**70E "Table Method": Hazard/Risk Categories**

130.5 Exception and 130.5 (B)(2)
130.7(C)(15)
Table 130.7(C)(15)(a)

1. When permitted to use & conditions of use
2. Reading time-current curves and determining clearing time
3. Calculating available short-circuit current
4. Putting it together

## What Will Be Covered: Pathway to HRC Method

- Prerequisite definitions
- Overview requirements for Arc Flash Hazard Analysis (130.5):
  - What output is required with exception
  - OCPD condition of maintenance
  - Quick overview of incident energy method
- 130.5 requirements pertinent to HRC "Table Method"
  - 130.7(C)(15) & 130.7(C)(16) permitted as exception "in lieu of determining the incident energy."
- 130.7(C)(15) Provide understanding when permitted to use HRC (Table Method):
  - Understanding of basis of this exception (Informational Notes 1 & 3)
  - Understanding of Table parameters (second and third sentence)
- Table 130.7(15)(a)
  - Understanding conditions of use for Table (must be met)
  - Understanding Table Notes
- Provide some helpful tool information at end of session (calculating short-circuit current and reading OCPD time-current curves)

**Article 100 Definitions**

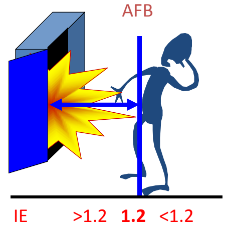
**Incident Energy.** The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. One of the units used to measure incident energy is calories per centimeter squared (cal/$cm^2$).

**Article 100 Definitions**

**Boundary, Arc Flash.**

When an arc flash hazard exists, an approach limit at a distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur.

– Informational Note: A second degree burn is possible by an exposure of unprotected skin to an electric arc flash above the incident energy level of 5 J/cm2 (1.2 cal/cm2).




**Arc Flash Hazard Analysis – 130.5**

*130.5 Arc Flash Hazard Analysis. An arc flash hazard analysis shall determine the arc flash boundary, the incident energy at the working distance, and the personal protective equipment that people within the arc flash boundary shall use. …*

[Ties to 130.5(B)(1)]

*Exception: The requirements of 130.7(C)(15) and 130.7(C)(16) shall be permitted to be used in lieu of determining the incident energy at the working distance.*

[Ties to 130.5(B)(2)]

Arc Flash Testing - Test 4

480V 3Ø, 22,600A Available Short-Circuit Current (bolted)

Test 4
640A Non-Current-Limiting OCPD:
6 cycle (0.1s) Clearing Time


5.8 cal/cm² @ 18", AFB 47"
(IEEE 1584)

Test 3
601 Current-Limiting OCPD:
Less than 1/2 cycle
(0.01) Clearing Time


1.58 cal/cm² @ 18", AFB 21"
(IEEE 1584)

## Arc Flash Hazard Analysis – 130.5 Cont

The arc flash hazard analysis shall take into consideration the design of the overcurrent protective device and its opening time, including its condition of maintenance.

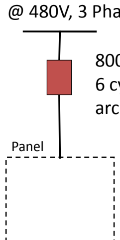
**Informational Note No. 1**: Improper or inadequate maintenance can result in increased opening time of the overcurrent protective device, thus increasing the incident energy.

**Informational Note No. 4**: For additional direction for performing maintenance on overcurrent protective devices, see Chapter 2, Safety-Related Maintenance Requirements.

## OCPD Maintenance can affect Arc Flash Hazard

What happens…
If lack of maintenance causes the OCPD to clear in **30** cycles rather than 6 cycles?

22.6 KA Symmetrical
Available Fault Current
@ 480V, 3 Phase




800 A OCPD
6 cycle opening for arcing current

Calculations for 6 cycles clearing time

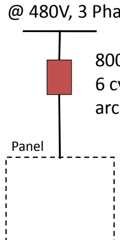
Arc Flash Hazard Analysis for this Panel
Incident Energy: **5.8** cal/cm² @ 18”
AFPB: **47** inches

## OCPD Maintenance can affect Arc Flash Hazard

What happens…
If lack of maintenance causes the OCPD to clear in **30** cycles rather than 6 cycles?

The actual Arc Flash Hazard would be much greater than the calculated Flash Hazard.

22.6 KA Symmetrical
Available Fault Current
@ 480V, 3 Phase




800 A OCPD
6 cycle opening for arcing current

**125”** **29** cal/cm²

Arc Flash Hazard Analysis for this Panel
Incident Energy: **5.8** cal/cm² @ 18”
AFPB: **47** inches

NFPA 70E Chapter 2 OCPD Maintenance Requirements

**210.5 Protective Devices.**
Protective devices shall be maintained to adequately withstand or interrupt available fault current.

FPN: Failure to properly maintain protective devices can have an adverse effect on the arc flash hazard analysis incident energy values.

NFPA 70E Chapter 2 OCPD Maintenance Requirements

**225.3 Circuit Breaker Testing After Electrical Faults.**
Circuit breakers that interrupt faults approaching their interrupting ratings shall be inspected and tested in accordance with the manufacturer's instructions.

**Arc Flash Hazard Analysis – 130.5 Cont**

**(B) Protective Clothing and Other Personal Protective Equipment (PPE) for Application with an Arc Flash Hazard Analysis**. Where it has been determined that work will be performed within the arc flash boundary, one of the following methods shall be used for the selection of protective clothing and other personal protective equipment (PPE):

## Arc Flash Hazard Analysis – 130.5 Cont

**(B)(1) Incident Energy Analysis**. The incident energy analysis shall determine, and 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. 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 distance at which the incident energy was determined.

Informational Note: For information on estimating the incident energy, see Annex D. For information on selection of arc-rated clothing and other PPE, see Table H.3(b) in Annex H.

## Steps in Performing Arc Flash Hazard Analysis (130.5(B)(1))

1 Determine bolted available fault current

2 Determine arcing current

3A A. OCPD Maintenance Considerations

3B B. Determine OCPD clearing time

4 Determine AFB and PPE
- Calculate incident energy and AFB (use IEEE 1584)

## IEEE 1584 Formula

Determining Arcing Current from
Available Bolted Short-Circuit Current

- For systems under 1 kV [per equation D.7.2(a)]:

$$\lg I_a = K + 0.662 \lg I_{bf} + 0.0966\, V + 0.000526\, G + 0.5588\, V (\lg I_{bf}) - 0.00304\, G (\lg I_{bf})$$

where:
$I_a$ = arcing current in kA
K = −0.153 for open air arcs; −0.097 for arcs-in-a-box
$I_{bf}$ = available short-circuit current (kA)
V = system voltage in kV
G = conductor gap (mm)

- $I_a = 10^{\lg I_a}$

0.85 Ia See Handbook p213 and Annex D 7.2 last paragraph
Handbook p 213

## Determining AFB – IEEE 1584 Method

IEEE 1584 method [70E Annex D D.7.5(a)]

$$D_B = \left[ 4.184\, C_f\, E_n \left( \frac{t}{0.2} \right) \left( \frac{610^X}{E_B} \right) \right]^{\frac{1}{X}}$$

$D_B$ = the distance (mm) of the AFB from the arcing point
$C_f$ = a calculation factor
= 1.0 for voltages above 1 kV
= 1.5 for voltages at or below 1 kV
$E_n$ = incident energy normalized – **additional formula**
$E_B$ = incident energy (J/cm²) at the distance of the AFB
t = time (seconds) – based on **arcing current/formula**
X = the distance exponent from Table D.7.2

Handbook p 220

## Determining Incident Energy – IEEE 1584 Basic Method

IEEE 1584 Basic Method:

$$E = 4.184\, C_f\, E_n \left( \frac{t}{0.2} \right) \left( \frac{610X}{D^X} \right)$$

E = incident energy (J/cm²)
$C_f$ = a calculation factor

- = 1.0 for voltages above 1 kV
- = 1.5 for voltages at or below 1 kV

$E_n$ = incident energy normalized – **additional formula required**
t = arcing time (seconds) – based on **arcing current/formula**
D = distance (mm) from the arc to the person
X = the distance exponent from Table D.7.2

Handbook p 223

## Spreadsheet Calculator

**Formulas Based on Basic Equations in IEEE 1584 and 2009 NFPA 70E Annex D.7, D.7.1, D.7.2, D.7.3, D.7.4 and D.7.**

**PART 1: Determine the Three Phase Arcing Current that can flow during the event.**

| | | | |
|---|---|---|---|
| Enter the three phase bolted fault current in kA. | 22.6 | kA | (Valid from 700A to 106,000A) |
| Enter the Amperage of the Overcurrent Protective Device in A. | 640 | A | |
| Enter the system voltage. | 480 | V | (Valid from 208V to 1kV) |
| Select the Equipment Type. | 2 | 1 - Switchgear | 2 - MCC/Panel 3 - Open Air 4 - Cable |
| Select the arc configuration. | 2 | 1 - Open Air | 2 - In a Box |
| **The three phase calculated arcing current Ia =** | 13.16 | kA | |

Due to fluctuations in the calculated arcing current, 85% of Ia should also be used to calculate Incident Energy.
The higher value from the two calculations should be used as the incident energy exposure.

| | | |
|---|---|---|
| **The three phase calculated 85% arcing current 0.85 Ia=** | 11.19 | kA |

**Part II: Select System Type and Detemine the OCPD Clearing Time based on Arcing Current**

| | | | |
|---|---|---|---|
| Enter the type of Grounding System | 1 | 1 - Ungrounded and High-Resistance Grounded<br>2 - Solidly Grounded Systems | |
| Enter total clearing time of OCPD based on Ia **from TCC** | 0.1 | seconds | See Time Current Curve (TCC) |
| Enter total clearing time of OCPD based on 0.85 Ia **from TCC** | 0.1 | seconds | See Time Current Curve (TCC) |
| Enter the Working Distance from the possible arc to the person | 18 | inches | |

**Part III: Detemine the Incident Energy Exposure (Use Higher Value in Red Text)**

| | | |
|---|---|---|
| Incident Energy using Ia = | 5.79 | Cal/cm² |
| Incident Energy using 0.85 Ia = | 4.86 | Cal/cm² |

**Part IV: Detemine the Flash Protection Boundary (Use Higher Value in Red Text)**

| | | |
|---|---|---|
| Arc Flash Protection Boundary using Ia = | 46.98 | Inches |
| Arc Flash Protection Boundary using 0.85 Ia = | 42.21 | Inches |

E - Incident Energy 1.2 cal/cm² Adjust E from 1.2 to 1.5 if over 600V and Clearing time is

**Arc Flash Hazard Analysis – 130.5 Cont**

**(B)(2)** Hazard/Risk Categories.

The requirements of 130.7(C)(15) and 130.7(C)(16) shall be permitted to be used for the selection and use of personal and other protective equipment.

(Note: this method is permitted in lieu of doing incident energy calculation.)

**130.7 Personal and Other Protective Equipment**
**(C) Personal Protective Equipment**

**130.7(C)(15) Selection of Personal Protective Equipment When Required for Various Tasks.** Where selected in lieu of the incident energy analysis of 130.5(B)(1), Table 130.7(C)(15)(a) and Table 130.7(C)(15)(b) shall be used to determine the **hazard/risk** category and requirements for use of rubber insulating gloves and insulated and insulating hand tools for a task. The assumed **maximum short-circuit current capacities** and **maximum fault clearing times** for various tasks are listed in Table 130.7(C)(15)(a). For tasks not listed, or for power systems with greater than the assumed maximum short-circuit current capacity or with longer than the assumed maximum fault clearing times, an incident energy analysis shall be required in accordance with 130.5.

**130.7(C)(15)**

**Informational Note No. 1:** The hazard/risk category, work tasks, and protective equipment identified in Table 130.7(C)(15)(a) were identified by a task group, and the hazard/risk category, protective clothing, and equipment selected were **based on the collective experience of the task group**. The hazard/risk category protective clothing and equipment are generally based on determination of **estimated exposure levels**.

In several cases, where the risk of an arc flash incident is considered low, very low, or extremely low by the task group, the hazard/risk category number has been reduced by 1, 2, or 3 numbers, respectively.

**130.7(C)(15)**

**Informational Note No. 2:** The collective experience of the task group is that, in most cases, closed doors do not provide enough protection to eliminate the need for PPE for instances where the state of the equipment is known to readily change (for example, doors open or closed, rack in or rack out).

**130.7(C)(15)**

**Informational Note No. 3:** The **premise** used by the task group in developing the criteria discussed in Informational Note No. 1 and Informational Note No. 2 is **considered to be reasonable, based on the consensus judgment** of the full NFPA 70E Technical Committee.

- IN No. 1 & 3: What is meaning?
  - Tables: HRC (PPE AR) is ***not*** based on incident energy calculation
  - ***Based on*** "collective experience of the task group"
    - HRC
    - Protective clothing and equipment

**130.7 Personal and Other Protective Equipment**
**(C) Personal Protective Equipment**

**130.7(C)(15) …**

The assumed **maximum short-circuit current capacities** and **maximum fault clearing times** for various tasks are listed in Table 130.7(C)(15)(a). …

What are these terms (underlined)?

Not defined or clarified in NFPA 70E

Maximum available bolted short-circuit current

Clearing time of type of OCPD for maximum available bolted short-circuit in the table parameters

## Example Table 130.7(C)(15)(a)
*Conditions of Use*

| | |
|---|---|
| Panelboards or other equipment rated > 240 V and up to 600 V<br>Parameters:<br>Maximum of 25 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time; minimum 18 in. working distance<br>Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 30 in. | |
| Perform infrared thermography and other non-contact inspections outside the restricted approach boundary | 1 |
| Circuit breaker (CB) or fused switch operation with covers on | 0 |

**25kA is max. available bolted fault current**
**0.03 (2 cycle) is the max. clearing time for type of OCPD at the 25kA bolted short-circuit current.**

## Example Fuses and CB Types/Amp Ratings

| Table 130.7(C)(15)(a) | Fuse Class Amp Rating | | Molded Case Circuit Breaker Max. Frame† | | Insulated Case CB Max. Frame† | LV Power CB Max Frame† |
|---|---|---|---|---|---|---|
| Conditions of Use Type Equipment, Voltage, Parameters, AFB | Fuse UL Class | Max. Amp Rating | Non-Current-Limiting Largest Frame | Current-Limiting‡ | | |
| Panelboards or other equipment rated 240 V and below<br>Parameters:<br>Maximum of 25 kA short circuit current available;<br>maximum of 0.03 sec (2 cycle) fault clearing time;<br>minimum 18 in. working distance<br>Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 19 in. | J (LPJ or JKS)<br>RK1 (LPN-RK)<br>RK5 (FRN-R)<br>L (KRP-C) | 600A*<br>600A*<br>600A*<br>1600A | 1200A | 600A | None | None |

## Table 130.7(C)(15)(a) Note 5

(5) For power systems up to 600 V the arc flash boundary was determined by using the following information: When 0.03 second trip time was used, that indicated MCC or panelboard equipment protected by a molded-case circuit breaker. Working distance used was 18 in. (455 mm). Arc gap used was 32 mm for switchgear and 25 mm for MCC and protective device type 0 for all. When 0.33 or 0.5 second trip time was used, that indicated a LVPCB (drawout circuit breaker) in switchgear. Working distance was 24 in. (610 mm). Arc gap used was 32 mm and protective device type 0 for all. All numbers were rounded up or down depending on closest multiple of 5.

(Note: Table AFBs was calculated using IEEE 1584 and the parameters in the table.)

2002 IEEE 1584 Calculation Spreadsheet

- Type 0 input opening time; not dependent on type fuse or circuit breaker
- Type 1 to 8 for certain fuse types and IEEE 1584 simplified fuse method
- Type 9 to 14 for certain circuit breaker types and IEEE 1584 simplified circuit breaker method

| Protective Device Type: |
|---|
| 0 – Other |
| 1 - RK1-100 |
| 2 - RK1-200 |
| 3 - RK1-400 |
| 4 - RK1-600 |
| 5 - L-800 |
| 6 - L-1200 |
| 7 - L-1600 |
| 8 - L-2000 |
| 9 - MCCB-100-400 |
| 10 - MCCB-600-1200-M |
| 11 - MCCB-600-1200-LI |
| 12 - MCCB-1600-6000 |
| 13 - LVPCB-800-6300-LI |
| 14 - LVPCB-800-6300-LS |

IEEE 1584 Calc of AFB for Panelboard: 600V, 25KA, 0.03 sec

**Formulas Based on Basic Equations in IEEE 1584 and 2009 NFPA 70E Annex D.7, D.7.1, D.7.2, D.7.3, D.7.4 and D.7.**

**PART 1: Determine the Three Phase Arcing Current that can flow during the event.**

| | | | | |
|---|---|---|---|---|
| Enter the three phase bolted fault current in kA. | 25.0 | kA (Valid from 700A to 106,000A) | | |
| Enter the Amperage of the Overcurrent Protective Device in A. | 1 | A | | |
| Enter the system voltage. | 600 | V (Valid from 208V to 1kV) | | |
| Select the Equipment Type. | 2 | 1 - Switchgear | 2 - MCC/Panel | 3 - Open Air 4 - Cable |
| Select the arc configuration. | 2 | 1 - Open Air | 2 - In a Box | |
| **The three phase calculated arcing current Ia =** | 18.28 | kA | | |

Due to fluctuations in the calculated arcing current, 85% of Ia should also be used to calculate Incident Energy.
The higher value from the two calculations should be used as the incident energy exposure.

| | | |
|---|---|---|
| **The three phase calculated 85% arcing current 0.85 Ia=** | 15.54 | kA |

**Part II: Select System Type and Detemine the OCPD Clearing Time based on Arcing Current**

| | | | |
|---|---|---|---|
| Enter the type of Grounding System | 1 | 1 - Ungrounded and High-Resistance Grounded<br>2 - Solidly Grounded Systems | |
| Enter total clearing time of OCPD based on Ia **from TCC** | 0.03 | seconds | See Time Current Curve (TCC) |
| Enter total clearing time of OCPD based on 0.85 Ia **from TCC** | 0.03 | seconds | See Time Current Curve (TCC) |
| Enter the Working Distance from the possible arc to the person | 18 | inches | |

**Part III: Detemine the Incident Energy Exposure (Use Higher Value in Red Text)**

| | | |
|---|---|---|
| Incident Energy using Ia = | 2.48 | Cal/cm$^2$ |
| Incident Energy using 0.85 Ia = | 2.08 | Cal/cm$^2$ |

**Part IV: Detemine the Flash Protection Boundary (Use Higher Value in Red Text)**

| | | |
|---|---|---|
| Arc Flash Protection Boundary using Ia = | 28.01 | Inches |
| Arc Flash Protection Boundary using 0.85 Ia = | 25.17 | Inches |

E - Incident Energy 1.2 cal/cm$^2$ Adjust E from 1.2 to 1.5 if over 600V and Clearing time is

**Table 130.7(C)(15)(a) Note 4**

(4) For equipment protected by upstream current limiting fuses with arcing fault current in their current limiting range (1⁄2 cycle fault clearing time or less), the hazard/risk category required may be reduced by one number.

(Note: this requires determining arcing fault current. Might as well do incident energy method)