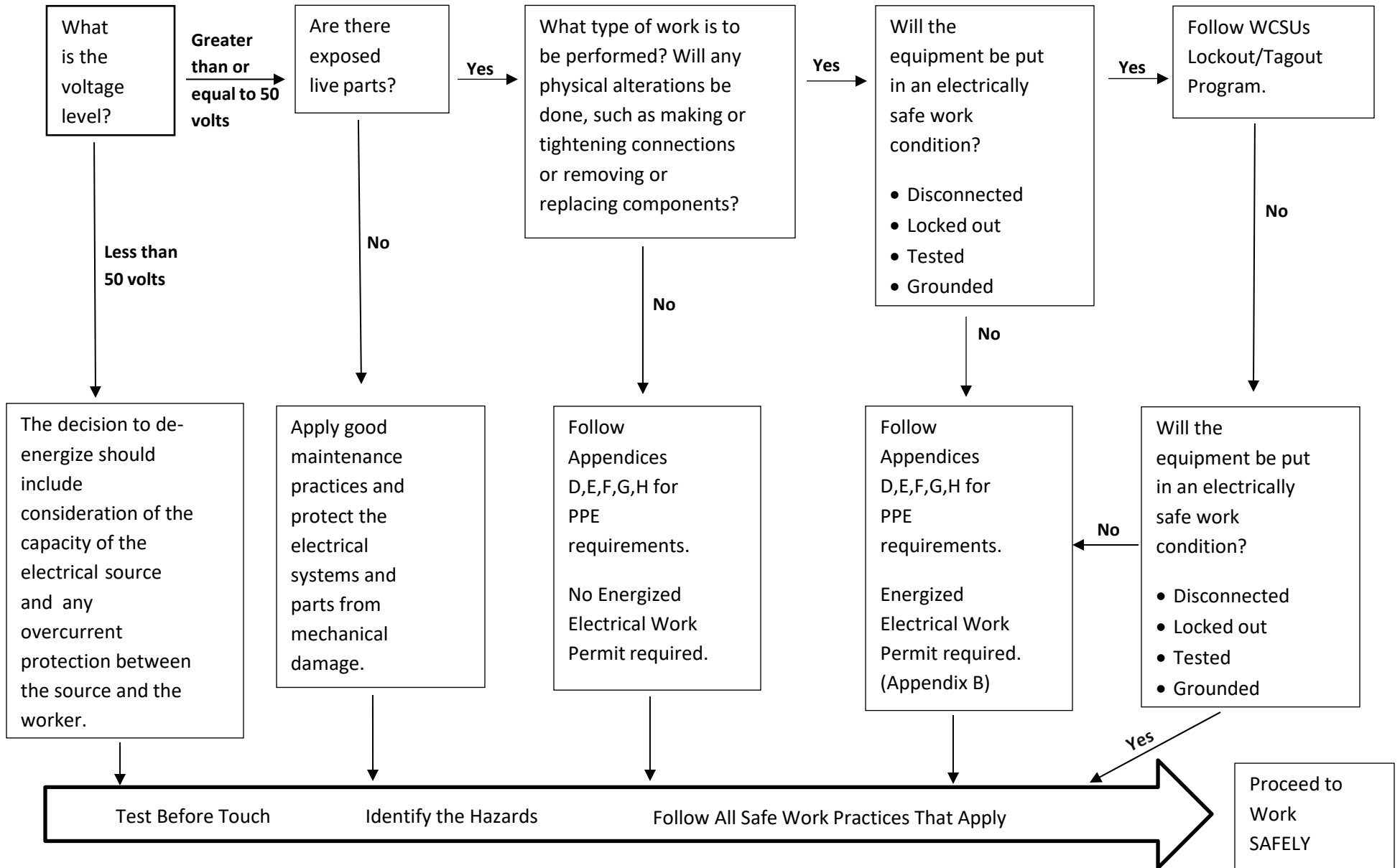
^a List needs to be kept up-to-date

10. REFERENCES

- NFPA 70E, Standard for Electrical Safety in the Workplace: 2018 edition
- OSHA 29 CFR 1910.331 through 1910.335, Electrical Safety-Related Work Practices
- WCSU Control of Hazardous Energy (Lockout/Tagout) Program

APPENDICES

Appendix A: Energized Electrical Work Flow Chart



Appendix C: Approach Boundaries to Live Parts for Shock Protection

(All dimensions are distances from live part to employee)

NFPA 70E 2018: Table 130.4 (D) (a) Alternating Current (AC) Systems

Nominal System Voltage (phase to phase) ^a	Limited Approach Boundary ^b		Restricted Approach Boundary ^b ; Includes Inadvertent Movement Adder
	Exposed Movable Conductor ^c	Exposed Fixed Circuit Part	
Less than 50V	Not specified	Not specified	Not specified
50V to 300V	10 ft	3 ft 6 in	Avoid Contact
301V to 750V	10 ft	3 ft 6 in	1 ft
751V to 15 kV	10 ft	5 ft	2 ft 2 in
15.1 kV - 36 kV	10 ft	6 ft	2 ft 9 in
36.1 kV - 46 kV	10 ft	8 ft	2 ft 9 in
46.1 kV - 72.5 kV	10 ft	8 ft	3 ft 6 in
72.6 kV - 121 kV	10 ft 8 in	8 ft	3 ft 6 in
138 kV - 145 kV	11 ft	8 ft	3 ft 10 in
161 kV - 169 kV	11 ft 8 in	11 ft 8 in	4 ft 3 in
230 kV - 242 kV	13 ft	13 ft	5 ft 8 in
345 kV - 362 kV	15 ft 4 in	15 ft 4 in	9 ft 2 in
500 kV - 550 kV	19 ft	19 ft	11 ft 8 in
765 kV - 800 kV	23 ft 9 in	23 ft 9 in	15 ft 11 in

Notes:

(1) For arc flash boundary, see 130.5 A

(2) All dimensions are distances from exposed energized electrical conductors or circuit part to employee

^a For single-phase systems above 250 volts, select the range that is equal to the systems maximum phase to ground multiplied by 1.732.

^b See definition in Article 100 and text 130.4 (D) (a) 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 the overhead line conductors supported by poles.

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

NFPA 70E 2018: Table 130.4 (D) (b) Direct Current (DC) Voltage Systems

Nominal System Voltage (phase to phase)	Limited Approach Boundary		Restricted Approach Boundary; Includes Inadvertent Movement Adder
	Exposed Movable Conductor ^c	Exposed Fixed Circuit Part	
Less than 50V	Not specified	Not specified	Not specified
50V to 300V	10 ft	3 ft 6 in	Avoid Contact
301V to 1 kV	10 ft	3 ft 6 in	1 ft
1.1 kV - 5 kV	10 ft	5 ft	1 ft 5 in
5 kV - 15 kV	10 ft	5 ft	2 ft 2 in
15.1 kV - 45 kV	10 ft	8 ft	2 ft 9 in
45.1 kV - 75 kV	10 ft	8 ft	3 ft 6 in
75.1 kV - 150 kV	10 ft 8 in	10 ft	3 ft 10 in
150.1 kV - 250 kV	11 ft 8 in	11 ft 8 in	5 ft 3 in
250.1 kV - 500 kV	20 ft	20 ft	11 ft 6 in
500.1 kV - 800 kV	26 ft	26 ft	16 ft 5 in

Note: All dimensions are distance from exposed energized electrical conductors or circuit parts to worker.

^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 the overhead line conductors supported by poles.

Appendix D: Arc-Flash PPE Categories for Alternating Current (AC) Systems

NFPA 70E 2018: Table 130.7 (C)(15)(a) – Arc-Flash PPE Categories for Alternating Current (AC) Systems

Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Panelboards or other equipment rated 240 volts and below Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycle) fault clearing time; minimum working distance 455mm (18 in.)	1	485 mm (19 in)
Panelboards or other equipment rated greater than 240 volts and up to 600 volts Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycle) fault clearing time; minimum working distance 455mm (18 in.)	2	900 mm (3 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Maximum of 42 kA available fault current; maximum of up to 0.33 sec (20 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	4.3 m (14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Maximum of 35 kA available fault current; maximum of up to 0.5 sec (30 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	6 m (20ft)
Other 600-volt class (277 volts through 600 volts, nominal) equipment Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Maximum of 35 kA working distance 910 mm (36 in.)	4	12 m (40 ft)
Metal- clad switchgear, 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)

<p>Arc-resistant switchgear 1 kV through 15 kV [for clearing times of less than 0.5 sec (30 cycles) with an available fault current not to exceed the arc-resistant rating of the equipment], and metal-enclosed interrupter switchgear, fused or unfused of arc-resistant-type construction, 1 kV through 15 kV</p> <p>Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)</p>	<p>N/A (doors closed)</p> <p>4 (doors open)</p>	<p>N/A (doors closed)</p> <p>12 m (40 ft)</p>
<p>Other equipment 1 kV through 15 kV</p> <p>Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)</p>	<p>4</p>	<p>12 m (40 ft)</p>

Note: For equipment rated 600 volts and below and protected by upstream current-limiting fuses or current-limiting circuit breakers sized at 200 amperes or less, the arc flash PPE category can be reduced by one number but not below arc flash category 1.

Informational Note 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 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 of relay operated trip.
- (4) 5.0 cycle fault clearing time is typical for relay operated circuit breakers rated 1 kV to 35 kV when the relay operates in 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 instantaneous trip.
- (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.

Informational Note No. 1: See Table 1 of IEEE 1584TM, *Guide for Performing Arc Flash Hazard Calculations*, for further information regarding Notes b through d of Appendix C.

Informational Note No. 2: An example of a standard that provides information for arc-resistant switchgear referred to in Table 130.7 (C)(15)(a) is IEEE C37.20.7, *Guide for Testing Metal-Enclosed Switch gear Rated Up to 38 kV for Internal Arcing Faults*.

Appendix E: Arc-Flash PPE Categories for Direct Current (DC) Systems

NFPA 70E 2018 : Table 130.7 (C)(15)(b) – Arc-Flash PPE Categories for 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 V. Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.)		
Available fault current less than 4 kA	2	900 mm (3ft)
Available fault current greater than or equal to 4 kA and less than 7 kA	2	1.3 m (4 ft)
Available fault current greater then or equal to 7 kA and less than 15 kA	3	1.8 m (6 ft)
Storage batteries, DC switchboards and other DC supply sources Parameters: Greater than 250 V and less than or equal to 600 V Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.)		
Available fault current less than 1.5 kA	2	900 mm (3 ft)
Available fault current greater than or equal to 1.5 kA and less than 3 kA	2	1.3 m (4 ft)
Available fault current greater than or equal to 3 kA and less than 7 kA	3	1.8 m (6 ft)
Available fault current greater than or equal to 7 kA and less than 10 kA	4	2.5 m (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
Informational Note: ASTM 1296, *Standard Guide for Evaluating Chemical Protective Clothing*, contains information on evaluating apparel for protection from electrolyte.
 - b. Be arc-rated
Informational Note: ASTM F1891, *Standard Specifications for Arc Rated and Flame-Resistant Rainwear*, contains information on evaluating arc-rated apparel.
- (2) A two-second arc duration is assumed if there is no overcurrent protective device (OCPD) or if the fault clearing time is known and is less than 2 seconds; an incident energy analysis could provide a more representative result.

Informational Note No. 1: When determining available fault current, the effects of cables and any other impedances in the circuit should be included. Power system modeling is the best method to determine the available short-circuit current at the point of the arc. Battery cell short-circuit current can be obtained from the battery manufacturer. See informative Annex D.5 for the basis for table values and alternative methods to determine DC incident energy. Methods should be used with good engineering judgement.

Informational Note No. 2: The methods for estimating the DC arc-flash incident energy that were used to determine the categories for this table are based on open-air incident energy calculations. Open-air calculations were used because many battery systems and other DC process systems are in open areas or rooms. If the specific task is within an enclosure, it would be prudent to consider additional PPE protection beyond the value shown in this table. Research with arc flash has shown a multiplier of as much as 3x for arc-in-a-box [508 mm (20 in.) cube] versus open air. Engineering judgment is necessary when reviewing the specific conditions of the equipment and task to be performed, including the dimensions of the enclosure and the working distance involved.

Appendix F: PPE When the Incident Energy Analysis Method Is Used

NFPA 70E 2018 Table 130.5 (G) – Selection of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method Is Used

Incident energy exposure equal to 1.2 cal/cm ² up to 12 cal/cm ²	Incident energy exposure greater than 12 cal/cm ²
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy	Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy
Long-sleeve shirt and pants or coverall or arc flash suit (SR)	Long-sleeve shirt and pants or coverall or arc flash suit (SR)
Arc-rated face shield and arc-rated balaclava or arc flash suit hood (SR) ^b	Arc-rated arc flash suit hood
Arc-rated outerwear(e.g. jacket, parka, rainwear, hard hat liner) (AN)	Arc-rated outerwear(e.g. jacket, parka, rainwear, hard hat liner) (AN)
Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors(SR) ^c	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors(SR) ^c
Hard Hat	Hard Hat
Safety Glasses or Safety Goggles (SR)	Safety Glasses or Safety Goggles (SR)
Hearing Protection	Hearing Protection
Leather Footwear	Leather Footwear

SR: Selection of one in group is required

AN: As needed

^a Arc ratings can be for a single layer, such as an arc-rated shirt and pants or a coverall, or for an arc flash suit or a multi-layer system if tested as a combination consisting of an arc-rated shirt and pants, coverall, and arc flash suit.

^b Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area are required by 130.7 (C)(10)(c). Where the back of the head is inside the arc flash boundary, a balaclava or an arc flash hood shall be required for full head and neck protection.

^c 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.

Appendix G: Personal Protective Equipment (PPE)

NFPA 70E 2018 Table 130.7 (C)(15)(c) – Arc-Flash PPE Category

Risk Category	Min. Arc Rating of PPE	PPE Requirements – NFPA -70E 2018
1	4 cal/cm ²	<ol style="list-style-type: none"> 1. Arc-rated long-sleeve shirt and pants or arc-rated coverall 2. Arc-rated face shield^b or arc flash suit hood 3. Arc-rated jacket, parka, rainwear, or hard hat liner (AN) <p>Protective Equipment</p> <ol style="list-style-type: none"> 4. Hard hat 5. Safety glasses or safety goggles (SR) 6. Hearing protection (ear canal inserts)^c 7. Heavy-duty leather gloves^d 8. Leather footwear (AN)
2	8 cal/cm ²	<ol style="list-style-type: none"> 1. Arc-rated long-sleeve shirt and pants or Arc-rated coverall 2. Arc-rated flash suit hood or arc-rated face shield^b and arc-rated balaclava 3. Arc-rated jacket, parka, rainwear, or hard hat liner (AN) <p>Protective Equipment</p> <ol style="list-style-type: none"> 4. Hard hat 5. Safety glasses or safety goggles (SR) 6. Hearing protection (ear canal inserts)^c 7. Heavy-duty leather gloves^d 8. Leather footwear (AN)
3	25 cal/cm ²	<ol style="list-style-type: none"> 1. Arc-rated long-sleeve shirt (AR) 2. Arc-rated pants (AR) 3. Arc-rated coverall (AR) 4. Arc-rated flash suit jacket (AR) 5. Arc-rated flash suit pants (AR) 6. Arc-rated flash suit hood 7. Arc-rated gloves^d 8. Arc-rated jacket, parka, rainwear, or hard hat liner (AN) <p>Protective Equipment</p> <ol style="list-style-type: none"> 9. Hard hat 10. Safety glasses or safety goggles (SR) 11. Hearing protection (ear canal inserts)^c 12. Heavy-duty leather gloves^d 13. Leather footwear (AN)
4	40 cal/cm ²	<ol style="list-style-type: none"> 1. Arc-rated long-sleeve shirt (AR) 2. Arc-rated pants (AR) 3. Arc-rated coverall (AR) 4. Arc-rated flash suit jacket (AR) 5. Arc-rated flash suit pants (AR) 6. Arc-rated flash suit hood 7. Arc-rated gloves^d 8. Arc-rated jacket, parka, rainwear, or hard hat liner (AN) <p>Protective Equipment</p> <ol style="list-style-type: none"> 9. Hard hat 10. Safety glasses or safety goggles (SR) 11. Hearing protection (ear canal inserts)^c 12. Heavy-duty leather gloves^d 13. Leather footwear (AN)

AN: As needed (optional). **AR:** As required. **SR:** Selection required

^a Arc rating is defined in Article 100.

^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 If rubber insulating gloves with leather protectors are used, additional leather or arc-rated gloves are not required. The combination of rubber insulated gloves with leather protectors satisfies the arc flash protection requirement.

Figure 1: PPE Clothing Based on Hazard Risk Levels





PPE CATEGORY 1	PPE CATEGORY 2	PPE CATEGORY 3	PPE CATEGORY 4
<p>Minimum Arc Rating of 4 cal/cm²</p> <p>Arc Rated Clothing:</p> <ul style="list-style-type: none"> • AR long-sleeve shirt and pants, or AR coverall • AR face shield, or AR flash suit hood • AR jacket, parka, rainwear, or hard hat liner (as needed) <p>Protective Equipment:</p> <ul style="list-style-type: none"> • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Heavy-duty leather gloves • Leather footwear (as needed) 	<p>Minimum Arc Rating of 8 cal/cm²</p> <p>Arc Rated Clothing:</p> <ul style="list-style-type: none"> • AR long-sleeve shirt and pants, or AR coverall • AR flash suit hood, or AR face shield and AR balaclava • AR jacket, parka, rainwear, or hard hat liner (as needed) <p>Protective Equipment:</p> <ul style="list-style-type: none"> • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Heavy-duty leather gloves • Leather footwear 	<p>Minimum Arc Rating of 25 cal/cm²</p> <p>Arc Rated Clothing:</p> <ul style="list-style-type: none"> • As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and/or AR flash suit pants • AR flash suit hood • AR gloves • AR jacket, parka, rainwear, or hard hat liner (as needed) <p>Protective Equipment:</p> <ul style="list-style-type: none"> • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Leather footwear (as needed) 	<p>Minimum Arc Rating of 40 cal/cm²</p> <p>Arc Rated Clothing:</p> <ul style="list-style-type: none"> • As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and/or AR flash suit pants • AR flash suit hood • AR gloves • AR jacket, parka, rainwear, or hard hat liner (as needed) <p>Protective Equipment:</p> <ul style="list-style-type: none"> • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Leather footwear (as needed) 

Figure 2: Voltages for Insulated Rubber Gloves

Rubber Glove Class	Protection Against Voltage Up To:
00	500 V
0	1,000 V
1	7,500 V
2	17,000 V
3	26,500 V
4	36,000 V

Appendix H: Inspection Schedule for Rubber Insulating Equipment

NFPA 70E 2018: Table 130.7 (C)(7) – Rubber Insulating Equipment, Maximum Test Intervals

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

* New insulating equipment is not permitted to be placed into service unless it has been electrically tested within the previous 12 months. Insulating equipment that has been issued for service and is not new is required to be retested in accordance with the intervals in this table.
