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 Shaded text = Revisions. Δ = Text deletions and figure/table revisions. • = Section deletions. *N* = New material.

Informative Annex B Reserved

Informative Annex C Limits of Approach

This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 Preparation for Approach. Observing a safe approach distance from exposed energized electrical conductors or circuit parts is an effective means of maintaining electrical safety. As the distance between a person and the exposed energized conductors or circuit parts decreases, the potential for electrical incident increases.

C.1.1 Unqualified Persons, Safe Approach Distance. Unqualified persons are safe when they maintain a distance from the exposed energized conductors or circuit parts, including the longest conductive object being handled, so that they cannot contact or enter a specified air insulation distance to the exposed energized electrical conductors or circuit parts. This safe approach distance is the limited approach boundary. Further, persons must not cross the arc flash boundary unless they are wearing appropriate personal protective clothing and are under the close supervision of a qualified person. Only when continuously escorted by a qualified person should an unqualified person cross the limited approach boundary. Under no circumstance should an unqualified person cross the restricted approach boundary, where special shock protection techniques and equipment are required.

C.1.2 Qualified Persons, Safe Approach Distance.

C.1.2.1 Determine the arc flash boundary and, if the boundary is to be crossed, appropriate arc-rated protective equipment must be utilized.

C.1.2.2 For a person to cross the limited approach boundary and enter the limited space, a person should meet the following criteria:

(1) Be qualified to perform the job/task
(2) Be able to identify the hazards and associated risks with the tasks to be performed

C.1.2.3 To cross the restricted approach boundary and enter the restricted space, qualified persons should meet the following criteria:

(1) As applicable, have an energized electrical work permit authorized by management.
(2) Use personal protective equipment (PPE) that is rated for the voltage and energy level involved.
(3) Minimize the likelihood of bodily contact with exposed energized conductors and circuit parts from inadvertent movement by keeping as much of the body out of the restricted space as possible and using only protected body parts in the space as necessary to accomplish the work.
(4) Use insulated tools and equipment.

(See Figure C.1.2.3.)

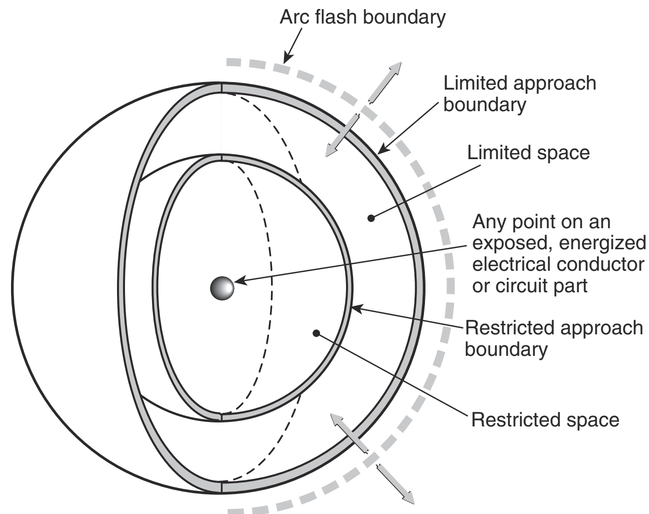

FIGURE C.1.2.3 Limits of Approach.

C.2 Basis for Distance Values in Tables 130.4(E)(a) and 130.4(E)(b).

C.2.1 General Statement. Columns 2 through 5 of Table 130.4(E)(a) and Table 130.4(E)(b) show various distances from the exposed energized electrical conductors or circuit parts. They include dimensions that are added to a basic minimum air insulation distance. Those basic minimum air insulation distances for voltages 72.5 kV and under are based on IEEE 4, *Standard Techniques for High Voltage Testing*, Appendix 2B; and voltages over 72.5 kV are based on IEEE 516, *Guide for Maintenance Methods on Energized Power Lines*. The minimum air insulation distances that are required to avoid flashover are as follows:

(1) ≤300 V: 1 mm (0 ft 0.03 in.)
(2) >300 V to ≤750 V: 2 mm (0 ft 0.07 in.)
(3) >750 V to ≤2 kV: 5 mm (0 ft 0.19 in.)
(4) >2 kV to ≤15 kV: 39 mm (0 ft 1.5 in.)
(5) >15 kV to ≤36 kV: 161 mm (0 ft 6.3 in.)
(6) >36 kV to ≤48.3 kV: 254 mm (0 ft 10.0 in.)
(7) >48.3 kV to ≤72.5 kV: 381 mm (1 ft 3.0 in.)
(8) >72.5 kV to ≤121 kV: 640 mm (2 ft 1.2 in.)
(9) >138 kV to ≤145 kV: 778 mm (2 ft 6.6 in.)
(10) >161 kV to ≤169 kV: 915 mm (3 ft 0.0 in.)
(11) >230 kV to ≤242 kV: 1.281 m (4 ft 2.4 in.)
(12) >345 kV to ≤362 kV: 2.282 m (7 ft 5.8 in.)
(13) >500 kV to ≤550 kV: 3.112 m (10 ft 2.5 in.)
(14) >765 kV to ≤800 kV: 4.225 m (13 ft 10.3 in.)

C.2.1.1 Column 1. The voltage ranges have been selected to group voltages that require similar approach distances based on the sum of the electrical withstand distance and an inadvertent movement factor. The value of the upper limit for a range is the maximum voltage for the highest nominal voltage in the range, based on ANSI C84.1, *Electric Power Systems and Equipment — Voltage Ratings (60 Hz)*. For single-phase systems, select the range that is equal to the system's maximum phase-to-ground voltage multiplied by 1.732.

C.2.1.2 Column 2. The distances in column 2 are based on OSHA's rule for unqualified persons to maintain a 3.05 m (10 ft) clearance for all voltages up to 50 kV (voltage-to-ground), plus 100 mm (4.0 in.) for each 10 kV over 50 kV.

C.2.1.3 Column 3. The distances in column 3 are based on the following:

(1) ≤750 V: Use *NEC* Table 110.26(A)(1), Working Spaces, Condition 2, for the 151 V to 600 V range.
(2) >750 V to ≤145 kV: Use *NEC* Table 110.34(A), Working Space, Condition 2.
(3) >145 kV: Use OSHA's 3.05 m (10 ft) rules as used in Column 2.

C.2.1.4 Column 4. The distances in column 4 are based on adding to the flashover dimensions shown in C.2.1 the following inadvertent movement distance:

≤300 V: Avoid contact.

Based on experience and precautions for household 120/240-V systems:

>300 V to ≤750 V: Add 304.8 mm (1 ft 0 in.) for inadvertent movement.

These values have been found to be adequate over years of use in ANSI/IEEE C2, *National Electrical Safety Code,* in the approach distances for communication workers.

>72.5 kV: Add 304.8 mm (1 ft 0 in.) for inadvertent movement.

These values have been found to be adequate over years of use in ANSI/IEEE C2, *National Electrical Safety Code,* in the approach distances for supply workers.

Informative Annex D Incident Energy and Arc Flash Boundary Calculation Methods

This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Introduction. Informative Annex D summarizes calculation methods available for calculating arc flash boundary and incident energy. It is important to investigate the limitations of any methods to be used. The limitations of methods summarized in Informative Annex D are described in Table D.1.

D.2 Ralph Lee Calculation Method.

Δ **D.2.1 Basic Equations for Calculating Arc Flash Boundary Distances.** The short-circuit symmetrical ampacity, I_{sc}, from a bolted three-phase fault at the transformer terminals is calculated with the following formula:

[D.2.1a]

$$I_{sc} = \{[MVA \text{ Base } \times 10^6] \div [1.732 \times V]\} \times \{100 \div \%Z\}$$

where I_{sc} is in amperes, V is in volts, and $\%Z$ is based on the transformer *MVA*.

A typical value for the maximum power, P (in MW) in a three-phase arc can be calculated using the following formula:

[D.2.1b]

$$P = [\text{maximum bolted fault, in } MVA_{bf}] \times 0.707^2$$

[D.2.1c]

$$P = 1.732 \times V \times I_{sc} \times 10^{-6} \times 0.707^2$$

The arc flash boundary distance is calculated in accordance with the following formulae:

N **[D.2.1d]**

$$D_c = [2.65 \times MVA_{bf} \times t]^{1/2}$$

[D.2.1e]

$$D_c = [53 \times MVA \times t]^{1/2}$$

where:

D_c = distance in feet of person from arc source for a just curable burn (that is, skin temperature remains less than 80°C).

MVA_{bf} = bolted fault *MVA* at point involved.

MVA = *MVA* rating of transformer. For transformers with *MVA* ratings below 0.75 *MVA*, multiply the transformer *MVA* rating by 1.25.

t = time of arc exposure in seconds.

The clearing time for a current-limiting fuse is approximately ¼ cycle or 0.004 second if the arcing fault current is in the fuse's current-limiting range. The clearing time of a 5-kV and 15-kV circuit breaker is approximately 0.1 second or 6 cycles if the instantaneous function is installed and operating. This can be broken down as follows: actual breaker time (approximately 2 cycles), plus relay operating time of approximately 1.74 cycles, plus an additional safety margin of 2 cycles, giving a total time of approximately 6 cycles. Additional time must be added if a time delay function is installed and operating.

The formulas used in this explanation are from Ralph Lee, "The Other Electrical Hazard: Electrical Arc Flash Burns," in *IEEE Trans. Industrial Applications*. The calculations are based on the worst-case arc impedance. *(See Table D.2.1.)*

D.2.2 Single-Line Diagram of a Typical Petrochemical Complex. The single-line diagram *(see Figure D.2.2)* illustrates the complexity of a distribution system in a typical petrochemical plant.

Δ **Table D.1 Limitation of Calculation Methods**

Section	Source	Limitations/Parameters
D.2	Lee, "The Other Electrical Hazard: Electrical Arc Flash Burns"	Calculates incident energy and arc flash boundary for arc in open air; conservative over 600 volts and becomes more conservative as voltage increases
D.3	Doughty, et al., "Predicting Incident Energy to Better Manage the Electrical Arc Hazard on 600 V Power Distribution Systems"	Calculates incident energy for three-phase arc on systems rated 600 volts and below; applies to short-circuit currents between 16 kA and 50 kA
D.4	IEEE 1584, *Guide for Performing Arc Flash Hazard Calculations*	Calculates incident energy and arc flash boundary for 208 volts to 15 kV; three-phase; 50 Hz to 60 Hz; 500 amperes to 106,000 amperes short-circuit current (208 volts to 600 volts); 200 amperes to 65,000 amperes short-circuit current (600 volts to 15,000 volts); and conductor gaps of 6.35 mm to 76.2 mm (0.25 in. to 3 in.) for 208 volts to 600 volts and 13 mm to 152 mm (0.75 in. to 10 in.) for 601 volts to 15,000 volts
D.5	Doan, "Arc Flash Calculations for Exposure to DC Systems"	Calculates incident energy for dc systems rated up to 1000 volts dc

Table D.2.1 Flash Burn Hazard at Various Levels in a Large Petrochemical Plant

(1)	(2)	(3)	(4)	(5)	(6)	(7)	
						Arc Flash Boundary Typical Distance*	
Bus Nominal Voltage Levels	System (MVA)	Transformer (MVA)	System or Transformer (% Z)	Short-Circuit Symmetrical (A)	Clearing Time of Fault (cycles)	SI	U.S.
230 kV	9000		1.11	23,000	6.0	15 m	49.2 ft
13.8 kV	750		9.4	31,300	6.0	1.16 m	3.8 ft
Load side of all 13.8-V fuses	750		9.4	31,300	1.0	184 mm	0.61 ft
4.16 kV		10.0	5.5	25,000	6.0	2.96 m	9.7 ft
4.16 kV		5.0	5.5	12,600	6.0	1.4 m	4.6 ft
Line side of incoming 600-V fuse		2.5	5.5	44,000	60.0–120.0	7 m–11 m	23 ft–36 ft
600-V bus		2.5	5.5	44,000	0.25	268 mm	0.9 ft
600-V bus		1.5	5.5	26,000	6.0	1.6 m	5.4 ft
600-V bus		1.0	5.57	17,000	6.0	1.2 m	4 ft

*Distance from an open arc to limit skin damage to a curable second degree skin burn [less than 80°C (176°F) on skin] in free air.

Δ **D.2.3 Sample Calculation.** Many of the electrical characteristics of the systems and equipment are provided in Table D.2.1. The sample calculation is made on the 4160-volt bus 4A or 4B. Table D.2.1 tabulates the results of calculating the arc flash boundary for each part of the system. For this calculation, based on Table D.2.1, the following results are obtained:

(1) Calculation is made on a 4160-volt bus.
(2) Transformer *MVA* (and base *MVA*) = 10 *MVA*.
(3) Transformer impedance on 10 *MVA* base = 5.5 percent.
(4) Circuit breaker clearing time = 6 cycles.

Using Equation D.2.1(a), calculate the short-circuit current:

N **[D.2.3a]**

$$\begin{aligned} I_{sc} &= \{[MVA \text{ Base } \times 10^6] \div [1.732 \times V]\} \times \{100 \div \%Z\} \\ &= \{[10 \times 10^6] \div [1.732 \times 4160]\} \times \{100 \div 5.5\} \\ &= 25{,}000 \text{ amperes} \end{aligned}$$

Using Equation D.2.1(b), calculate the power in the arc:

N **[D.2.3b]**

$$\begin{aligned} P &= 1.732 \times 4160 \times 25{,}000 \times 10^{-6} \times 0.707^2 \\ &= 91 \text{ MW} \end{aligned}$$

Using Equation D.2.1(d), calculate the second degree burn distance:

N **[D.2.3c]**

$$\begin{aligned} D_c &= \{2.65 \times [1.732 \times 25{,}000 \times 4160 \times 10^{-6}] \times 0.1\}^{1/2} \\ &= 6.9 \text{ or } 7.00 \text{ ft} \end{aligned}$$

Or, using Equation D.2.1(e), calculate the second degree burn distance using an alternative method:

N **[D.2.3d]**

$$\begin{aligned} D_c &= [53 \times 10 \times 0.1]^{1/2} \\ &= 7.28 \text{ ft} \end{aligned}$$

Δ **D.2.4 Calculation of Incident Energy Exposure Greater Than 600 V for an Arc Flash Hazard Analysis.** The equation that follows can be used to predict the incident energy produced by a three-phase arc in open air on systems rated above 600 V. The parameters required to make the calculations follow.

(1) The maximum bolted fault, three-phase short-circuit current available at the equipment.
(2) The total protective device clearing time (upstream of the prospective arc location) at the maximum short-circuit current. If the total protective device clearing time is longer than 2 seconds, consider how long a person is likely to remain in the location of the arc flash. It is likely that a person exposed to an arc flash will move away quickly if it is physically possible, and 2 seconds is a reasonable maximum time for calculations. A person in a bucket truck or a person who has crawled into equipment will need more time to move away. Sound engineering judgment must be used in applying the 2-second maximum clearing time, since there could be circumstances where an employee's egress is inhibited.
(3) The distance from the arc source.
(4) Rated phase-to-phase voltage of the system.

[D.2.4]

$$E = \frac{793 \times F \times V \times t_A}{D^2}$$

where:
E = incident energy, cal/cm²
F = bolted fault short-circuit current, kA
V = system phase-to-phase voltage, kV
t_A = arc duration, sec
D = distance from the arc source, in.

D.3 Doughty Neal Paper.

D.3.1 Calculation of Incident Energy Exposure. The following equations can be used to predict the incident energy produced by a three-phase arc on systems rated 600 V and below. The results of these equations might not represent the worst case in all situations. It is essential that the equations be used only within the limitations indicated in the definitions of the variables shown under the equations. The equations must be used only under qualified engineering supervision.

Informational Note: Experimental testing continues to be performed to validate existing incident energy calculations and to determine new formulas.

The parameters required to make the calculations follow.

(1) The maximum bolted fault, three-phase short-circuit current available at the equipment and the minimum fault level at which the arc will self-sustain. (Calculations should be made using the maximum value, and then at lowest fault level at which the arc is self-sustaining. For 480-volt systems, the industry accepted minimum level for a sustaining arcing fault is 38 percent of the available bolted fault, three-phase short-circuit current. The highest incident energy exposure could occur at these lower levels where the overcurrent device could take seconds or minutes to open.)

(2) The total protective device clearing time (upstream of the prospective arc location) at the maximum short-circuit current, and at the minimum fault level at which the arc will sustain itself.

(3) The distance of the worker from the prospective arc for the task to be performed.

Typical working distances used for incident energy calculations are as follows:

(1) Low voltage (600 V and below) MCC and panelboards — 455 mm (18 in.)

(2) Low voltage (600 V and below) switchgear — 610 mm (24 in.)

(3) Medium voltage (above 600 V) switchgear — 910 mm (36 in.)

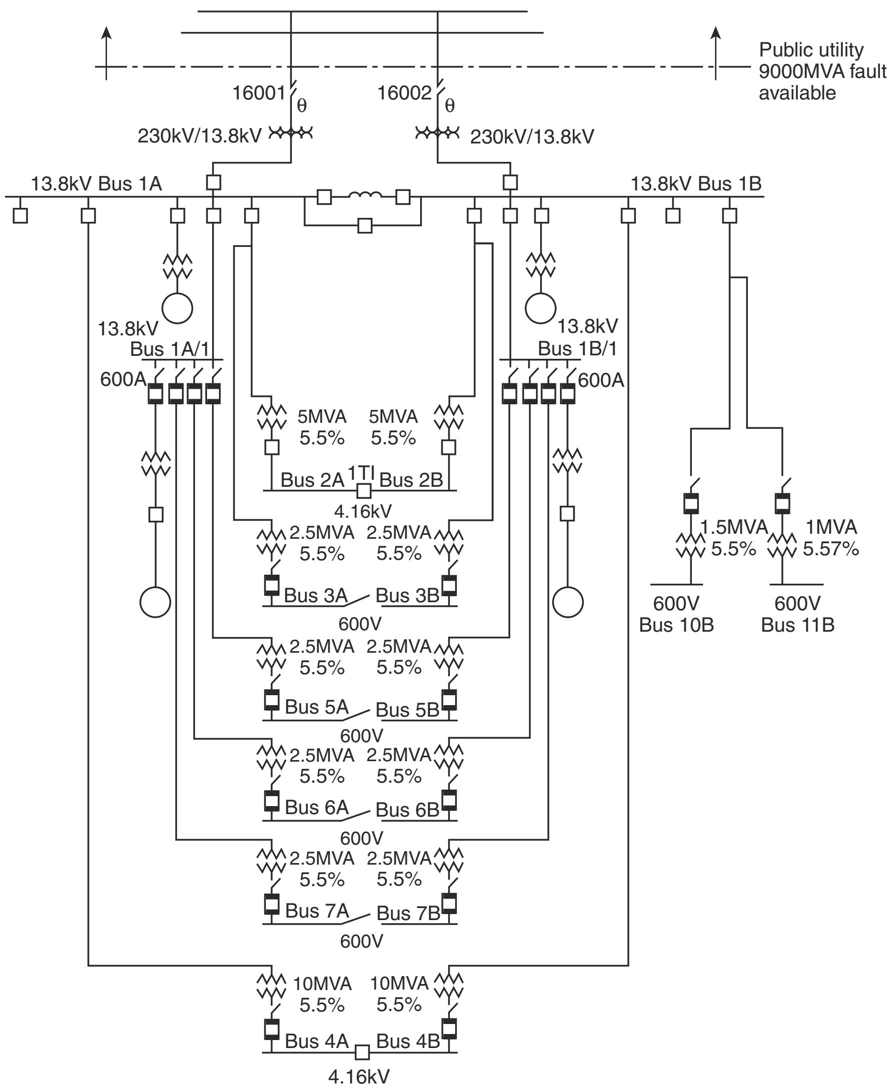

FIGURE D.2.2 Single-Line Diagram of a Typical Petrochemical Complex.

D.3.2 Arc in Open Air. The estimated incident energy for an arc in open air is as follows:

[D.3.2a]

$$E_{MA} = 5271 D_A^{-1.9593} t_A \begin{bmatrix} 0.0016F^2 \\ -0.0076F \\ +0.8938 \end{bmatrix}$$

where:

E_{MA} = maximum open arc incident energy, cal/cm^2
D_A = distance from arc electrodes, in. (for distances 18 in. and greater)
t_A = arc duration, sec
F = short-circuit current, kA (for the range of 16 kA to 50 kA)

Sample Calculation: Using Equation D.3.2(a), calculate the maximum open arc incident energy, cal/cm^2, where D_A = 18 in., t_A = 0.2 second, and F = 20 kA.

[D.3.2b]

$$\begin{aligned} E_{MA} &= 5271\ D_A^{-1.9593} t_A \begin{bmatrix} 0.0016F^2 - 0.0076F \\ +0.8938 \end{bmatrix} \\ &= 5271 \times .0035 \times 0.2 [0.0016 \times 400 - 0.0076 \times 20 + 0.8938] \\ &= 3.69 \times [1.381] \\ &= 21.33\ \text{J/cm}^2 (5.098\ \text{cal/cm}^2) \end{aligned}$$

D.3.3 Arc in a Cubic Box. The estimated incident energy for an arc in a cubic box (20 in. on each side, open on one end) is given in the equation that follows. This equation is applicable to arc flashes emanating from within switchgear, motor control centers, or other electrical equipment enclosures.

[D.3.3a]

$$E_{MB} = 1038.7 D_B^{-1.4738} t_A \begin{bmatrix} 0.0093F^2 \\ -0.3453F \\ +5.9675 \end{bmatrix}$$

where:

E_{MB} = maximum 20 in. cubic box incident energy, cal/cm^2
D_B = distance from arc electrodes, in. (for distances 18 in. and greater)
t_A = arc duration, sec
F = short-circuit current, kA (for the range of 16 kA to 50 kA)

Sample Calculation: Using Equation D.3.3(a), calculate the maximum 20 in. cubic box incident energy, cal/cm^2, using the following:

(1) D_B = 18 in.
(2) t_A = 0.2 sec
(3) F = 20 kA

[D.3.3b]

$$\begin{aligned} E_{MB} &= 1038.7 D_B^{-1.4738} t_A \begin{bmatrix} 0.0093F^2 - 0.3453F \\ +5.9675 \end{bmatrix} \\ &= 1038 \times 0.0141 \times 0.2 \begin{bmatrix} 0.0093 \times 400 - 0.3453 \times 20 \\ +5.9675 \end{bmatrix} \\ &= 2.928 \times [2.7815] \\ &= 34.1\ \text{J/cm}^2 (8.144\ \text{cal/cm}^2) \end{aligned}$$

D.3.4 Reference. The equations for this section were derived in the IEEE paper by R. L. Doughty, T. E. Neal, and H. L. Floyd, II, "Predicting Incident Energy to Better Manage the Electric Arc Hazard on 600 V Power Distribution Systems."

D.4 IEEE 1584-2018 Calculation Method.

N **D.4.1 Introduction.** This section provides a summary of the scope and purpose of IEEE 1584-2018, *Guide for Performing Arc Flash Hazard Calculations,* and it also provides an overview of the model range of parameters. Readers are encouraged to consult IEEE 1584-2018 for further information and detailed guidelines for proper application of the standard.

IEEE 1584-2018 is a revision of IEEE 1584-2002 as amended by IEEE 1584a-2004 and IEEE 1584b-2011.

The scope and purpose of IEEE 1584-2018 are in D.4.2 and D.4.3.

N **D.4.2 Scope.** This guide provides models and an analytical process to enable calculation of the predicted incident thermal energy and the arc-flash boundary (AFB). The process covers a collection of applicable field data, consideration of power system operating scenarios, and calculation parameters. Applications include electrical equipment and conductors for three-phase alternating current (ac) voltages from 208 volts to 15 kV. Calculations for single-phase ac systems and direct current (dc) systems are not a part of this guide, but some guidance and references are provided for those applications. Recommendations for personal protective equipment (PPE) to mitigate arc-flash hazards are not included in this guide.

N **D.4.3 Purpose.** The purpose of the guide is to enable qualified person(s) to analyze power systems for the purpose of calculating the incident energy (IE) to which employees could be exposed during operations and maintenance work. Contractors and facility owners can use this information to provide appropriate protection for employees in accordance with the requirements of applicable electrical workplace safety standards.

The new arc-flash model is a result of the IEEE/NFPA Arc-Flash Phenomena Collaborative Research Project and is based on over 1800 tests. The tests were performed at five different testing facilities over a 6-year period to ensure consistency and repeatability.

N **D.4.4 Range of the Model.** The range of the IEEE 1584-2018 model is provided in Table D.4.4.

N **D.4.5 Comparison with IEEE 1584-2002.** The following are differences between the IEEE 1584-2018 and the IEEE 1584-2002 arc flash models:

(1) The IEEE 1584-2002 arc-flash model was based on approximately 300 tests.
(2) The IEEE 1584-2018 model was based on over 1800 tests.
(3) IEEE 1584-2002 used two configurations.
(4) IEEE 1584-2018 includes five configurations.
(5) Five different labs were used for performing the tests.
(6) IEEE 1584-2002 test results were also used in new model.
(7) Based on the testing performed it was observed that sustainable arcs are possible but less likely in three-phase systems operating at 240 volts nominal or less with an available short-circuit current less than 2000 amperes.

N **D.4.6 Electrode Configuration.** The orientation and arrangement of the electrodes used in the testing performed for the model development.

The following electrode configurations (test arrangements) in Table D.4.6 are defined and utilized in the incident energy model:

(1) VCB: Vertical conductors/electrodes inside a metal box/enclosure
(2) VCBB: Vertical conductors/electrodes terminated in an insulating barrier inside a metal box/enclosure
(3) HCB: Horizontal conductors/electrodes inside a metal box/enclosure
(4) VOA: Vertical conductors/electrodes in open air
(5) HOA: Horizontal conductors/electrodes in open air

N **Table D.4.4 Range of Input Parameters for IEEE 1584-2018**

Input parameter	Range
Voltage (Voc)	208 volts to 15,000 volts 3-phase (line-to-line)
Bolted fault current (I_{bf}): 208 volts to 600 volts — low voltage (LV)	500 amperes to 106 000 amperes (rms symmetrical)
Bolted fault current (I_{bf}): 601 volts to 15,000 volts — medium voltage (MV)	200 to 65 000 A (rms symmetrical)
Gap (G): 208 volts to 600 volts	6.35 mm to 76.2 mm (0.25 in. to 3 in.)
Gap (G): 601 volts to 15,000 volts	19.05 mm to 254 mm (0.75 in. to 10 in.)
Working distance (D)	≥ 305 mm (12 in.)
Fault clearing time (T)	No limit
Maximum height	1244.6 mm (49 in.)
Maximum width	1244.6 mm (49 in.)
Minimum width	Four times the gap mm ($4 \times G$)
Opening area	1.549 m^2 (2401 $in.^2$)
Frequency	50 Hz or 60 Hz

N **D.4.7 Enclosure Size Correction Factor.** The VCB, VCBB, and HCB equations were normalized for a 508 mm × 508 mm × 508 mm (20 in. × 20 in. × 20 in.) enclosure. This model provides instructions on how to adjust incident energy for smaller and larger enclosures using a calculated correction factor.

N **D.4.8 Cautions and Disclaimers.** As an IEEE guide, this document suggests approaches for conducting an arc-flash hazard analysis but does not contain any mandatory requirements that preclude alternate methods. Following the suggestions in this guide does not guarantee safety, and users should take all reasonable, independent steps necessary to reduce risks from arc-flash events.

This information is offered as a tool for conducting an arc-flash hazard analysis. It is intended for use only by qualified persons who are knowledgeable about power system studies, power distribution equipment, and equipment installation practices. It is not intended as a substitute for the engineering judgment and adequate review necessary for such studies.

This guide is based upon testing and analysis of the thermal burn hazard presented by incident energy. Due to the explosive nature of arc-flash incidents, injuries can occur from ensuing molten metal splatters, projectiles, pressure waves, toxic arc by-products, the bright light of the arc, and the loud noise produced. These other effects are not considered in this guide.

This guide is subject to revision as additional knowledge and experience is gained. IEEE, those companies that contributed test data, and those people who worked on the development of this standard make no guarantee of results and assume no obligation or liability whatsoever in connection with this information.

The methodology in this guide assumes that all equipment is installed, operated, and maintained as required by applicable codes, standards, and manufacturers' instructions, and applied in accordance with its ratings. Equipment that is improperly installed or maintained may not operate correctly, possibly increasing the arc flash incident energy or creating other hazards.

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N **Table D.4.6 Electrode Orientation and Configurations**

E.C.	Standard	Orientation	Configuration	Termination
VOA	2002/2018	Vertical	Open air	Open air
VCB	2002/2018	Vertical	Metal enclosure	Open air
VCBB	2018	Vertical	Metal enclosure	Insulating barrier
HOA	2018	Horizontal	Open air	Open air
HCB	2018	Horizontal	Metal enclosure	Open air