

Alternating Current (AC) Shock Protection Boundaries and PPE
Fermilab Summary for NFPA 70E, 2018 Edition. [Based on Table 130.4(D)(a).]

System Voltage Range Phase to Phase	Limited Approach Boundary (Fixed Parts) (LAB)	Restricted Approach Boundary (RAB)	Shock Protection Insulating PPE
50 to <u>150</u> Includes 120	3 Ft 6 In	Avoid Contact	LAB - None RAB - Wear/Use if Contact Likely
<u>150</u> to 750 Includes 208, 240, 277 and 480	3 Ft 6 In	1 Foot	LAB - None RAB - Must Wear
751 to 15K Including 13.8K	5 Feet	2 Ft 2 In	LAB - None RAB - Must Wear
345K to 362K	15 Ft 4 In	9 Ft 2 In	LAB - None RAB - Must Wear

Within the Limited Approach Boundary	Non-Qualified Worker Allowed Within Only if Advised and Escorted by a Qualified Worker. Insulated Equipment/Tools if Contact Likely.
Within the Restricted Approach Boundary	Only Qualified Worker Allowed Within. May Not Cross Into with Conductive Objects. Conductive Objects Prohibited. Body Parts Must be Insulated.

**(New Table) Direct Current (DC) Shock Protection Boundaries and PPE
Fermilab Summary for NFPA 70E, 2018 Edition [Based on Table 130.4(D)(b).]**

System Voltage Range Phase to Phase [* NFPA 70E 350.9(2)]	Limited Approach Boundary (Fixed Parts) (LAB)	Restricted Approach Boundary (RAB)	Shock Protection Insulating PPE
100* to 300	3 Ft 6 In	Avoid Contact	LAB - None RAB - Wear/Use if Contact Likely
301 to 1000	3 Ft 6 In	1 Foot	LAB - None RAB - Must Wear
1001 to 5K	5 Feet	1 Ft 5 In	LAB - None RAB - Must Wear
5K to 15K	5 Feet	2 Ft 2 In	LAB - None RAB - Must Wear

Within the Limited Approach Boundary	Non-Qualified Worker Allowed Within Only if Advised and Escorted by a Qualified Worker. Insulated Equipment/Tools if Contact Likely.
Within the Restricted Approach Boundary	Only Qualified Worker Allowed Within. May Not Cross Into with Conductive Objects. Conductive Objects Prohibited. Body Parts Must be Insulated.
Capacitor energy limits [NFPA 70E 350.9(3)]	Consult with your D/S Electrical Coordinator if capacitors operate at below 100 V and over 100 Joules, 100 to 400 volts and over 1 Joule, over 400 volts and over 0.25 Joule (1 Joule = 0.5 * C * V * V)

Arc-Flash PPE Categories - Required Clothing - Required PPE
Fermilab Summary for NFPA 70E, 2018 Edition [Based on Table 130.7(C)(15)(c).]

Calculated Exposure from Prospective Arc-Flash	PPE Category	Minimum Required Arc-rating	Clothing Requirements	Additional PPE
Zero up to 1.2 cal/cm ²	0*	NA	Long Sleeve Cotton Shirt and Pants	Safety Glasses required, Hearing Protection and Leather Gloves recommended
More than 1.2 and up to 4 cal/cm ²	1	4 cal/cm²	FR Coverall**	Hard Hat, Safety Glasses, Arc-rated Face Shield, Hearing Protection, Leather Gloves, Leather Work Shoes
More than 4 and up to 8 cal/cm ²	2	8 cal/cm²	Cotton Clothing Under FR Coverall**	Hard Hat, Safety Glasses, Flash Suit Hood, Hearing Protection, Leather Gloves, Leather Work Shoes
More than 8 and up to 25 cal/cm ²	3	25 cal/cm²	Cotton Clothing Under FR Coveralls* plus Multilayer Flash Suit Jacket & Pants	Hard Hat, FR Hard Hat Liner, Safety Glasses, Flash Suit Hood, Hearing Protection, Arc-Rated Gloves, Leather Work Shoes
More than 25 and up to 40 cal/cm ²	4	40 cal/cm²	Cotton Clothing Under FR Coverall* plus Multilayer Flash Suit Jacket & Pants	Hard Hat, FR Hard Hat Liner, Safety Glasses, Flash Suit Hood, Hearing Protection, Arc-Rated Gloves, Leather Work Shoes

*Fermilab policy ** Coverall Rated at 8 cal/cm² Available from Fermilab Stockroom

Simplified Arc-Flash Guidance for Electrical Work on Fermilab AC POWER DISTRIBUTION Equipment Diagnostic Work Including LOTO Voltage Testing Unless Otherwise Noted The Fermilab Default AC Arc-Flash Boundary is 4 Feet (1.2 meters)				
Equipment	Voltage	Rated Full Load Current	PPE Category	Conditions or Qualifications
Primary Panelboards SWBD DHP	480/277 VAC	More than 1,200 Amps	<u>4</u>	Primary Transformer Larger than 1000 KVA (Assuming More Than 25,000 ISC Available with Fault Clearing Time >2 Cycles) Take Advantage of Installed Panelboard Meter for LOTO Verification if Present.
Motor Control Centers MCC	480 VAC	Typical 600 Amps and Above	<u>4 or 2</u>	Category 2 permitted only if overcurrent protective device will clear fault in under two line cycles (0.03 s). Take Advantage of Installed Central Monitoring Unit for LOTO Verification if Present
Primary or Secondary Panelboards DHP PHP LP	480/277 VAC	400 to 1,200 Amps	2	Proximity to Transformer Power Source Presumed
Operating 13.8 KV Disconnects with Doors Closed	13.8 KV	NA	2	Booster Brentford or RF Anode Power Supplies are Examples
Secondary Panelboards PHP LP	480/277 VAC	100 to 225 Amps	<u>2</u>	More Than 200 Feet from Panelboard Sourcing Power
Work in Lighting Panelboards (LP) including LOTO Verification	480/277 VAC	100 Amps	<u>2</u>	More Than 100 Feet from Secondary Panelboard Sourcing Power
Work in Utility Panelboards including LOTO Verification	120/208 VAC 120/240 VAC	Below 350 Amps	<u>1</u>	Requirement Direct from NFPA 70E 130.7(C)(15)(a), Applies if overcurrent protective device will clear fault in under two line cycles (0.03 s).
Operating Circuit Breakers and Disconnect Switches with Covers On or Closed	480/277 VAC	NA	0	Equipment must be in Normal condition as defined by NFPA 70E Table 130.5(C)
	120/208 VAC 120/240 VAC	NA	0	Equipment must be in Normal condition as defined by NFPA 70E Table 130.5(C)
This Simplified Table for AC Power Distribution Equipment Has Been Approved by the Electrical Safety Subcommittee, based on the 2018 Edition of NFPA 70E If Stated Conditions or Qualifications Are Not Met or the Circumstances of the Work Activity Appear Unique, Refer to NFPA 70E Table 130.7(C)(15)(a) or Consult with Your D/S Electrical Coordinator.				

Simplified Arc-Flash Guidance for Electrical Work on Fermilab **AC UTILIZATION** Equipment

Diagnostic Work Including LOTO Voltage Testing Unless Otherwise Noted

The Fermilab Default AC Arc-Flash Boundary is 4 Feet (1.2 meters)

Equipment	Voltage	Sourcing Branch CB	PPE Category	Conditions or Qualifications
Power Supplies	480 VAC	Various	Can Range from 1 to 3	Ask Your Department for an Assessment. Take Advantage of Installed Panel Meters for LOTO Verification.
Various Equipment	480 VAC or 480/277 VAC	100 to Less than 400 Amps	2	Distance from Primary Panelboards and Feed Conductors Limit Available Fault Currents
Various Equipment	480 VAC or 480/277 VAC	Less Than 100 Amps	1	Distance from Primary Panelboards and Feed Conductors Limit Available Fault Currents
Sump Pump Controllers Motor Controllers HVAC Equipment	480 VAC	60 Amps and Below	1	Distance from Primary Panelboards and Feed Conductors Limit Available Fault Currents
Ballasts and Light Fixtures	277 VAC	30 Amps and Below	1	Typical Lighting Ballast
Power Supplies	208 VAC	350 Amps and Below	0	Equipment and branch circuit overcurrent protective device(s) must be in Normal condition as defined by NFPA 70E Table 130.5(C)
Various Equipment	120/208 VAC	350 Amps and Below	0	Equipment and branch circuit overcurrent protective device(s) must be in Normal condition as defined by NFPA 70E Table 130.5(C)
Various Equipment	120 VAC	30 Amps and Below	0	Equipment and branch circuit overcurrent protective device must be in Normal condition as defined by NFPA 70E Table 130.5(C)

This Simplified Table for **AC Utilization Equipment Has Been Approved by the Electrical Safety Subcommittee, based on the 2018 Edition of NFPA 70E
If Stated Conditions or Qualifications Are Not Met or the Circumstances of the Work Activity Appear Unique,
Consult with Your D/S Electrical Coordinator.**

(New Table) Simplified Guidance for Electrical Work on Fermilab DIRECT CURRENT Equipment
 Diagnostic Work Including LOTO Voltage Testing Unless Otherwise Noted. The Fermilab Default Arc-Flash Boundary does not apply

Equipment	Voltage	Fault Current	PPE Category	Arc-Flash Boundary	Conditions or Qualifications
DS Batteries, Switchboards, or other sources exceeding limits on voltage, current, or both	> 600	Various	Varies	Varies	Also applies to arc durations over 2 seconds or working distance under 18 inches. Ask Your Department for an Assessment.
DS Batteries, Switchboards, or other sources	251 - 600	7 - 10 kA	4	8 Feet	Maximum arc duration of 2 seconds and working distance of not less than 18 inches
DS Batteries, Switchboards, or other sources	251 - 600	3 - 7 kA	3	6 Feet	Maximum arc duration of 2 seconds and working distance of not less than 18 inches
DS Batteries, Switchboards, or other sources	251 - 600	1.5 - 3 kA	2	4 Feet	Maximum arc duration of 2 seconds and working distance of not less than 18 inches
DS Batteries, Switchboards, or other sources	251 - 600	< 1.5 kA	2	3 Feet	Maximum arc duration of 2 seconds and working distance of not less than 18 inches
DS Batteries, Switchboards, or other sources	100 - 250	7 - 15 kA	3	6 Feet	Maximum arc duration of 2 seconds and working distance of not less than 18 inches
DS Batteries, Switchboards, or other sources	100 - 250	4 - 7 kA	2	4 Feet	Maximum arc duration of 2 seconds and working distance of not less than 18 inches
DS Batteries, Switchboards, or other sources	100 - 250	< 4 kA	2	3 Feet	Maximum arc duration of 2 seconds and working distance of not less than 18 inches

**This Simplified Table for Direct Current Equipment Has Been Approved by the
 Electrical Safety Subcommittee, based on the 2018 Edition of NFPA 70E
 If Stated Conditions or Qualifications Are Not Met or the Circumstances of the Work Activity Appear Unique,
 Refer to NFPA 70E Table 130.7(C)(15)(b) or Consult with Your D/S Electrical Coordinator.**