

## NFPA 70E® Table Samples: Approach Boundaries

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**Table 130.4(D) (a) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems**

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

Notes:

(1) For arc flash boundary, see 130.5(A).

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

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

<sup>b</sup>See definition in Article 100 and text in 130.4(D) (2) and Informative Annex C for elaboration.

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

<sup>d</sup>This includes circuits where the exposure does not exceed 120 volts nominal.

**Table 130.4(D) (b) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Direct-Current Voltage Systems**

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

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

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

# NFPA 70E Table Samples: PPE Categories

130.7

ARTICLE 130 — WORK INVOLVING ELECTRICAL HAZARDS

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<br>Parameters: Maximum of 25 kA available fault current; maximum of 0.05 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)   | 1  | 485 mm (19 in.)                        |
| Panelboards or other equipment rated greater than 240 volts and up to 600 volts<br>Parameters: Maximum of 25 kA available fault current; maximum of 0.05 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)  | 2  | 900 mm (3 ft)                          |
| 600-volt class motor control centers (MCCs)<br>Parameters: Maximum of 65 kA available fault current; maximum of 0.05 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)  | 2  | 1.5 m (5 ft)                           |
| 600-volt class motor control centers (MCCs)<br>Parameters: Maximum of 42 kA available fault current; maximum of 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<br>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 (20 ft)                            |
| Other 600-volt class (277 volts through 600 volts, nominal) equipment<br>Parameters: Maximum of 65 kA available fault current; maximum of 0.05 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<br>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)                           |
| Metal-clad switchgear, 1 kV through 15 kV<br>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<br>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)<br><br>4 (doors open) | N/A (doors closed)<br><br>12 m (40 ft) |
| Other equipment 1 kV through 15 kV<br>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 PPE 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 the instantaneous range (i.e., "no intentional delay").
- (5) 20 cycle fault clearing time is typical for low-voltage power and insulated case circuit breakers with a short time fault clearing delay for motor inrush.
- (6) 30 cycle fault clearing time is typical for low-voltage power and insulated case circuit breakers with a short time fault clearing delay without instantaneous trip.

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.

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 Switchgear Rated Up to 38 kV for Internal Arcing Faults*.

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<br>Parameters: Greater than or equal to 100 V and less than or equal to 250 V<br>Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.) |                        |                    |
| Available fault current less than 4 kA  | 2                      | 900 mm (3 ft)      |
| Available fault current greater than or equal to 4 kA and less than 7 kA  | 2                      | 1.2 m (4 ft)       |
| Available fault current greater than 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<br>Parameters: Greater than 250 V and less than or equal to 600 V<br>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                      | 1.2 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 F1296, *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 not known. If the fault clearing time is known and is less than 2 seconds, an incident energy analysis could provide a more representative result.

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 judgment.

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 ac arc flash has shown a multiplier of as much as 3× 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.

# NFPA 70E Table Sample: PPE

130.7

ARTICLE 130 — WORK INVOLVING ELECTRICAL HAZARDS

Table 130.7(C)(15)(c) Personal Protective Equipment (PPE)

| Arc-Flash PPE Category | PPE   |
|------------------------|---|
| 1                      | <p><b>Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm<sup>2</sup> (16.75 J/cm<sup>2</sup>)<sup>a</sup></b><br/>           Arc-rated long-sleeve shirt and pants or arc-rated coverall<br/>           Arc-rated face shield<sup>b</sup> or arc flash suit hood<br/>           Arc-rated jacket, parka, rainwear, or hard hat liner (AN)<br/> <b>Protective Equipment</b><br/>           Hard hat<br/>           Safety glasses or safety goggles (SR)<br/>           Hearing protection (ear canal inserts)<sup>c</sup><br/>           Heavy-duty leather gloves<sup>d</sup><br/>           Leather footwear (AN)</p>   |
| 2                      | <p><b>Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm<sup>2</sup> (33.5 J/cm<sup>2</sup>)<sup>a</sup></b><br/>           Arc-rated long-sleeve shirt and pants or arc-rated coverall<br/>           Arc-rated flash suit hood or arc-rated face shield<sup>b</sup> and arc-rated balaclava<br/>           Arc-rated jacket, parka, rainwear, or hard hat liner (AN)<br/> <b>Protective Equipment</b><br/>           Hard hat<br/>           Safety glasses or safety goggles (SR)<br/>           Hearing protection (ear canal inserts)<sup>c</sup><br/>           Heavy-duty leather gloves<sup>d</sup><br/>           Leather footwear</p>   |
| 3                      | <p><b>Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm<sup>2</sup> (104.7 J/cm<sup>2</sup>)<sup>a</sup></b><br/>           Arc-rated long-sleeve shirt (AR)<br/>           Arc-rated pants (AR)<br/>           Arc-rated coverall (AR)<br/>           Arc-rated arc flash suit jacket (AR)<br/>           Arc-rated arc flash suit pants (AR)<br/>           Arc-rated arc flash suit hood<br/>           Arc-rated gloves<sup>d</sup><br/>           Arc-rated jacket, parka, rainwear, or hard hat liner (AN)<br/> <b>Protective Equipment</b><br/>           Hard hat<br/>           Safety glasses or safety goggles (SR)<br/>           Hearing protection (ear canal inserts)<sup>c</sup><br/>           Leather footwear</p> |
| 4                      | <p><b>Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40 cal/cm<sup>2</sup> (167.5 J/cm<sup>2</sup>)<sup>a</sup></b><br/>           Arc-rated long-sleeve shirt (AR)<br/>           Arc-rated pants (AR)<br/>           Arc-rated coverall (AR)<br/>           Arc-rated arc flash suit jacket (AR)<br/>           Arc-rated arc flash suit pants (AR)<br/>           Arc-rated arc flash suit hood<br/>           Arc-rated gloves<sup>d</sup><br/>           Arc-rated jacket, parka, rainwear, or hard hat liner (AN)<br/> <b>Protective Equipment</b><br/>           Hard hat<br/>           Safety glasses or safety goggles (SR)<br/>           Hearing protection (ear canal inserts)<sup>c</sup><br/>           Leather footwear</p> |

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

<sup>a</sup>Arc rating is defined in Article 100.

<sup>b</sup>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.

<sup>c</sup>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.

<sup>d</sup>If rubber insulating gloves with leather protectors are used, additional leather or arc-rated gloves are not required. The combination of rubber insulating gloves with leather protectors satisfies the arc flash protection requirement.