

Electrical PPE 101

Do you need to protect your workers from electrical hazards while working on energized equipment? How do you figure out what you need? The National Electrical Safety Code (for utilities) and the NFPA 70E (for industry) try to make selection easier. But, in the end, virtually every facility needs an Arc Flash Hazard Analysis done – there’s no way around it.

The NESC, Section 41.410.A.3 (page 246) states “Effective as of January 1, 2009, the employer shall ensure that an assessment is performed to determine potential exposure to an electric arc for employees who work on or near energized parts or equipment. If the assessment determines a potential employee exposure greater than 2 cal/cm² exists..., the employer shall require employees to wear clothing or a clothing system that has an effective arc rating not less than the anticipated level of arc energy.”

The NFPA 70E: Standard for Electrical Safety in the Workplace® specifically addresses how to deal with arc flash hazards. Article 130.3 states, “A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use... It shall be reviewed periodically, not to exceed five years, to account for changes in the electrical distribution system that could affect the results of the arc flash hazard analysis.” Article 130.3(c) states “Equipment shall be field marked with a label containing the available incident energy or required level of PPE.”

BUT, if you haven’t completed your Arc Flash Hazard Analysis yet, what do you do? In this short document, we try to give you some guidance on how to select PPE in the meantime.

Disclaimer

AVO Training Institute, Inc. accepts NO liability for your use of this document in choosing PPE. We recommend completing an Arc Flash Hazard Analysis, as directed by the NFPA 70E or NESC, in order to accurately choose your PPE.

Choosing gloves

Insulated gloves are a special case – they are designed to protect workers from **shock hazards**. Glove selection is solely based on voltage. The NFPA is currently researching the effectiveness of the combination of rubber gloves and leather protectors as arc flash protection. This chart is based on ASTM D 120.

Max AC Voltage	Max DC Voltage	Glove Class
500	750	00
1000	1500	0
7500	11250	1
17000	25500	2
26500	39750	3
36000	54000	4

Do you have a utility or industrial power system?

You may wonder why industrial and utility power systems are so dramatically different. Utilities are generally much higher voltages. Why are the ATPV (Arc Thermal Performance Value) requirements so much less? The calculations used to create the NESC tables take into account that the blast will dissipate in all directions, i.e. arc in open air. In an industrial environment the blast is usually enclosed and will be concentrated in a specific direction, i.e. arc in a box.

After you decide on a hazard rating (cal/cm^2) go to page 8 for PPE requirements.

Utility Power Systems

Based on NESC 410 Tables

For medium and high voltage applications

For low-voltage systems use Industrial Power Systems

Do you know:

- Phase-to Phase Voltage (kV)?
- Fault Current (kA)?
- Maximum Clearing Time?

No? Assume a worst case scenario of 12 cal/cm^2 .

Yes? Use the NESC tables on the following page. Understand that there are a ton of assumptions that were made in generating these tables – See the NESC (page 246-249) for details.

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From NESC Table 410-1 and Table 410-2

Voltage (kV) phase-to-phase	Fault Current	4 cal/cm ²	8 cal/cm ²	12 cal/cm ²
		Max Clearing Time (cycles)	Max Clearing Time (cycles)	Max Clearing Time (cycles)
1 to 15	5	46.5	93	139.5
	10	18	36.1	54.1
	15	10	20.1	30.1
	20	6.5	13	19.5
15.1 to 25	5	27.6	55.2	82.8
	10	11.4	22.7	34.1
	15	6.6	13.2	19.8
	20	4.4	8.8	13.2
25.1 to 36	5	20.9	41.7	62.6
	10	8.8	17.6	26.5
	15	5.2	10.4	15.7
	20	3.5	7.1	10.6
36.1 to 46	5	16.2	32.4	48.6
	10	7	13.9	20.9
	15	4.3	8.5	12.8
	20	3	6.1	0.1
46.1 to 72.5	20	8.5	17	25.5
	30	5.3	10.5	15.8
	40	3.7	7.3	11
	50	2.8	5.5	8.3
72.6 to 121	20	8.2	16.5	24.7
	30	4.7	9.4	14.1
	40	3.1	6.2	9.3
	50	2.2	4.4	6.6
138 to 145	20	9.8	19.5	29.3
	30	5.6	11.2	16.8
	40	3.7	7.4	11.1
	50	2.6	5.3	7.9
161 to 169	20	9.3	18.6	27.9
	30	5.7	11.5	17.2
	40	4	8	12
	50	3	6	9
230 to 242	20	10.4	20.9	31.3
	30	6.4	12.9	19.3
	40	4.5	9	13.5
	50	3.4	6.8	10.1
345 to 362	20	22.6	45.3	67.9
	30	14	28.1	42.1
	40	9.8	19.6	29.4
	50	7.4	14.7	22.1
500 to 550	20	18.9	37.8	56.7
	30	11.7	23.3	35
	40	8.1	16.3	24.4
	50	6.1	12.2	18.3
765 to 800	20	43.6	87.3	130.9
	30	27	53.9	80.9
	40	18.9	37.8	56.7
	50	14.2	28.4	42.6

Industrial Power Systems

Based on NFPA 70E Annex D

Do your panelboards, switchboards and other equipment 600 V and below:

- Have a maximum short circuit current of 25 kA?
- Have a maximum 0.03 sec (2 cycle) fault clearing time?

Yes? Use the information taken from the NFPA 70E tables below.

No? Assume a worst case scenario. The NFPA 70E tables don't apply to your situation.

Minimum ATPV (cal/cm ²)	Tasks on Panelboards or Other Equipment Rated 240 V and below
0	Perform infrared thermography and other non-contact inspections outside the restricted approach boundary
0	Circuit breaker (CB) or fused switch operation with covers on
0	CB or fused switch operation with covers off
4	Work on energized electrical conductors and circuit parts, including voltage testing
4	Remove / Install CBs or fused switches
4	Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)
0	Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)
4	Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard
Tasks on Panelboards or Switchboards Rated 240 < 600 V	
4	Perform infrared thermography and other non-contact inspections outside the restricted approach boundary
0	CB or fused switch operation with enclosure doors closed
4	CB or fused switch operation with covers off
8	Work on energized electrical conductors and circuit parts, including voltage testing
8	Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard or switchboard

Does your 600 V MCCs and other 600 V Class Equipment:

- Have a maximum short circuit current of 65 kA?
- Have a maximum 0.03 sec (2 cycle) fault clearing time?

Yes? Use the information taken from the NFPA 70E tables below.

No? Assume a worst case scenario. The NFPA 70E tables don't apply to your situation.

Minimum ATPV (cal/cm2)	Tasks on 600 V Class Motor Control Centers (MCCs)
4	Perform infrared thermography and other non-contact inspections outside the restricted approach boundary
0	CB or fused switch or starter operation with enclosure doors closed
0	Reading a panel meter while operating a meter switch
4	CB or fused switch or starter operation with enclosure doors open
8	Work on energized electrical conductors and circuit parts, including voltage testing
0	Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed
8	Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed
40	Insertion or removal of individual starter "buckets" from MCC
8	Application of safety grounds, after voltage test
40	Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts) (Assumes Max. of 42 kA short circuit current available; max. of 0.33 sec (20 cycle) fault clearing time.)
4	Opening hinged covers (to expose bare, energized electrical conductors and circuit parts) (Assumes Max. of 42 kA short circuit current available; max. of 0.33 sec (20 cycle) fault clearing time.)
8	Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the motor control center
Tasks on Other 600 V Class Equipment (277 < 600 V, nominal)	
8	Lighting or small power transformers (600 V maximum)
4	Removal of bolted covers
8	Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)
8	Work on energized electrical conductors and circuit parts, including voltage testing
8	Revenue meters (kW-hour, at primary voltage and current) Insertion or removal
4	Cable trough or tray cover removal or installation
4	Miscellaneous equipment cover removal or installation
8	Application of safety grounds, after voltage test
8	Insertion or removal of plug-in devices into or from busway

Does your 600 V Class Switchgear:

- Have a maximum short circuit current of 35 kA?
- Have a maximum 0.5 sec (30 cycle) fault clearing time?

Yes? Use the information taken from the NFPA 70E tables below.

No? Assume a worst case scenario. The NFPA 70E tables don't apply to your situation.

Minimum ATPV (cal/cm2)	Tasks on 600 V Class Switchgear (with power circuit breakers or fused switches)
8	Perform infrared thermography and other non-contact inspections outside the restricted approach boundary
0	CB or fused switch operation with enclosure doors closed
0	Reading a panel meter while operating a meter switch
4	CB or fused switch operation with enclosure doors open
8	Work on energized electrical conductors and circuit parts, including voltage testing
0	Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed
8	Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed
40	Insertion or removal (racking) of CBs from cubicles, doors open or closed
8	Application of safety grounds, after voltage test
40	Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)
8	Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)

For 1 kV through 38 kV Equipment

Minimum ATPV (cal/cm²)	Metal Clad Switchgear, 1 kV through 38 kV
25	Perform infrared thermography and other non-contact inspections outside the restricted approach boundary
8	CB operation with enclosure doors closed
0	Reading a panel meter while operating a meter switch
40	CB operation with enclosure doors open
40	Work on energized electrical conductors and circuit parts, including voltage testing
8	Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed
40	Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed
40	Insertion or removal (racking) of CBs from cubicles, doors open or closed
40	Application of safety grounds, after voltage test
40	Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)
25	Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)
40	Opening voltage transformer or control power transformer compartments
Other Equipment, 1 kV through 38 kV	
0	Metal-enclosed interrupter switchgear, fused or unfused
8	Switch operation or arc-resistant type construction, testing in accordance with IEEE C37.20.7, doors closed only
40	Switch operation, doors closed
40	Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)
25	Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)
25	Outdoor disconnect switch operation (hookstick operated)
8	Outdoor disconnect switch operation (gang operated, from grade)
40	Insulated cable examination, in manhole or confined space
8	Insulated cable examination, in open area

PPE Systems

These are the PPE requirements for the associated arc hazard levels. Make sure you choose arc rated clothing and head protection that has an ATPV equal to, or greater than, the hazard level. For information on layering clothing to achieve a total system arc rating, see NFPA 70E, Annex M. Keep in mind that you cannot simply add the arc ratings of individual layers – in some cases, layering has actually decreased the total protection. The only way to use a layering system to achieve protection is

Hazard Level	Head Protection	Clothing
4 cal/cm ²	Ear plugs, safety glasses, hard hat, face shield or hood	Arc Rated clothing, leather glove protectors, leather work shoes
8 cal/cm ²	Ear plugs, safety glasses, hard hat, face shield or hood	Arc Rated clothing, leather glove protectors, leather work shoes
12 cal/cm ²	Ear plugs, safety glasses, hard hat, arc rated hood	Arc Rated clothing, leather work shoes, arc rated gloves
25 cal/cm ²	Ear plugs, safety glasses, hard hat, arc rated hood	Arc Rated clothing, leather work shoes, arc rated gloves
40 cal/cm ²	Ear plugs, safety glasses, hard hat, arc rated hood	Arc Rated clothing, leather work shoes, arc rated gloves

to conduct a multilayer arc test.