

# ARC Flash Boundary & NFPA-70E Requirements PPE Program

## 1. Purpose and Scope

The Arc Flash Boundary – PPE Program was developed to minimize the risk to AMS employees from safety and health hazards in the work place related to the discharge of electrical energy when working within the arc flash boundary distance. The type of electrical equipment, voltage of the equipment and job task being performed determines this distance. The protection shall be provided by the correct selection of PPE when employees are within the Arc Flash Boundary Distance.

This program meets the requirements establish by OSHA's Electric Power Transmission 1910.269(l)(1)m Distribution Standards 1910.269(l)(6)(iii) and Safety Related Electrical Work Practices 1910.331, Electrical Protective Devices 1910.137, as well as National Fire Protection Association (NFPA) standards No. 70 National Electrical Code, and No. 70 E Personal and Other Protective Equipment.

The general requirements of the ~~ARC~~ Arc Flash Boundary (AFB) - Personal Protection Equipment (PPE) program include access to reference tables, personal protective equipment matrix, equipment selection electrical assessment, signage, proper equipment storage and training.

## 2. Definitions

Arc Flash Boundary (ARC) – is the distance at which an electrical arc can flash outward, which may endanger employees working on electrical equipment.

Flash Protection Boundary (FPB) – the calculated safe working distance from electrical equipment which would not expose the employee to the hazards associated with an electrical arc flash.

Electrical Assessment – an analytical evaluation which would calculate the arc flash potential of an electrical component / hazard, used to establish the flash protection boundary and the correct level of required PPE, determined by an electrical engineer or the equivalent.

Qualified Employees (per NFPA 70E, 2000 Edition, Standard for Electrical Safety Requirements for Employee Workplaces) – a qualified person shall be trained and knowledgeable of the construction and operation of equipment or a specific work method, and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Such persons shall also be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding material, and insulating

tools and test equipment. A person can be considered qualified with respect to certain equipment and methods but still be unqualified for others. Such persons permitted to work within limited approach of exposed energized conductors and circuit parts shall at a minimum, be additionally trained in the following;

- The skills and techniques necessary to distinguish exposed energized parts from other parts of the electric equipment.
- The skills and techniques necessary to determine the nominal voltage of exposed energized parts.
- The approach distance specified in the tables and the corresponding voltage to which the qualified person will be exposed.
- Employees will be capable of reading and understanding the attached PPE matrix, and listed approach boundaries and hazard/risk category tables, which are necessary to perform the task safely.

### **3. Working on or Near Living Parts**

#### Justification for Work

Live parts to which an employee might be exposed shall be put into an electrically safe work condition before an employee works on or near them, unless the employer can demonstrate that deenergizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. Energized parts that operate at less than 50 volts to ground shall not be required to be deenergized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.

#### Energized Electrical Work Permit

##### A. Where Required

If live parts are not placed in an electrically safe work condition (for the reasons of increased or additional hazards or infeasibility) work to be performed shall be considered energized electrical work and shall be performed by written permit only.

##### B. Elements of Work Permit

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

- A description of the circuit and equipment to be worked on and their location.
- Justification for why the work must be performed in an energized condition.
- A description of the safe work practices to be employed.
- Results of the shock hazards analysis.
- Determination of shock protection boundaries.  
Results of the flash hazard analysis.

- The Flash Protection Boundary
- The necessary personal protective equipment to safely perform the assigned task.
- Means employed to restrict the access of unqualified persons from the work area.
- Evidence of completion of a job briefing, including a discussion of any job-specific hazards:
- Energized work approval (authorizing or responsible management, safety officer, or owner, etc.) signature(s).

C. Exemptions to work Permit

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

#### 4. Approach Boundaries to Live Parts

A. Shock Hazard Analysis

A shock hazard analysis shall determine the voltage to which personnel will be exposed, boundary requirements, and the personnel protective equipment necessary in order to minimize the possibility of electric shock to personnel.

B. Shock Protection Boundaries

The shock protection boundaries identified as Limited, Restricted, and Prohibited Approach Boundaries are applicable to the situation in which approaching personnel are exposed to live parts. See NFPA Table 130.2(C) for the distances associated with various system voltages.

C. Approach to Exposed Live Parts Operating at 50 Volts or More

No qualified person shall approach or take any conductive object closer to exposed live parts operating at 50 volts or more than the Restricted Approach Boundary set forth in NFPA Table 130.2(C), unless any of the following apply:

- The qualified person is insulated or guarded from the live parts operating at 50 volts or more (insulating gloves or insulating gloves and sleeves are considered insulation only with regard to the energized parts upon which work is being performed), and no uninsulated part of the qualified person's body crosses the Prohibited Approach Boundary set forth in Table 130.2(C).
- The live part operating at 50 volts or more is insulated from the qualified person and from any other conductive object at a different potential.
- The qualified person is insulated from any other conductive object as during live-line bare-hand work.

D. Approach by Unqualified Persons

Unqualified persons shall not be permitted to enter spaces that are accessible to qualified employees only, unless the electric conductors and equipment involved are in an electrically safe work condition.

**E. 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 cooperate with the designated person in charge of the unqualified person(s) to ensure that all work can be done safely. This shall include advising and warning him or her to stay outside of the Limited Approach Boundary.

**Table 130.2(C) Approach Boundaries to Live Parts for Shock Protection (all dimensions are distance from live part to employee).**

Nominal System Voltage Range, Phase to Phase	Limited Approach Boundary		Restricted Approach Boundary; Includes Inadvertent Movement Adder	Prohibited Approach Boundary
	Exposed Movable Conductor	Exposed Fixed Circuit Part		
Less than 50	Not specified	Not specified	Not specified	Not specified
50 to 300	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	Avoid contact	Avoid Contact
301 to 750	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	304.8 mm (1ft 0 in.)	25.4 mm (0 ft 1 in.)
751 to 15 kV	3.05 m (10 ft 0 in.)	1.53 m (5ft 0 in.)	660.4 mm (2 ft 2 in.)	177.8 mm (0 ft 7 in.)
15.1 kV to 36 kV	3.05 m (10 ft 0 in.)	1.83 m (6 ft 0 in.)	787.4 mm (2 ft 7 in.)	254 mm (0 ft 10 in.)
36.1 kV to 46 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	838.2 mm (2 ft 9 in.)	431.8 mm (1 ft 5 in.)
46.1 kV to 72.5 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	965.2 mm (3 ft 2 in.)	635 mm (2 ft 1 in.)
72.6 kV to 121 kV	3.25 m (10 ft 8 in.)	2.44 m (8 ft 0 in.)	991 mm (3 ft 3 in.)	812.8 mm (2 ft 8 in.)
138 kV to 145 kV	3.36 m (11 ft 0 in.)	3.05 m (10 ft 0 in.)	1.093 m (3 ft 7 in.)	939.8 mm (3 ft 1 in.)
161 kV to 169 kV	3.56 m (11 ft 8 in.)	3.56 m (11 ft 8 in.)	1.22 m (4 ft 0 in.)	1.07 m (3 ft 6 in.)
230 kV to 242 kV	3.97 m (13 ft 0 in.)	3.97 m (13 ft 0 in.)	1.6 m (5 ft 3 in.)	1.45 m (4 ft 9 in.)
345 kV to 362 kV	4.68 m (15 ft 4 in.)	4.68 m (15 ft 4 in.)	2.59 m (8 ft 6 in.)	2.44 m (8 ft 0 in.)
500 kV to 550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.43 m (11 ft 3 in.)	3.28 m (10 ft 9 in.)
765 kV to 800 kV	7.24 m (23 ft 9 in.)	7.24 m (23 ft 9 in.)	4.55 m (14 ft 11 in.)	4.4 m (14 ft 5 in.)

**F. Entering the Limited Approach Boundary**

Where there is a need for an unqualified person(s) to cross the Limited Approach Boundary, a qualified person shall advise him or her of the possible hazards and continuously escort the unqualified person(s) while inside the limited Approach Boundary. Under no circumstance shall the escorted unqualified person(s) be permitted to cross the Restricted Approach Boundary.

**G. Flash Hazard Analysis**

A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use.

#### H. Flash Protection Boundary

For systems that are 600 volts or less, the Flash Protection Boundary shall be 4.0 ft, based on the product of clearing times of 6 cycles (0.1 second) and the available bolted fault current of 50kA or any combination not exceeding 300 kA cycles (5000 ampere seconds). For clearing times and bolted fault currents other than 300 kA cycles, or under engineering supervision, the Flash Protection Boundary shall alternatively be permitted to be calculated in accordance with the following general formula:

$$D_c = [2.65 \times MVA_{bf} \times t]^{1/2} \quad \text{or} \quad D_c = [53 \times MVA \times t]^{1/2}$$

Where:

$D_c$  = distance in feet from an arc source for a second-degree burn

$MVA_{bf}$  = bolted fault capacity available at point involved (in mega volt-amperes)

MVA = capacity rating of transformer (mega volt-amperes). For transformers with MVA ratings below 0.75 MVA, multiply the transformer MVA rating by 1.25

$t$  = time of arc exposure (in seconds)

At voltage levels above 600 volts, the Flash Protection Boundary is the distance at which the incident energy equals  $5 \text{ J/cm}^2$  ( $1.2 \text{ cal/cm}^2$ ). For situations where fault-clearing time is 0.1 seconds (or faster), the Flash Protection Boundary is the distance at which the incident energy level equals  $6.24 \text{ J/cm}^2$  ( $1.5 \text{ cal/cm}^2$ ).

#### I. Protective Clothing and Personal Protective Equipment for Application with a Flash Hazard Analysis.

Where it has been determined that work will be performed within the Flash Protection Boundary, the flash hazard analysis shall determine, the employer shall document, the incident energy exposure of the worker (in calories per square centimeter). The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. Flame-resistant (FR) clothing and personal protective equipment (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 distance at which the incident energy was determined as an alternative, the PPE requirements of 130.7(C) shall be permitted to be used in lieu of the detailed flash hazard analysis approach.

#### J. Test Instruments and Equipment Use

Only qualified persons shall perform testing work on or near live parts operating at 50 volts or more.

### 5. Work On or Near Uninsulated Overhead Lines

A. Uninsulated and Energized

Where work is performed in locations containing uninsulated energized overhead lines that are not guarded or isolated, precautions shall be taken to prevent employees from contacting such lines directly with any unguarded parts of their body or indirectly through conductive materials, tools, or equipment. Where the work to be performed is such that contact with uninsulated energized overhead is possible, the lines shall be deenergized and visibly grounded at the point of work, or suitably guarded.

B. Deenergizing or Guarding

If the lines are to be deenergized, arrangements shall be made with the person or organization that operates or controls the lines to deenergize them and visibly ground them at the point of work. If arrangements are made to use protective measures, such as guarding, isolating, or insulation, these precautions shall prevent each employee from contacting such lines directly with any part of his body or indirectly through conductive materials, tools, or equipment.

C. Employer and Employee Responsibility

AMS shall be responsible for ensuring that guards or protective measures are satisfactory for the conditions. Employees shall comply with established work methods and the use of protective equipment.

D. Approach Distance for Unqualified Persons

When employees without electrical training are working on the ground or in an elevated position near overhead lines, the location shall be such that the employee and the longest conductive object the employee might contact cannot come closer to any unguarded, energized overhead power line than the Limited Approach Boundary. If the voltage on the line exceeds 50 kV, the distance shall be 3.04 m (10 ft) plus 100 mm (4 in.) for every 10 kV over 50 kV.

E. Equipment Grounding

If any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines is intentionally grounded, employees working on the ground near the point of grounding shall not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades or insulation, shall be taken to protect employees from hazardous ground potentials (step and touch potential), which can develop within a few feet or more outward from the grounded point.

## 6. Other Precautions for Personnel Activities

A. Alertness

- **When Hazardous**  
Employees shall be instructed to be alert at all times when they are working near live parts operating at 50 volts or more and in work situations where unexpected electrical hazards might exist.
- **When Impaired**  
Employees shall not knowingly be permitted to work in areas containing live parts operating at 50 volts or more or other electrical hazards while their alertness is recognizably impaired due to illness, fatigue, or other reasons.

**B. Blind Reaching**

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

**C. Illumination**

- **General**  
Employees shall not enter spaces containing live parts unless illumination is provided that enables the employees to perform the work safely.
- **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 near live parts operating at 50 volts or more or where an electrical hazard exists.

**D. 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 from glasses) shall not be worn where they present an electrical contact hazard with exposed live parts.

**E. Conductive Material, Tools, and Equipment Being Handled**

- **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 accidental contact with live parts. Such materials and equipment include, but are 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.
- **Approach to Live Parts**

Means shall be employed to ensure that conductive materials approach exposed live parts no closer than that permitted by Table 130.2(C).

F. Confined or Enclosed Work Spaces

When an employee works in a confined or enclosed space (such as a manhole or vault) that contains exposed live parts operating at 50 volts or more or 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. Doors, hinged panels, and the like shall be secured to prevent their swinging into an employee and causing the employee to contact exposed live parts operating at 50 volts or more or where an electrical hazard exists.

G. Housekeeping Duties

Where live parts present an electrical contact hazard, employees shall not perform housekeeping duties inside the Limited Approach Boundary where there is a possibility of contact, unless adequate safeguards (such as insulating equipment or barriers) are provided to prevent contact. Electrically conductive cleaning materials (including conductive solids such as steel wool, metalized cloth, and silicone carbide, as well as conductive liquid solutions) shall not be used inside the Limited Approach Boundary unless procedures to prevent electrical contact are followed.

H. Occasional Use of Flammable Materials

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

I. Anticipating Failure

When there is evidence that electric equipment could fail and injure employees, the electric equipment shall be deenergized or repaired, employees shall be protected from hazards associated with the impending failure of the equipment.

J. 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 purposes, except in an emergency.

K. Reclosing Circuits After Protective Device Operation

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

## 7. Personal and Other Protective Equipment

### A. General

Employees working in areas where electrical hazards are present 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.

### B. Care of Equipment

Protective equipment shall be maintained in a safe, reliable condition. The protective equipment shall be visually inspected before each use.

### C. Personal Protective Equipment

#### 1. General

When an employee is working within the Flash Protection Boundary he/she shall wear protective clothing and other personal protective equipment in accordance with NFPA 70E.

#### 2. Movement and Visibility

When flame-resistant (FR) 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 Protection

Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with live parts or from flying objects resulting from electrical explosion. Employees shall wear nonconductive protective equipment for the face, neck, and chin whenever there is a danger of injury from exposure to electric arcs or flashes or from flying objects resulting from electrical explosion.

#### 4. Eye Protection

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

### 5. Body Protection

Employees shall wear FR clothing wherever there is possible exposure to an electric arc flash above the threshold incident-energy level for a second-degree burn.  $5 \text{ J/cm}^2$  ( $1.2 \text{ cal/cm}^2$ ). Such clothing can be provided as shirt and trousers, or as coveralls, or as a combination of jacket and trousers, or, for increased protection, as coveralls with jacket and trousers. Various weight fabrics are available. Generally, the higher degree of protection is provided by heavier weight fabrics and/or by layering combinations of one or more layers of FR clothing. In some cases one or more layers of FR clothing are worn over flammable, non melting clothing. Non-melting, flammable, clothing, used alone, can provide protection at low incident energy levels of  $8.36 \text{ J/cm}^2$  ( $2.0 \text{ cal/cm}^2$ ) and below.

### 6. Hand and Arm Protection

Employees shall wear rubber insulating gloves where there is danger of hand and arm injury from electric shock due to contact with live parts. Hand and arm protection shall be worn where there is possible exposure to arc flash burn.

### 7. Foot and Leg Protection

Where insulated footwear is used as protection against step and touch potential, dielectric overshoes shall be required. Insulated soles shall not be used as primary electrical protection.

### 8. Selection of Personal Protective Equipment

- When Required for Various Tasks

When selected in lieu of the flash hazard analysis, NFPD table 130.7(C)(9)(a) shall be used to determine the hazard/risk category for a task. The assumed short-circuit current capacities and fault clearing times for various tasks are listed in the text and notes to Table 130.7(C)(9)(a). for tasks not listed, or for power systems with greater than the assumed fault clearing times, a flash hazard analysis shall be required.

- Both larger and smaller available short-circuit currents could result in higher available arc-flash energies. If the available short-circuit current increases without a decrease in the opening time of the overcurrent protective device, the arc-flash energy will increase. If the available short-circuit current decreases, resulting in a longer opening time for the overcurrent protective device, arc-flash energies could also increase.

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

<b>Task (Assumes Equipment is Energized, and Work is Done Within the Flash Protection Boundary)</b>	<b>Hazard/Risk Category</b>	<b>V-Rated Gloves</b>	<b>V-Rated Tools</b>
<b>Panelboards Rated 240 V and Below – Notes 1 and 3</b>			
Circuit breaker(CB) or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	0	N	N
Work on energized parts, including voltage testing	1	Y	Y
Remove/install CBs or fused switches	1	Y	Y
Removal of bolted covers (to expose bare, energized parts)	1	N	N
Opening hinged covers (to expose bare, energized parts)	0	N	N
<b>Panelboards or Switchboards Rated &gt;240 V and up to 600 V (with molded case or insulated case circuit breakers) - Note 1 and 3</b>			
CB or fused switch operation with covers on	0	N	N
CB of fused switch operation with cover off	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
<b>600 V Class Motor Control Center (MCCs) – Notes 2 (except as indicated) and 3</b>			
CB or fused switch or starter operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch or starter operation with enclosure door open	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized parts > 120 V, exposed	2*	Y	Y
Insertion or removal of individual starter “buckets” from MCC – Note 4	3	Y	N
Application of safety grounds, after voltage test	2*	Y	N
Removal of bolted covers (to expose bare, energized parts)	2*	N	N
Opening hinged covers (to expose bare, energized parts)	1	N	N
<b>600 V Class Switchgear (with power circuit breakers or fused switches) – Notes 5 and 6</b>			
CB or fused switch operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch operation with enclosure door open	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized parts >120 V, exposed	2*	Y	Y
Insertion or removal (racking) of CBs from cubicles, door open	3	N	N
Insertion or removal (racking) of CBs from cubicles, doors closed	2*	N	N
Application of safety grounds, after voltage test	2*	Y	N
Removal of bolted covers (to expose bare, energized parts)	3	N	N
Opening hinged covers (to expose bare, energized parts)	2*	N	N

Task (Assumes Equipment is Energized, and Work is Done Within the Flash Protection Boundary)	Hazard/Risk Category	V-Rated Gloves	V-Rated Tools
<b>Other 600 V Class (277 V through 600 V, nominal) Equipment - Note 3</b>			
Lighting or small power transformer (600 V, maximum)	-	-	-
Removal of bolted covers (to expose bare, energized parts)	2*	N	N
Opening hinged covers (to expose bare, energized parts)	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Application of safety grounds, after voltage testing	2*	Y	N
Revenue meters (kW-hour, at primary voltage and current)	-	-	-
Insertion or removal	2*	Y	N
Cable trough or tray cover removal or installation	1	N	N
Miscellaneous equipment cover removal or installation	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Application of safety grounds, after voltage test	2*	Y	N
<b>NEMA E2 (fused contractor) Motor Starters, 2.3 kV through 7.2 kV</b>			
Contractor operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
Contractor operation with enclosure doors open	2*	N	N
Work on energized parts, including voltage testing	3	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized parts >120 V, exposed	3	Y	Y
Insertion or removal (racking) of starters from cubicles, doors open	3	N	N
Insertion or removal (racking) of starters from cubicles, doors closed	2*	N	N
Application of safety grounds, after voltage test	3	Y	N
Removal of bolted covers (to expose bare, energized parts)	4	N	N
Opening hinged covers (to expose bare, energized parts)	3	N	N
<b>Metal Clad Switchgear, 1 kV and Above</b>			
CB or fused switch operation with enclosure doors closed	2	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch operation with enclosure doors open	4	N	N
Work on energized parts, including voltage testing	4	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	2	Y	Y
Work on control circuits with energized parts >120 V, exposed	4	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open	4	N	N
Insertion or removal (racking) of CBs from cubicles, doors closed	2	N	N
Application of safety grounds, after voltage test	4	Y	N
Removal of bolted covers (to expose bare, energized parts)	4	N	N
Opening hinged covers (to expose bare, energized parts)	3	N	N
Opening voltage transformer or control power transformer compartments	4	N	N
<b>Other Equipment 1 kV and Above</b>			
Metal Clad load interrupter switches, fused or unfused	-	-	-
Switch operation, doors closed	2	N	N
Work on energized parts, including voltage testing	4	Y	Y
Removal of bolted covers (to expose bare, energized parts)	4	N	N
Opening hinged covers (to expose bare, energized parts)	3	N	N
Outdoor disconnect switch operation (hookstick operated)	3	Y	Y
Outdoor disconnect with operation (gang-operated, from grade)	2	N	N
Insulated cable examination, in manhole or other confined space	4	Y	N
Insulated cable examination, in open area	2	Y	N

Note:

- V-rated Gloves are gloves rated and tested for the maximum line-to-line voltage upon which work will be done.
- V-rated Tools are tools rated and tested for the maximum line-to-line voltage upon which work will be done.
- 2\* means that a double-layer switching hood and hearing protection are required for this task in addition to the other Hazards/Risk Category 2 requirements of Table 130.7(C)(10).
- Y = yes (required)
- N = no (not required)
- 25 kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
- 65 kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
- For < 10 kA short circuit current available, the hazard/risk category required may be reduced by one number.
- 65 kA short circuit current available, 0.33 second (20 cycle) fault clearing time.
- 65 kA short circuit current available, up to 1.0 second (60 cycle) fault clearing time.
- For < 25 KA short circuit current available, the hazard/risk category required may be reduced by one number.

## 9. Protective Clothing and Personal Protective Equipment Matrix

Once the Hazard/Risk Category has been identified NFPA Table 130.7(C)(10) shall be used to determine the required personal protective equipment (PPE) for the task. Table 130.7(C)(10) lists the requirements for protective clothing and other protective equipment based on Hazard/Rick Category numbers 1 through 4. This clothing and equipment shall be used when working on or near energized equipment within the Flash Protection Boundary.

See annex H for a suggested simplified approach to ensure adequate PPE for electrical workers within facilities with large and divers electrical systems.

## 10. Protective Clothing Characteristics

Table 130.7(C)(11) lists examples of protective clothing systems and typical characteristics including the degree of protection for various clothing, The protective clothing selected for the corresponding hazard/risk category number shall have an arc rating of at least the value listed in the last column of Table 130.7(C)(11).

## 11. Factors in Selection of Protective Clothing

Clothing and equipment that provide worker protection from shock and arc flash hazards shall be utilized. Clothing and equipment required for the degree of exposure shall be permitted to be worn alone or integrated with flammable , nonmelting apparel. If FR clothing is required, it shall cover associated parts of the body as well a all flammable apparel while allowing movement and visibility. All personal protective equipment shall be maintained is a sanitary and functionally effective condition. Personal protective equipment items will normally be used in conjunction with one another as a system to provide the appropriate level of protection.

- Layering

Nonmelting, flammable fiber garments shall be permitted to be used as under layers in conjunction with FR garments in a layered system for added protection. If nonmelting, flammable fiber **garments are** used as underlayers the system arc rating shall be sufficient to prevent breakopen of the innermost FR layer at the expected arc exposure incident energy level to prevent ignition of

flammable underlayers. A typical layering system might include cotton shirt and trouser, and a FR coverall. Specific tasks might call for additional FR layers to achieve the required protection level.

- **Outer Layers**  
Garments worn as outer layers over FR clothing, such as jackets or rainwear, shall also be made from FR material.
- **Underlayers**  
Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric underlayers (underwear) next to the skin.

Exception: an incidental amount of elastic used on non-melting fabric underwear or socks shall be permitted.

- **Coverage**  
Clothing shall cover potentially exposed areas as completely as possible. Shirt sleeves shall be fastened at the wrist, and shirts and jackets shall be closed at the neck.
- **Fit**  
Tight-fitting clothing shall be avoided. Loose fitting clothing provides additional thermal insulation because of air spaces. FR apparel shall fit properly such that it does not interfere with the work task.
- **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.

## 12. Arc Flash Protective Equipment

- **Flash Suits**  
Flash suit design shall permit easy and rapid removal by the wearer. The entire 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 FR materials or constructed of nonmelting and nonflammable materials.
- **Face Protection**

Face shields shall have an arc rating suitable for the arc flash exposure. Face shields without an arc rating shall not be used. Eye protection (safety glasses or goggles) shall be worn under face shields or hoods.

Protective Clothing and Equipment Hazard/Risk Category Number	Protective Systems for Hazard/Risk Category					
	-1 (Note 3)	0	1	2	3	4
<b>Non-melting (according to ASTM F 1506-00) or Untreated Natural Fiber</b>						
a. T-shirt (short-sleeve)	X			X	X	X
b. Shirt (long-sleeve)		X				
c. Pants (long)	X	X	X (Note 4)	X (Note 6)	X	X
<b>FR Clothing (Note 1)</b>						
a. Long-sleeve shirt			X	X	X (Note 9)	X
b. Pants			X (Note 4)	X (Note 6)	X (Note 9)	X
c. Coverall					X (Note 9)	
d. Jacket, parka, or rainwear			(Note 5) AN	(Note 7) AN	(Note 9) AN	(Note 5) AN
<b>FR Protective Equipment</b>						
a. Flash suit jacket (multilayer)						X
b. Flash suit pants (multilayer)						X
c. Head protection						
1. Hard Hat			X	X	X	X
2. FR hard hat liner					AR	AR
d. Eye Protection			-	-	-	-
1. Safety glasses	X		X	AL	AL	AL
2. Safety goggles				AL	AL	AL
e. Face and head area protection						
1. Arc-rated face shield, or flash suit hood				X (Note 8)		
2. Flash suit hood					X	X
3. Hearing protection (ear canal inserts)				X (Note 8)	X	X
f. Hand protection						
Leather gloves (Note 2)			AN	X	X	X
g. Foot protection						
Leather work shoes			AN	X	X	X
AN = as needed      AL = select one in group      AR = as required      X – minimum required						

**Notes:**

- See Table 130.7(C)(11). Arc rating for a garment is expressed in cal/cm<sup>2</sup>.
- If voltage-rated gloves are required, the leather protectors worn external to the rubber gloves satisfy this requirement.
- Hazard/Risk Category Number "-1" is only defined if determined by Notes 3 or 6 of Table 130.7(C)(9)(a).
- Regular weight (minimum 12 oz/yd<sup>2</sup> fabric weight), untreated, denim cotton blue jeans are acceptable in lieu of FR pants. The FR pants used for Hazard/Risk Category 1 shall have a minimum arc rating of 4.
- Alternate is to use FR coveralls (minimum arc rating of 4) instead of FR shirt and FR pants.
- If the FR pants have a minimum arc rating of 8, long pants of non-melting or untreated natural fiber are not required beneath the FR pants.
- Alternate is to use FR coveralls (minimum arc rating of 4) over non-melting or untreated natural fiber pants and T-shirt.
- A face shield with a minimum arc rating of 8, with wrap-around guarding to protect not only the face, but also the forehead, ears, and neck (or, alternatively, a flash suit hood), is required.
- Alternate is to use two sets of FR coveralls (the inner with a minimum arc rating of 4 and outer coverall with a minimum arc rating of 5) over non-melting or untreated natural fiber clothing, instead of FR coveralls over FR shirt and FR pants over non-melting or untreated natural fiber clothing.

<b>Typical Protective Clothing Systems</b>		
<b>Hazard/Risk Category</b>	<b>Clothing Description (Typical number of clothing layers is given in parentheses)</b>	<b>Required Minimum Arc Rating of PPE [J/cm<sup>2</sup>(cal/cm<sup>2</sup>)]</b>
0	Non-melting, flammable materials (i.e., untreated cotton, wool, rayon, or silk, or blends of these materials) with a fabric weight at least 4.5 oz/yd <sup>2</sup> (1)	N/A
1	FR shirt and FR pants or FR coverall (1)	16.74 (4)
2	Cotton underwear – conventional short sleeve and brief/shorts, plus FR shirt and FR pants (1 or 2)	33.47 (8)
3	Cotton underwear plus FR shirt and FR pants plus FR coverall, or cotton underwear plus two FR coveralls (2 or 3)	104.6 (25)
4	Cotton underwear plus FR shirt and FR pants plus multilayer flash suit (3 or more)	167.36 (40)

Note: Arc rating is defined in Article 100 and can be either ATPV. Or E<sub>BT</sub>. ATPV is defined in ASTM F 1959-99 as the incident energy on a fabric or material that results in sufficient heat transfer through the fabric or material to cause the onset of a second-degree burn based on the Stoll curve. E<sub>BT</sub> is defined in ASTM F 1959-99 as the average of the five highest incident energy exposure values below the Stoll curve where the specimens do not exhibit breakopen. E<sub>sk</sub> is reported when ATPV cannot be measured due to FR fabric breakopen.

### 13. Hand Protection

Leather or FR gloves shall be worn where required for arc flash protection. Where insulating rubber gloves are used for shock protection, leather protectors shall be worn over the rubber gloves.

### 14. Foot Protection

Heavy-duty leather work shoes provide some arc flash protection to the feet and shall be used in all tasks in Hazard/Risk Category 2 and higher.

## D. Clothing Material Characteristics

FR clothing shall meet the requirements described in NFPA 70E.

### 1. Melting

Clothing made from flammable synthetic materials that melt at temperatures below 315°C (600°F), such as acetate, nylon, polyester, polypropylene, and spandex, wither alone or in blends, shall not be used.

### 2. Flammability

Clothing made from nonmelting flammable natural materials, such as cotton, wool, rayon, or silk, shall be permitted for Hazard/Risk Categories 0 and -1 considered acceptable if it is determined by flash hazard analysis that the exposure level is 8.36 J/cm<sup>2</sup> (2.0 cal/cm<sup>2</sup>) or less, and that the fabric will not ignite and continue to burn under the arc exposure hazard conditions to which it will be exposed.

### 3. Care and Maintenance of FR Clothing and FR Flash Suits

- **Inspection**  
FR apparel shall be inspected before each use. Work clothing or flash suits that are contaminated, or damaged to the extent 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.
- **Manufacturer's Instructions**  
The garment manufacturer's instruction for care and maintenance of FR apparel shall be followed.

## E. Other Protective Equipment

### Insulated Tools and Equipment

Employees shall use insulated tools and/or handling equipment when working inside the Limited Approach Boundary of exposed live parts where tools or handling equipment might make accidental contact. Insulated tools shall be protected from damage to the insulating material.

1. **Requirements for insulated Tools**  
The following requirements shall apply to insulated tools:
  - Insulated tools shall be rated for the voltages on which they are used.
  - Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.
2. **Fuse or Fuse Holding Equipment**  
Fuse or fuse holder handling equipment, insulated for the circuit voltage, shall be used to remove or install a fuse if the fuse terminals are energized.
3. **Ropes and Handlines**  
Ropes and handlines used near exposed live parts operating at 50 volts or more, or used where an electrical hazard exists, shall be nonconductive.
4. **Fiberglass-Reinforced Plastic Rods.**  
Fiberglass-reinforced plastic rod and tube used for live line tools shall meet the requirements of ASTM F 7.11.
5. **Portable Ladders**  
Portable ladders shall have nonconductive side rails if they are used where the employee or ladder could contact exposed live parts operating at 50 volts or more or where an electrical hazard exists.

Nonconductive ladders shall meet the requirements of ANSI standards for ladder.

6. **Protective Shields**  
Protective shields, protective barriers, or insulating materials shall be used to protect each employee from shock, burns, or other electrically related injuries while that employee is working near live parts that might be accidentally contacted or where dangerous electric heating or arcing might occur. When normally enclosed live parts are exposed for maintenance or repair, they shall be guarded to protect unqualified persons from contact with the live parts.
7. **Rubber Insulating Equipment**  
Rubber insulating equipment used for protection from accidental contact with live parts shall meet the requirements of the ASTM standards.
8. **Voltage Rated Plastic Guard Equipment**  
Plastic guard equipment for protection of employees from accidental contact with live parts, or for protection of employees or energized equipment or material from contact with ground, shall meet the requirements of the ASTM standards.

#### F. Alerting Techniques

1. **Safety Signs and Tags**  
Safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards that might endanger them. Such signs and tags shall meet the requirements of ANSI Standard Z535.
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 live parts. Conductive barricades shall not be used where it might cause an electrical hazard. Barricades shall be placed no closer than the Limited Approach Boundary.