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REDUCING ARC FLASH HAZARD BY REMOTE SWITCHING

One of the effective methods of reducing the arc flash hazard is to switch devices remotely rather than at the circuit breaker, contactor, or switch. Two of the key factors in reducing the energy are the reduction in the clearing time and the increase in the distance from the energized piece of equipment. This document focuses on the distance.

The arc flash calculations in this document are based on the formulas given in IEEE Standard 1584-2002 – Guide for Performing Arc-Flash Hazard Calculations. Four cases are evaluated and remote switching distances are plotted for each case:

- Case 1: 208V To 999V Systems
  Equipment Class = 3
  Grounding = 1 or 2
  18” Working Distance

- Case 2: 208V To 999V Systems
  Equipment Class = 3
  Grounding = 1 or 2
  24” Working Distance

- Case 3: 1 kV to 14.9 kV Systems
  Equipment Class = 3
  Grounding = 1 or 2
  24” Working Distance

- Case 4: 1 kV to 14.9 kV Systems
  Equipment Class = 3
  Grounding = 1 or 2
  36” Working Distance

Case 1: 208V To 999V Systems – Equipment Class = 3 – Grounding = 1 or 2 18" Working Distance

The calculations for this case are based on the following:

1. 208V to 999V systems
2. 18 inch working distance
3. Equipment Class = 3, which is switchgear. Equipment Classes 1, 2, and 4 are less severe. The distances determined in this section can conservatively be applied to all of these types of equipment.
4. The grounding type does not change the results determined below. The distances determined here can be applied to three-phase systems with any grounding type.

Based on the above parameters, calculations of remote switching distances are given in Table 1.

For example, if the incident energy was calculated to be 100 cal/cm^2 at 18",

- PPE = 4 (40 cal/cm^2) would be appropriate at $\geq$ 2.8 feet,
- PPE = 2 (8 cal/cm^2) would be appropriate at $\geq$ 8.3 feet, and
- PPE = 0 (1.2 cal/cm^2) would be appropriate at $\geq$ 30.2 feet.

Table 1
Remote Switching Distances
208V to 999V Systems

Calculated Incident Energy At Working Distance = 18" (cal/cm^2)	Distance Required to Achieve The PPE Indicated (Feet)		
	PPE = 4	PPE = 2	PPE = 0
1.2			1.5
8.0		1.5	5.4
40.0	1.5	4.5	16.2
100.0	2.8	8.3	30.2
400.0	7.2	21.4	77.4
800.0	11.5	34.3	123.9
1300.0	16.0	47.6	172.3
2000.0	21.4	63.8	230.9

High incident energies are given in Table 1 for reference, but it is generally recommended to apply protection methods that would give lower energies whenever possible.

The calculated results in Table 1 are also plotted in Figures 1A and 1B for easy reference in determining at what distance lower PPE levels will be appropriate.

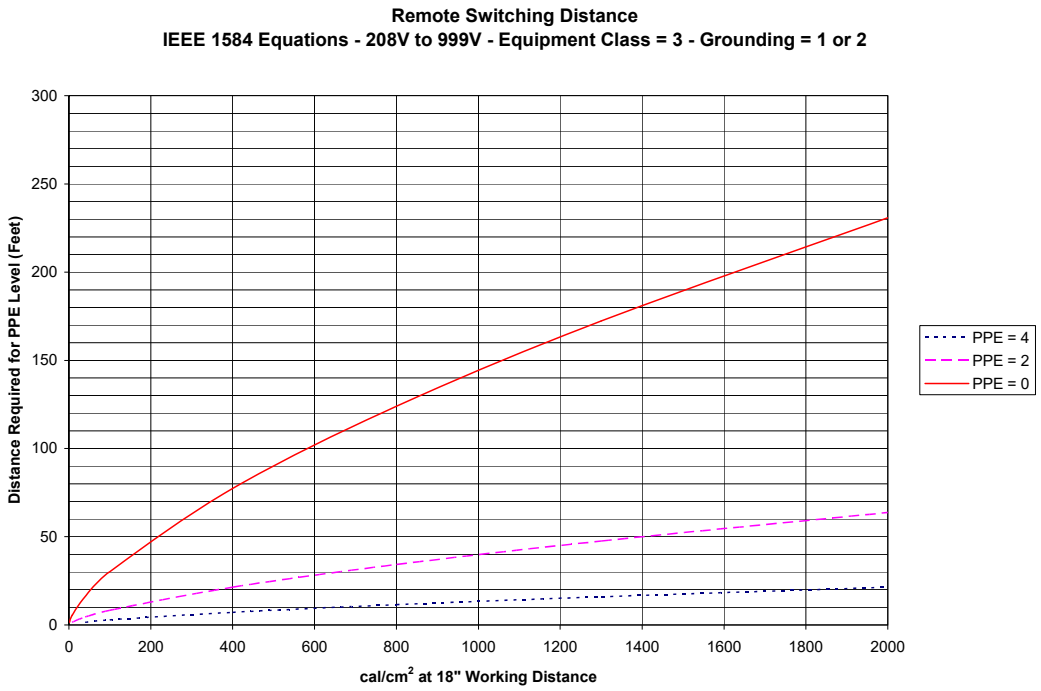

Figure 1A

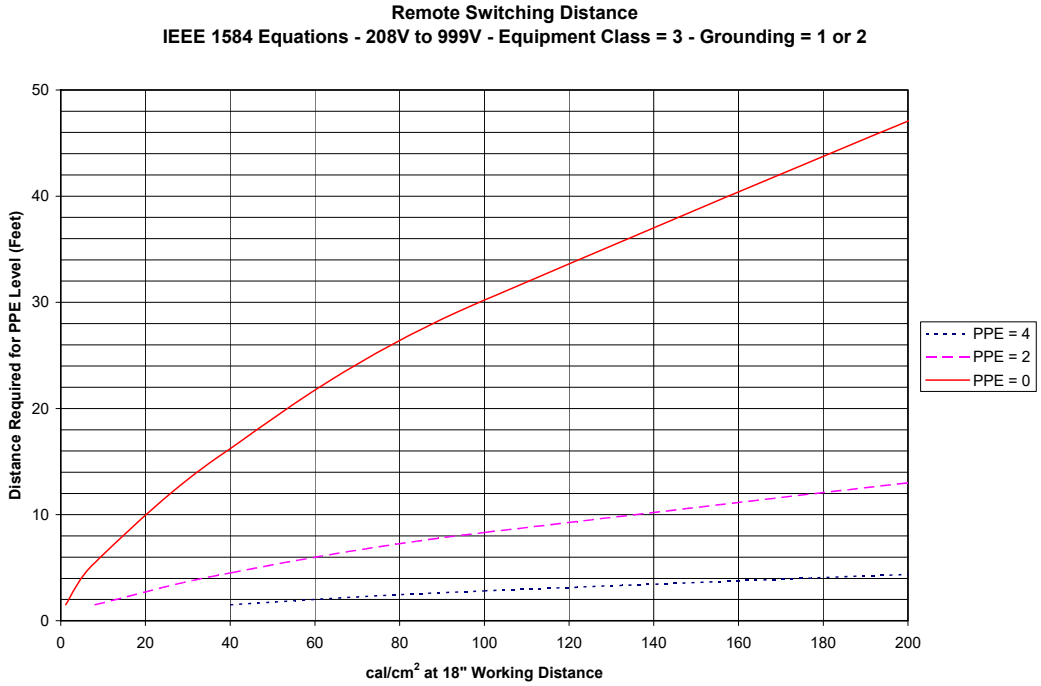

Figure 1B

Case 2: 208V To 999V Systems – Equipment Class = 3 – Grounding = 1 or 2 24" Working Distance

The calculations for this case are based on the following:

1. 208V to 999V systems
2. 24 inch working distance
3. Equipment Class = 3, which is switchgear. Equipment Classes 1, 2, and 4 are less severe. The distances determined in this section can conservatively be applied to all of these types of equipment.
4. The grounding type does not change the results determined below. The distances determined here can be applied to three-phase systems with any grounding type.

Based on the above parameters, calculations of remote switching distances are given in Table 2.

For example, if the incident energy was calculated to be 100 cal/cm^2 at 24",

- PPE = 4 (40 cal/cm^2) would be appropriate at $\geq$ 3.8 feet,
- PPE = 2 (8 cal/cm^2) would be appropriate at $\geq$ 11.2 feet, and
- PPE = 0 (1.2 cal/cm^2) would be appropriate at $\geq$ 40.3 feet.

Table 2
Remote Switching Distances
208V to 999V Systems

Calculated Incident Energy At Working Distance = 24" (cal/cm^2)	Distance Required to Achieve The PPE Indicated (Feet)		
	PPE = 4	PPE = 2	PPE = 0
1.2			2.0
8.0		2.0	7.3
40.0	2.0	6.0	21.6
100.0	3.8	11.2	40.3
400.0	9.6	28.5	103.2
800.0	15.3	45.6	165.3
1300.0	21.3	63.4	229.8
2000.0	28.5	84.9	307.8

High incident energies are given in Table 2 for reference, but it is generally recommended to apply protection methods that would give lower energies whenever possible.

The calculated results in Table 2 are also plotted in Figures 2A and 2B for easy reference in determining at what distance lower PPE levels will be appropriate.

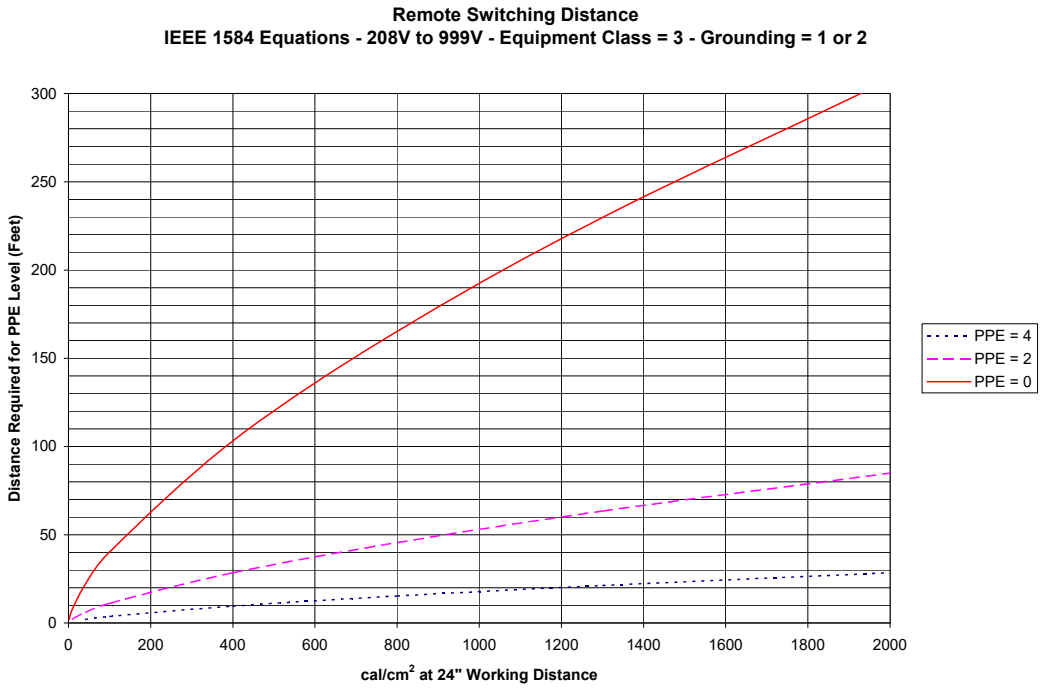

Figure 2A

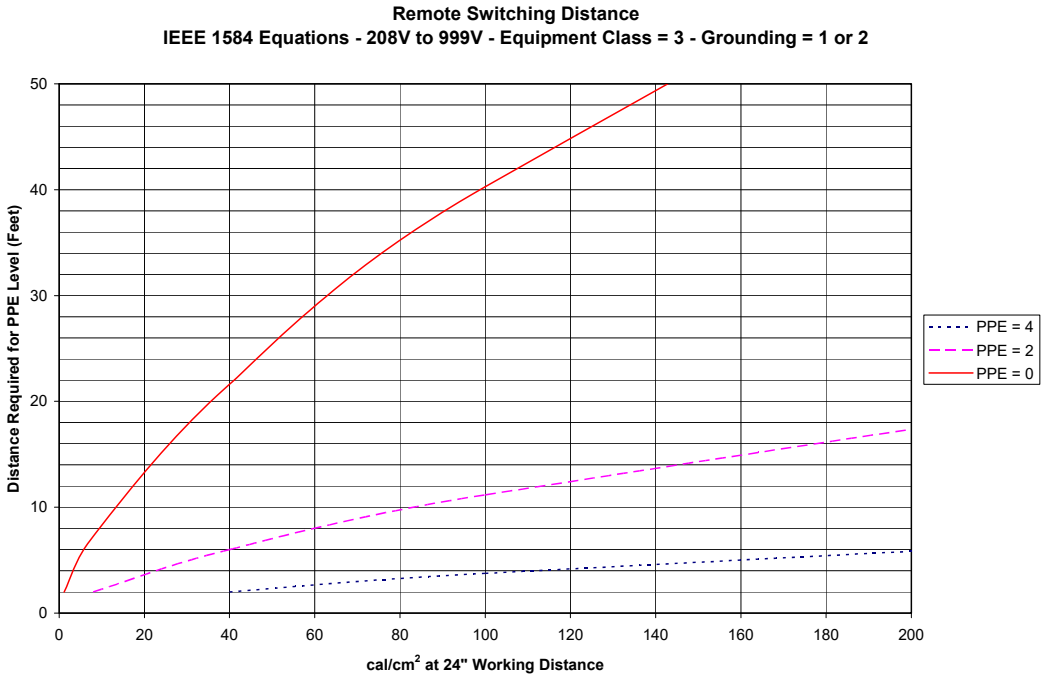

Figure 2B

Case 3: 1 kV to 14.9 kV Systems – Equipment Class = 3 – Grounding = 1 or 2 24" Working Distance

The calculations for this case are based on the following:

1. 1 kV to 14.9 kV systems
2. 24 inch working distance
3. Equipment Class = 3, which is switchgear. Equipment Classes 1, 2, and 4 are less severe. The distances determined in this section can conservatively be applied to all of these types of equipment.
4. The grounding type does not change the results determined below. The distances determined here can be applied to three-phase systems with any grounding type.

Based on the above parameters, calculations of remote switching distances are given in Table 3.

For example, if the incident energy was calculated to be 100 cal/cm^2 at 24",

- PPE = 4 (40 cal/cm^2) would be appropriate at $\geq$ 5.2 feet,
- PPE = 2 (8 cal/cm^2) would be appropriate at $\geq$ 26.8 feet, and
- PPE = 0 (1.2 cal/cm^2) would be appropriate at $\geq$ 188.4 feet.

Table 3
Remote Switching Distances
1 kV to 14.9 kV Systems

Calculated Incident Energy At Working Distance = 24" (cal/cm^2)	Distance Required to Achieve The PPE Indicated (Feet)		
	PPE = 4	PPE = 2	PPE = 0
1.2			2.0
8.0		2.0	14.1
40.0	2.0	10.5	73.5
100.0	5.2	26.8	188.4
400.0	21.3	111.5	783.3
800.0	43.5	227.3	1597.0
1300.0	71.6	374.2	2630.3
2000.0	111.5	582.5	4095.3

High incident energies are given in Table 3 for reference, but it is generally recommended to apply protection methods that would give lower energies whenever possible.

The calculated results in Table 3 are also plotted in Figures 3A and 3B for easy reference in determining at what distance lower PPE levels will be appropriate.

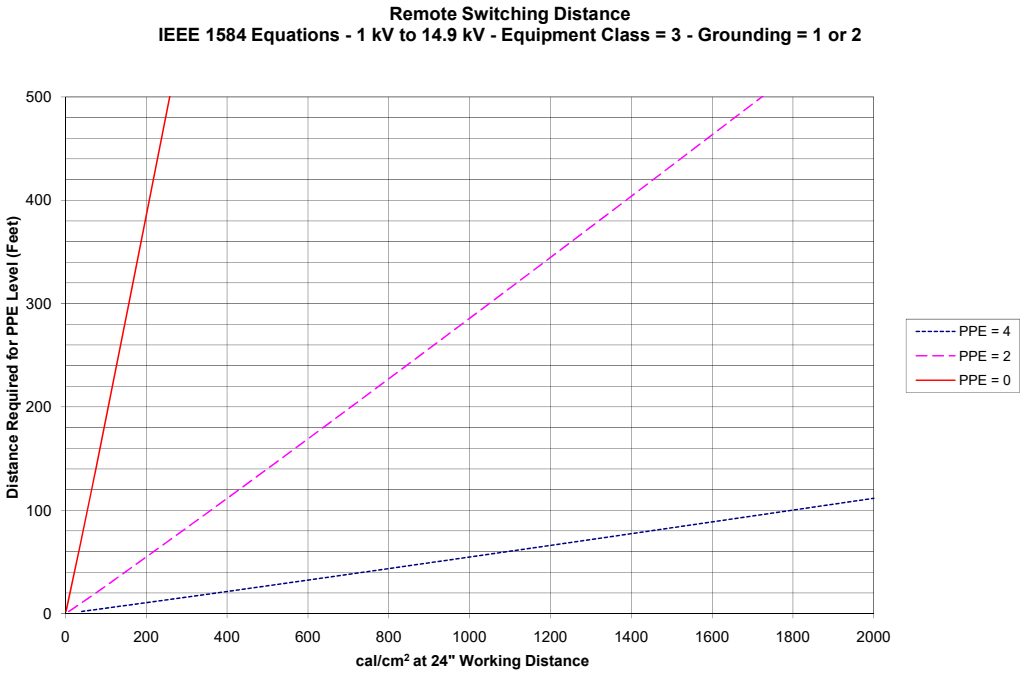

Figure 3A

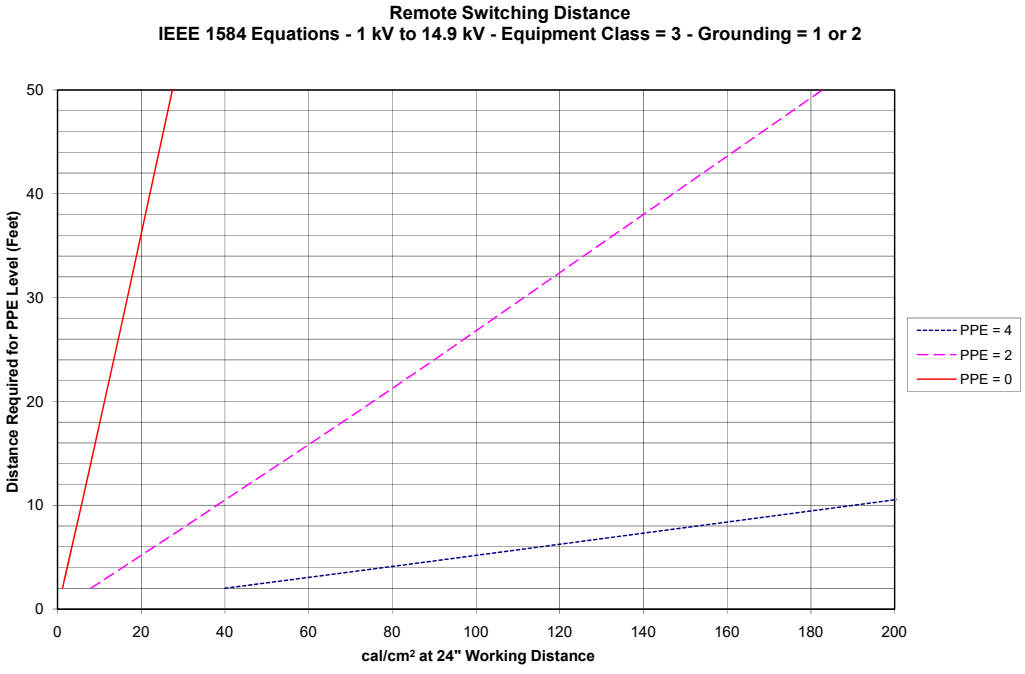

Figure 3B

Case 4: 1 kV to 14.9 kV Systems – Equipment Class = 3 – Grounding = 1 or 2 36" Working Distance

The calculations in this section are based on the following:

1. 1 kV to 14.9 kV systems
2. 36 inch working distance
3. Equipment Class = 3, which is switchgear. Equipment Classes 1, 2, and 4 are less severe. The distances determined in this section can conservatively be applied to all of these types of equipment.
4. The grounding type does not change the results determined below. The distances determined here can be applied to three-phase systems with any grounding type.

Based on the above parameters, calculations of remote switching distances are given in Table 4.

For example, if the incident energy was calculated to be 100 cal/cm^2 at 36",

- PPE = 4 (40 cal/cm^2) would be appropriate at $\geq$ 7.8 feet,
- PPE = 2 (8 cal/cm^2) would be appropriate at $\geq$ 40.3 feet, and
- PPE = 0 (1.2 cal/cm^2) would be appropriate at $\geq$ 282.6 feet.

Table 4
Remote Switching Distances
1 kV to 14.9 kV Systems

Calculated Incident Energy At Working Distance = 36" (cal/cm^2)	Distance Required to Achieve The PPE Indicated (Feet)		
	PPE = 4	PPE = 2	PPE = 0
1.2			3.0
8.0		3.0	21.1
40.0	3.0	15.8	110.2
100.0	7.8	40.3	282.6
400.0	32.0	167.3	1174.9
800.0	65.3	340.8	2395.5
1300.0	107.4	561.7	3945.4
2000.0	167.3	873.8	6142.9

High incident energies are given in Table 4 for reference, but it is generally recommended to apply protection methods that would give lower energies whenever possible.

The calculated results in Table 4 are also plotted in Figures 4A and 4B for easy reference in determining at what distance lower PPE levels will be appropriate.

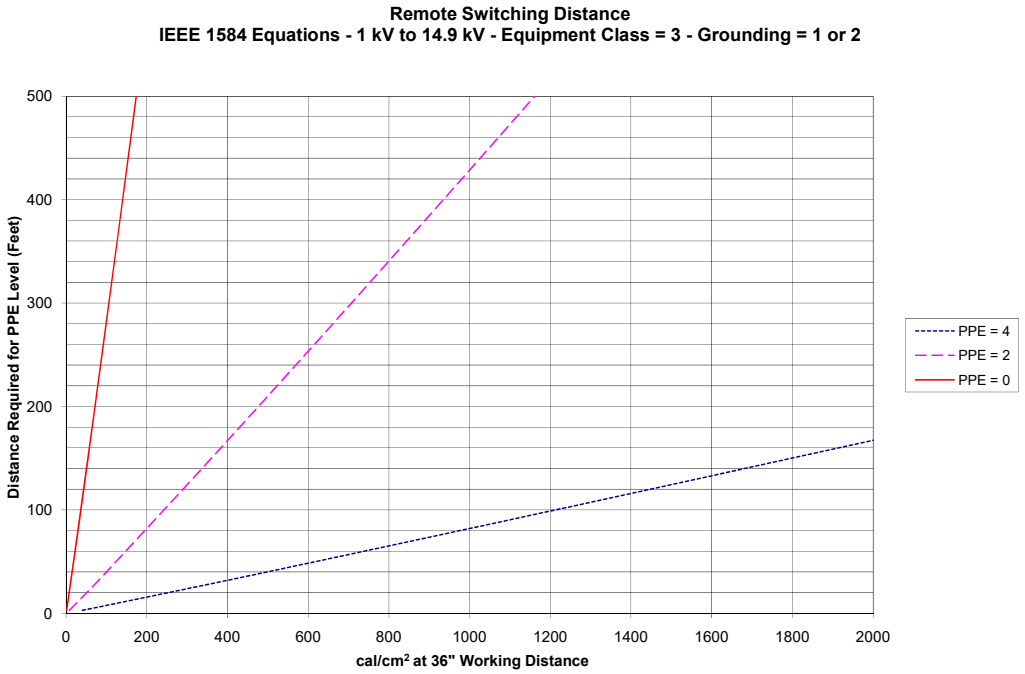

Figure 4A

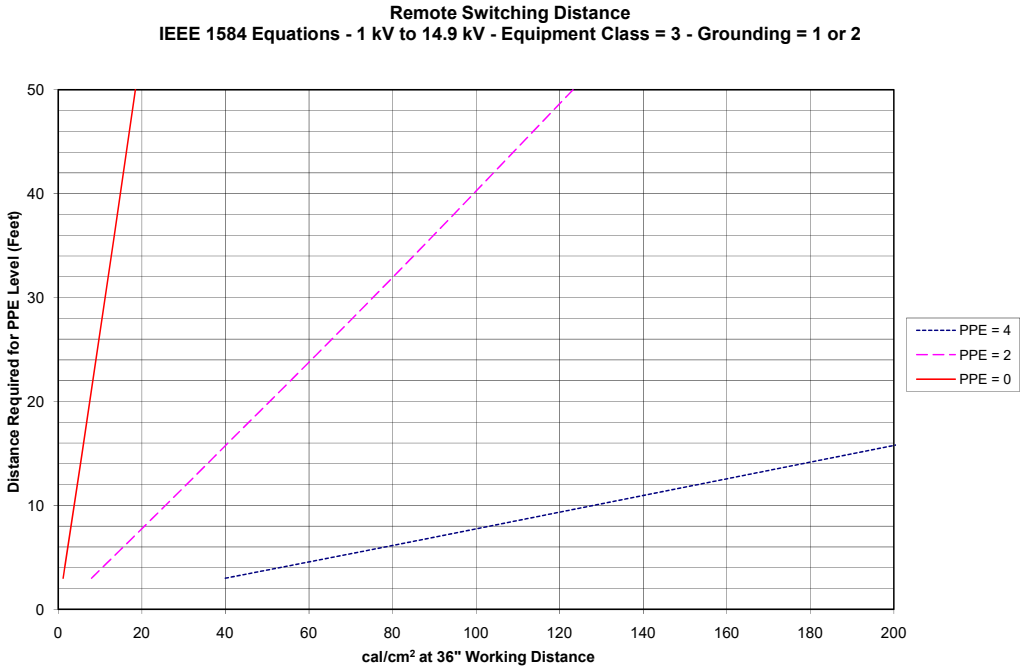

Figure 4B

Note: ***The analysis in this document was done based on the arc flash methodology given in IEEE Standard 1584-2002. Recently, this standard was updated in 1584-2018. Although the results in this document are based on 1584-2002, they are comparable to those calculated based on 1584-2018 at low voltage for the VCB electrode configuration and at medium voltage based on the VCBB electrode configuration. The arc flash boundaries are significantly shorter at medium voltage based on the 1584-2018 calculation methodology compared to the 1584-2002 formulas.***