

## UMBC Electrical Safety Written Plan

### Appendix D: Arc Flash PPE Selection Guide Using the Category/Table Method

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)

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 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.)	N/A (doors closed)	N/A (doors closed)
	4 (doors open)	12 m (40 ft)
Other equipment 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)

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 or 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*.

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 mm (4 ft)
Available fault current greater than or equal to 3 kA and less than 7 kA	3	1.8 mm (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.



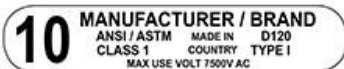


Informational Note No. 1: When determining available fault current, the effects of cables and any other impedances in the circuit should be included. Power system modeling is the best method to determine the available short-circuit current at the point of the arc. Battery cell short-circuit current can 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.

## PPE Categories – Picture References

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

## ASTM LABELING CHART FOR RUBBER INSULATING GLOVES

CLASS	TEST AC VOLTS	USE AC VOLTS	USE DC VOLTS	LABEL COLOR	LABEL IMAGE
00	2,500	500	750	BEIGE	
0	5,000	1,000	1,500	RED	
1	10,000	7,500	11,250	WHITE	
2	20,000	17,000	25,500	YELLOW	
3	30,000	26,500	39,750	GREEN	
4	40,000	36,000	54,000	ORANGE	