APPLICATION GUIDE

Arc Flash Mitigation for battery systems in Data Centers

IEC

Arc flashes are always a risk in facilities where electric power usage is high. Although, for the most part, passive protection for vital components of data centers like UPS battery systems is considered sufficient, an active protection system for increased safety of equipment is also necessary. Discover our complete Arc flash mitigation bundle for UPS battery systems in Data Centers.

What is arc flash mitigation for UPS battery systems?
It is the capability of coordinating the arc flash monitoring relay with the direct current protection devices of battery systems so as to reduce the impact of an arc. A relay with optical sensors detects the light produced by an arc flash and sends a signal to the breakers in less than 1 ms. The total fault clearing time of systems with coordinated breakers is less than 100 ms.

Why you need arc flash mitigation for UPS battery systems
Arc flashes do not only occur in alternating current distribution systems but in direct current distribution ones as well and battery systems are an essential part of UPS. Active measure protection, as in the solution proposed here, increases personnel and equipment safety by reducing arc flash energy. As a result, repair costs are lower and downtime is reduced since the electrical installation can be returned to normal operation faster than installations without an active arc mitigation system.

Main benefits

Maximum protection
Protect personnel and minimize the risk of injuries thanks to our solution.

Maximized uptime
Reduced downtime, equipment damage and recovery costs.

Maximum peace of mind
Relays in tested ABB application.

UPS battery system

Typical Architecture and main components

The typical distribution system for UPS battery systems comprises individual battery modules connected in series and in parallel in order to reach the desired power and voltage level.

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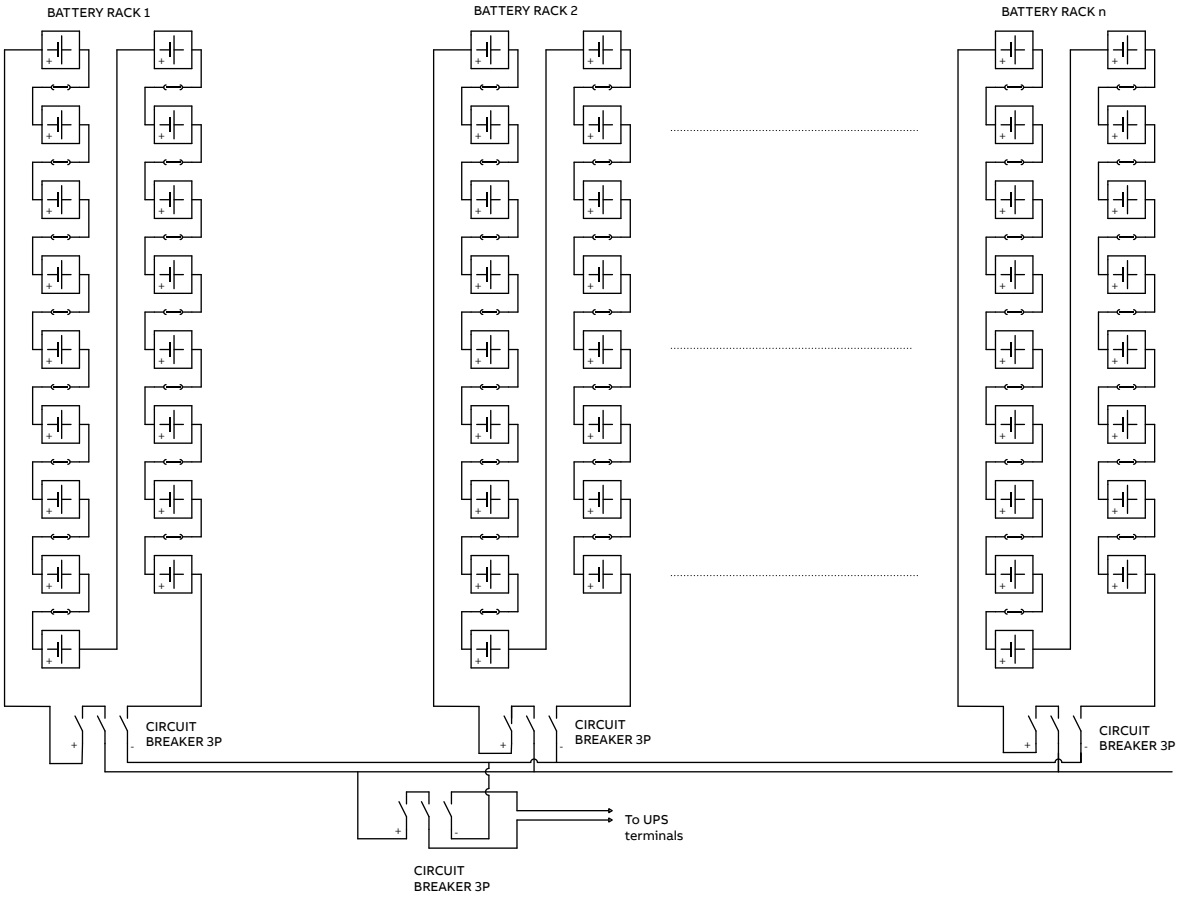
Typical DC power distribution system for UPS battery units



The batteries in a UPS are responsible for supplying power during unexpected outages. The most commonly used types are Lithium-ion (Li-ion), batteries, which do not contain mercury, lead or other hazardous materials. In addition, Li-ion batteries are much more tolerant of ambient temperature changes. They can also operate over a broader temperature range and have a lower total cost of ownership.

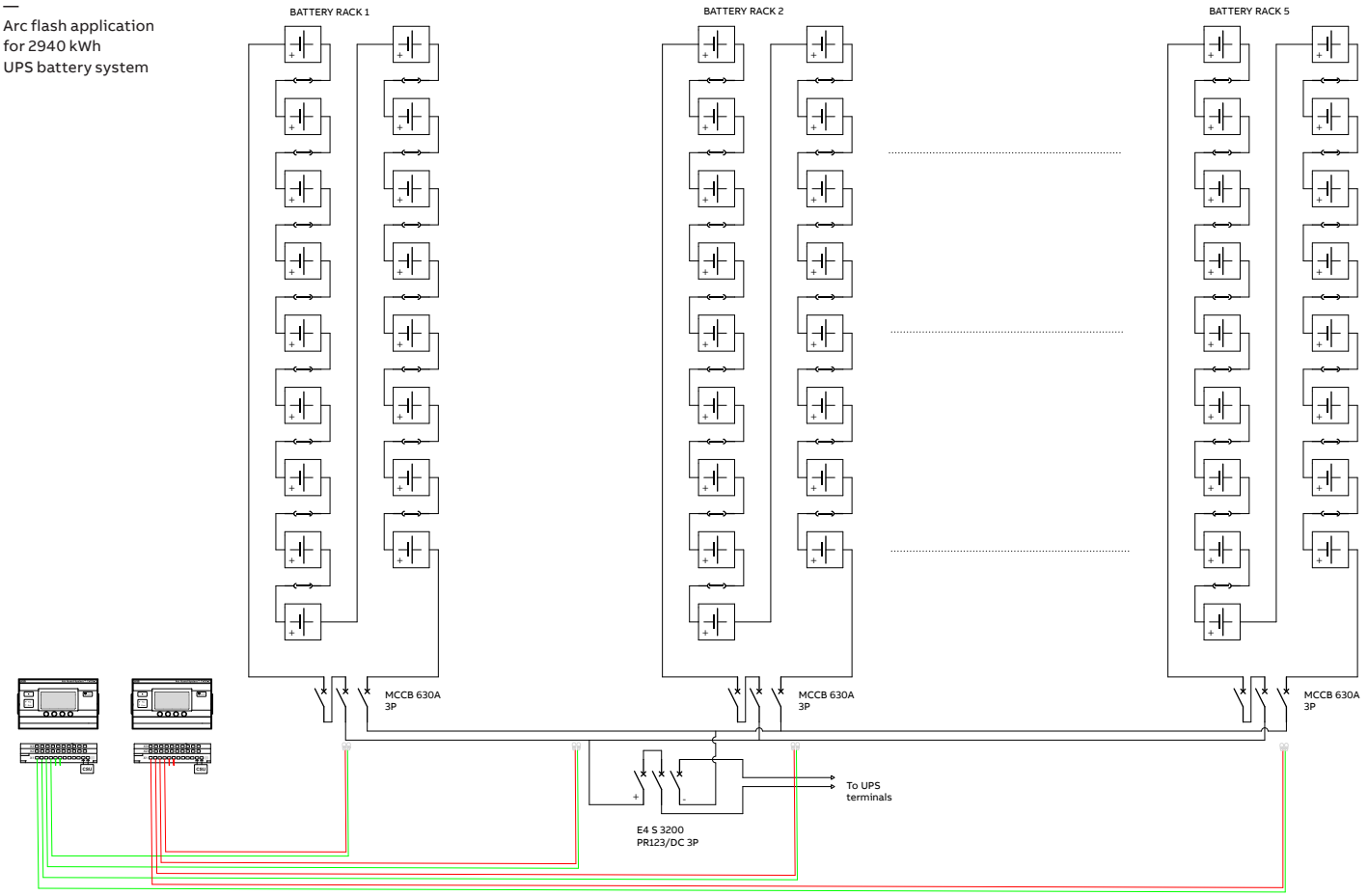
Each battery system has various battery management systems for single modules, single strings and for complete systems (multiple racks in parallel), plus fuses and circuit breaker protection. A single rack configuration generally comprises a switchgear, Switch Mode Power Supply (SMPS) and battery modules.

Arc flash mitigation for UPS Li-ion battery systems in Data Centers

DC busbar protection

Discover our Arc flash mitigation solution for IT load supply in a 2940 kWh UPS battery system - DC busbar protection

Arc flash application
for 2940 kWh
UPS battery system



Technical assumptions		
Type of battery		Lithium-ion
Operating DC voltage	[V]	From 435 to 571
Number of battery modules in series per rack		17
Number of battery racks in parallel		5
Total battery system capacity	[kWh]	2941
Breaker rating for Battery Control Unit	[A]	600

When deciding on arc flash protection, it is important to differentiate between two main configurations based on the type of arc: series arc, the most common, and parallel arc [1].

1) Carlos, E.R., “Arc Fault Detection and Discrimination Methods”, Proceedings of the IEEE Holm Conference on Electrical Contacts, 2007

Arc Flash Mitigation solution

Series Arc

The series arc occurs in series with the load, thus between two parts of the same conductor, as shown in the figure below. Breaks in wires, plugging and unplugging connectors under load or loose wires are its most common causes.
Such faults cannot be detected and cleared by fuses and circuit breakers before they cause further damage since the arcing current is lower than the load current due to the existence of arc impedance and load impedance [2].

2) Sultana, Q., "Novel Control Methodology for Detecting Series Arcs in DC Circuits", IEEE Second International Conference on DC Microgrids, 2017

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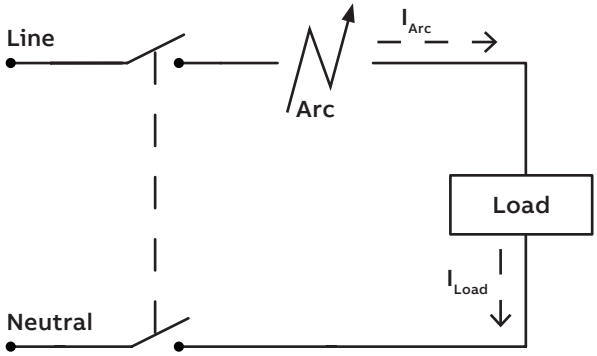
Series arc



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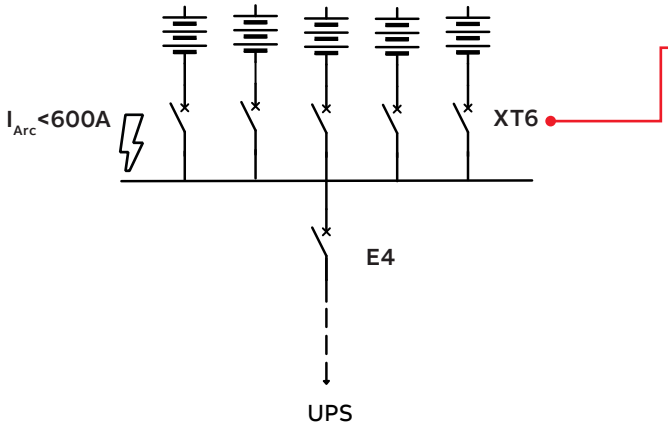
Series arc flash in busbar



Main components
XT6S 800 TMA 630-6300 3p F F

- Trip Unit Settings
  - Overload: I1: 600A
  - Instantaneous short-circuit: I3: 3150A
- For the above settings, the tripping line starts at 600A, the tripping time of which is 10000 seconds. The breaker will never trip when the arcing current is lower than the I1 setting.

In these cases, the arc flash mitigation solution is proposed as an active protection. The main component is arc flash relay TVOC-2, which is connected to several optical sensors.
Optical sensors are provided for paralleling the connections of the battery units.

If a series arc occurs on the paralleling connection of the battery units, TVOC-2 will send a trip signal to all Tmax XT6 breakers, thereby interrupting the contribution provided by all the units.

Arc Flash Mitigation solution

Parallel Arc

Parallel arc faults are in parallel to the load, thus between different conductors. Damaged or broken wires forming an arc to the ground or to a low voltage potential are examples of parallel arcs.

These arcs are relatively easy to detect by circuit breakers and fuses [2].

2) Sultana, Q., "Novel Control Methodology for Detecting Series Arc in DC Circuits", IEEE Second International Conference on DC Microgrids, 2017

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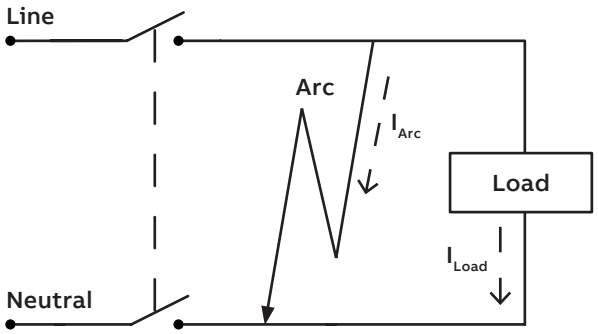
Parallel arc



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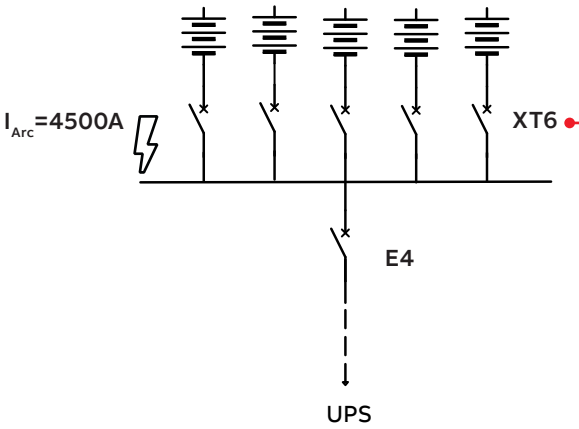
Parallel arc flash in busbar



Main components
XT6S 800 TMA 630-6300 3p F F

- Trip Unit Settings
  - Overload: I1: 600A
  - Instantaneous short-circuit: I3: 3150A
- For the above settings, tripping time at 4500A is between 15-18ms.

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Result of parallel arc incident energy calculation per battery unit

As shown by the arc incident calculation below, the tripping time of a molded-case circuit-breaker when a parallel arc occurs is already short enough for protection against the effects of the arc. (further information is provided in annex A)

Result of parallel arc incident energy calculation per battery unit

		Over Current Protection without TVOC-2	Arc Flash Mitigation with TVOC-2
V_{sys}	[V]	571.2	571.2
I_{bf}	[A]	9000	9000
I_{arc}	[A]	4500	4500
T_{arc}	[s]	0,018	0,08
D	[cm]	80	80
$IE_{max\ power}$	[cal/cm²]	0,072	0,400
PPE Category		1	1

To conclude, arc flashes are important events in direct current distribution and must be considered. Depending on the architecture, even parallel arcing current can be low enough to remain in the overload zone. Even if protection devices detect the fault, they take much longer to react, even as long as 1000s. As a safeguard against all possible events, it is obvious that an active measure protection solution increases personnel and equipment safety by reducing the energy of the arc.

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To know more about **protection against electric arcs discover our White paper.**

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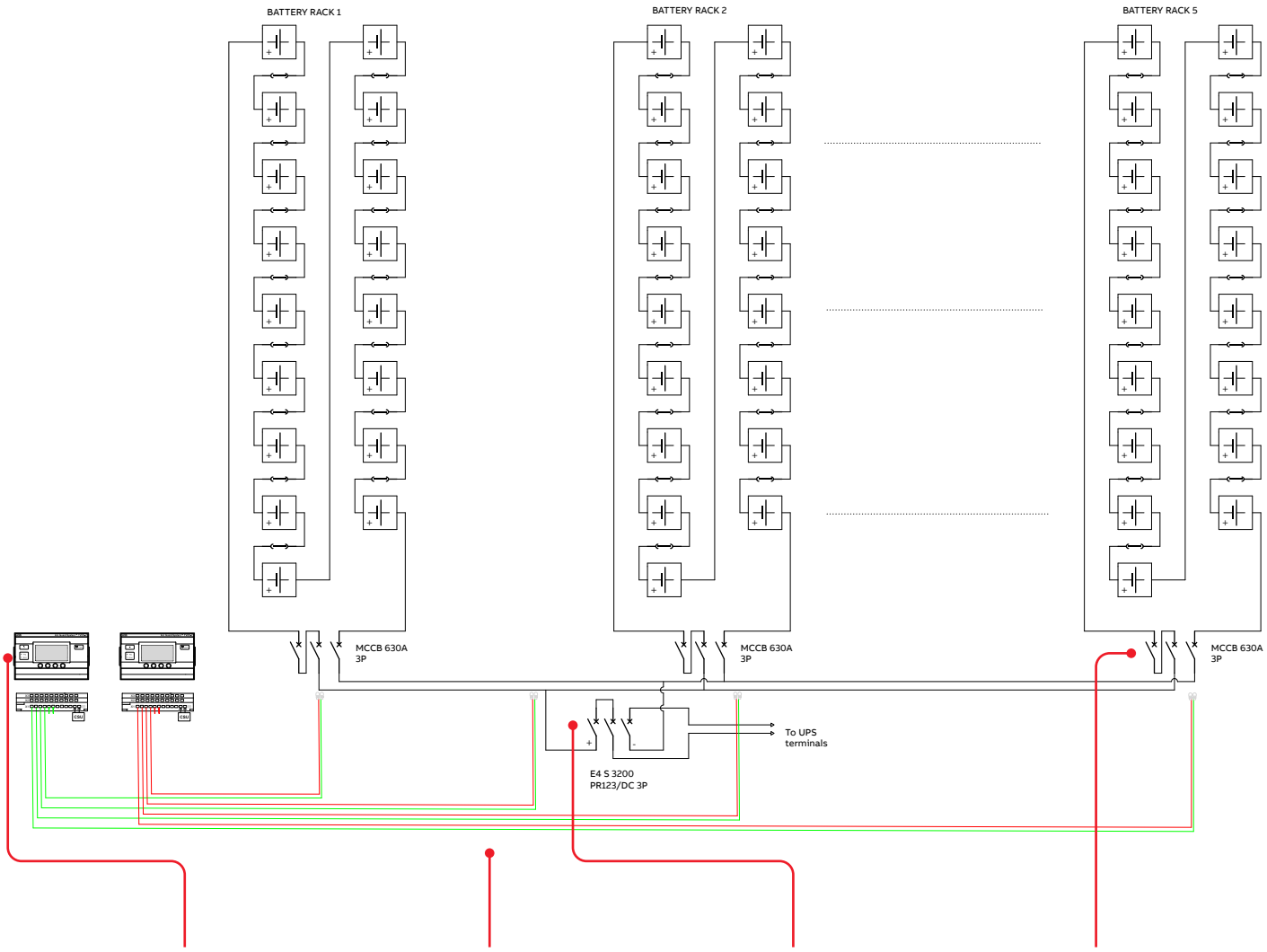
Discover ABB **IEC solutions for low and medium voltage Arc flash protection and mitigation.**

ABB offering (IEC)



TVOC-2-240 Arc Monitor - main unit

Detectors with various cable lengths

E4S 3200 PR123/DC In=3200A 3p F VR

XT6S 800 TMA 630-6300 3p F F

Bill of materials

Order Code	Description	Quantity
1SFA664001R1001	TVOC-2-240 Arc Monitor	2
1SFA664003R1080	TVOC-2-DP8 Detectors with 8 m cable length	2
1SFA664003R1060	TVOC-2-DP6 Detectors with 6 m cable length	4
1SFA664003R1040	TVOC-2-DP4 Detectors with 4 m cable length	4
1SFA664003R1010	TVOC-2-DP1 Detectors with 1 m cable length	2
1SFA664006R1001	TVOC-2-MK1 Cable Strap. Includes 50 pieces	1
1SDA107574R1	XT6S 800 TMA 630-6300 3p F F	5
1SDA104926R1	YO XT5-XT6 110..240 VAC - 110..250 VDC	5
1SDA064727R1	E4S 3200 PR123/DC In=3200A 3p FVR	1

*Power supply for TVOC-2 and YO shunt opening release is not included.

APPLICATION FINDER

We've made it simpler for you to set up your project!
Click here to find the reference architecture that best fits your needs and download the Bill of Materials.

Product offering

TVOC-2:

WEB PAGE

CATALOG

Emax DC:

WEB PAGE

CATALOG

Tmax XT:

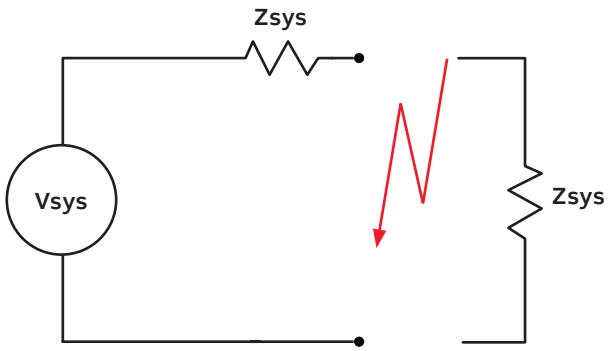
WEB PAGE

CATALOG

Annex A - Arc Incident Energy Calculation

In this paper, the maximum power method by Doan, as published in the IEEE Transactions on Industry Applications [3] and mentioned in Annex D of Standard NFPA 70E, is used to estimate DC parallel arc flash incident energy. This method applies to DC systems rated up to 1000V.
An example of this calculation method for a basic circuit is given below:

3) Doan, D.R., "Arc Flash Calculations for Exposures to DC Systems," IEEE Transactions On Industry Applications, Vol. 46, No 6., 2010.



Simple DC system model

After certain assumptions, arc flash incident energy can be estimated by the maximum power method formula below:

$$I_{arc} = 0.5 \times I_{bf}$$

$$IE_{maxpower} = 0.01 \times V_{sys} \times I_{arc} \times T_{arc}/D^2$$

V_{sys}	system voltage [V]
I_{bf}	system bolted fault current [A]
I_{arc}	arcing current [A]
T_{arc}	arcing time [s]
D	working distance [cm]
$IE_{maxpower}$	estimated DC arc flash incident energy at maximum power point [cal/cm^2]

Based on incident energy, a table of the personal protective equipment (PPE) required is given below. Consult Table 130.7(C)(15)(c) of standard NFPA 70 [4] for further information about the clothing required.

4) NFPA 70E-2021 Standard for Electrical Safety Requirements for Employee Workplaces.

Personal Protective Equipment (PPE) required, based on Arc Flash Incident Energy [4]

Arc Flash PPE category	Arc Rating Minimum (cal/cm^2)
1	4 cal/cm^2
2	8 cal/cm^2
3	25 cal/cm^2
4	40 cal/cm^2

To discover more

APPLICATION FINDER

Find the reference architecture tailored to your needs and speed up your project thanks to our new Application Finder Tool!

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