



## Arc Flash

# T<sub>2</sub>G

## TECHNICAL TRAINING GROUP

It has been said that we only use 10 percent of our brain. Here is some information to help you fill the other 90 percent. **Brainfiller.com<sup>tm</sup>**

### Flash Protection Boundary

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NFPA 70E Defines the Flash Protection Boundary as:

*An approach limit at a distance from exposed live parts which a person could receive a second degree burn if an electrical arc flash were to occur.*

A few very important words in this description are often overlooked. "second degree burn" I think of arc flash protection as similar to wearing a seat belt in a car. The idea of the seat belt is to protect you against severe injury during a crash, but depending on how severe the accident, you will still likely get banged up during the car wreck, or maybe worse. The same thing holds true for protection against the arc flash. Complying with NFPA 70E is a great beginning and is extremely important for working around live electrical equipment, however NFPA 70E strongly states the safest way to work around electrical equipment is to put it in an electrically safe condition – de-energized it!

How do you determine the flash protection boundary? It is based on a distance from the arc source that you would be exposed to no more than 1.2 cal /cm<sup>2</sup> in most cases. This level of energy is thought to be the minimum to produce a second degree burn. Article 130.3 requires that a Flash Hazard Analysis must be performed in order to determine the Flash Protection Boundary and the Personal Protective Equipment (PPE) required for people working within the Boundary.

Article 130.3 (A) has three different methods for determining the Flash Protection Boundary. The easiest and simplest method requires using a distance of 4 feet for systems with voltages ≤ 600 Volts and a combined bolted short circuit current and protective device clearing time of 5000 Ampere-Seconds. This value is based on a short circuit current of 50,000 Amps and a protective device clearing time of 6 Cycles (0.1 Seconds). The short circuit current would be determined from a short circuit study and the clearing time would be derived from time current curves as I have discussed in previous articles. Usually, overcurrent devices rated below 600 Volts operate instantaneously for larger short circuits. This means around 1 to 6 cycles for the typical device. Current limiting devices such as fuses and some circuit breakers, can operate much faster in the ¼ to ½ cycle range.

NFPA 70E also states that for the combination of current and time other than 5000 Ampere-Seconds or under engineering supervision, There are two other formulas that can be used to determine the flash protection boundary.

Method 1:  $D_c = [53 \times \text{MVAt}_r \times t]^{1/2}$

Method 2:  $D_c = [2.65 \times \text{MVA}_{bf} \times t]^{1/2}$

$D_c$  = Flash Protection Boundary in Feet

$\text{MVA}_{bf}$  = Short Circuit MVA for a three phase bolted fault

$\text{MVAt}_r$  = Transformer MVA i.e. 1500 kVA = 1.5 MVA

Multiply  $\text{MVAt}_r$  X 1.25 if MVA < 0.75

$t$  = Clearing time in seconds

Since the actual boundary is dependent on short circuit current and clearing time, the two formulas lead to more accurate answers but they are not perfect. Method One correlates the effect that transformer size has on the short circuit current. The larger the transformer, the larger the short circuit current. However, method one does not use the source impedance or the actual transformer impedance so it is approximate. The 1.25 multiplier for transformers smaller than 750 kVA (0.75 MVA) is because smaller transformers tend to have lower impedances which allow more short circuit current to flow. Therefore the 1.25 factor compensates for the higher fault current that could exist.

To compare using the standard 4 foot boundary with the two calculation methods I have the following example:  
Determine the Flash Protection Boundary for an arc flash on the secondary side of a 3750 kVA transformer rated 480 Volts with a short circuit current of 50,000 Amps and an over current device clearing time of 6 cycles (0.1 Seconds)

**Method 1:  $D_c = [53 \times \text{MVAt}_r \times t]^{1/2}$**

$D_c = [53 \times 3.75 \text{ MVA} \times 0.1 \text{ Sec.}]^{1/2}$

$D_c = 4.45$  Feet (Greater than 4 feet but does not include source impedance)

**Method 2:  $D_c = [2.65 \times \text{MVA}_{bf} \times t]^{1/2}$**

$\text{MVA}_{bf} = 50,000 \text{ Amps} \times \text{sqrt}(3) \times 0.48 \text{ kV} = 41.569 \text{ MVA}_{bf}$

$D_c = [2.65 \times \text{MVA}_{bf} \times t]^{1/2} = [2.65 \times 41.569 \text{ MVA}_{bf} \times 0.1 \text{ Sec.}]^{1/2}$

$D_c = 3.32$  Feet (Less than 4 feet and is based on actual impedances since short circuit current is given)

**Method 3 Article 130.3 (4) – 5000 Ampere-Seconds:**

$D_c = 4.0$  Feet

Method two is more accurate than method one since it uses the actual short circuit current rather than the estimated value based on the size of the transformer only. However, the arc flash event has so many variables, including the gap of the arc, the magnitude of the arcing current and many others, at best the values are approximate.



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#### Page 2

Caution should be used in determining the boundary because it is possible that an overcurrent device could have a significant time delay allowing a greater duration of the arc and significantly increasing the arc flash hazard and boundary. It is possible that having a short circuit that is lower could cause a longer overcurrent device time delay resulting in a boundary that is much greater.

Research continues by various dedicated groups such as NFPA and IEEE to refine and improve the accuracy of the methods for calculating the flash protection boundary and improving worker safety. NFPA 70E is the main document used for electrical safety and it is heavily relied on by OSHA as well.

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