First Revision No. 100-NFPA 70E-2024 [Global Input]

See attached for new Article 380

Supplemental Information

File Name	Description	Approved
FR_100_attachment.docx	attachment for FR 100	
Global_FR_100_Article_380-new.docx	For editorial use only	
Global_FR_100_Article_380-new_edited.SL_cxs.docx	sl response	
70E_Global_FR-100_Article_380_for_ballot.pdf	For ballot	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 08 10:52:53 EDT 2024

Committee Statement

Committee Statement: Electrical double-layer capacitors (EDLCs) are a category of supercapacitors having different risks from conventional capacitors, particularly when used in energy storage applications. This technology utilizes non-Faradaic energy storage which, depending upon the system implementation, can present electrocution, thermal and arc flash hazards. Conventional capacitor technologies have a risk of arc blast that can create a supersonic pressure wave and cause lung damage triggered by the rapid rate of rise of current during a fault. EDLC's do not have this risk due to the inherent design of the capacitor. Unlike many battery technologies, EDLC's do not have the risk of thermal runaway or electrochemical exposure. This revision addresses the unique safety hazards associated with EDLC supercapacitors which have a combination of battery and capacitor hazards already identified in this standard.

First and/or second level subdivision titles were added to comply with the NEC Style Manual.

Response Message: FR-100-NFPA 70E-2024

Public Input No. 131-NFPA 70E-2024 [New Article after 360]

Article 380 Safety-Related Work Practices: Electrical Double Layer Capacitors (EDLCs)

380.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while working with exposed electrical double layer capacitors (EDLCs) that exceed 100 volts dc nominal or a theoretical maximum power exceeding 1000 watts.

380.2 Specific Measures for Personnel Safety.

(A) Qualification and Training.

The following qualifications and training shall be required for personnel safety:

(1) Employees who perform work on electrical equipment with EDLCs shall be qualified and shall be trained in and familiar with the specific hazards and controls required for safe work.

(2) Unqualified persons who perform work on electrical equipment with EDLCs shall be trained in and familiar with any electrical safety-related work practices necessary for their safety.

(B) Performing a Risk Assessment for EDLCs.

(1) Process.

The risk assessment process for EDLCs shall follow the overall risk assessment procedures in 110.3(H).

(2) Protective Measures.

If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk control identified in 110.3(H)(3).

(3) Electric Hazards.

If the additional protective measures require the use of PPE, the EDLC system's voltage and theoretical maximum power shall be used to determine the thermal, electric shock, and arc flash hazards to the worker of an exposed conductor or circuit part that could potentially remain energized with hazardous stored energy.

(4) PPE.

The appropriate PPE for the hazards shall be determined meeting the following conditions:

(1) Contact thermal hazard — the appropriate thermal PPE if the theoretical maximum power of the exposed part is greater than 1000 watts

(2) Electric shock hazard — the appropriate electric shock PPE in accordance with 130.7 if the voltage is greater than or equal to 100 volts dc

(3) Arc flash at the appropriate working distance — the appropriate protection for the arc flash, as follows:

a. Arc flash PPE in accordance with 130.7 if the voltage exceeds 150 volts dc and the incident energy exceeds 1.2 cal/cm^2 (5 J/cm^2) at the working distance

b. Alerting techniques in accordance with 130.8(O) to warn employees of the hazards

380.3 Establishing an Electrically Safe Work Condition for EDLCs.

(A) Written Procedure.

(1) Documentation.

Where a conductor or circuit part is connected to an EDLC system, a written procedure shall be used to document the necessary steps and sequence to safely work on that part.

Informational Note: This may involve a procedure to discharge the EDLCs and place the equipment into an electrically safe work condition.

(2) Risk Assessment.

The written procedure shall incorporate the results of the risk assessment performed in 380.2(B) and be in accordance with 120.6.

(B) Required Discharge and Test Method.

(1) EDLC Discharge.

Unless a discharge method is provided by the manufacturer, an appropriately sized and safeguarded resistor shall be selected, and a method shall be described to fully discharge the EDLC system.

(2) Discharge Method.

The method shall include a description of how to test for the absence of voltage, the expected discharge time, and what to do in the event there is still energy present.

(3) Residual Charge.

The method shall also include a means to prevent residual charge build up on the EDLC system after it has been discharged.

Informational Note: EDLCs can build up a residual charge without an external circuit.

(C) Storage and Transport.

For storage or transport, any residual charge from EDLCs shall be removed by discharging.

(1) Uninstalled Capacitors.

All uninstalled capacitors shall be short-circuited with a conductor of appropriate size after being discharged.

(2) Charged Capacitors.

When an uninstalled capacitor is discovered without the shorting conductor attached to the terminals, it shall be treated as if charged to its full rated voltage until determined safe by a qualified person.

First Revision No. 102-NFPA 70E-2024 [Global Input]

See attached for new Article 390

Supplemental Information

File Name	Description	Approved
Global_FR-102_Article_390-new.docx	For editorial use only	
Global_FR-102_Article_390-new.SL_cxs.docx	SL response	
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Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 08 11:16:37 EDT 2024

Committee Statement

Committee Statement: A new article for PV addresses the unique electrical hazards associated with work practices on PV installations.

First and/or second level subdivision titles were added to comply with the NEC Style Manual.

Response Message: FR-102-NFPA 70E-2024

Public Input No. 245-NFPA 70E-2024 [New Article after 300]

Public Input No. 142-NFPA 70E-2024 [Global Input]

Article 390 Safety-Related Requirements: Photovoltaic Systems

390.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while working on dc photovoltaic (PV) systems.

390.2 Energy Hazard Thresholds.

Appropriate controls shall be applied where any of the following thresholds are exceeded:

(1) Direct-current (dc) contact thermal hazard: 1000 watts

(2) Direct-current (dc) electric shock hazard: 100 volts and 40 milliamperes

(3) Direct-current (dc) arc flash hazard: 150 volts and 1.2 cal/cm^2

390.3 PV Risk Assessment.

Prior to any work on an energized PV array, a risk assessment shall be performed to identify the thermal, electrical shock, and arc flash hazards and assess the risks associated with the type of tasks to be performed.

390.4 Specific Work Procedures.

(A) Hazard Thresholds.

No work shall be performed on exposed PV terminals greater than the electric shock or arc flash thresholds.

(B) Conductor Manipulation.

Before manipulating any connectors on an energized system (plugging or unplugging), a risk assessment shall be performed to determine the maximum open circuit voltage that would be generated and the maximum current to be interrupted.

Informational Note: This risk assessment will determine if the action can be performed safely and what PPE would be required.

(C) Plugging and Unplugging Connectors.

Robust procedures for plugging and unplugging connectors on an energized PV system shall be developed that consider the possibility of making wrong connections and creating a short circuit and the controls necessary to prevent such a situation.

First Revision No. 107-NFPA 70E-2024 [Global Input]

See attached for new Annex T

Supplemental Information

File Name	Description	Approved
Global_FR-107_Annex_T-new.docx	For editorial use only	
70E_Global_FR-107_Annex_T_for_ballot.pdf	For ballot	

Submitter Information Verification

Committee: EEW-AAA
Submittal Date: Wed Aug 14 13:01:58 EDT 2024

Committee Statement

Committee Statement: The annex is added to accompany a new article on EDLCs.
Response Message: FR-107-NFPA 70E-2024

Informative Annex T Electrical Double Layer Capacitor (EDLC) Characteristics

T.1 Introduction

EDLCs are a category of supercapacitors having properties of both capacitors and electrochemical cells. They store energy in a non-Faradaic fashion in an electric field similar to a conventional capacitor, but instead of utilizing a dielectric, an electrode-electrolyte interface is used. EDLCs have a much higher capacitance than conventional capacitors. Arrays of EDLC cells can expose a worker to high voltages and high power levels, presenting a risk of electrocution, thermal hazard and arc flash.

Unlike rechargeable batteries that rely on a chemical storage mechanism, the physical separation of charge in the double layer at the electrode-electrolyte interface is the origin of the charge storage in EDLCs. The double layer capacitance of carbon materials is much greater than conventional capacitors owing to their high electrode surface area and nano-level thickness of the double layer. An EDLC cell includes two activated carbon electrodes that are separated by a nonconductive, ion-permeable separator, an electrolyte ionically connecting both electrodes, and two current collectors directly attached to electrodes.

T.2 Elimination of Arc Blast Risk.

In a load circuit fault, the current rises to the peak slower than conventional capacitors, such as power factor correction capacitors, and therefore do not present a risk of an acoustic shock wave that can cause lung damage. This is due to several factors that are described in T.2.1 through T.2.3.

T.2.1 Porous Electrodes.

EDLCs use highly porous carbon-based electrodes to achieve high surface area. This increases the area available to hold charge, but it also means that the electrons must travel inside the electrode (electrode resistance) and the ions must travel through an intricate pore structure to reach the electrode surface (diffusion-controlled adsorption). This distribution of electric charge means much of the energy is not available immediately to feed a load circuit fault.

T.2.2 Double Layer Charge Separation.

In EDLCs, energy is stored at the interface between each electrode and the electrolyte. The movement and arrangement of ions that form this double layer is inherently slower than the purely electrostatic mechanism of conventional capacitors. This is because of the mobility of ions in the electrolyte, which is affected by the diffusion coefficients and is slower than the change in shape of the electric field in the dielectric in conventional capacitors.

T.2.3 Cell Voltage.

Another factor that can affect the rate of rise of current in a load circuit fault is that each cell is rated at a lower voltage than commonly found with many other capacitor technologies, which can operate well above 100 volts dc. Most EDLC cells operate at less than 3 volts dc. When connected in series to achieve higher voltages, the equivalent series impedance of the EDLC stack is significantly higher than conventional capacitors. This impedance contributes to the limitation of the rate of rise of current feeding a fault.

First Revision No. 22-NFPA 70E-2024 [Global Input]

add the phrase "safety-related" to the following article scopes in Chapter 2

205.1 Scope. (this is has general in the scope)

This article covers general safety -related maintenance requirements for electrical equipment.

210.1 Scope.

215.1 Scope.

220.1 Scope.

220.1 Scope.

230.1 Scope.

235.1 Scope.

240.1 Scope.

240.1 Scope.

250.1 Scope.

so that they read:

This article covers safety - related maintenance requirements for .....

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 08:20:33 EDT 2024

Committee Statement

Committee Statement: Adding the term “safety-related” to the scope statement for each article within Chapter 2 helps usability and reinforces that the specific maintenance requirements identified are safety-related.

Response Message: FR-22-NFPA 70E-2024

Public Input No. 152-NFPA 70E-2024 [Section No. 240.1]

Public Input No. 150-NFPA 70E-2024 [Section No. 230.1]

Public Input No. 148-NFPA 70E-2024 [Section No. 220.1]

Public Input No. 147-NFPA 70E-2024 [Section No. 215.1]

Public Input No. 153-NFPA 70E-2024 [Section No. 245.1]

Public Input No. 149-NFPA 70E-2024 [Section No. 225.1]

Public Input No. 154-NFPA 70E-2024 [Section No. 250.1]

Public Input No. 143-NFPA 70E-2024 [Section No. 205.1]

Public Input No. 146-NFPA 70E-2024 [Section No. 210.1]

Public Input No. 151-NFPA 70E-2024 [Section No. 235.1]

First Revision No. 80-NFPA 70E-2024 [Global Input]

Reorganize Chapter 3 aritcles as follows.

Article 300 Introduction

Article ~~310~~ 350 Safety-Related Work Practices for Electrolytic Cells

Article 310 Safety-Related Work Practices: DC Electrical Hazards RESERVIED (New article existing 310 moved to 350)

Article ~~320~~ 360 Safety Requirements Related to Batteries and Battery Rooms

Article ~~340~~ 330 Safety-Related Work Practices: Power Electronic Equipment

Article 340 Safety-Related Work Practices: Electrical Hazards for Mixed Frequencies RESERVED (New article existing 340 moved to 330)

Article ~~350~~ 370 Safety-Related Work Requirements: Research and Development Laboratories

Article ~~360~~ 320 Safety-Related Work Requirements for Capacitors

Supplemental Information

File Name	Description	Approved
Chapter_3_Article_reorg_map_Global_FR-80.docx	For prod use	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 13:42:41 EDT 2024

Committee Statement

Committee Statement: This First Revision is editorial only without technical changes to Chapter 3. Since its inception, Chapter 3 has evolved using a patchwork of subjects generally developed in isolation from other parts of Chapter 3 and the remainder of the Standard. This revision is the result of work over two cycles attempting to harmonize common methods of special equipment and comply with correlating committee direction to avoid redundancy whenever practicable. It provides improved usability and makes future additions to Chapter 3 more efficient in addressing only those unique circumstances for the added special equipment.

Response Message: FR-80-NFPA 70E-2024

Public Input No. 236-NFPA 70E-2024 [Chapter 3]

First Revision No. 101-NFPA 70E-2024 [Detail]

[130.2(A)]

When energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts are not put into an electrically safe work condition, and work is performed as permitted in accordance with 110.2(B), all of the following requirements shall apply:

(1) Only qualified persons shall be permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition.

(2) An energized electrical work permit shall be completed as required by 130.2.

(3) An electric shock risk assessment shall be performed as required by 130.4.

(4) An arc flash risk assessment shall be performed as required by 130.5.

(5) If an energized electrical work permit is required in accordance with 130.2(A), at least one additional person meeting the emergency response training requirements of 110.4(C) (1) shall be present in the vicinity of, but outside of, either the limited approach boundary or arc flash boundary, whichever is greater.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 08 11:11:56 EDT 2024

Committee Statement

Committee Statement: The 2-person requirement is to provide the immediate availability of emergency response if an employee is performing work under an energized electrical work permit.

First and/or second level subdivision titles were added to comply with the NEC Style Manual.

Response Message: FR-101-NFPA 70E-2024

Public Input No. 54-NFPA 70E-2024 [Section No. 130.1]

First Revision No. 104-NFPA 70E-2024 [Detail]

Revise 90.3 title as follows:

90.3 ~~Workplaces Covered and Not Covered~~ Scope of the Standard.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 08 14:55:53 EDT 2024

Committee Statement

Committee Statement: The NFPA 70E Technical Committee recognizes that the Correlating Committee on the National Electrical Code has purview over the scope of NFPA 70E, . This first revision changes the title of 90.3 to clearly indicate that the scope of the document outlines the workplaces covered and not covered.

Response Message: FR-104-NFPA 70E-2024

Public Input No. 60-NFPA 70E-2024 [Section No. 90.1]

Public Input No. 61-NFPA 70E-2024 [Section No. 90.3]

First Revision No. 105-NFPA 70E-2024 [Detail]

Revised Article 105 title as follows:

ARTICLE 105 ~~Application of Safety-Related Work Practices and Procedures~~Employer and Employee Responsibilities

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 08 14:59:04 EDT 2024

Committee Statement

Committee Statement: The title of Article 105 and the content of Sections 105.1 and 105.2 are a holdover from previous editions of the standard when the scope of Article 105 covered Chapter 1. The 2021 revision that limited the scope of Article 105 to the requirements contained in Article 105 did not address this fact. This first revision addresses this change in scope and aligns Article 105 with the other Articles in Chapter 1 to more accurately reflect the content.

Response Message: FR-105-NFPA 70E-2024

First Revision No. 29-NFPA 70E-2024 [Detail]

Section 120.6 Item 7, Exception to 7.

Exception No. 2 to 7: On electrical systems over 1000 volts, adequately rated noncontact capacitive test instruments shall be permitted to be used to test for the absence of detectable voltage at each phase conductorin lieu of using a contact test instrument for testing for absence of voltage both phase to phase and phase to ground .

Informational Note No. 1: See UL 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements, for rating, overvoltage category, and design requirements for voltage measurement and test instruments intended for use on electrical systems 1000 volts and below.

Informational Note ~~No. 2~~ to Exception No. 1 to 7 : See UL 1436, Outlet Circuit Testers and Other Similar Indicating Devices, for additional information on rating and design requirements for permanently mounted absence of voltage testers.

Informational Note No. 1 to Exception No. 2 to 7: Noncontact capacitive test instruments require a minimum voltage to operate and are therefore not suitable to test for the absence of voltage.

Informational Note No. 2 to Exception No. 2 to 7 ~~3~~ : See IEC 61243-1, Live Working — Voltage Detectors — Part 1: Capacitive type to be used for voltages exceeding 1kV a.c., or IEC 61243-2, Live Working — Voltage Detectors — Part 2: Resistive type to be used for voltages of 1kV to 36 kV a.c., or IEC 61243-3, Live Working — Voltage Detectors — Part 3: Two-pole low voltage type, for additional information on rating and design requirements for voltage detectors.

Supplemental Information

File Name	Description	Approved
70E_Detail_FR-29_120.6.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 13:26:26 EDT 2024

Committee Statement

Committee Statement: Exception No. 2 to 7 was editorially revised for clarity. An informational note was added to provide information on why presence of voltage rather than absence of voltage was used in this exception. Informational notes were editorially corrected to reference the applicable exception.

Response Message: FR-29-NFPA 70E-2024

Public Input No. 36-NFPA 70E-2023 [Section No. 120.6]

First Revision No. 54-NFPA 70E-2024 [Detail]

130.7(C)(14)(b)

(b) *Conformity Assessment.*

A ll arc-rated PPE shall be listed .

~~(1) Self-declaration with a Supplier's Declaration of Conformity~~

~~(2) Self-declaration under a registered quality management system and product testing by an accredited laboratory and a Supplier's Declaration of Conformity~~

~~(3) Certification by an accredited independent third-party certification organization~~

Informational Note No. 1: See Informative Annex H.4 and ANSI/ISEA 125, *American National Standard for Conformity Assessment of Safety and Personal Protective Equipment*, for examples of a process for conformity assessment to an appropriate product standard.

Informational Note No. 2: See ISO 17065, *Conformity assessment — Requirements for bodies certifying products, processes, and services*, for an example of a process to accredit independent third-party certification organizations.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 15:16:38 EDT 2024

Committee Statement

Committee Statement: Arc-rated PPE is important for worker safety. While most arc-rated PPE manufacturers are reliable, merely relying upon self-certification by the arc-rated PPE manufacturer is insufficient to ensure that the PPE provides the appropriate level of protection. All other PPE must conform to 130.7(C)(14)(a).

Response Message: FR-54-NFPA 70E-2024

Public Input No. 59-NFPA 70E-2024 [Section No. 130.7(C)(14)]

First Revision No. 58-NFPA 70E-2024 [Detail]

Table 130.5(C) Estimate of the Likelihood of Occurrence of an Arc Flash Incident for ac and dc Systems

Task	Operating Condition [a]	Likelihood of Occurrence [b]
Reading a panel meter while operating a meter switch.	Any	No
Performing infrared thermography and other noncontact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers.		
Working on control circuits with exposed energized electrical conductors and circuit parts, nominal 125 volts ac or dc, or below without any other exposed energized equipment over nominal 125 volts ac or dc, including opening of hinged covers to gain access.		
Examination of insulated cable with no manipulation of cable.		
For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack.		
Working on battery equipment below 600 V where the exposed electrical conductors are separated by more than 1 millimeter (0.039 in.) per volt		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 08:56:29 EDT 2024

Committee Statement

Committee Statement: A new task “working on battery equipment below 600 V where the exposed electrical conductors are separated by more than 1 millimeter per volt” is added to provide clarity with respect to impact of separation distance on the likelihood of an arc-flash.

The following peer reviewed journal article derived 1mm / V from the published minimum voltage of thousands of arc experiments over a range of arc gaps. D. M. Rosewater, "Reducing Risk When Performing Energized Work on Batteries," in IEEE Transactions on Industry Applications, vol. 60, no. 2, pp. 2732-2741, March-April 2024, doi: 10.1109/TIA.2023.3332828.

Response Message: FR-58-NFPA 70E-2024

Public Input No. 155-NFPA 70E-2024 [Section No. 130.7(C)(15)]

First Revision No. 63-NFPA 70E-2024 [Detail]

Revise title of 130.8 to the following:

130.8 Other Precautions. ~~for Personnel Activities.~~

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 10:25:36 EDT 2024

Committee Statement

Committee Statement: Section 130.8 title is revised to be more generic to account for the diverse requirements of this section, some of which do not involve personnel or employee activities.

Response Message: FR-63-NFPA 70E-2024

Public Input No. 21-NFPA 70E-2023 [Section No. 130.8]

First Revision No. 79-NFPA 70E-2024 [Detail]

Table 130.7(C)(15)(b) Arc Flash PPE Categories for dc Systems

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Storage batteries, dc switchboards, and other dc supply sources, (exc luding capacitors covered in Article 360)		
Parameters: Greater than 150 volts and less than or equal to 600 volts		
Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.)		
Available fault current less than 1.5 kA	2	900 mm
		(3 ft)
Available fault current greater than or equal to 1.5 kA and less than 3 kA	2	1.2 m
		(4 ft)
Available fault current greater than or equal to 3 kA and less than 7 kA	3	1.8 m
		(6 ft.)
Available fault current greater than or equal to 7 kA and less than 10 kA	4	2.5 m
		(8 ft)

Notes:

(1) Apparel that can be expected to be exposed to electrolyte must meet both of the following conditions:

(a) Be evaluated for electrolyte protection

Informational Note: See ASTM F1296, *Standard Guide for Evaluating Chemical Protective Clothing*, for information on evaluating apparel for protection from electrolyte.

(b) Be arc rated

Informational Note: See ASTM F1891, *Standard Specification for Arc and Flame Resistant Rainwear*, for information on evaluating arc-rated apparel.

(1) A two-second arc duration is assumed if there is no overcurrent protective device (OCPD) or if the fault clearing time is not known. If the fault clearing time is known and is less than 2 seconds, an incident energy analysis could provide a more representative result.

Informational Note No. 1: See D.5 for the basis for table values and alternative methods to determine dc incident energy. Methods should be used with good engineering judgment. When determining available fault current, the effects of cables and any other impedances in the circuit should be included. ~~Power system~~ DC circuit modeling is the best method to determine the available short-circuit current at the point of the arc. Battery cell short-circuit current can be obtained from the battery manufacturer.

Informational Note No. 2: The methods for estimating the dc arc flash incident energy that were used to determine the categories for this table are based on open-air incident energy calculations. Open-air calculations were used because many battery systems and other dc process systems are in open areas or rooms. If the specific task is within an enclosure, the incident energy can be higher and ~~it would be prudent to consider~~ additional PPE protection beyond the value shown in this tableshould be considered .

Informational Note No. 3: See the following references for dc voltages below 150 volts nominal:

(1) J. G. Hildreth and K. Feeney, “Arc Flash Hazards of 125 Vdc Station Battery Systems,” 2018 IEEE Power & Energy Society General Meeting (PESGM), 2018, pp. 1–5, ~~.~~ doi: 10.1109/PESGM.2018.8586181.

(2) US Department of Energy Bonneville Power Administration Engineering and Technical Services Report BPA F 5450.05, “DC Arc Flash: 125V, 1300 amp-hour battery,” May 11, 2017~~; doi: 10.1109/PESGM.2018.8586181~~ .

(1) K. Gray, S. Robert, and T. L. Gauthier, "Low Voltage 100–500 Vdc Arc Flash Testing," 2020 IEEE IAS Electrical Safety Workshop (ESW), 2020, pp. 1–7, doi: 10.1109/ESW42757.2020.9188336.

Submitter Information Verification

Committee: EEW-AAA
Submittal Date: Wed Aug 07 13:15:04 EDT 2024

Committee Statement

Committee Statement: This revision corrects the title of Reference (1) and makes an editorial correction that assigned the doi reference to the wrong citation.

DC circuit modeling is a more appropriate term. The term "power system modeling" is used for ac systems to include transformer impedances, system ac impedances (resistance and inductance) and over current protection, etc. A dc circuit model uses the short circuit current of a source, such as a battery, the busbar and connection resistances, and any dc overcurrent protection.

Capacitor is a class of dc source, but not a dc power system. Capacitor arc flash incident energy analysis is covered in Article 360 and Informational Annex R with methods not used to develop this table. This revision only affects capacitors covered in Article 360. Arc flash protection from hazards associated with supercapacitors can be determined with this table.

The revised language is clearer and explains why additional PPE may be needed.

Response Message: FR-79-NFPA 70E-2024

Public Input No. 201-NFPA 70E-2024 [Section No. 130.7(C)(15)]

Public Input No. 58-NFPA 70E-2024 [Section No. 130.7(C)(15)]

Public Input No. 200-NFPA 70E-2024 [Section No. 130.7(C)(15)]

Public Input No. 198-NFPA 70E-2024 [Section No. 130.7(C)(15)]

First Revision No. 84-NFPA 70E-2024 [Detail]

See attached for new structure to 320.3. [360.3 after reorg]

320.3(A)(2)(a) Battery Chemical Risk Assessment.

(A) Estimate of Likelihood and Severity.

The estimate of likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health from chemical hazards shall take into consideration all the following:

1. The design of the equipment
2. The safety data sheet of the battery and electrolyte
3. The equipment operating condition and the condition of maintenance.

Informational Note: Many batteries are sealed, preventing the worker from exposure to chemical hazards of the electrolyte unless the battery has been damaged.

(B) Additional Protective Measures.

(1) If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls identified in 110.3(H)(3).
(2) When the additional protective measures include the use of PPE, the following shall be determined:

1. Proper hand and eye/face protection based on performance characteristics relative to the task, conditions present, duration of use, and chemical hazards
2. Gloves and aprons appropriate for the chemical hazards
3. Portable or stationary eye wash facilities and equipment within the work area that are capable of drenching or flushing of the eyes and body for the duration necessary to mitigate injury from the chemical hazards.

Informational Note No. 1: See ANSI/ISEA Z358.1, *American National Standard for Emergency Eye Wash and Shower Equipmen*t, for guidelines for the use and maintenance of eye wash facilities for vented batteries in non-telecom environments.

Informational Note No. 2: Where electrolyte is pumped or otherwise stored above atmospheric pressure, including head pressure in large storage tanks, additional protective equipment for the head neck and arms may be required to protect employees.

Supplemental Information

File Name	Description	Approved
70E_Detail_FR-84_320.3_1.docx		
70E_Detail_FR-84_320.3_for_ballot.docx	For ballot	

Submitter Information Verification

Committee: EEW-AAA
Submittal Date: Wed Aug 07 14:10:00 EDT 2024

Committee Statement

Committee Statement: This section consolidates 320(B)(1) into the risk assessment section. The first informational note provides information that engineered controls may be available.

	Informational Note 2 identifies that the chemical PPE requirements for flow batteries may exceed those for non-flow batteries.
Response Message:	FR-84-NFPA 70E-2024

Public Input No. 113-NFPA 70E-2024 [New Section after 320.3(A)(2)]

320.3 Safety Procedures. [360.3 after reorg]

(A) ~~General Safety Hazards~~Electrical Hazard Thresholds.

(1) Electrical Hazard Thresholds. [Move to (A)]
Exposure levels shall not exceed those identified in the following list unless appropriate controls are implemented:

(1) AC: 50 volts and 5 milliamperes

(2) DC: 100 volts and 40 milliamperes

(3) Thermal: 1000 watts short-circuit power

Informational Note No. 1: Available short-circuit power is calculated by multiplying the battery's nominal voltage by its available short-circuit current at the battery terminals then dividing the result by two.

Informational Note 2: See Department of Energy, *DOE Electrical Safety Handbook*, DOE-HDBK-1092, for electrical hazard thresholds.

(2) Battery Risk Assessment. [Move to (B)]
Prior to any work on a battery system, a risk assessment shall be performed to identify the chemical, thermal, electrical shock, and arc flash hazards and assess the risks associated with the type of tasks to be performed.
Informational Note: See Informative Annex F Figure F.7 for an example of a risk assessment method for work on batteries.

(1) Battery Chemical Assessment.

(a) *Estimate of Likelihood and Severity.* The estimate of likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health from chemical hazards shall take into consideration all the following:

(1) The design of the equipment

(2) The safety data sheet of the battery and electrolyte

(3) The equipment operating condition and the condition of maintenance

Informational Note: Many batteries are sealed, preventing the worker from exposure to chemical hazards of the electrolyte unless the battery has been damaged.

(b) *Additional Protective Measures.* Additional protective measures shall be as follows:

(1) If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls identified in 110.3(H)(3).

(2) When the additional protective measures include the use of PPE, the following shall be determined:

a. Proper hand and eye/face protection based on performance characteristics relative to the task, conditions present, duration of use, and chemical hazards

b. Gloves and aprons appropriate for the chemical hazards

c. Portable or stationary eye wash facilities and equipment within the work area that are capable of drenching or flushing of the eyes and body for the duration necessary to mitigate injury from the chemical hazards.

Informational Note No. 1: See ANSI/ISEA Z358.1, *American National Standard for Emergency Eye Wash and Shower Equipment*, for guidelines for the use and maintenance of eye wash facilities for vented batteries in non-telecom environments.

Informational Note No. 2: Where electrolyte is pumped or otherwise stored above atmospheric pressure, including head pressure in large storage tanks, additional protective equipment for the head neck and arms may be required to protect employees.

(3) Battery Room or Enclosure Requirements. [Move to (C)]

(a) *Personnel Access to Energized Batteries.* Each battery room or battery enclosure shall be accessible only to authorized personnel.

(b) *Illumination.* Employees shall not enter spaces containing batteries unless illumination is provided that enables the employees to perform the work safely.

Informational Note: Battery terminals are normally exposed and pose possible electric shock hazard. Batteries are also installed in steps or tiers that can cause obstructions.

(4) Apparel. [Move to (D)]
Personnel shall not wear electrically conductive objects such as jewelry while working on a battery system.

(5) Abnormal Battery Conditions. [Move to (E)]
Instrumentation that provides alarms for early warning of abnormal conditions of battery operation, if present, shall be tested annually.
Informational Note: See IEEE 1491, *Guide for the Selection and Use of Battery Monitoring Equipment in Stationary Applications*, for guidance on battery monitoring systems. Battery monitoring systems typically include alarms for such conditions as overvoltage, undervoltage, overcurrent, ground fault, and overtemperature. The type of conditions monitored will vary depending upon the battery technology.

(6) Warning Signs. [Move to (F)]
The following warning signs or labels shall be posted in appropriate locations:

(1) Electrical hazard warnings indicating the electric shock hazard due to the battery voltage and the arc flash hazard due to the prospective short-circuit current, and the thermal hazard.

Informational Note No.1: Because internal resistance, prospective short-circuit current, or both are not always provided on battery container labels or data sheets, and because many variables can be introduced into a battery layout, the battery manufacturer should be consulted for accurate data. Variables can include, but are not limited to, the following:

(1) Series connections

(2) Parallel connections

(3) Charging methodology

(4) Temperature

(5) Charge status

(6) Dc distribution cable size and length

Informational Note No. 2: See 130.5(H) for requirements for equipment labeling.

(2) Chemical hazard warnings, applicable to the worst case when multiple battery types are installed in the same space, indicating the following:

a. Potential presence of explosive gas (when applicable to the battery type)

b. Prohibition of open flame and smoking

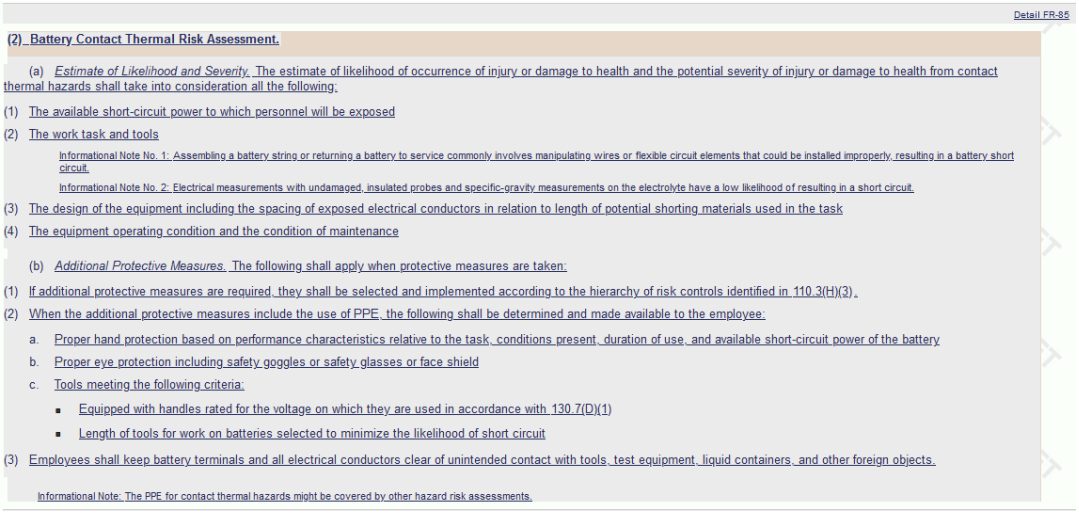
c. Danger of chemical burns from the electrolyte (when applicable to the battery type)

(3) Notice for personnel to use and wear protective equipment and apparel appropriate to the hazard for the battery

(4) Notice prohibiting access to unauthorized personnel

First Revision No. 85-NFPA 70E-2024 [Detail]

Add a new sub in 320.3 [360.3 after reorg]



Detail FR-85

(2) Battery Contact Thermal Risk Assessment.

(a) *Estimate of Likelihood and Severity.* The estimate of likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health from contact thermal hazards shall take into consideration all the following:

(1) The available short-circuit power to which personnel will be exposed

(2) The work task and tools

Informational Note No. 1: Assembling a battery string or returning a battery to service commonly involves manipulating wires or flexible circuit elements that could be installed improperly, resulting in a battery short circuit.

Informational Note No. 2: Electrical measurements with undamaged, insulated probes and specific-gravity measurements on the electrolyte have a low likelihood of resulting in a short circuit.

(3) The design of the equipment including the spacing of exposed electrical conductors in relation to length of potential shorting materials used in the task

(4) The equipment operating condition and the condition of maintenance

(b) *Additional Protective Measures.* The following shall apply when protective measures are taken:

(1) If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls identified in 110.3(H)(3).

(2) When the additional protective measures include the use of PPE, the following shall be determined and made available to the employee:

a. Proper hand protection based on performance characteristics relative to the task, conditions present, duration of use, and available short-circuit power of the battery

b. Proper eye protection including safety goggles or safety glasses or face shield

c. Tools meeting the following criteria:

- Equipped with handles rated for the voltage on which they are used in accordance with 130.7(D)(1)
- Length of tools for work on batteries selected to minimize the likelihood of short circuit

(3) Employees shall keep battery terminals and all electrical conductors clear of unintended contact with tools, test equipment, liquid containers, and other foreign objects.

Informational Note: The PPE for contact thermal hazards might be covered by other hazard risk assessments.

Supplemental Information

File Name	Description	Approved
70E_Detail_FR-85_320.3_B_1.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 14:11:26 EDT 2024

Committee Statement

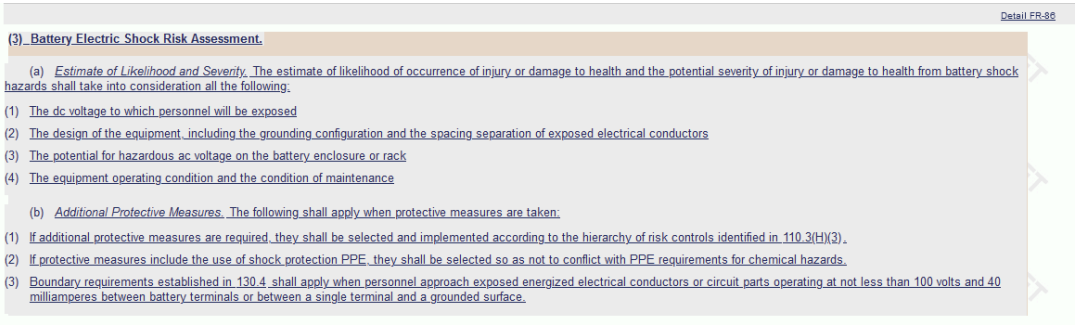
Committee Statement: The changes clarify the requirements for contact thermal risk assessment and PPE involving batteries currently missing from the Standard.

Response Message: FR-85-NFPA 70E-2024

Public Input No. 109-NFPA 70E-2024 [New Section after 320.3(A)(2)]

First Revision No. 86-NFPA 70E-2024 [Detail]

Add new subsection in 320.3 [360.3 after reorg]



Detail FR-86

(3) Battery Electric Shock Risk Assessment.

(a) *Estimate of Likelihood and Severity.* The estimate of likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health from battery shock hazards shall take into consideration all the following:

(1) The dc voltage to which personnel will be exposed

(2) The design of the equipment, including the grounding configuration and the spacing separation of exposed electrical conductors

(3) The potential for hazardous ac voltage on the battery enclosure or rack

(4) The equipment operating condition and the condition of maintenance

(b) *Additional Protective Measures.* The following shall apply when protective measures are taken:

(1) If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls identified in 110.3(H)(3).

(2) If protective measures include the use of shock protection PPE, they shall be selected so as not to conflict with PPE requirements for chemical hazards.

(3) Boundary requirements established in 130.4 shall apply when personnel approach exposed energized electrical conductors or circuit parts operating at not less than 100 volts and 40 milliamperes between battery terminals or between a single terminal and a grounded surface.

Supplemental Information

File Name	Description	Approved
70E_Detail_FR-86_320.3_B_2.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 14:12:58 EDT 2024

Committee Statement

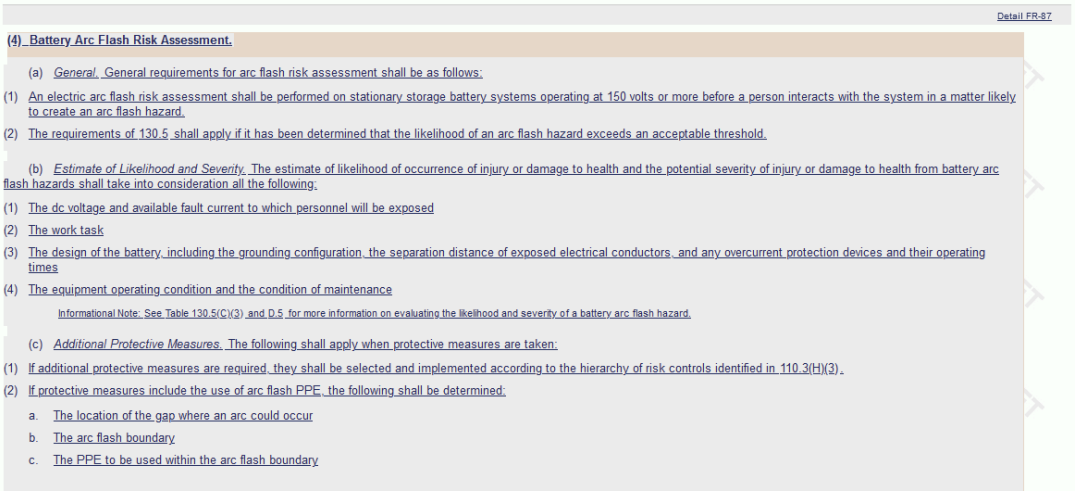
Committee Statement: Electric shock risk assessment is different enough in battery systems from general dc sources for additional requirements to apply. The existing requirements in 130.4 do not account for reduced risk of shock when the positive and negative voltages of a battery are separated farther than can be reached by a worker. The existing requirements in 130.4 identify a circuit only as either ac or dc and so unique conditions applicable to batteries are often overlooked shock risk assessments.

Response Message: FR-86-NFPA 70E-2024

Public Input No. 108-NFPA 70E-2024 [New Section after 320.3(A)(2)]

First Revision No. 87-NFPA 70E-2024 [Detail]

Add new subsection in 320.3 [360.3 after reorg]



Detail FR-87

(4) Battery Arc Flash Risk Assessment.

(a) *General.* General requirements for arc flash risk assessment shall be as follows:

(1) An electric arc flash risk assessment shall be performed on stationary storage battery systems operating at 150 volts or more before a person interacts with the system in a matter likely to create an arc flash hazard.

(2) The requirements of 130.5 shall apply if it has been determined that the likelihood of an arc flash hazard exceeds an acceptable threshold.

(b) *Estimate of Likelihood and Severity.* The estimate of likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health from battery arc flash hazards shall take into consideration all the following:

(1) The dc voltage and available fault current to which personnel will be exposed

(2) The work task

(3) The design of the battery, including the grounding configuration, the separation distance of exposed electrical conductors, and any overcurrent protection devices and their operating times

(4) The equipment operating condition and the condition of maintenance

Informational Note: See Table 130.5(C)(3) and D.5 for more information on evaluating the likelihood and severity of a battery arc flash hazard.

(c) *Additional Protective Measures.* The following shall apply when protective measures are taken:

(1) If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls identified in 110.3(H)(3).

(2) If protective measures include the use of arc flash PPE, the following shall be determined:

a. The location of the gap where an arc could occur

b. The arc flash boundary

c. The PPE to be used within the arc flash boundary

Supplemental Information

File Name	Description	Approved
70E_Detail_FR-87_320_3_B_3.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 14:14:14 EDT 2024

Committee Statement

Committee Statement: The changes clarify how to perform an electric arc flash risk assessment for work involving batteries. For example, accounting for separation distance is critical to understanding and controlling the hazard appropriately.

Response Message: FR-87-NFPA 70E-2024

Public Input No. 110-NFPA 70E-2024 [New Section after 320.3(A)(2)]

First Revision No. 2-NFPA 70E-2024 [Section No. 90.3(A)]

(A) Workplaces Covered.

This standard addresses electrical safety-related work practices, safety-related maintenance requirements, and other administrative controls for employee workplaces that are necessary for the practical safeguarding of employees relative to the hazards associated with electrical energy during activities such as the installation, removal, inspection, operation, maintenance, and demolition of electric conductors, electric equipment, signaling and communications conductors and equipment, and raceways. This standard also includes safe work practices for employees performing other work activities that can expose them to electrical hazards as well as safe work practices for the following:

(1) Installations of conductors and equipment that connect to the supply of electricity

(2) Installations used by the electric utility, such as office buildings, warehouses, garages, machine shops, and recreational buildings that are not an integral part of a generating plant, substation, or control center

(3) Installations used by the communications utility, such as office buildings, warehouses, garages, machine shops, and recreational buildings that are not an integral part of communications equipment associated with the network infrastructure

Informational Note: This standard addresses safety of workers whose job responsibilities involve interaction with energized electrical equipment and systems with potential exposure to electrical hazards. Concepts in this standard are often adapted to other workers whose exposure to electrical hazards is unintentional or not recognized as part of their job responsibilities. The highest risk for injury from electrical hazards for other workers involve unintentional contact with overhead power lines and electric shock from machines, tools, and appliances.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 13:27:32 EDT 2024

Committee Statement

Committee Statement: The addition of “s” to installations in item 1 is for clarity and consistency.

Item 3 adds electrical equipment that is owned by a communications utility but is not associated with the network infrastructure to the list of workplaces covered. The resulting text mirrors the existing language for electric utilities. This addition will expand the scope to help protect workers whose job responsibilities may involve interaction with energized electrical equipment and systems and the associated electrical hazards.

Response Message: FR-2-NFPA 70E-2024

Public Input No. 279-NFPA 70E-2024 [Section No. 90.3(A)]

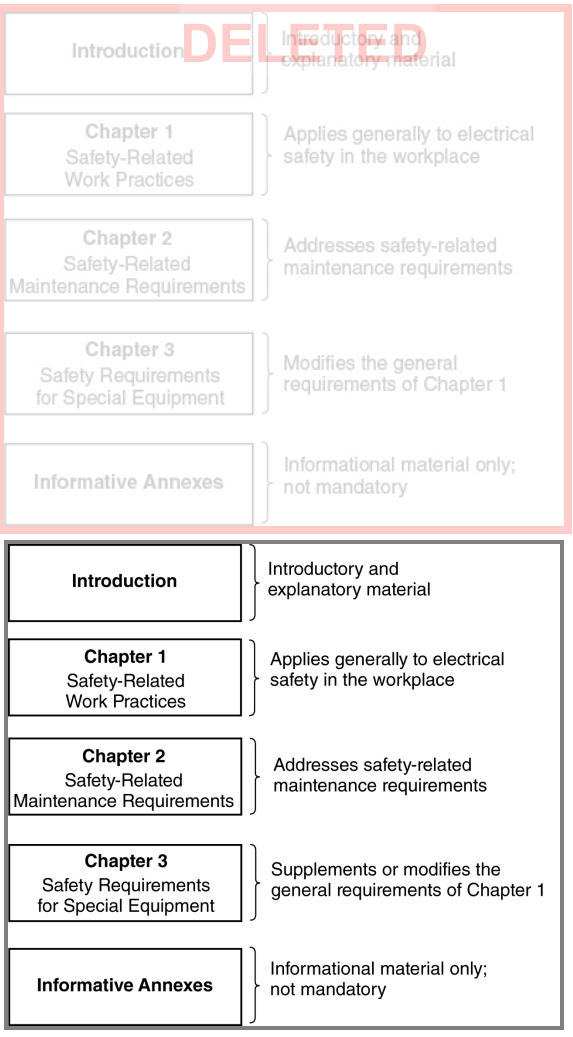
First Revision No. 3-NFPA 70E-2024 [Section No. 90.4]

90.4 Standard Arrangement.

This standard is divided into the introduction and three chapters, as shown in Figure 90.4. Chapter 1 applies generally, Chapter 2 addresses safety-related maintenance requirements, and Chapter 3 supplements or modifies Chapter 1 with safety requirements for special equipment.

Informative annexes are not part of the requirements of this standard but are included for informational purposes only.

Figure 90.4 Standard Arrangement.



Supplemental Information

File Name	Description	Approved
FR_3_attachement.docx	attachment for FR 3	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 13:36:25 EDT 2024

Committee Statement

Committee Statement: The text in the Chapter 3 row of Figure 90.4 is modified to align with the provisions in Section 90.4 for correlation and clarity.

Response Message: FR-3-NFPA 70E-2024

Public Input No. 62-NFPA 70E-2024 [Section No. 90.4]

First Revision No. 5-NFPA 70E-2024 [Definition: Competent Person.]

~~**Competent Person.**~~

~~A person who meets all the requirements of~~ *qualified person* ~~, and who, in addition, is responsible for all work activities or safety procedures related to custom or special equipment and has detailed knowledge regarding the exposure to electrical hazards, the appropriate control methods to reduce the risk associated with those hazards, and the implementation of those methods. (350)~~

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 13:52:26 EDT 2024

Committee Statement

Committee Statement: The definition of competent person is deleted to correlate with other actions that removed the term from the standard.

Response Message: FR-5-NFPA 70E-2024

Public Input No. 41-NFPA 70E-2023 [Definition: Competent Person.]

Public Input No. 163-NFPA 70E-2024 [Definition: Competent Person.]

First Revision No. 6-NFPA 70E-2024 [Definition: Electrical Safety.]

~~**Electrical Safety.**~~

~~Identifying hazards associated with the use of electrical energy and taking precautions to reduce the risk associated with those hazards.~~

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 13:53:29 EDT 2024

Committee Statement

Committee Statement: The definition is deleted as it does not correlate with other sections of the standard.

Response Message: FR-6-NFPA 70E-2024

Public Input No. 42-NFPA 70E-2023 [Definition: Electrical Safety.]

First Revision No. 7-NFPA 70E-2024 [Definition: Electrically Safe Work Condition.]

Electrically Safe Work Condition.

A state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested for the absence of voltage, and, if necessary, temporarily grounded for personnel protection.

Informational Note: See 110.2(C) and 120.2 through 120.6 for the requirements to establish and verify an electrically safe work condition.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 13:54:57 EDT 2024

Committee Statement

Committee Statement: An informational note raises awareness of the sections that provide the necessary steps to establish and verify an electrically safe work condition.

Response Message: FR-7-NFPA 70E-2024

Public Input No. 7-NFPA 70E-2023 [Definition: Electrically Safe Work Condition.]

First Revision No. 8-NFPA 70E-2024 [Definition: Enclosure.]

Enclosure.

The case or housing of apparatus, — or the fence or walls surrounding an installation, intended to prevent personnel from unintentionally contacting energized electrical conductors or circuit parts or to protect the equipment from physical damage.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 13:57:27 EDT 2024

Committee Statement

Committee Statement: The definition is revised to make it clear that prevention of personnel contact and protection of equipment apply to both apparatus housings as well as the fences or walls of an installation.

Response Message: FR-8-NFPA 70E-2024

Public Input No. 43-NFPA 70E-2023 [Definition: Enclosure.]

First Revision No. 9-NFPA 70E-2024 [Definition: Ground Stick.]

Ground Stick.

A device that is used to ensure that the capacitor is discharged by applying it to all terminals of the capacitor element and to ground . (360)

Informational Note: This is also called a ground hook and could incorporate power-rated discharge resistors for high-energy applications.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 13:58:42 EDT 2024

Committee Statement

Committee Statement: The definition is clarified to include “and to ground” to align with the actual application and use of a ground stick.

Response Message: FR-9-NFPA 70E-2024

Public Input No. 191-NFPA 70E-2024 [Definition: Ground Stick.]

First Revision No. 11-NFPA 70E-2024 [Definition: Grounding, Hard (Low-Z). (Hard Grounding)]

Grounding, Hard (Low-Z). (Hard Grounding)

The practice of discharging ~~a capacitor through a low impedance, also called Low-Z (impedance) grounding~~ capacitance by connecting to ground through a low impedance . (360)

Informational Note: Capacitors are either grounded or ungrounded. Capacitors that are ungrounded will not discharge unless the discharge resistor is connected between the terminals.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 14:04:36 EDT 2024

Committee Statement

Committee Statement: The definition is modified, and an informational note is added for improved clarity. Not all capacitors are connected to ground and no discharge will occur if terminals of ungrounded capacitors are grounded.

Response Message: FR-11-NFPA 70E-2024

First Revision No. 10-NFPA 70E-2024 [Definition: Grounding, Soft (High-Z). (Soft Grounding)]

Grounding, Soft (High-Z). (Soft Grounding)

The practice of discharging capacitance by connecting ~~a capacitor~~ to ground through a power resistor to avoid the hazards related with ~~hard grounding~~ a low impedance short circuit . (360)

Informational Note: Capacitors are either grounded or ungrounded. Capacitors that are ungrounded will not discharge unless the discharge resistor is connected between the terminals.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 14:01:53 EDT 2024

Committee Statement

Committee Statement: The definition is modified, and an informational note is added for improved clarity. Not all capacitors are connected to ground and no discharge will occur if terminals of ungrounded capacitors are grounded.

Response Message: FR-10-NFPA 70E-2024

Public Input No. 129-NFPA 70E-2024 [Definition: Grounding, Soft (High-Z). (Soft Grounding)]

First Revision No. 12-NFPA 70E-2024 [Definition: Hazard, Arc Blast (as applied to capacitors). (...]

Hazard, Arc Blast (as applied to capacitors). (Arc Blast Hazard)

A source of possible injury or damage to health from the energy deposited into an acoustical supersonic shock wave and high-velocity shrapnel. (360)

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 14:06:21 EDT 2024

Committee Statement

Committee Statement: The modified definition provides clarity by denoting that only a conventional capacitor can create a supersonic acoustic wave.

Response Message: FR-12-NFPA 70E-2024 Shrapnel may be present during an arc blast hazard.

Public Input No. 247-NFPA 70E-2024 [Definition: Hazard, Arc Blast (as applied to capacitors). (...]

First Revision No. 13-NFPA 70E-2024 [Definition: Hazard, Electric Shock. (Electric Shock Hazard)]

Hazard, Electric Shock. (Electric Shock Hazard)

A source of possible injury or damage to health associated with current through the body caused by contact or approach to exposed energized electrical conductors or circuit parts.

~~Informational Note: Injury and damage to health resulting from electric shock is dependent on the magnitude of the electrical current, the power source frequency (e.g., 60 Hz, 50 Hz, dc), and the path and time duration of current through the body. The physiological reaction ranges from perception, muscular contractions, inability to let go, ventricular fibrillation, tissue burns, and death.~~

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 14:07:58 EDT 2024

Committee Statement

Committee Statement: The informational note is removed as it is incomplete and does not include all types of electric shock hazards.

Response Message: FR-13-NFPA 70E-2024

Public Input No. 250-NFPA 70E-2024 [Definition: Hazard, Electric Shock. (Electric Shock Hazard)]

First Revision No. 14-NFPA 70E-2024 [Definition: Hazard, Electrical. (Electrical Hazard)]

Hazard, Electrical. (Electrical Hazard)

A ~~dangerous condition such that contact or equipment failure~~ source of possible injury or damage to health that can result in electric shock~~,~~ arc flash burn, contact thermal burn, or arc blast injury.

Informational Note: Class 2 power supplies, listed low- voltage lighting systems, and similar sources are examples of circuits or systems that are not considered an electrical hazard.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 14:09:10 EDT 2024

Committee Statement

Committee Statement: The definition is modified to align with the other hazard definitions and to correlate with the new definition of contact thermal hazard.

Response Message: FR-14-NFPA 70E-2024

Public Input No. 232-NFPA 70E-2024 [Definition: Hazard, Electrical. (Electrical Hazard)]

First Revision No. 15-NFPA 70E-2024 [Definition: Incident Energy.]

Incident Energy.

The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. ~~Incident energy is typically expressed in calories per square centimeter (cal/cm ^{2}).~~

Informational Note: Incident energy is typically expressed in calories per square centimeter (cal/cm^2).

Supplemental Information

File Name	Description	Approved
70E_FR-15_100-Incident_Energy.docx		

Submitter Information Verification

Committee: EEW-AAA
Submittal Date: Tue Jul 30 14:12:29 EDT 2024

Committee Statement

Committee Statement: This revision is made to comply with the NEC Style Manual.
Response Message: FR-15-NFPA 70E-2024

First Revision No. 16-NFPA 70E-2024 [Definition: Premises Wiring (System).]

Premises Wiring (System).

Interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all their associated hardware, fittings, and wiring devices, both permanently and temporarily installed. This includes~~: (a) wiring from the service point or power source to the outlets; or (b) wiring from and including the power source to the outlets where there is no service point.~~ one of the following:

(1) Wiring from the service point or power source to the outlets

(2) Wiring from and including the power source to the outlets where there is no service point

Such wiring does not include wiring internal to appliances, luminaires, motors, controllers, motor control centers, and similar equipment. [**70:**100]

Informational Note: Power sources include, but are not limited to, interconnected or stand-alone batteries, solar photovoltaic systems, other distributed generation systems, or generators.

Supplemental Information

File Name	Description	Approved
70E_FR-16_100-Premises_Wiring_System_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Jul 31 13:23:29 EDT 2024

Committee Statement

Committee Statement: This revision modifies the extracted definition of premises wiring (system) to match the 2023 National Electrical Code verbatim.

Response Message: FR-16-NFPA 70E-2024

Public Input No. 47-NFPA 70E-2023 [Definition: Premises Wiring (System).]

First Revision No. 17-NFPA 70E-2024 [Definition: Safeguarding.]

~~**Safeguarding.**~~

~~Safeguards for personnel include the consistent administrative enforcement of safe work practices. Safeguards include training in safe work practices, cell line design, safety equipment, PPE, operating procedures, and work checklists. (310)~~

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Jul 31 13:36:46 EDT 2024

Committee Statement

Committee Statement: The term and description for “safeguarding” is deleted as it not necessary to define commonly defined terms or phrases. The existing definition does not meet the NEC Style Manual as it only provides a list of examples.

Response Message: FR-17-NFPA 70E-2024

Public Input No. 46-NFPA 70E-2023 [Definition: Safeguarding.]

First Revision No. 21-NFPA 70E-2024 [New Definition after Definition: Dwelling Unit.]

Electric Double Layer Capacitor (EDLC).

A device having properties of both capacitors and electrochemical cells that stores energy in a non-Faradaic fashion in an electric field similar to a conventional capacitor, but instead of utilizing a dielectric, an electrode-electrolyte interface is used.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Jul 31 13:52:32 EDT 2024

Committee Statement

Committee Statement: A definition is added to define the term electric double layer capacitor which is used in a new Chapter 3 article.

Response Message: FR-21-NFPA 70E-2024

Public Input No. 128-NFPA 70E-2024 [New Definition after Definition: Electrical Safety Program.]

First Revision No. 18-NFPA 70E-2024 [New Definition after Definition: Cell, Vented. (Vented Cell)]

Cell Line Working Zone. (Electrolytic Cell Line Working Zone)

The space envelope wherein operation or maintenance is performed on or in proximity to exposed energized surfaces of electrolytic cell lines or their attachments. (310)

Informational Note: See Article 310, Informative Annex L, and IEEE 463, *Electrical Safety Practices in Electrolytic Cell Line Working Zones* , for information on the minimum space envelope dimensions and other information on electrolytic cell lines.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Jul 31 13:44:25 EDT 2024

Committee Statement

Committee Statement: This first revision adds a definition to improve the clarity and understanding of a term used in Article 310 and Informative Annex L. A new informational note provides a resource for obtaining additional information related to electrolytic cell lines.

Response Message: FR-18-NFPA 70E-2024

Public Input No. 162-NFPA 70E-2024 [New Definition after Definition: Cell.]

First Revision No. 19-NFPA 70E-2024 [New Definition after Definition: Short-Circuit Current Rati...]

Shorting Stick.

A device that is used to discharge a capacitor from terminal to terminal. (360)

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Jul 31 13:47:10 EDT 2024

Committee Statement

Committee Statement: This adds a clear, concise definition for shorting stick to improve understanding of the term used in Chapter 3 and Annex R.

Response Message: FR-19-NFPA 70E-2024

Public Input No. 194-NFPA 70E-2024 [New Article after 100]

First Revision No. 20-NFPA 70E-2024 [New Definition after Definition: Switching Device.]

Hazard, Contact Thermal. (Contact Thermal Hazard)

A source of possible injury or damage to health associated with contact with the heat dissipated by a conductive object as it conducts current.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Jul 31 13:49:40 EDT 2024

Committee Statement

Committee Statement: This adds a clear, concise definition for contact thermal hazard to improve understanding of the term.

Response Message: FR-20-NFPA 70E-2024

Public Input No. 241-NFPA 70E-2024 [New Article after 100]

First Revision No. 4-NFPA 70E-2024 [Article 100 [Excluding any Sub-Sections]]

Scope. This article contains only those definitions essential to the ~~proper~~ application of this standard. It is not intended to include commonly defined general terms or commonly defined technical terms from related codes and standards. An article number in parentheses following the definition indicates that the definition only applies to that article.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Jul 30 13:49:24 EDT 2024

Committee Statement

Committee Statement: This removes the word “proper” from this section. The resulting text is more closely aligned with the language found in the National Electrical Code.

Response Message: FR-4-NFPA 70E-2024

Public Input No. 40-NFPA 70E-2023 [Article 100 [Excluding any Sub-Sections]]

First Revision No. 31-NFPA 70E-2024 [Sections 105.1, 105.2]

105.1 Scope.

This article covers employer and employee responsibilities for the application of electrical safety-related work practices and procedures for employees who are exposed to an electrical hazard in workplaces covered in 90.3.

Informational Note: See Informative Annex K for general categories of electrical hazards.

~~**105.2** Purpose.~~

~~These practices and procedures are intended to provide for employee safety relative to electrical hazards in the workplace.~~

~~Informational Note: See Informative Annex K for general categories of electrical hazards.~~

Supplemental Information

File Name	Description	Approved
70E_FR-31_105.1.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 14:02:47 EDT 2024

Committee Statement

Committee Statement: The title of Article 105 and the content of Sections 105.1 and 105.2 are a holdover from previous editions of the standard when the scope of Article 105 covered Chapter 1. The 2021 revision that limited the scope of Article 105 to the requirements contained in Article 105 did not address this fact. This first revision addresses this change in scope and aligns Article 105 with the other Articles in Chapter 1 as follows:

• Section 105.1 has been revised to more accurately reflect the content of Article 105, which is mostly regarding employer and employee responsibilities.

• Section 105.2 has been deleted as it is inaccurate, given the change in scope of Article 105, and it is unnecessary. No other article, other than Article 90 – Introduction, contains a purpose section. In accordance with NEC Style Manual Section 2.1.1: “The Introduction shall contain the scope, purpose, and administrative provisions.” Section 2.1.4.4 requires each Article to have a scope but does not require an Article to have a purpose.

Response Message: FR-31-NFPA 70E-2024

First Revision No. 32-NFPA 70E-2024 [Section No. 105.3(A)]

(A) Employer Responsibility.

The employer shall have the following responsibilities:

(1) Establish, document, and implement the safety-related work practices and procedures required by this standard.

(2) Provide and document employee~~s with~~ training in the employer's safety-related work practices and procedures.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 14:05:19 EDT 2024

Committee Statement

Committee Statement: The revision is made to correlate 105.3(A) with similar requirements throughout the standard to document employee training.

Response Message: FR-32-NFPA 70E-2024

Public Input No. 8-NFPA 70E-2023 [Section No. 105.3(A)]

First Revision No. 33-NFPA 70E-2024 [Section No. 105.5]

105.5 Organization.

Chapter 1 of this standard is divided into five articles. Article 100 provides definitions for terms used in one or more of the chapters of this ~~document~~ standard . Article 105~~provides~~ covers employer and employee responsibilities for the application of safety-related work practices and procedures. Article 110~~provides~~ covers general requirements for electrical safety-related work practices and procedures. Article 120~~provides~~ covers requirements for establishing an electrically safe work condition. Article 130~~provides~~ covers requirements requirements for work involving electrical hazards.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 14:08:37 EDT 2024

Committee Statement

Committee Statement: The revision is made to correlate 105.5 with the terminology used in corresponding sections of the standard.

“Document” is revised to "standard" to correlate with the use of the word “standard” in first sentence of 105.5 and with 90.2.

The word provide” is replaced with covers in the references to Articles 105, 110, 120 and 130 to correlate with the scope statements in those articles.

Response Message: FR-33-NFPA 70E-2024 "And verifying" is not added to the reference to Article 120 as the current language correlates with Section 120.1 Scope statement “This article covers requirements for establishing an electrically safe work condition.”

Public Input No. 39-NFPA 70E-2023 [Section No. 105.5]

First Revision No. 34-NFPA 70E-2024 [Section No. 110.2(B)]

(B) When Required.

Energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts or where an electrical hazard exists shall be put into an electrically safe work condition before an employee performs work if any of the following conditions exist:

(1) The employee is within the limited approach boundary.

(2) The employee interacts with equipment where conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.

Informational Note: See 120.2 through 120.6 for requirements to establish and verify an electrically safe work condition for the period of time for which the state is maintained.

Exception No. 1: Normal operation of electric equipment shall be permitted where a normal operating condition exists. A normal operating condition exists when all of the following conditions are satisfied:

(1) The equipment is properly installed.

(2) The equipment is properly maintained.

(3) The equipment is rated for the available fault current.

(4) The equipment is used in accordance with instructions included in the listing and labeling and in accordance with manufacturer's instructions.

(5) The equipment doors are closed and secured.

(6) All equipment covers are in place and secured.

(7) There is no evidence of impending failure.

Informational Note No. 1: The phrase *properly installed* means that the equipment is installed in accordance with applicable industry codes and standards and the manufacturer's recommendations. The phrase *properly maintained* means that the equipment has been maintained in accordance with the manufacturer's recommendations and applicable industry codes and standards. The phrase *evidence of impending failure* means that there is evidence such as arcing, overheating, loose or bound equipment parts, visible damage, deterioration, or water damage.

Informational Note No. 2: See NEMA GD 1-2019, *Evaluating Water-Damaged Electrical Equipment*, as an example of a document that provides further information on evaluating electrical equipment that may have been exposed to water.

Exception No. 2: An energized disconnecting means or isolating element shall be permitted to be operated to achieve an electrically safe work condition or to return equipment to service that has been placed in an electrically safe work condition. The equipment supplying the disconnecting means or isolating element shall not be required to be placed in an electrically safe work condition provided a risk assessment is performed and there is no unacceptable risk identified.

Exception No. 3: Energized work shall be permitted where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations.

Informational Note: Examples of work that might be performed within the limited approach boundary of exposed energized electrical conductors or circuit parts because of infeasibility due to equipment design or operational limitations include performing diagnostics and testing (e.g., start-up or troubleshooting) of electric circuits that can only be performed with the circuit energized and work on circuits that form an integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.

Exception No. 4: Energized work shall be permitted where the employer can demonstrate that de-energizing introduces additional hazards or increased risk.

Informational Note: Examples of additional hazards or increased risk include, but are not limited to, interruption of life-support equipment, deactivation of emergency alarm systems, and shutdown of hazardous location ventilation equipment.

Exception No. 5: Energized electrical conductors and circuit parts that operate at less than 50 volts shall not be required to be de-energized where the capacity of the source and any overcurrent protection between the energy source and the worker are considered and it is determined that there will be no increased exposure to electrical burns or to explosion due to electric arcs.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 14:11:31 EDT 2024

Committee Statement

Committee Statement: The phrase “or where an electrical hazard exists” has been added to the requirement to address situations where an electrical hazard might exist below 50 volts.

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Response Message: FR-34-NFPA 70E-2024 The threshold of equal to or greater than 50 volts is not deleted as it is a well-established threshold, it is easy to identify and apply, and it is used throughout NFPA 70E. The phrase “risk of” should not be used when referring to a possibility or likelihood of occurrence in order to maintain clarity and consistency when referring risk in the standard.

Public Input No. 165-NFPA 70E-2024 [Section No. 110.2(B)]

First Revision No. 35-NFPA 70E-2024 [Section No. 110.2(C)]

(C) Requirements Until Established.

~~Electrical conductors and circuit parts shall not be considered to be in an electrically safe work condition until all of the applicable requirements of 120.2 through 120.6 have been met.~~

~~Safe work practices applicable to the circuit voltage and energy level shall be used until such time that electrical conductors and circuit parts are in an electrically safe work condition.~~

(1) When Established.

Electrical conductors and circuit parts shall not be considered to be in an electrically safe work condition until all of the applicable requirements of 120.2 through 120.6 have been met.

(2) Work Practices Until Established..

Safe work practices applicable to the circuit voltage and energy level shall be used until such time that electrical conductors and circuit parts are in an electrically safe work condition.

Supplemental Information

File Name	Description	Approved
70E_FR-35_110.2_C_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 14:15:26 EDT 2024

Committee Statement

Committee Statement: This first revision is made to comply with the NEC Style Manual Section 2.1.6.3 Subdivisions and Section 2.1.6.3.2 Subdivision Titles.

Response Message: FR-35-NFPA 70E-2024

First Revision No. 39-NFPA 70E-2024 [Section No. 110.3(C)]

(C) Condition of Maintenance.

The electrical safety program shall include elements that consider condition of maintenance of electrical equipment and systems.

Informational Note: See Informative Annex S for guidance on assessing the condition of maintenance.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 13:46:37 EDT 2024

Committee Statement

Committee Statement: An informational note is added to 110.3(C) Condition of Maintenance to refer the user to Annex S Assessing the Condition of Maintenance. The reference is made to Annex S rather than to NFPA 70B as the guidance provided by Annex S already includes a reference to 70B.

Response Message: FR-39-NFPA 70E-2024

Public Input No. 117-NFPA 70E-2024 [Section No. 110.3(C)]

First Revision No. 40-NFPA 70E-2024 [Section No. 110.3(I)(1)]

(1) Job Safety Planning.

The job safety plan shall be in accordance with the following:

(1) Be completed by a qualified person

(2) Be documented

(3) Include the following information:

a. A description of the job and the individual tasks

b. Identification of the electrical hazards associated with each task

c. An electric shock risk assessment in accordance with 130.4 for tasks involving an electric shock hazard

d. An arc flash risk assessment in accordance with 130.5 for tasks involving an arc flash hazard

e. Work procedures involved, special precautions, and energy source controls

f. An emergency response plan

Informational Note No. 1: See Figure I.2 for an example of a job safety planning checklist.

Informational Note No. 2: An emergency response plan could include actions to be taken during an electrical injury emergency, roles and responsibilities during response efforts, and contingency plans for when equipment is unintentionally de-energized while performing energized work.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 13:48:47 EDT 2024

Committee Statement

Committee Statement: An informational note is added to provide guidance regarding the information that would be typically included in an emergency response plan, including the planned response to unintentional de-energization.

Response Message: FR-40-NFPA 70E-2024

Public Input No. 216-NFPA 70E-2024 [Section No. 110.3(I)(1)]

First Revision No. 41-NFPA 70E-2024 [Section No. 110.3(L)(2)]

(2) ~~Field~~ Work Practices Audit.

~~Field work shall be audited to verify that the requirements contained in the procedures of the electrical safety program are being followed. When the auditing determines that the principles and procedures of the electrical safety program are not being followed, the appropriate revisions to the training program or revisions to the procedures shall be made. Audits shall be performed at intervals not to exceed 1 year.~~

(a) ~~Field~~ Employee work practices shall be audited to verify that the requirements contained in the procedures of the employer's electrical safety program are being followed.

(b) When the auditing determines that the principles and procedures of the electrical safety program are not being followed, the appropriate revisions to the training program or revisions to the procedures shall be made.

(c) Audits shall be performed at intervals not to exceed 1 year.

Supplemental Information

File Name	Description	Approved
70E_FR-41_110.3_L_2_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 13:51:56 EDT 2024

Committee Statement

Committee Statement: The section is revised to clarify that auditing for employee compliance with the safety procedures in the employers electrical safety program shall be performed at all work locations. Revisions are made to comply with the NEC Style Manual.

Response Message: FR-41-NFPA 70E-2024

First Revision No. 42-NFPA 70E-2024 [Section No. 110.3(L)(3)]

(3) Lockout/Tagout Program Audit.

(a) The lockout/tagout program shall be audited to verify that the principles of the lockout/tagout program are in compliance with this standard.

(b) Audits shall be performed at intervals not to exceed 3 years.

(4) Lockout/Tagout ~~Program and~~ Procedure Audit.

~~The lockout/tagout program and procedures required by 120.2 through 120.6 shall be audited by a qualified person at intervals not to exceed 1 year. The audit shall cover at least one lockout/tagout in progress. The audit shall be designed to identify and correct deficiencies in the following:~~

(0) ~~The lockout/tagout program and procedures~~

(0) ~~The lockout/tagout training~~

(0) ~~Worker execution of the lockout/tagout procedure~~

(a) The lockout/tagout ~~program and~~ procedures required by 120.2 through 120.6 shall be audited by a qualified person at intervals not to exceed 1 year.

(b) The audit shall cover at least one lockout/tagout in progress.

(c) The audit shall cover at least one lockout/tagout in progress. The audit shall be designed to identify and correct deficiencies in the following:

(1) The lockout/tagout ~~program and~~ procedures

(2) The lockout/tagout training

(3) Worker execution of the lockout/tagout procedure

Supplemental Information

File Name	Description	Approved
FR_42_attachement.docx	attachment for FR 42	
70E_FR_42_110.3_L_3_.docx	For prod use	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 14:00:58 EDT 2024

Committee Statement

Committee Statement: This revision aligns the requirement to audit lockout/tagout procedures with 29 CFR 1910.147(C)(6), which requires periodic inspections of procedures at least annually. The revision also aligns the requirement to audit the lockout program, which is not required by 1910.147, with the requirement to audit the electrical safety program at

intervals not to exceed 3 years.

The reference to 120.6 has been revised to 120.5 with respect to lockout/tagout procedures as 120.6 does not specify requirements for procedures.

Third level subdivisions have been created to comply with the NEC Style Manual Section 2.1.6.

Response Message: FR-42-NFPA 70E-2024

Public Input No. 264-NFPA 70E-2024 [Section No. 110.3(L)(3)]

First Revision No. 43-NFPA 70E-2024 [Section No. 110.4(A)(1)]

(1) Qualified Person.

A qualified person shall be trained and knowledgeable in the construction and operation of equipment or a specific work method and be trained to identify and avoid the electrical hazards that might be present with respect to that equipment or work method.

(a) Such persons shall also be familiar with the proper use of applicable precautionary techniques, electrical policies, procedures, PPE, insulating materials, shielding materials, and insulated tools and test equipment.

(b) A person shall be permitted to be considered qualified ~~for~~ with respect to certain equipment and tasks, ~~to be performed.~~ but unqualified for others .

(c) Such persons permitted to work within the limited approach boundary shall, at a minimum, be additionally trained in all of the following:

(1) Skills and techniques necessary to distinguish exposed energized electrical conductors and circuit parts from other parts of electrical equipment

(2) Skills and techniques necessary to determine the nominal voltage of exposed energized electrical conductors and circuit parts

(3) Approach distances specified in Table 130.4(E)(a) and Table 130.4(E)(b) and the corresponding voltages to which the qualified person will be exposed

(4) Decision-making process necessary to be able to do the following:

a. Perform the job safety planning

b. Identify electrical hazards

c. Assess the associated risk

d. Select the appropriate risk control methods from the hierarchy of controls identified in 110.3(H)(3), including PPE

(d) An employee who is undergoing on-the-job training for the purpose of obtaining the skills and knowledge necessary to be considered a qualified person, and who in the course of such training demonstrates an ability to perform specific duties safely at his or her level of training, and who is under the direct supervision of a qualified person shall be considered to be a qualified person for the performance of those specific duties.

(e) Employees shall be trained to select an appropriate test instrument and shall demonstrate how to use a device to ~~verify~~ test for the absence of voltage, including interpreting indications provided by the device. The training shall include information that enables the employee to understand all limitations of each test instrument that might be used.

(f) The employer shall determine through regular supervision or through inspections conducted on at least an annual basis that each employee is complying with the safety-related work practices required by this standard.

Supplemental Information

File Name	Description	Approved
FR_43_attachement.docx	attachment for FR 43	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 14:05:58 EDT 2024

Committee Statement

Committee Statement: The revision to 110.4(A)(1)(b) in the 2024 edition replaced the word “can” in accordance with NEC Style Manual 3.1.1 which states: “The terms may or can shall not be used in mandatory rules.” In previous editions 110.4(A)(1)(b) was phrased as follows: “A person can be considered qualified with respect to certain equipment and tasks but still be unqualified for others.” This revision clarifies and the restores the concept contained in the 2021 and earlier editions that a person might be qualified with respect to certain equipment and tasks but unqualified for others.

The First Revision edits 110.4(A)(1)(e) from “verify” to “test for” to make the wording consistent with 110.6 and 120.6(7).

Response Message: FR-43-NFPA 70E-2024

Public Input No. 13-NFPA 70E-2023 [Section No. 110.4(A)(1)]

Public Input No. 254-NFPA 70E-2024 [Section No. 110.4(A)(1)]

First Revision No. 44-NFPA 70E-2024 [Section No. 110.5(A)]

(A) Host Employer Responsibilities.

(1) Provide Hazard Information to Contract Employer.

The host employer shall inform contract employers of the following:

(1) Known hazards that are covered by this standard, that are related to the contract employer's work, and that might not be recognized by the contract employer or its employees

(2) Information about the employer's installation that the contract employer needs to make the assessments required by Chapter 1

(2) Report Violations to Contract Employer.

The host employer shall report observed contract employer–related violations of this standard to the contract employer.

Informational Note: Examples of a host employer can include owner or their designee, construction manager, general contractor, or employer.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 14:14:50 EDT 2024

Committee Statement

Committee Statement: Revisions are made to comply with NEC Style Manual requiring titles for second level subdivisions.

Response Message: FR-44-NFPA 70E-2024

First Revision No. 45-NFPA 70E-2024 [Section No. 110.5(B)]

(B) Contract Employer Responsibilities.

(1) Communicate Hazard Information to Employees.

~~The contract employer shall ensure that each of his or her employees is instructed in the hazards communicated to the contract employer by the host employer. This instruction shall be in addition to the basic training required by this standard.~~

(a) The contract employer shall ensure that each of his or her employees is instructed in the hazards communicated to the contract employer by the host employer.

(b) This instruction shall be in addition to the basic training required by this standard.

(2) Ensure Employee Compliance.

The contract employer shall ensure that each of his or her employees follows the work practices required by this standard and safety-related work rules required by the host employer.

(3) Provide Hazard Information and Report Corrective Actions to the Host Employer.

The contract employer shall advise the host employer of the following:

(1) Any unique hazards presented by the contract employer's work

(2) Hazards identified during the course of work by the contract employer that were not communicated by the host employer

(3) The measures the contractor took to correct any violations reported by the host employer under 110.5(A)(2) and to prevent such violation from recurring in the future

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 14:17:32 EDT 2024

Committee Statement

Committee Statement: Revisions are made to comply with NEC Style Manual requiring titles for second level subdivisions.

Response Message: FR-45-NFPA 70E-2024

First Revision No. 46-NFPA 70E-2024 [Section No. 110.6(D)]

(D) Visual Inspection and Repair.

~~Test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors shall be visually inspected for external defects and damage before each use. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service. No employee shall use it until a person(s) qualified to perform the repairs and tests that are necessary to render the equipment safe has done so.~~

(1) Inspection.

~~Test~~ Portable test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors shall be visually inspected for external defects and damage before each use.

(2) Repair.

If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service~~. No employee shall use it~~ until a person(s) qualified to perform the repairs and tests that are necessary to render the equipment safe has done so.

Supplemental Information

File Name	Description	Approved
70E_FR-46_110.6_D_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 14:23:36 EDT 2024

Committee Statement

Committee Statement: This revision clarifies that the inspection and repair requirements in this section apply to portable test instruments and equipment only.

Second level subdivisions and titles were added to comply with the NEC Style Manual Section 2.1.6.

Response Message: FR-46-NFPA 70E-2024

Public Input No. 243-NFPA 70E-2024 [Section No. 110.6(D)]

First Revision No. 47-NFPA 70E-2024 [Section No. 110.7(D)]

(D) Conductive or Wet Work Locations.

~~Portable~~ Cord sets (extension cords) and portable cord-and-plug-connected electric equipment used in conductive or wet work locations shall be approved for use in those locations. ~~In work locations where employees are likely to contact or be drenched with water or conductive liquids, ground-fault circuit-interrupter protection for personnel shall be used.~~

Informational Note: The risk assessment procedure can also include identifying when the use of portable tools and equipment powered by sources other than 120 volts ac, such as batteries, air, and hydraulics, should be used to minimize the potential for injury from electrical hazards for tasks performed in conductive or wet locations.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 14:27:36 EDT 2024

Committee Statement

Committee Statement: This revision clarifies that 110.7(D) also applies to cord sets used in conductive or wet work locations.

The UL/CSA Classification “W” means a cord set is approved for outdoor use and includes sunlight resistant jacket and wet location rated conductors.

The requirement to use GFCI protection in conductive or wet work locations has been relocated to 110.8 to consolidate it with similar GFCI requirements.

Response Message: FR-47-NFPA 70E-2024

First Revision No. 48-NFPA 70E-2024 [Sections 110.8(B), 110.8(C)]

(B) ~~Maintenance and Construction~~ Additional Circumstances Requiring GFCI Protection .

~~GFCI protection shall be provided where an employee is operating or using cord sets (extension cords) or cord- and plug-connected tools related to maintenance and construction activity supplied by 120-volt, 15-, 20-, or 30-ampere circuits. Where employees operate or use equipment supplied by greater than 120-volt, 15-, 20-, or 30-ampere circuits, GFCI protection or an assured equipment grounding conductor program shall be implemented.~~

(1) 120-Volt Cord Circuits.

~~GFCI protection shall be provided where an employee is operating or using cord~~ Cord sets (extension cords) ~~or~~ and cord- and plug-connected tools ~~related to~~ used for maintenance ~~and~~ or construction activity, or outdoors, or in conductive or wet work locations and that are supplied by 120-volt, 15-, 20-, or 30-ampere circuits shall be provided with GFCI protection .

(2) Greater then 120-Volt Cord Circuits.

~~Where employees operate or use equipment~~ Cord sets (extension cords) and cord- and plug-connected tools used for construction or maintenance activity, outdoors, or in conductive or wet work locations and that are supplied by greater than 120-volt, 15-, 20-, or 30-ampere circuits, GFCI protection or an assured equipment grounding conductor program shall be implemented.

Informational Note No. 1: See Informative Annex O. Where an assured equipment grounding conductor program is used, a special purpose ground-fault circuit interrupter may provide additional protection.

Informational Note No. 2: See applicable state, federal, or local codes and standards such as *NFPA 70*, *National Electrical Code*, Section 590.6(B)(2) for more information regarding implementation of an assured equipment grounding conductor program.

~~**(C)** Outdoors.~~

~~GFCI protection shall be provided when an employee is outdoors and operating or using cord sets (extension cords) or cord- and plug-connected equipment supplied by 120-volt, 15-, 20-, or 30-ampere circuits. Where employees working outdoors operate or use equipment supplied by greater than 120-volt, 15-, 20-, or 30-ampere circuits, GFCI protection or an assured equipment grounding conductor program shall be implemented.~~

~~Informational Note No. 1: See Informative Annex O . Where an assured equipment grounding conductor program is used, a special purpose ground-fault circuit interrupter may provide additional protection.~~

~~Informational Note No. 2: See applicable state, federal, or local codes and standards such as *NFPA 70* , *National Electrical Code* , Section 590.6(B)(2) for more information regarding implementation of an assured equipment grounding conductor program.~~

Supplemental Information

File Name	Description	Approved
FR_48_attachment.docx	attachment for FR 48	
FR_48_110.8_B_.docx	For prod use	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 14:36:12 EDT 2024

Committee Statement

Committee Statement: The requirement to use GFCI protection in conductive or wet work locations is relocated from 110.7(D) to 110.8 to consolidate it with similar GFCI requirements

The requirements of this section are editorially revised to be simpler to identify and apply.

Response Message: FR-48-NFPA 70E-2024

Public Input No. 272-NFPA 70E-2024 [Sections 110.8(B), 110.8(C)]

First Revision No. 24-NFPA 70E-2024 [Section No. 120.3(C)]

(C) Control of Energy.

All sources of electrical energy shall be controlled in such a way as to eliminate or minimize employee exposure to electrical hazards.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 08:23:56 EDT 2024

Committee Statement

Committee Statement: The addition of eliminate aligns with the requirements of establishing an electrically safe work condition.

Response Message: FR-24-NFPA 70E-2024

Public Input No. 18-NFPA 70E-2023 [Section No. 120.3(C)]

First Revision No. 25-NFPA 70E-2024 [Section No. 120.4(D)]

(D) Tagout Device.

The tagout device shall meet the following requirements:

(1) A tagout device shall include a tag together with an attachment means.

(2) The tagout device shall be readily identifiable as a tagout device and suitable for the environment and duration of the tagout.

(3) A tagout device attachment means shall ~~be capable of withstanding at least 222.4 N (50 lb) of force exerted at a right angle to the disconnecting means surface. The tag attachment means shall be nonreusable, attachable by hand, self-locking, nonreleasable, and equal to an all-environmental tolerant nylon cable tie.~~ comply with the following:

a. Be capable of withstanding at least 222.4 N (50 lb) of force exerted at a right angle to the disconnecting means surface

b. Be nonreusable, attachable by hand, self-locking, and nonreleasable~~, and equal to an all-environmental tolerant nylon~~ cable tie

c. Be suitable for the environment where used

(4) Tags shall contain a statement prohibiting unauthorized operation of the disconnecting means or removal of the tag.

(5) A hold card tagging tool on an overhead conductor in conjunction with a hotline tool to install the tagout device safely on a disconnect that is isolated from the work(s) shall be permitted. Where a hold card is used, the tagout procedure shall include the method of accounting for personnel who are working under the protection of the hold card.

Supplemental Information

File Name	Description	Approved
70E_FR-25_120.4_D_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 08:25:39 EDT 2024

Committee Statement

Committee Statement: Specifying nylon is too restrictive, as other types of fasteners may be appropriate to attach tagout devices. Revisions are made to Item 3 to comply with the NEC Style Manual.

Response Message: FR-25-NFPA 70E-2024

Public Input No. 177-NFPA 70E-2024 [Section No. 120.4(D)]

First Revision No. 26-NFPA 70E-2024 [Section No. 120.5(B)(6)]

(6) Testing.

The procedure shall establish the following:

(1) Test instrument to be used, the required PPE, and the person who will use it to verify proper operation of the test instrument on a known voltage source before and after use

(2) Requirement to define the boundary of the electrically safe work condition

(3) Requirement to test ~~before touching every~~ each exposed conductor or circuit part(s) for the absence of voltage within the defined boundary of the work area before touching.

(4) Requirement to retest for absence of voltage when circuit conditions change or when the job location has been left unattended

(5) Planning considerations that include methods of verification where there is no accessible exposed point to take voltage measurements

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 08:41:37 EDT 2024

Committee Statement

Committee Statement: The change modifies list item 3 for clarity.

Response Message: FR-26-NFPA 70E-2024

Public Input No. 75-NFPA 70E-2024 [Section No. 120.5(B)(6)]

First Revision No. 27-NFPA 70E-2024 [Section No. 120.5(B)(7)]

(7) Temporary Protective Grounding.

~~Grounding requirements for the circuit shall be established, including whether the temporary protective grounding equipment shall be installed for the duration of the task or is temporarily established by the procedure. Grounding needs or requirements shall be permitted to be covered in other work rules and might not be part of the lockout/tagout procedure.~~

(a) ~~Grounding~~ Temporary protective grounding requirements for the circuit shall be established, including whether the temporary protective grounding equipment shall be installed for the duration of the task or is temporarily established by the procedure.

(b) ~~Grounding~~ Temporary protective grounding needs or requirements shall be permitted to be covered in other work rules and might not be part of the lockout/tagout procedure.

Supplemental Information

File Name	Description	Approved
70E_FR-27_120.5_B_7_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 08:43:54 EDT 2024

Committee Statement

Committee Statement: As used in the context of this requirement the term "grounding" is ambiguous and is replaced with "temporary protective grounding". This change correlates with 120.6(8), Revisions are made to comply with the NEC Style Manual.

Response Message: FR-27-NFPA 70E-2024

Public Input No. 281-NFPA 70E-2024 [Section No. 120.5(B)(7)]

First Revision No. 28-NFPA 70E-2024 [Section No. 120.6]

Detail FR-29

120.6 Process for Establishing and Verifying an Electrically Safe Work Condition.

Establishing and verifying an electrically safe work condition shall include all of the following steps~~, , which shall be performed in the order presented, if~~The steps shall be performed in the order presented to the extent feasible:

(1) Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.

(2) After properly interrupting the load current, open the disconnecting device(s) for each source.

(3) Wherever possible, visually verify that all blades of the disconnecting devices are fully open or that drawout-type circuit breakers are withdrawn to the test or fully disconnected position.

(4) Release stored electrical energy.

(5) Block or relieve stored nonelectrical energy in devices to the extent the circuit parts cannot be unintentionally energized by such devices.

(6) Apply lockout/tagout devices in accordance with a documented and established procedure.

(7) Use an adequately rated portable test instrument to test for the absence of voltage of each phase conductor or circuit part at each point of work, phase to phase and phase to ground~~to test for the absence of voltage~~. ~~Test each phase conductor or circuit part both phase-to-phase and phase-to-ground.~~ Before and after ~~each test~~testing, determine that the test instrument is operating satisfactorily through verification on any known voltage source.

Informational Note No. 1: See UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements*, for rating, overvoltage category, and design requirements for voltage measurement and test instruments intended for use on electrical systems 1000 volts and below.

Exception No. 1 to 7: An adequately rated permanently mounted absence of voltage tester shall be permitted to be used to test for the absence of voltage of the conductors or circuit parts at the work location, provided it meets all of the following requirements: ~~(1) It is permanently mounted and installed in accordance with the manufacturer's instructions and tests the conductors and circuit parts at the point of work; (2) It is listed and labeled for the purpose of testing for the absence of voltage; (3) It tests each phase conductor or circuit part both phase-to-phase and phase-to-ground; (4) The test device is verified as operating satisfactorily on any known voltage source before and after testing for the absence of voltage.~~

(1) It is permanently mounted and installed in accordance with the manufacturer's instructions and tests the conductors and circuit parts at the point of work.

(2) It is listed and labeled for the purpose of testing for the absence of voltage.

(3) It tests each phase conductor or circuit part both phase-to-phase and phase-to-ground.

(4) The test device is verified as operating satisfactorily on any known voltage source before and after testing for the absence of voltage.

Informational Note 2: See UL 1436, *Outlet Circuit Testers and Other Similar Indicating Devices*, for additional information on rating and design requirements for permanently mounted absence of voltage testers.

Exception No. 2 to 7: On electrical systems over 1000 volts, adequately rated noncontact capacitive test instruments shall be permitted to be used to test for the absence of detectable voltage at each phase conductor in lieu of using a contact test instrument for testing for absence of voltage both phase to phase and phase to ground.

~~Informational Note No. 1: See UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements*, for rating, overvoltage category, and design requirements for~~

~~voltage measurement and test instruments intended for use on electrical systems 1000 volts and below.~~

Informational Note No. 3: Noncontact capacitive test instruments require a minimum voltage to operate and are therefore not suitable to test for the absence of voltage.

Informational Note No. 4: See IEC 61243-1, *Live Working — Voltage Detectors — Part 1: Capacitive type to be used for voltages exceeding 1kV a.c.*, or IEC 61243-2, *Live Working — Voltage Detectors — Part 2: Resistive type to be used for voltages of 1kV to 36 kV a.c.*, or IEC 61243-3, *Live Working — Voltage Detectors — Part 3: Two-pole low voltage type*, for additional information on rating and design requirements for voltage detectors.

(8) Temporary protective grounding equipment shall be applied to electrical conductors and circuit parts before touching them where the following conditions exist:

a. Where there is the possibility of induced voltages or stored electrical energy exists, all circuit conductors and circuit parts shall be grounded before touching them in those conductors or circuit parts.

b. Where it could be reasonably anticipated that the conductors or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, temporary protective grounding equipment shall be applied.

(9) ~~Where the possibility of induced voltages or stored electrical energy exists, ground all circuit conductors and circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, apply~~If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

a. *Placement.* ~~Temporary protective grounding equipment shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to an electric shock hazard (i.e., hazardous differences in electrical potential). The location, sizing, and application of temporary protective grounding equipment shall be identified as part of the employer's job planning.~~ Placement of temporary grounding equipment shall meet the following requirements:

i. Temporary protective grounding equipment shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to an electric shock hazard (i.e., hazardous differences in electrical potential).

ii. The location, sizing, and application of temporary protective grounding equipment shall be identified as part of the employer's job planning.

b. *Capacity.* Temporary protective grounding equipment shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.

Informational Note No. 5: See ASTM F855, *Standard Specification for Temporary Protective Grounds to be Used on De-energized Electric Power Lines and Equipment*, which is an example of a standard that contains information on capacity of temporary protective grounding equipment.

c. *Impedance.* Temporary protective grounding equipment and connections shall have an impedance low enough to cause immediate operation of protective devices in case of unintentional energizing of the electric conductors or circuit parts.

Supplemental Information

File Name	Description	Approved
FR_28_attachment.docx	attachment for FR 28	
FR_28_120.6.docx	For prod use	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 01 13:18:50 EDT 2024

Committee Statement

Committee Statement: Changes to the charging statement of 120.6 clarify the intent of the process where "to the extent feasible," applies to the order presented.

List item No. 7 is reordered for clarity.

Separating list item 8 into two list items meets NEC Style Manual Section 3.5.1.2.

Response Message: FR-28-NFPA 70E-2024

Public Input No. 33-NFPA 70E-2023 [Section No. 120.6]

Public Input No. 25-NFPA 70E-2023 [Section No. 120.6]

Public Input No. 24-NFPA 70E-2023 [Section No. 120.6]

Public Input No. 119-NFPA 70E-2024 [Section No. 120.6]

First Revision No. 59-NFPA 70E-2024 [Section No. 130.1]

130.1 Scope.

This article covers requirements for work involving electrical hazards such as the electrical safety-related work practices, assessments, precautions, and procedures when an electrically safe work condition cannot be established.

~~Safety-related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from electrical conductors or circuit parts that are or can become energized.~~

~~When energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts are not put into an electrically safe work condition, and work is performed as permitted in accordance with 110.2(B) , all of the following requirements shall apply:~~

(0) ~~Only qualified persons shall be permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition.~~

(0) ~~An energized electrical work permit shall be completed as required by 130.2 .~~

(0) ~~An electric shock risk assessment shall be performed as required by 130.4 .~~

(0) ~~An arc flash risk assessment shall be performed as required by 130.5 .~~

~~All requirements of Article 130 shall apply whether an incident energy analysis is completed or if Table 130.7(C)(15)(a) , Table 130.7(C)(15)(b) , and Table 130.7(C)(15)(c) are used in lieu of an incident energy analysis.~~

130.2 Work Involving Electrical Hazards.

Safety-related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from electrical conductors or circuit parts that are or can become energized.

(A) Energized Electrical Parts Not in an Electrically Safe Work Condition.

Detail FR-101

(1) Energized Work in Accordance with 110.2(B).

When energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts are not put into an electrically safe work condition, and work is performed as permitted in accordance with 110.2(B), all of the following requirements shall apply:

(1) Only qualified persons shall be permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition.

(2) An energized electrical work permit shall be completed as required by 130.3.

(3) An electric shock risk assessment shall be performed as required by 130.4.

(4) An arc flash risk assessment shall be performed as required by 130.5.

(5) If an energized electrical work permit is required in accordance with 130.2(A), at least one additional person meeting the emergency response training requirements of 110.4(C)(1) shall be present in the vicinity of, but outside of, either the limited approach boundary or arc flash boundary, whichever is greater.

(2) Additional Person.

If an energized electrical work permit is required in accordance with ~~130.2(A)~~ 130.3(A), at least one additional person meeting the emergency response training requirements of 110.4(C)(1) shall be present in the vicinity of, but outside of, either the limited approach boundary or arc flash boundary, whichever is greater.

(B) Application of Requirements.

All requirements of Article 130 shall apply whether an incident energy analysis is completed or if Table 130.7(C)(15)(a), Table 130.7(C)(15)(b), and Table 130.7(C)(15)(c) are used in lieu of an incident energy analysis.

Supplemental Information

File Name	Description	Approved
70E_FR-59_130.1.docx		
70E_FR-59_130.1_edited._sl_cxs.docx	sl response	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 10:06:08 EDT 2024

Committee Statement

Committee Statement: Section 130.1 contained more than the scope of Article 130. Text was relocated as a new 130.2 to comply with the NEC Style Manual.

First and/or second level subdivision titles were added to comply with the NEC Style Manual.

Response Message: FR-59-NFPA 70E-2024

Public Input No. 1-NFPA 70E-2023 [Section No. 130.1]

Public Input No. 3-NFPA 70E-2023 [Section No. 130.2]

First Revision No. 60-NFPA 70E-2024 [Section No. 130.2(B)]

(B) Elements of Work Permit.

The work permit shall include, but not be limited to, the following items:

(1) Description of the circuit and equipment to be worked on and their location

(2) Description of the work to be performed

(3) Justification for why the work must be performed in an energized condition *[see 110.2(B)]*

(4) Description of the safe work practices to be employed *(see 130.1)*

(5) Results of the electric shock risk assessment *[see 130.4(A)]*

a. Voltage to which personnel will be exposed

b. Limited approach boundary *[see 130.4(F), Table 130.4(E)(a), and Table 130.4(E)(b)]*

c. Restricted approach boundary *[see 130.4(G), Table 130.4(E)(a), and Table 130.4(E)(b)]*

d. Personal and other protective equipment required by this standard to safely perform the assigned task and to protect against the electric shock hazard *[see 130.4(F), 130.5(G), 130.7(C)(1) through 130.7(C)(15) , and 130.7(D)]*

(6) Results of the arc flash risk assessment *[see 130.5(A)]*

a. ~~Available incident~~ Incident energy at the working distance or arc flash PPE category *[see 130.5(F)]*

b. Personal and other protective equipment required by this standard to protect against the arc flash hazard *[see 130.5(F), 130.7(C)(1) through 130.7(C)(15) , Table 130.7(C)(15)(c), and 130.7(D)]*

c. Arc flash boundary *[see 130.5(E)]*

(7) Means employed to restrict the access of unqualified persons from the work area *[see 130.8(O)]*

(8) Evidence of completion of a job briefing, including a discussion of any job-specific hazards *[see 110.3(I)]*

(9) Energized work approval (authorizing or responsible management, safety officer, or owner, etc.) signature(s)

Informational Note: See ~~Informative Annex~~ Figure J.1 for an example of an acceptable energized work permit.

Supplemental Information

File Name	Description	Approved
70E_FR-60_130.2_B_.docx		

Submitter Information Verification

Committee: EEW-AAA

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Committee Statement

Committee Statement: This revision is made to correlate with the definition of incident energy.

Response Message: FR-60-NFPA 70E-2024

Public Input No. 9-NFPA 70E-2023 [Section No. 130.2(B)]

First Revision No. 61-NFPA 70E-2024 [Section No. 130.4(C)]

(C) Additional Protective Measures.

~~If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk control identified in 110.3(H)(3) . When the additional protective measures include the use of PPE, the following shall be determined:~~

(0) ~~The voltage to which personnel will be exposed~~

(0) ~~The boundary requirements~~

(0) ~~The personal and other protective equipment required by this standard to protect against the electric shock hazard~~

(1) Selection.

If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk control identified in 110.3(H)(3).

(2) Requirements.

When the additional protective measures include the use of PPE, the following shall be determined:

(1) The voltage to which personnel will be exposed

(2) The electric shock boundary requirements

(3) The personal and other protective equipment required by this standard to protect against the electric shock hazard

Supplemental Information

File Name	Description	Approved
70E_FR-61_130.4_C_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 10:16:44 EDT 2024

Committee Statement

Committee Statement: The revised text clarifies which boundary requirements are involved. The section was revised to comply with the NEC Style Manual.

Response Message: FR-61-NFPA 70E-2024

Public Input No. 179-NFPA 70E-2024 [Section No. 130.4(C)]

First Revision No. 68-NFPA 70E-2024 [Section No. 130.4(E)]

(E) Electric Shock Protection Boundaries.

The electric shock protection boundaries identified as limited approach boundary and restricted approach boundary shall be applicable where personnel are approaching exposed energized electrical conductors or circuit parts. Table 130.4(E)(a) shall be used for the distances associated with various ac system voltages. Table 130.4(E)(b) shall be used for the distances associated with various dc system voltages.

Informational Note: In certain instances, the arc flash boundary might be a greater distance from the energized electrical conductors or circuit parts than the limited approach boundary. The electric shock protection boundaries and the arc flash boundary are independent of each other.

Table 130.4(E)(a) Electric Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems

(1)	(2)	(3)	(4)
	Limited Approach Boundary[b]		
Nominal System Voltage Range, Phase to Phase[a]	Exposed Movable Conductor[c]	Exposed Fixed Circuit Part	Restricted Approach Boundary[b,d]; Includes Inadvertent Movement Adder
Less than 50 V	Not specified	Not specified	Not specified
50 V–150 V[e]	3.1 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
151 V–750 V	3.1 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.31 m (1 ft 0 in.)
751 V–5 kV	3.1 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.63 m (2 ft 1 in.)
5.1 kV–15 kV	3.1 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.65 m (2 ft 2 in.)
15.1 kV–36 kV	3.1 m (10 ft 0 in.)	1.8 m (6 ft 0 in.)	0.77 m (2 ft 7 in.)
36.1 kV–46 kV	3.1 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.84 m (2 ft 10 in.)
46.1 kV–72.5 kV	3.1 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 4 in.)
72.6 kV–121 kV	3.3 m (10 ft 8 in.)	2.5 m (8 ft 0 in.)	1.2 m (3 ft 9 in.)
121.1 kV–145 kV	3.4 m (11 ft 0 in.)	3.1 m (10 ft 0 in.)	1.3 m (4 ft 4 in.)
145.1 kV–169 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	1.5 m (4 ft 10 in.)
169.1 kV–242 kV	4.0 m (13 ft 0 in.)	4.0 m (13 ft 0 in.)	2.1 m (6 ft 8 in.)
242.1 kV–362 kV	4.7 m (15 ft 4 in.)	4.7 m (15 ft 4 in.)	3.5 m (11 ft 2 in.)
362.1 kV–420 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	4.3 m (14 ft 0 in.)
420.1 kV–550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	5.1 m (16 ft 8 in.)
550.1 kV–800 kV	7.2 m (23 ft 9 in.)	7.2 m (23 ft 9 in.)	6.9 m (22 ft 7 in.)

Notes:

(1) For arc flash boundary, see 130.5(E).

(2) All dimensions are distance from exposed energized electrical conductors or circuit part to ~~employee~~ personnel .

[a]For single-phase systems above 250 volts, select the range that is equal to the system's maximum phase-to-ground voltage multiplied by 1.732.

[b]See definition in Article 100 and text in 130.4(F)(3) and Informative Annex C for elaboration.

[c] *Exposed movable conductors* describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

[d] The restricted approach boundary in Column 4 is based on an elevation not exceeding 900 m (3000 ft). For higher elevations, adjustment of the restricted approach boundary shall be considered.

Informational Note: See 29 CFR 1910.269, Table R-5, Altitude Correction Factor; ANSI/IEEE C2-2023, *National Electrical Safety Code* ; and IEEE 516-2021, *Guide for Maintenance Methods on Energized Power Lines* , Section 4.7.6 for information on adjusting the restricted approach boundary for elevations exceeding 900 m (3000 ft).

[e] ~~This includes circuits where the exposure does not exceed 120 volts nominal.~~ This voltage range applies to line to ground voltages up to 240 volts.

Table 130.4(E)(b) Electric Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Direct-Current Voltage Systems

(1)	(2)	(3)	(4)[b]
Nominal Potential Difference	**Limited Approach Boundary**		**Restricted Approach Boundary; Includes Inadvertent Movement Adder**
	Exposed Movable Conductor*[a]	**Exposed Fixed Circuit Part**	
Less than 50 V	Not specified	Not specified	Not specified
50 V–300 V	3.1 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
301 V–1 kV	3.1 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)
1.1 kV–5 kV	3.1 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.5 m (1 ft 5 in.)
5.1 kV–15 kV	3.1 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.7 m (2 ft 2 in.)
15.1 kV–45 kV	3.1 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.8 m (2 ft 9 in.)
45.1 kV– 75 kV	3.1 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
75.1 kV–150 kV	3.3 m (10 ft 8 in.)	3.1 m (10 ft 0 in.)	1.2 m (3 ft 10 in.)
150.1 kV–250 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	1.6 m (5 ft 3 in.)
250.1 kV–500 kV	6.0 m (20 ft 0 in.)	6.0 m (20 ft 0 in.)	3.5 m (11 ft 6 in.)
500.1 kV–800 kV	8.0 m (26 ft 0 in.)	8.0 m (26 ft 0 in.)	5.0 m (16 ft 5 in.)

Note: All dimensions are distance from exposed energized electrical conductors or circuit parts to worker.

*[a] *Exposed movable conductor* describes a condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.

[b] The restricted approach boundary in Column 4 is based on an elevation not exceeding 900 m (3000 ft). For higher elevations, adjustment of the restricted approach boundary shall be considered.

Informational Note: See 29 CFR 1910.269, Table R-5, Altitude Correction Factor; ANSI/IEEE C2-2023, *National Electrical Safety Code* ; and IEEE 516-2021, *Guide for Maintenance Methods on Energized Power Lines* , Section 4.7.6 for information on adjusting the restricted approach boundary for elevations exceeding 900 m (3000 ft).

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 10:47:25 EDT 2024

Committee Statement

Committee Statement:	The word "employee" was replaced with "personnel" to correlate to the existing word in 130.4E. An informational note is added to note (d) to Tables 130.4(E)(a) and 130.4(E)(b) to direct users to more information on altitude impacts. Note e was revised to indicate that the line vs. phase issue applies only at the lowest voltage range.
Response Message:	FR-68-NFPA 70E-2024

Public Input No. 73-NFPA 70E-2024 [Section No. 130.4(E)]

Public Input No. 214-NFPA 70E-2024 [Section No. 130.4(E)]

First Revision No. 62-NFPA 70E-2024 [Section No. 130.4(F)(3)]

(3) Entering the Limited Approach Boundary.

~~Where~~ The following shall apply where there is a need for an unqualified person(s) to cross the limited approach ~~boundary, a qualified person shall advise the unqualified person(s) of the possible hazards and continuously escort the unqualified person(s) while inside the limited approach boundary. Under no circumstance shall unqualified person(s) be permitted to cross the restricted approach~~ boundary:

(1) A qualified person shall advise the unqualified person(s) of the possible hazards and continuously escort the unqualified person(s) while inside the limited approach boundary.

(2) Under no circumstance shall unqualified person(s) be permitted to cross the restricted approach boundary.

Supplemental Information

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Submitter Information Verification

Committee: EEW-AAA

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Committee Statement

Committee Statement: The section was revised to comply with the NEC Style Manual.

Response Message: FR-62-NFPA 70E-2024

First Revision No. 36-NFPA 70E-2024 [Section No. 130.5(B)]

(B) Estimate of Likelihood and Severity.

The estimate of the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health shall take into consideration the following:

(1) The design of the electrical equipment~~, including its overcurrent protective device and its operating time~~

(2) The overcurrent protective device for the electrical equipment and its operating time and operation condition

(3) The electrical equipment operating condition and condition of maintenance

Informational Note: In most cases, closed doors do not provide enough protection to eliminate the need for PPE in situations in which the state of the equipment is known to readily change (e.g., doors open or closed, rack in or rack out).

Supplemental Information

File Name	Description	Approved
70E_FR-36_130.5_B_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Fri Aug 02 08:04:10 EDT 2024

Committee Statement

Committee Statement: The revision clarifies that the overcurrent protective device that is to be taken into consideration when estimating the potential severity of injury or damage to health is that which is intended to interrupt a fault in the electrical equipment referred to in list item (1).

Response Message: FR-36-NFPA 70E-2024

Public Input No. 67-NFPA 70E-2024 [Section No. 130.5(B)]

First Revision No. 37-NFPA 70E-2024 [Section No. 130.5(C)]

Detail FR-58

(C) Additional Protective Measures.

If additional protective measures are required they shall be selected and implemented according to the hierarchy of risk control identified in 110.3(H) (3). When the additional protective measures include the use of PPE, the following shall be determined:

(0) Appropriate safety-related work practices

(0) The arc flash boundary

(0) The PPE to be used within the arc flash boundary

Table 130.5(C) shall be permitted to be used to estimate the likelihood of occurrence of an arc flash event to determine if additional protective measures are required.

Table 130.5(C) Estimate of the Likelihood of Occurrence of an Arc Flash Incident for ac and dc Systems

Task	Operating Condition[a]	Likelihood of Occurrence[b]
Reading a panel meter while operating a meter switch.	Any	No
Performing infrared thermography and other noncontact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers.	-	-
Working on control circuits with exposed energized electrical conductors and circuit parts, nominal 125 volts ac or dc, or below without any other exposed energized equipment over nominal 125 volts ac or dc, including opening of hinged covers to gain access.	-	-
Examination of insulated cable with no manipulation of cable.	-	-
For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack.	-	-
-	-	-
For ac systems, work on energized electrical conductors and circuit parts, including electrical testing.	Any	Yes
Operation of a CB or switch the first time after installation or completion of maintenance in the equipment.	-	-
For dc systems, working on energized electrical conductors and circuit parts of series-connected battery cells, including electrical testing.	-	-
Removal or installation of CBs or switches.	-	-
Opening hinged door(s) or cover(s) or removal of bolted covers (to expose bare, energized electrical conductors and circuit parts). For dc systems, this includes bolted covers, such as battery terminal covers.	-	-
Application of temporary protective grounding equipment, after voltage test.	-	-
Working on control circuits with exposed energized electrical conductors and circuit parts, greater than 120 volts.	-	-
Insertion or removal of individual starter buckets from motor control center (MCC).	-	-
Insertion or removal (racking) of circuit breakers (CBs) or starters from cubicles, doors open or closed.	-	-
Insertion or removal of plug-in devices into or from busways.	-	-
Examination of insulated cable with manipulation of cable.	-	-

Task	Operating Condition[a]	Likelihood of Occurrence[b]
Working on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panelboard or motor control center.	-	-
Insertion or removal of revenue meters (kW-hour, at primary voltage and current).	-	-
Insertion or removal of covers for battery intercell connector(s).	-	-
For dc systems, working on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source.	-	-
Opening voltage transformer or control power transformer compartments.	-	-
Operation of outdoor disconnect switch (hookstick operated) at 1 kV through 15 kV.	-	-
Operation of outdoor disconnect switch (gang-operated, from grade) at 1 kV through 15 kV.	-	-
Operation of a CB, switch, contactor, or starter.	Normal	No
-	Abnormal	Yes
Voltage testing on individual battery cells or individual multi-cell units.	-	-
Removal or installation of covers for equipment such as wireways, junction boxes, and cable trays that does not expose bare, energized electrical conductors and circuit parts.	-	-
Opening a panelboard hinged door or cover to access dead front overcurrent devices.	-	-
Removal of battery nonconductive intercell connector covers.	-	-
Maintenance and testing on individual battery cells or individual multi-cell units in an open rack	-	-
Insertion or removal of individual cells or multi-cell units of a battery system in an open rack.	-	-
Arc-resistant equipment with the DOORS CLOSED and SECURED, and where the available fault current and fault clearing time does not exceed that of the arc-resistant rating of the equipment in one of the following conditions:	-	-
(1) Insertion or removal of individual starter buckets	-	-
(2) Insertion or removal (racking) of CBs from cubicles	-	-
(3) Insertion or removal (racking) of ground and test device	-	-
(4) Insertion or removal (racking) of voltage transformers on or off the bus	-	-
-	-	-

[a] Equipment is considered to be in a “normal operating condition” if all of the conditions in 110.2(B), Exception No. 1 are satisfied.

[b] As defined in this standard, the two components of risk are the likelihood of occurrence of injury or damage to health and the severity of injury or damage to health that results from a hazard. Risk assessment is an overall process that involves estimating both the likelihood of occurrence and severity to determine if additional protective measures are required. The estimate of the likelihood of occurrence contained in this table does not cover every possible

~~condition or situation, nor does it address severity of injury or damage to health. Where this table identifies "No" as an estimate of likelihood of occurrence, it means that an arc flash incident is not likely to occur. Where this table identifies "Yes" as an estimate of likelihood of occurrence, it means an arc flash incident should be considered likely to occur. The likelihood of occurrence must be combined with the potential severity of the arcing incident to determine if additional protective measures are required to be selected and implemented according to the hierarchy of risk control identified in 110.3(H).~~

~~Informational Note No. 1: See IEEE C37.20.7, *Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults* , as an example of a standard that provides information for arc-resistant equipment referred to in Table 130.5(C) .~~

~~Informational Note No. 2: Improper or inadequate maintenance can result in increased fault clearing time of the overcurrent protective device, thus increasing the incident energy. Where equipment is not properly installed or maintained, PPE selection based on incident energy analysis or the PPE category method might not provide adequate protection from arc flash hazards.~~

~~Informational Note No. 3: Both larger and smaller available fault currents could result in higher incident energy. If the available fault current increases without a decrease in the fault clearing time of the overcurrent protective device, the incident energy will increase. If the available fault current decreases, resulting in a longer fault clearing time for the overcurrent protective device, incident energy could also increase.~~

~~Informational Note No. 4: See Informative Annex O for safety-related design requirements. The occurrence of an arcing fault inside an enclosure produces a variety of physical phenomena very different from a bolted fault. For example, the arc energy resulting from an arc developed in the air will cause a sudden pressure increase and localized overheating. Equipment and design practices are available to minimize the energy levels and the number of procedures that could expose an employee to high levels of incident energy. Proven designs such as arc-resistant switchgear, remote racking (insertion or removal), remote opening and closing of switching devices, high-resistance grounding of low-voltage and 5000-volt (nominal) systems, current limitation, and specification of covered bus or covered conductors within equipment are available to reduce the risk associated with an arc flash incident.~~

~~Informational Note No. 5: See 205.4, 225.1, 225.2, and 225.3 for additional direction for performing maintenance on overcurrent protective devices.~~

~~Informational Note No. 6: See IEEE 1584, *Guide for Performing Arc Flash Hazard Calculations* , for more information regarding incident energy and the arc flash boundary for three-phase systems.~~

(1) Hierarchy of Risk Controls.

If additional protective measures are required they shall be selected and implemented according to the hierarchy of risk control identified in 110.3(H)(3).

(2) When PPE is Used.

When the additional protective measures include the use of PPE, the following shall be determined:

(1) Appropriate safety-related work practices

(2) The arc flash boundary

(3) The PPE to be used within the arc flash boundary

(3) Use of Table 130.5(C)(3).

Table 130.5(C)(3) shall be permitted to be used to estimate the likelihood of occurrence of an arc flash event to determine if additional protective measures are required.

Table 130.5(C)(3) Estimate of the Likelihood of Occurrence of an Arc Flash Incident for ac and dc Systems

Task	Operating Condition[a]	Likelihood of Occurrence[b]
Reading a panel meter while operating a meter switch.	Any	No
Performing infrared thermography and other noncontact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers.		
Working on control circuits with exposed energized electrical conductors and circuit parts, nominal 125 volts ac or dc, or below without any other exposed energized equipment over nominal 125 volts ac or dc, including opening of hinged covers to gain access.		
Examination of insulated cable with no manipulation of cable.		
For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack.		
Working on battery equipment below 600 volts where the exposed electrical conductors are separated by more than 1 mm (0.039 in.) per volt.		
For ac systems, work on energized electrical conductors and circuit parts, including electrical testing.	Any	Yes
Operation of a CB or switch the first time after installation or completion of maintenance in the equipment.		
For dc systems, working on energized electrical conductors and circuit parts of series-connected battery cells, including electrical testing.		
Removal or installation of CBs or switches.		
Opening hinged door(s) or cover(s) or removal of bolted covers (to expose bare, energized electrical conductors and circuit parts). For dc systems, this includes bolted covers, such as battery terminal covers.		
Application of temporary protective grounding equipment, after voltage test.		
Working on control circuits with exposed energized electrical conductors and circuit parts, greater than 120 volts.		
Insertion or removal of individual starter buckets from motor control center (MCC).		
Insertion or removal (racking) of circuit breakers (CBs) or starters from cubicles, doors open or closed.		
Insertion or removal of plug-in devices into or from busways.		
Examination of insulated cable with manipulation of cable.		
Working on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panelboard or motor control center.		
Insertion or removal of revenue meters (kW-hour, at primary voltage and current).		
Insertion or removal of covers for battery intercell connector(s).		

Task	Operating Condition[a]	Likelihood of Occurrence[b]
For dc systems, working on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source.		
Opening voltage transformer or control power transformer compartments.		
Operation of outdoor disconnect switch (hookstick operated) at 1 kV through 15 kV.		
Operation of outdoor disconnect switch (gang-operated, from grade) at 1 kV through 15 kV.		
Operation of a CB, switch, contactor, or starter.	Normal	No
	Abnormal	Yes
Voltage testing on individual battery cells or individual multi-cell units.		
Removal or installation of covers for equipment such as wireways, junction boxes, and cable trays that does not expose bare, energized electrical conductors and circuit parts.		
Opening a panelboard hinged door or cover to access dead front overcurrent devices.		
Removal of battery nonconductive intercell connector covers.		
Maintenance and testing on individual battery cells or individual multi-cell units in an open rack		
Insertion or removal of individual cells or multi-cell units of a battery system in an open rack.		
Arc-resistant equipment with the DOORS CLOSED and SECURED, and where the available fault current and fault clearing time does not exceed that of the arc-resistant rating of the equipment in one of the following conditions:		
(1) Insertion or removal of individual starter buckets		
(2) Insertion or removal (racking) of CBs from cubicles		
(3) Insertion or removal (racking) of ground and test device		
(4) Insertion or removal (racking) of voltage transformers on or off the bus		

[a]Equipment is considered to be in a “normal operating condition” if all of the conditions in 110.2(B), Exception No. 1 are satisfied.

[b]As defined in this standard, the two components of risk are the likelihood of occurrence of injury or damage to health and the severity of injury or damage to health that results from a hazard. Risk assessment is an overall process that involves estimating both the likelihood of occurrence and severity to determine if additional protective measures are required. The estimate of the likelihood of occurrence contained in this table does not cover every possible condition or situation, nor does it address severity of injury or damage to health. Where this table identifies “No” as an estimate of likelihood of occurrence, it means that an arc flash incident is not likely to occur. Where this table identifies “Yes” as an estimate of likelihood of occurrence, it means an arc flash incident should be considered likely to occur. The likelihood of occurrence must be combined with the potential severity of the arcing incident to determine if additional protective measures are required to be selected and implemented according to the hierarchy of risk control identified in 110.3(H).

Informational Note No. 1: See IEEE C37.20.7, *Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults*, as an example of a standard that provides

information for arc-resistant equipment referred to in Table 130.5(C)(3).

Informational Note No. 2: Improper or inadequate maintenance can result in increased fault clearing time of the overcurrent protective device, thus increasing the incident energy. Where equipment is not properly installed or maintained, PPE selection based on incident energy analysis or the PPE category method might not provide adequate protection from arc flash hazards.

Informational Note No. 3: Both larger and smaller ~~available~~ fault currents could result in higher incident energy. If the ~~available~~ fault current increases without a decrease in the fault clearing time of the overcurrent protective device, the incident energy will increase. If the ~~available~~ fault current decreases, resulting in a longer fault clearing time for the overcurrent protective device, incident energy could also increase.

Informational Note No. 4: See Informative Annex O for safety-related design requirements. The occurrence of an arcing fault inside an enclosure produces a variety of physical phenomena very different from a bolted fault. For example, the arc energy resulting from an arc developed in the air will cause a sudden pressure increase and localized overheating. Equipment and design practices are available to minimize the energy levels and the number of procedures that could expose an employee to high levels of incident energy. Proven designs such as arc-resistant switchgear, remote racking (insertion or removal), remote opening and closing of switching devices, high-resistance grounding of low-voltage and 5000-volt (nominal) systems, current limitation, and specification of covered bus or covered conductors within equipment are available to reduce the risk associated with an arc flash incident.

Informational Note No. 5: See 205.4, 225.1, 225.2, and 225.3 for additional direction for performing maintenance on overcurrent protective devices.

Informational Note No. 6: See IEEE 1584, *Guide for Performing Arc Flash Hazard Calculations*, for more information regarding incident energy and the arc flash boundary for three-phase systems.

Supplemental Information

File Name	Description	Approved
70E_FR-37_130.5_C_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Fri Aug 02 08:09:29 EDT 2024

Committee Statement

Committee Statement: The section was revised to comply with the NEC Style Manual Sections 3.5.1.2 Multiple Requirements and 2.1.6.3 Subdivisions and 2.1.6.3.2 Subdivision Titles.

The revision in Informational Note No. 3 clarifies the application of this informational note and correlates the note with the related definition of fault current.

Response Message: FR-37-NFPA 70E-2024

Public Input No. 10-NFPA 70E-2023 [Section No. 130.5(C)]

First Revision No. 38-NFPA 70E-2024 [Section No. 130.5(F)]

(F) Arc Flash PPE Selection Methods .

~~One of the following methods shall be used for the selection of arc flash PPE:~~

(0) ~~The incident energy analysis method in accordance with 130.5(G)~~

(0) ~~The arc flash PPE category method in accordance with 130.7(C)(15)~~

~~Either, but not both, methods shall be permitted to be used on the same piece of equipment. The results of an incident energy analysis to specify an arc flash PPE category in Table 130.7(C)(15)(c) shall not be permitted.~~

(1) Selection Methods.

One of the following methods shall be used for the selection of arc flash PPE:

(1) The incident energy analysis method in accordance with 130.5(G)

(2) The arc flash PPE category method in accordance with 130.7(C)(15)

(2) One Method Per Equipment.

Either, but not both, methods shall be permitted to be used on the same piece of equipment.

(3) Incident Energy and PPE Categories.

The results of an incident energy analysis to specify an arc flash PPE category in Table 130.7(C)(15)(c) shall not be permitted.

Exception: A task specific incident energy value shall be permitted to be used for the selection of arc flash PPE if the equipment complies with all of the following:

(1) The equipment is listed.

(2) The equipment is installed in accordance with the manufacturer's instructions.

(3) The equipment is installed in accordance with its ratings.

(4) The equipment has been tested by a third party qualified electrical testing laboratory to verify the task specific incident energy information.

(5) The task specific incident energy information is marked on the equipment.

Informational Note: See UL RP 2986, *Recommended Practice for Measuring Incident Energy Exposure* , for further information.

Supplemental Information

File Name	Description	Approved
70E_FR-38_130.5_F_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Fri Aug 02 08:12:38 EDT 2024

Committee Statement

Committee Statement:	This revision adds an exception with multiple conditions that allows workers to use arc flash information that was obtained through third party verified testing to select arc flash PPE without altering the existing provisions of this section. The new exception permits additional methods to be utilized for specific tasks in specific situations. The section was revised to comply with the NEC Style Manual Sections 3.5.1.2 Multiple Requirements and 2.1.6.3 Subdivisions and 2.1.6.3.2 Subdivision Titles.
Response Message:	FR-38-NFPA 70E-2024

Public Input No. 100-NFPA 70E-2024 [Section No. 130.5(F)]

First Revision No. 49-NFPA 70E-2024 [Section No. 130.7(A)]

(A) General.

Employees exposed to electrical hazards when the risk associated with that hazard is not adequately reduced by the applicable electrical installation requirements shall be provided with, and shall use, personal protective equipment that is designed and constructed for the specific part of the body to be protected and for the work to be performed.

Informational Note: The PPE requirements of 130.7 are intended to protect a person from arc flash and electric shock hazards. While some situations could result in burns to the skin, even with the protection selected, burn injury should be reduced and survivable. Due to the explosive effect of some arc events, physical trauma injuries could occur. The PPE requirements of 130.7 do not address protection against physical trauma other than exposure to the thermal effects of an arc flash.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 14:45:28 EDT 2024

Committee Statement

Committee Statement: The addition of the word “personal” clarifies the application of the requirement. The protective equipment in the requirement in the context used, is personal protective equipment.

Response Message: FR-49-NFPA 70E-2024

Public Input No. 17-NFPA 70E-2023 [Section No. 130.7(A)]

First Revision No. 50-NFPA 70E-2024 [Section No. 130.7(B)]

(B) Care of Equipment.

Protective equipment shall ~~be maintained in a safe, clean, and reliable condition and in accordance with manufacturers' instructions. The protective equipment shall be visually inspected before each use. Protective equipment shall be stored in a manner to prevent damage from physically damaging conditions and from moisture, dust, or other deteriorating agents.~~ comply with all of the following:

(1) Be maintained in a safe, clean, and reliable condition and in accordance with manufacturers' instructions

(2) Be visually inspected before each use

(3) Be stored in a manner to prevent damage from physically damaging conditions and from moisture, dust, or other deteriorating agents

Informational Note No. 1: See ~~130.7(C)(14) and 130.7(E)~~ 130.7(C)(7)(a) , 130.7(C)(7)(c) , 130.7(C)(7)(d) , Table 130.7(C)(7)(a) , and Table 130.7(C)(7)(b) for specific requirements for specific requirements for periodic testing of electrical protective equipment.

Informational Note No. 2: See 130.7(C)(14) for standards for PPE and 130.7(E) for standards for other protective equipment.

Supplemental Information

File Name	Description	Approved
70E_FR-50_130.7_B_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 14:47:18 EDT 2024

Committee Statement

Committee Statement: The existing informational note did not address requirements for periodic testing of electrical protective equipment and this revision modifies Informational Note No. 1 to reference the applicable requirements. The existing reference in Informational Note No.1 is relocated and modified as new Informational Note No. 2 addressing other protective equipment.

The section was revised to comply with the NEC Style Manual Section 3.5.1.2 Multiple Requirements.

Response Message: FR-50-NFPA 70E-2024

Public Input No. 15-NFPA 70E-2023 [Section No. 130.7(B)]

First Revision No. 51-NFPA 70E-2024 [Section No. 130.7(C)(6)]

(6) Body Protection.

Employees shall wear arc-rated clothing wherever there is possible exposure to ~~an electric arc flash above the threshold~~ incident energy ~~level for a second degree burn [~~ of 1.2 cal/cm^2 (5 J/cm^2)~~]~~ .

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 14:54:11 EDT 2024

Committee Statement

Committee Statement: Stating the requirement in terms of incident energy correlates with the definition of arc flash boundary, which is “an approach limit from an arc source at which incident energy equals 1.2 cal/cm2 (5 J/cm2).”

This revision also correlates with Table 130.5(G), which requires arc flash protection when the incident energy exposure is equal to or greater than 1.2 cal/cm2.

Response Message: FR-51-NFPA 70E-2024

Public Input No. 98-NFPA 70E-2024 [Section No. 130.7(C)(6)]

Public Input No. 275-NFPA 70E-2024 [Section No. 130.7(C)(6)]

First Revision No. 103-NFPA 70E-2024 [Section No. 130.7(C)(7)]

(7) Hand and Arm Protection.

Hand and arm protection shall be provided in accordance with 130.7(C)(7)(a), 130.7(C)(7)(b), and 130.7(C)(7)(c).

(a) *Electric Shock Protection.* Employees shall wear rubber insulating gloves with protectors where there is a danger of hand injury from electric shock due to contact with exposed energized electrical conductors or circuit parts. Employees shall wear rubber insulating gloves with protectors and rubber insulating sleeves where there is a danger of hand and arm injury from electric shock due to contact with exposed energized electrical conductors or circuit parts. Rubber insulating gloves shall be rated for the voltage for which the gloves will be exposed. Rubber insulating gloves shall be permitted to be used without protectors, under the following conditions:

(1) There shall be no activity performed that risks cutting or damaging the glove.

(2) The rubber insulating gloves shall be electrically retested before reuse.

(3) The voltage rating of the rubber insulating gloves shall be reduced by 50 percent for class 00 and by one whole class for classes 0 through 4.

(b) *Arc Flash Protection.* Hand and arm protection shall be worn where there is possible exposure to arc flash burn. The apparel described in 130.7(C)(10)(d) shall be required for protection of hands from burns. Arm protection shall be accomplished by the apparel described in 130.7(C)(6).

(c) *Maintenance and Use.* Electrical protective equipment shall be maintained in a safe, reliable condition. Insulating equipment shall be inspected for damage before each day's use and immediately following any incident that can reasonably be suspected of having caused damage. Insulating gloves shall be given an air test, along with the inspection. Maximum use voltages for rubber insulating gloves shall not exceed that specified in Table 130.7(C)(7)(a). The top of the cuff of the protector glove shall be shorter than the rolled top of the cuff of the insulating glove by at least the distance specified in Table 130.7(C)(7)(a).

(d) *Periodic Electrical Tests*. Rubber insulating equipment shall be subjected to periodic electrical tests. Test voltages shall be in accordance with applicable state, federal, or local codes and standards. The maximum intervals between tests shall not exceed that specified in Table 130.7(C)(7)(b).

(e) *Thermal Hand Protection* . Hand protection shall be worn where there is possible exposure to a contact thermal hazard.

Informational Note: See OSHA 29 CFR 1910.137; ASTM F478, *Standard Specification for In-Service Care of Insulating Line Hose and Covers*; ASTM F479, *Standard Specification for In-Service Care of Insulating Blankets*; and ASTM F496, *Standard Specification for In-Service Care of Insulating Gloves and Sleeves*, which contain information related to in-service and testing requirements for rubber insulating equipment.

Table 130.7(C)(7)(a) Maximum Use Voltage for Rubber Insulating Gloves

Class Designation of Glove or Sleeve	Maximum ac Use Voltage rms, volts	Maximum dc Use Voltage avg, volts	Distances Between Protector Cuff and Rubber Insulating Glove Cuff, minimum
00	500	750	13 mm (0.5 in.)
0	1,000	1,500	13 mm (0.5 in.)
1	7,500	11,250	25 mm (1 in.)
2	17,000	25,500	51 mm (2 in.)
3	26,500	39,750	76 mm (3 in.)
4	36,000	54,000	102 mm (4 in.)

Table 130.7(C)(7)(b) Rubber Insulating Equipment, Maximum Test Intervals

Rubber Insulating Equipment	When to Test
Blankets	Before first issue; every 12 months thereafter*
Covers	If insulating value is suspect
Gloves	Before first issue; every 6 months thereafter*
Line hose	If insulating value is suspect
Sleeves	Before first issue; every 12 months thereafter*

*New insulating equipment is not permitted to be placed into service unless it has been electrically tested within the previous 12 months. Insulating equipment that has been issued for service is not new and is required to be retested in accordance with the intervals in this table.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 08 11:27:20 EDT 2024

Committee Statement

Committee Statement: This revision adds general PPE requirements for the hands, where exposed to a contact thermal hazard. See new definition for thermal contact hazard.

Response Message: FR-103-NFPA 70E-2024

Public Input No. 280-NFPA 70E-2024 [Section No. 130.7(C)(7)]

First Revision No. 52-NFPA 70E-2024 [Section No. 130.7(C)(10)]

(10) Arc Flash Protective Equipment.

(a) *Arc Flash Suits.*~~Arc flash suit design shall permit easy and rapid removal by the wearer. The entire arc flash suit, including the hood's face shield, shall have an arc rating that is suitable for the arc flash exposure. When exterior air is supplied into the hood, the air hoses and pump housing shall be either covered by arc-rated materials or constructed of nonmelting and nonflammable materials.~~ Arc flash suits shall meet the following requirements:

(1) Arc flash suit design shall permit easy and rapid removal by the wearer.

(2) The entire arc flash suit, including the hood's face shield, shall have an arc rating that is suitable for the arc flash exposure.

(3) When exterior air is supplied into the hood, the air hoses and pump housing shall be either covered by arc-rated materials or constructed of nonmelting and nonflammable materials.

(b) *Head Protection.* Head protection shall meet the following requirements:

(1) An arc-rated hood or an arc-rated balaclava with an arc-rated face shield shall be used when the back of the head is within the arc flash boundary.

(2) An arc-rated hood shall be used when the anticipated incident energy exposure exceeds 12 cal/cm^2 (50.2 J/cm^2).

(c) *Face Protection.*~~Face shields shall have an arc rating suitable for the arc flash exposure. Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area shall be used. Face shields without an arc rating shall not be used. Eye protection (safety glasses or goggles) shall always be worn under face shields or hoods.~~ Face protection shall meet the following requirements:

(1) Face shields shall have an arc rating suitable for the arc flash exposure.

(2) Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area shall be used.

(3) Face shields without an arc rating shall not be used.

(4) Eye protection (safety glasses or goggles) shall always be worn under face shields or hoods.

Informational Note: Face shields made with energy-absorbing formulations that can provide higher levels of protection from the radiant energy of an arc flash are available, but these shields are tinted and can reduce visual acuity and color perception. Additional illumination of the task area might be necessary when these types of arc-protective face shields are used.

(d) *Hand Protection.* Hand protection shall meet the following requirements:

(1) Heavy-duty leather gloves or arc-rated gloves shall be worn where required for arc flash protection.

Informational Note: Heavy-duty leather gloves are made entirely of leather with minimum thickness of 0.03 in. (0.7 mm) and are unlined or lined with nonflammable, nonmelting fabrics. Heavy-duty leather gloves meeting this requirement have been shown to have ATPV values in excess of 10 cal/cm^2 (41.9 J/cm^2).

(2) Where insulating rubber gloves are used for electric shock protection, protectors shall be worn over the rubber gloves.

Informational Note: The protectors worn over rubber insulating gloves provide additional arc flash protection for the hands for arc flash protection exposure.

(e) *Foot Protection.* ~~Leather footwear or dielectric footwear or both provide some arc flash protection to the feet and shall be used in all exposures greater than 4 cal/cm^2 (16.75 J/cm^2). Footwear other than leather or dielectric shall be permitted to be used provided it has been tested to demonstrate no ignition, melting, or dripping at the estimated incident energy exposure or the minimum arc rating for the respective arc flash PPE category.~~ Foot protection shall meet the following requirements:

(1) Leather footwear or dielectric footwear or both provide some arc flash protection to the feet and shall be used in all exposures greater than 4 cal/cm^2 (16.75 J/cm^2).

(2) Footwear other than leather or dielectric shall be permitted to be used provided it has been tested to demonstrate no ignition, melting, or dripping at the estimated incident energy exposure or the minimum arc rating for the respective arc flash PPE category.

Supplemental Information

File Name	Description	Approved
FR_52_attachement.docx	attachment for FR 52	
70E_FR-52_130.7_C_10_.docx	For prod use	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 15:04:13 EDT 2024

Committee Statement

Committee Statement: The section was revised to comply with the NEC Style Manual Section 3.5.1.2 Multiple Requirements

Response Message: FR-52-NFPA 70E-2024

First Revision No. 53-NFPA 70E-2024 [Section No. 130.7(C)(14)]

Detail FR-54

(14) Standards for PPE.

(a) *General.* PPE shall conform to applicable state, federal, or local codes and standards.

Note: See Table Informational Note 130.7(C)(14)for a list of examples of standards that contain information on the care, inspection, testing, and manufacturing of PPE.

Informational Note No. 2: See 130.7(C)(11) and 130.7(C)(12) for requirements on non-arc-rated or flammable fabrics not covered by any of the standards in Table Informational Note 130.7(C)(14).

(b) *Conformity Assessment.* ~~All suppliers or manufacturers of PPE shall demonstrate conformity with an appropriate product standard by one of the following methods:~~ All arc-rated PPE shall be listed.

(0) ~~Self-declaration with a Supplier's Declaration of Conformity~~

(0) ~~Self-declaration under a registered quality management system and product testing by an accredited laboratory and a Supplier's Declaration of Conformity~~

(0) ~~Certification by an accredited independent third-party certification organization~~

Informational Note No. 1: See ~~Informative Annex~~ H.4 and ANSI/ISEA 125, *American National Standard for Conformity Assessment of Safety and Personal Protective Equipment*, for examples of a process for conformity assessment to an appropriate product standard.

Informational Note No. 2: See ISO 17065, *Conformity assessment — Requirements for bodies certifying products, processes, and services*, for an example of a process to accredit independent third-party certification organizations.

(c) *Marking.* All suppliers or manufacturers of PPE shall provide the following information on the PPE, on the smallest unit container, or contained within the manufacturer's instructions:

(1) Name of manufacturer

(2) Conformity assessment method used

(3) Product performance standards to which the product conforms

(4) Arc rating where appropriate for the equipment

(5) One or more identifiers such as model, serial number, lot number, or traceability code

(6) Care instructions

Table Informational Note 130.7(C)(14) Standards for PPE

Subject	Document Title	Document Number
Clothing — Arc Rated	Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs	ASTM F1506
	Standard Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing	ASTM F1449
	Standard Guide for Home Laundering Care and Maintenance of Flame, Thermal, and Arc Resistant Clothing	ASTM F2757
	Live working — Protective clothing against the thermal hazards of an electric arc — Part 1-1: Test methods — Method 1: Determination of the arc rating (ELIM, ATPV,	IEC 61482–1–1

Subject	Document Title	Document Number
	and/or EBT) of clothing materials and of protective clothing using an open arc	
	Live working — Protective clothing against the thermal hazards of an electric arc — Part 2: Requirements	IEC 61482–2
Aprons — Insulating	Standard Specification for Electrically Insulating Aprons	ASTM F2677
Eye and Face Protection — General	American National Standard for Occupational and Educational Professional Eye and Face Protection	ANSI/ISEA Z87.1
Face — Arc Rated	Standard Test Method for Determining the Arc Rating and Standard Specification for Personal Eye or Face Protective Products	ASTM F2178
Fall Protection	Standard Specification for Personal Climbing Equipment	ASTM F887
Footwear — Dielectric Specification	Standard Specification for Dielectric Footwear	ASTM F1117
Footwear — Dielectric Test Method	Standard Test Method for Determining Dielectric Strength of Dielectric Footwear	ASTM F1116
Footwear — Standard Performance Specification	Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear	ASTM F2413
Footwear — Standard Test Method	Standard Test Methods for Foot Protections	ASTM F2412
Gloves — Arc Rated	Standard Test Method for Determining Arc Ratings of Hand Protective Products Developed and Used for Electrical Arc Flash Protection	ASTM F2675/F2675M
Gloves — Leather Protectors	Standard Specification for Leather Protectors for Rubber Insulating Gloves and Mittens	ASTM F696
Gloves — Non-Leather Protectors	Standard Specification for Protectors for Rubber Insulating Gloves Meeting Specific Performance Requirements	ASTM F3258
Gloves — Rubber Insulating	Standard Specification for Rubber Insulating Gloves	ASTM D120
Gloves and Sleeves — In-Service Care	Standard Specification for In-Service Care of Insulating Gloves and Sleeves	ASTM F496
Head Protection — Hard Hats	American National Standard for Head Protection	ANSI/ISEA Z89.1
Rainwear — Arc Rated	Standard Specification for Arc and Flame Resistant Rainwear	ASTM F1891
Rubber Protective Products — Visual Inspection	Standard Guide for Visual Inspection of Electrical Protective Rubber Products	ASTM F1236
Sleeves — Insulating	Standard Specification for Rubber Insulating Sleeves	ASTM D1051

Supplemental Information

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FR_53_attachment.docx	attachment for FR 53	
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Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Tue Aug 06 15:12:59 EDT 2024

Committee Statement

Committee Statement: This adds the “conformity assessment method used by the supplier” to the marking information that suppliers or manufacturers must provide to assist the purchaser of the PPE to make an informed decision on choosing PPE that is appropriate for their particular purchase.

Response Message: FR-53-NFPA 70E-2024

Public Input No. 184-NFPA 70E-2024 [Section No. 130.7(C)(14)]

First Revision No. 55-NFPA 70E-2024 [Section No. 130.7(C)(15)]

Detail FR-79

(15) Arc Flash PPE Category Method.

The requirements of 130.7(C)(15) shall apply when the arc flash PPE category method is used for the selection of arc flash PPE.

Informational Note: For both ac and dc systems, the arc flash PPE category of the protective clothing and equipment is generally based on determination of the estimated exposure level.

(a) *Alternating- Current (ac) Equipment.*~~When the arc flash risk assessment performed in accordance with 130.5 indicates that arc flash PPE is required and the arc flash PPE category method is used for the selection of PPE for ac systems in lieu of the incident energy analysis of 130.5(G) , Table 130.7(C)(15)(a) shall be used to determine the arc flash PPE category. The estimated maximum available fault current, maximum fault-clearing times, and minimum working distances for various ac equipment types or classifications are listed in Table 130.7(C)(15)(a) . An incident energy analysis shall be required in accordance with 130.5(G) for the following:~~ Alternating-current (ac) equipment shall meet the following requirements:

(1) When the arc flash risk assessment performed in accordance with 130.5 indicates that arc flash PPE is required and the arc flash PPE category method is used for the selection of PPE for ac systems in lieu of the incident energy analysis of 130.5(G), Table 130.7(C)(15)(a) shall be used to determine the arc flash PPE category.

Informational Note: The estimated maximum available fault current, maximum fault-clearing times, and minimum working distances for various ac equipment types or classifications are listed in Table 130.7(C)(15)(a).

(2) An incident energy analysis shall be required in accordance with 130.5(G) for the following:

a. Power systems with greater than the estimated maximum available fault current

b. Power systems with longer than the maximum fault clearing times

c. Less than the minimum working distance

(b) *Direct- Current (dc) Equipment.*~~When the arc flash risk assessment performed in accordance with 130.5(G) indicates that arc flash PPE is required and the arc flash PPE category method is used for the selection of PPE for dc systems in lieu of the incident energy analysis of 130.5(G) , Table 130.7(C)(15)(b) shall be used to determine the arc flash PPE category. The estimated maximum available fault current, maximum arc duration, and working distances for dc equipment are listed in 130.7(C)(15)(b) . An incident energy analysis shall be required in accordance with 130.5(G) for the following:~~ Direct-current (dc) equipment shall meet the following requirements:

(1) When the arc flash risk assessment performed in accordance with 130.5(G) indicates that arc flash PPE is required and the arc flash PPE category method is used for the selection of PPE for dc systems in lieu of the incident energy analysis of 130.5(G), Table 130.7(C)(15)(b) shall be used to determine the arc flash PPE category.

Informational Note: The estimated maximum available fault current, maximum arc duration, and working distances for dc equipment are listed in 130.7(C)(15)(b).The estimated maximum available fault current, maximum arc duration, and working distances for dc equipment are listed in 130.7(C)(15)(b).

(2) An incident energy analysis shall be required in accordance with 130.5(G) for the following:

a. Power systems with greater than the estimated maximum available fault current

b. Power systems with longer than the maximum arc duration

c. Less than the minimum working distance

(c) *Protective Clothing and Personal Protective Equipment (PPE).* ~~Once the arc flash PPE category has been identified from Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) , Table 130.7(C)(15)(c) shall be used to determine the required PPE. Table 130.7(C)(15)(c) lists the requirements for PPE based on arc flash PPE categories 1 through 4. This clothing and equipment shall be used when working within the arc flash boundary. The use of PPE other than or in addition to that listed shall be permitted provided it meets 130.7(C)(7) .~~ Protective clothing and PPE shall meet the following requirements:

(1) Once the arc flash PPE category has been identified from Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b), Table 130.7(C)(15)(c) shall be used to determine the required PPE.

Note: Table 130.7(C)(15)(c) lists the requirements for PPE based on arc flash PPE categories 1 through 4.

(2) This clothing and equipment shall be used when working within the arc flash boundary.

(3) The use of PPE other than or in addition to that listed shall be permitted provided it meets 130.7(C)(7).

Informational Note No. 1: See Informative Annex H for a suggested simplified approach to ensure adequate PPE for electrical workers within facilities with large and diverse electrical systems.

Informational Note No. 2: The PPE requirements of this section are intended to protect a person from arc flash hazards. While some situations could result in burns to the skin even with the protection described in Table 130.7(C)(15)(c), burn injury should be reduced and survivable. Due to the explosive effect of some arc events, physical trauma injuries could occur. The PPE requirements of this section do not address protection against physical trauma other than exposure to the thermal effects of an arc flash.

Informational Note No. 3: The arc rating for a particular clothing system can be obtained from the arc-rated clothing manufacturer.

Table 130.7(C)(15)(a) Arc Flash PPE Categories for ~~Alternating Current (~~ ac~~)~~ Systems

Equipment	**Arc Flash PPE Category**	**Arc Flash Boundary**
Panelboards or other equipment rated 240 volts and below Parameters: ~~Maximum of~~ Available fault current not exceeding 25 kA ~~available fault current~~ ; ~~maximum of~~ fault clearing time not exceeding 0.03 sec (2 cycles) ~~fault clearing time~~ ; minimum working distance 455 mm (18 in.)	1	485 mm (19 in.)
Panelboards or other equipment rated greater than 240 volts and up to 600 volts Parameters: ~~Maximum of 25 kA available fault current~~ Available fault current not exceeding 25 kA ; ~~maximum of~~ fault clearing time not exceeding 0.03 sec (2 cycles) ~~fault clearing time~~ ; minimum working distance 455 mm (18 in.)	2	900 mm (3 ft)
600-volt class motor control centers (MCCs) Parameters: ~~Maximum of 65 kA available fault current~~ Available fault current not exceeding 65 kA ; ~~maximum of~~ fault clearing time not exceeding 0.03 sec (2 cycles) ~~fault clearing time~~ ; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
600-volt class motor control centers (MCCs) Parameters: ~~Maximum of 42 kA available fault current; maximum~~ Available fault current not exceeding of 42 kA	4	4.3 m (14 ft)

Equipment	Arc Flash PPE Category	Arc Flash Boundary
fault clearing time not exceeding ~~of~~ 0.33 sec (20 cycles) ~~fault clearing time~~ ; minimum working distance 455 mm (18 in.)		
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards	4	6 m (20 ft)
Parameters: ~~Maximum of 35 kA available fault current; maximum of up to 0.5 sec (30 cycles) fault clearing time~~ Available fault current not exceeding 35 kA; fault clearing time not exceeding 0.5 sec (30 cycles) ; minimum working distance 455 mm (18 in.)		
Other 600-volt class (277 volts through 600 volts, nominal) equipment	2	1.5 m (5 ft)
Parameters: ~~Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time~~ Available fault current not exceeding 65 kA; fault clearing time not exceeding 0.03 sec (2 cycles) ; minimum working distance 455 mm (18 in.)		
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	4	12 m (40 ft)
Parameters: ~~Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time~~ Available fault current not exceeding 35 kA; fault clearing time not exceeding 0.24 sec (15 cycles) ; minimum working distance 910 mm (36 in.)		
Metal-clad switchgear, 1 kV through 15 kV	4	12 m (40 ft)
Parameters: ~~Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time~~ Available fault current not exceeding 35 kA; fault clearing time not exceeding 0.24 sec (15 cycles) ; minimum working distance 910 mm (36 in.)		
Metal enclosed interrupter switchgear, fused or unfused type construction, 1 kV through 15 kV Parameters: ~~Maximum of 35 kA available fault current; maximum of 0.24 sec (15 cycles) fault clearing time~~ Available fault current not exceeding 35 kA; fault clearing time not exceeding 0.24 sec (15 cycles) ; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Other equipment 1 kV through 15 kV Parameters: ~~Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time~~ Available fault current not exceeding 35 kA; fault clearing time not exceeding 0.24 sec (15 cycles) ; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Arc-resistant equipment up to 600-volt class Parameters: DOORS CLOSED and SECURED; with an available fault current and a fault clearing time that does not exceed the arc-resistant rating of the equipment*	N/A	N/A
Arc-resistant equipment 1 kV through 15 kV	N/A	N/A
Parameters: DOORS CLOSED and SECURED; with an available fault current and a fault clearing time that does not exceed the arc-resistant rating of the equipment*		

N/A: Not applicable

Note:

For equipment rated 600 volts and below and protected by upstream current-limiting fuses or current-limiting molded case circuit breakers sized at 200 amperes or less, the arc flash PPE category can be reduced by one number but not below arc flash PPE category 1.

*For DOORS OPEN refer to the corresponding non-arc-resistant equipment section of this table.

Informational Note No. 1 to Table 130.7(C)(15)(a): The following are typical fault clearing times of overcurrent protective devices:

(1) 0.5 cycle fault clearing time is typical for current-limiting fuses and current-limiting molded case circuit breakers when the fault current is within the current limiting range.

(2) 1.5 cycle fault clearing time is typical for molded case circuit breakers rated less than 1000 volts with an instantaneous integral trip when the fault current is within the instantaneous trip region .

(3) 3.0 cycle fault clearing time is typical for insulated case circuit breakers rated less than 1000 volts with an instantaneous integral trip or relay operated trip when the fault current is within the instantaneous trip region .

(4) 5.0 cycle fault clearing time is typical for relay operated circuit breakers rated 1 kV to 35 kV when the relay operates in the instantaneous range (i.e., “no intentional delay”) when the fault current is within the instantaneous trip region .

(5) 20 cycle fault clearing time is typical for low-voltage power and insulated case circuit breakers with a short time fault clearing delay for motor inrush when the fault current is within the instantaneous trip region .

(6) 30 cycle fault clearing time is typical for low-voltage power and insulated case circuit breakers with a short time fault clearing delay without instantaneous trip when the fault current is within the instantaneous trip region .

Informational Note No. 2 to Table 130.7(C)(15)(a): See Table 1 of IEEE 1584-2002 , *Guide for Performing Arc Flash Hazard Calculations*, for further information regarding list items (2) through (4) in Informational Note No. 1.

Informational Note No. 3 to Table 130.7(C)(15)(a): See IEEE C37.20.7, *Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults*, for an example of a standard that provides information for arc-resistant equipment referred to in Table 130.7(C)(15)(a).

Informational Note No. 4 to Table 130.7(C)(15)(a): See ~~Informative Annex~~ O.2.4(9) for information on arc-resistant equipment.

Table 130.7(C)(15)(b) Arc Flash PPE Categories for dc Systems

Equipment	**Arc Flash PPE Category**	**Arc Flash Boundary**
Storage batteries, dc switchboards, and other dc supply sources (excluding capacitors covered in Article 360)		
Parameters: Greater than 150 volts and less than or equal to 600 volts		
Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.)		
Available fault current less than 1.5 kA	2	900 mm (3 ft)
Available fault current greater than or equal to 1.5 kA and less than 3 kA	2	1.2 m (4 ft)
Available fault current greater than or equal to 3 kA and less than 7 kA	3	1.8 m (6 ft)
Available fault current greater than or equal to 7 kA and less than 10 kA	4	2.5 m (8 ft)

Notes:

(1) Apparel that can be expected to be exposed to electrolyte must meet both of the following conditions:

(a) Be evaluated for electrolyte protection

Informational Note: See ASTM F1296, *Standard Guide for Evaluating Chemical Protective Clothing*, for information on evaluating apparel for protection from electrolyte.

(b) Be arc rated

Informational Note: See ASTM F1891, *Standard Specification for Arc and Flame Resistant Rainwear*, for information on evaluating arc-rated apparel.

(2) A two-second arc duration is assumed if there is no overcurrent protective device (OCPD) or if the fault clearing time is not known. If the fault clearing time is known and is less than 2 seconds, an incident energy analysis could provide a more representative result.

Informational Note No. 1: See D.5 for the basis for table values and alternative methods to determine dc incident energy. Methods should be used with good engineering judgment. When determining available fault current, the effects of cables and any other impedances in the circuit should be included. ~~Power system~~ Direct-current (dc) circuit modeling is the best method to determine the available short-circuit current at the point of the arc. Battery cell short-circuit current can be obtained from the battery manufacturer.

Informational Note No. 2: The methods for estimating the dc arc flash incident energy that were used to determine the categories for this table are based on open-air incident energy calculations. Open-air calculations were used because many battery systems and other dc process systems are in open areas or rooms. If the specific task is within an enclosure, ~~it would be prudent to consider~~ the incident energy can be higher and additional PPE protection beyond the value shown in this table should be considered .

Informational Note No. 3: See the following references for dc voltages below 150 volts nominal:

(1) J. G. Hildreth and K. Feeney, “Arc Flash Hazards of 125 Vdc Station Battery Systems,” 2018 IEEE Power & Energy Society General Meeting (PESGM), 2018, pp. 1–5, doi: 10.1109/PESGM.2018.8586181 .

(2) US Department of Energy Bonneville Power Administration Engineering and Technical Services Report BPA F 5450.05, “DC Arc Flash: 125V, 1300 amp-hour battery,” May 11, 2017~~, doi: 10.1109/PESGM.2018.8586181~~ .

(3) K. Gray, S. Robert, and T. L. Gauthier, "Low Voltage 100–500 Vdc Arc Flash Testing," 2020 IEEE IAS Electrical Safety Workshop (ESW), 2020, pp. 1–7, doi: 10.1109/ESW42757.2020.9188336.

Table 130.7(C)(15)(c) Personal Protective Equipment (PPE)

Arc Flash PPE Category	PPE
1	**Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm^2 (16.75 J/cm^2)**[a]
	Arc-rated long-sleeve shirt and pants or arc-rated coverall
	Arc-rated face shield[b] or arc-rated arc flash suit hood
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[f c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[e d]

Arc Flash PPE Category	PPE
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[d e]
	Leather footwear[e f] (AN)
2	**Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm^2 (33.5 J/cm^2)[a]**
	Arc-rated long-sleeve shirt and pants or arc-rated coverall
	Arc-rated arc flash suit hood or arc-rated face shield[b] and arc-rated balaclava
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[f c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[e d]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[d e]
	Leather footwear[e f]
3	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm^2 (104.7 J/cm^2)[a]**
	Arc-rated long-sleeve shirt (AR)
	Arc-rated pants (AR)
	Arc-rated coverall (AR)
	Arc-rated arc flash suit jacket (AR)
	Arc-rated arc flash suit pants (AR)
	Arc-rated arc flash suit hood
	Arc-rated gloves or rubber insulating gloves with protectors (SR)[d e]
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[f c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[e d]
	Leather footwear[e f]
4	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40 cal/cm^2 (167.5 J/cm^2)[a]**
	Arc-rated long-sleeve shirt (AR)
	Arc-rated pants (AR)
	Arc-rated coverall (AR)
	Arc-rated arc flash suit jacket (AR)
	Arc-rated arc flash suit pants (AR)
	Arc-rated arc flash suit hood

Arc Flash PPE Category	PPE
	Arc-rated gloves or rubber insulating gloves with protectors (SR)[d] [e]
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[f] [c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[e] [d]
	Leather footwear[e] [f]

AN: As needed (optional). AR: As required. SR: Selection required.

[a] *Arc rating* is defined in Article 100.

[b] Face shields are to have wrap-around guarding to protect not only the face but also the forehead, ears, and neck, or, alternatively, an arc-rated arc flash suit hood is required to be worn.

[f] [c] The arc rating of outer layers worn over arc-rated clothing as protection from the elements or for other safety purposes, and that are not used as part of a layered system, shall not be required to be equal to or greater than the estimated incident energy exposure.

[e] [d] Other types of hearing protection are permitted to be used in lieu of or in addition to ear canal inserts provided they are worn under an arc-rated arc flash suit hood.

[d] [e] Rubber insulating gloves with protectors provide arc flash protection in addition to electric shock protection. Higher class rubber insulating gloves with protectors, due to their increased material thickness, provide increased arc flash protection.

[e] [f] Footwear other than leather or dielectric shall be permitted to be used provided it has been tested to demonstrate no ignition, melting or dripping at the minimum arc rating for the respective arc flash PPE category.

Supplemental Information

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Submitter Information Verification

Committee: EEW-AAA
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Committee Statement

Committee Statement: The qualifier “maximum” is deleted in front of “available fault current” in 130.7(C)(15)(a)(1) and 130.7(C)(15)(b)(1).

This revision is necessary to correlate with the definition of Available Fault Current. There is no such thing as the maximum largest.

The section was revised to comply with the NEC Style Manual Section 3.5.1.2 Multiple

Requirements.

Table 130.7(C)(15)(a): This revision correlates with revisions in the parent text of 130.7(C)(15)(a) and 130.7(C)(15)(b). In both of these revisions the qualifier “maximum” which was used to describe available fault current was deleted. The defined term “Fault Current, Available (Available Fault Current”, in Article 100 clarifies that it is the largest amount of current capable of being delivered at a point on the system during a short-circuit condition. A similar revision is made to all references of available fault current and fault clearing time in Table 130.7(C)(15)(a) for clarity and usability.

Table 130.7(C)(15(a) Informational Note No. 1: List items (2) through (6) are modified for clarity and correlation with list item (1).

Table 130.7(C)(15(a) Informational Note No.2: Table 1 of IEEE 1584 as referenced in the informational note is from the 2002 edition. The table is not included in the 2018 Edition of IEEE 1584. The year of the edition is added for clarification.

Table 130.7(C)(15)(c): The modifiers “arc-rated” and “arc” are added to the table for correlation and clarity.

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Public Input No. 269-NFPA 70E-2024 [Section No. 130.7(C)(15)]

Public Input No. 12-NFPA 70E-2023 [Section No. 130.7(C)(15)]

Public Input No. 234-NFPA 70E-2024 [Section No. 130.7(C)(15)]

Public Input No. 96-NFPA 70E-2024 [Section No. 130.7(C)(15)]

Public Input No. 19-NFPA 70E-2023 [Section No. 130.7(C)(15)]

Public Input No. 11-NFPA 70E-2023 [Section No. 130.7(C)(15)]

First Revision No. 56-NFPA 70E-2024 [Section No. 130.7(D)(1)]

(1) Insulated Tools and Equipment.

Tools and handling equipment used within the restricted approach boundary, or where they present an electrical contact hazard, shall be insulated. ~~Insulated tools shall be protected from damage to the insulating material.~~

Informational Note: See 130.4(E), Electric Shock Protection Boundaries.

(a) *Requirements for Insulated Tools.* The following requirements shall apply to insulated tools:

(1) Insulated tools shall be rated for the voltages on which they are used.

(2) Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.

(3) Insulated tools shall be protected from damage to the insulating material.

(4) Insulated tools and equipment shall be inspected prior to each use. ~~The inspection shall look for damage to the insulation or damage that can limit the tool from performing its intended function or could increase the potential for an incident (e.g., damaged tip on a screwdriver).~~

(5) ~~The inspection~~ Inspection shall look for damage to the insulation or damage that can limit the tool from performing its intended function or could increase the potential for an incident (e.g., damaged tip on a screwdriver).

(b) *Fuse or Fuseholder Handling Equipment.* Fuse or fuseholder handling equipment, insulated for the circuit voltage, shall be used to remove or install a fuse if the fuse terminals are energized.

(c) *Ropes and Handlines.* Ropes and handlines used within the limited approach boundary shall be nonconductive.

(d) *Fiberglass-Reinforced Plastic Rods.* Fiberglass-reinforced plastic rod and tube used for live line tools shall meet the requirements of applicable state, federal, or local codes and standards.

Informational Note: See ASTM F711, *Standard Specification for Fiberglass-Reinforced Plastic (FRP) Rod and Tube Used in Live Line Tools*, for further information concerning visual inspection and testing of fiberglass-reinforced plastic rods and tubes.

(e) *Portable Ladders.* Portable ladders shall have nonconductive side rails when used within the limited approach boundary or where the employee or ladder could contact exposed energized electrical conductors or circuit parts. Nonconductive ladders shall meet the requirements of applicable state, federal, or local codes and standards.

Informational Note: See Table Informational Note 130.7(E) for a list of standards that contain information on portable ladders.

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Submitter Information Verification

Committee: EEW-AAA

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Committee Statement

Committee Statement: This revision requires that tools and handling equipment that may present an electrical contact hazard, such as where they could fall into energized conductors or circuit parts, be insulated.

Revisions are also made to comply with the NEC Style Manual 3.5.1.2 Multiple Requirements.

The requirement to protect insulated tools from damage is moved from the second level subdivision to a list item in the third level subdivision (a) Requirements for Insulated Tools for two reasons: (1) to comply with the NEC Style Manual 3.5.1.2 Multiple Requirements, and (2) the requirement is specific to insulated tools.

Response Message: FR-56-NFPA 70E-2024

Public Input No. 168-NFPA 70E-2024 [Section No. 130.7(D)(1)]

First Revision No. 57-NFPA 70E-2024 [Section No. 130.7(D)(2)]

(2) Barriers.

~~Exposed energized electrical conductors or circuit parts operating at 50 volts or more shall be guarded by a barrier in accordance with 130.7(D)(2) (a) through 130.7(D)(2) (c) to prevent unintentional contact while an employee is working within the restricted approach boundary of those conductors or circuit parts. Barriers shall be supported to remain in place and shall prevent unintentional contact by a person, tool, or equipment.~~ The following requirements shall apply to barriers:

(1) Exposed energized electrical conductors or circuit parts operating at 50 volts or more shall be guarded by a barrier in accordance with 130.7(D)(2)(a) through 130.7(D)(2)(c) to prevent unintentional contact while an employee is working within the restricted approach boundary of those conductors or circuit parts.

(2) Barriers shall be supported to remain in place and shall prevent unintentional contact by a person, tool, or equipment.

(a) *Rubber Insulating Equipment.* Rubber insulating equipment used for protection from unintentional contact with energized conductors or circuit parts shall be rated for the voltage and shall meet the requirements of applicable state, federal, or local codes and standards.

Informational Note: See Table Informational Note 130.7(E) for a list of examples of standards that contain information on rubber insulating equipment.

(b) *Voltage-Rated Plastic Guard Equipment.* Plastic guard equipment for protection of employees from unintentional contact with energized conductors or circuit parts, or for protection of employees or energized equipment or material from contact with ground, shall be rated for the voltage and shall meet the requirements of applicable state, federal, or local codes and standards.

Informational Note: See Table Informational Note 130.7(E) for a list of examples of standards that contain information on voltage-rated plastic guard equipment.

(c) *Physical or Mechanical Barriers.* Physical or mechanical (field-fabricated) barriers shall be installed no closer than the restricted approach boundary distance given in Table 130.4(E)(a) and Table 130.4(E)(b). While the barrier is being installed, the restricted approach boundary distance specified in Table 130.4(E)(a) and Table 130.4(E)(b) shall be maintained, or the energized conductors or circuit parts shall be placed in an electrically safe work condition.

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Committee Statement

Committee Statement: The section was revised to comply with the NEC Style Manual.
Response Message: FR-57-NFPA 70E-2024

First Revision No. 64-NFPA 70E-2024 [Section No. 130.8(I)]

(I) Housekeeping Duties.

~~Employees shall not perform housekeeping duties inside the limited approach boundary where there is a possibility of contact with energized electrical conductors or circuit parts, unless adequate safeguards (such as insulating equipment or barriers) are provided to prevent contact. Electrically conductive cleaning materials (including conductive solids such as steel wool, metalized cloth, and silicone carbide, as well as conductive liquid solutions) shall not be used inside the limited approach boundary unless procedures to prevent electrical contact are followed.~~

(1) Employees shall not perform housekeeping duties inside the limited approach boundary where there is a possibility of contact with energized electrical conductors or circuit parts, unless adequate safeguards (such as insulating equipment or barriers) are provided to prevent contact.

(2) Electrically conductive cleaning materials (including conductive solids such as steel wool, metalized cloth, and ~~silicone~~ silicon carbide, as well as conductive liquid solutions) shall not be used inside the limited approach boundary unless procedures to prevent electrical contact are followed.

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Committee Statement

Committee Statement: The word “silicone” was editorially corrected to “silicon”. The section was revised to comply with the NEC Style Manual.

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Public Input No. 66-NFPA 70E-2024 [Section No. 130.8(I)]

First Revision No. 65-NFPA 70E-2024 [Section No. 130.8(K)]

(K) Anticipating Failure.

~~When~~ The following shall apply if there is evidence that electric equipment could fail and injure employees; ~~, the electric equipment shall be de-energized, unless the employer can demonstrate that de-energizing introduces additional hazards or increased risk or is infeasible because of equipment design or operational limitation. Until the equipment is de-energized or repaired, employees shall be protected from hazards associated with the impending failure of the equipment by suitable barricades and other alerting techniques necessary for safety of the employees.~~

(1) The electric equipment shall be de-energized, unless the employer can demonstrate that de-energizing introduces additional hazards or increased risk or is infeasible because of equipment design or operational limitation.

(2) Until the equipment is de-energized or repaired, employees shall be protected from hazards associated with the impending failure of the equipment by suitable barricades and other alerting techniques necessary for safety of the employees.

Informational Note: See 130.8(O) for alerting techniques.

Supplemental Information

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70E_FR-65_130.8_K_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 10:31:39 EDT 2024

Committee Statement

Committee Statement: This change aligns with the requirements of Section 110.2. The term "When" was revised to "If" to align with the NEC Style Manual. The section was revised to comply with the NEC Style Manual

Response Message: FR-65-NFPA 70E-2024

First Revision No. 66-NFPA 70E-2024 [Section No. 130.8(P)]

(P) Look-Alike Equipment.

Where work performed on equipment that is de-energized and placed in an electrically safe condition exists in a work area with other energized equipment that is similar in size, shape, and construction, one or more of the alerting methods in 130.8(O), ~~or~~ shall be employed to prevent the employee from entering look-alike equipment.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 10:34:15 EDT 2024

Committee Statement

Committee Statement: The sentence structure was editorially corrected.

"One" alerting method was changed to "one or more" to allow more than one alerting method to be used.

Response Message: FR-66-NFPA 70E-2024

Public Input No. 29-NFPA 70E-2023 [Section No. 130.8(P)]

Public Input No. 64-NFPA 70E-2024 [Section No. 130.8(P)]

First Revision No. 67-NFPA 70E-2024 [Section No. 130.12]

130.12 Cutting, Removing, or Rerouting of Electrical Conductors and Circuit Parts.

Where electrical conductors and circuit parts are de-energized in order to cut, remove, reroute, or otherwise work on them and the conductor terminations or circuit parts are not within sight from the point of work, such as where the electrical conductors or circuit parts are remote from the source of supply in a junction or pull box, additional steps to verify absence of voltage or identify the electrical conductors and circuit parts shall be taken prior to cutting, removing, rerouting, or otherwise work on the conductors and circuit parts.

Informational Note No. 1: ~~Additional steps to be taken where conductors are de-energized in order to cut, remove, or reroute them include, but are not limited to, remotely spiking the conductors, pulling conductors to visually verify movement, remotely cutting the conductors, or other approved methods. Nonshielded conductors could be additionally verified with a noncontact test instrument, and shielded conductors could be verified with devices that identify the conductors.~~ Examples of additional steps that can be taken to test for the absence of voltage or identify that the correct electrical conductors or circuit parts have been placed in an electrically safe work condition include:

(1) Remotely spiking the conductors

(2) Pulling conductors to visually verify movement where they are not terminated in a manner where conductor movement would compromise the termination or equipment to which the conductors are connected

(3) Remotely cutting the conductors

Informational Note No. 2: Nonshielded conductors could be additionally verified with a noncontact test instrument, and shielded conductors could be verified with devices that identify the conductors.

Informational Note No. 3: De-energizing is only one of several steps in lockout/tagout procedures and in establishing an electrically safe work condition.

Supplemental Information

File Name	Description	Approved
70E_FR-67_130.12.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 10:36:19 EDT 2024

Committee Statement

Committee Statement: Verify was changed to "to 'test for'" in two places to be consistent with 120.6(7)

Item (4) was deleted as it does not provide clarity.

Editorial changes were made throughout the text to improve clarity and to comply with the NEC Style Manual.

Response Message: FR-67-NFPA 70E-2024=

Public Input No. 170-NFPA 70E-2024 [Section No. 130.12]

First Revision No. 106-NFPA 70E-2024 [Article 300]

Article 300 Introduction

300.1 Scope.

Chapter 3 covers special electrical equipment in the workplace and modifies the general requirements of Chapter 1.

300.2 Responsibility.

(A) Employer Responsibility.

~~The~~ In addition to the general safety-related work practices in Chapter 1 , the employer shall provide safety-related work practices and employee training on the applicable material covered in this chapter .

(B) Employee Responsibility.

The employee shall follow those work practices.

300.3 Organization.

Chapter 3 of this standard is divided into Articles. Article 300 applies generally to electrical hazards associated with special equipment within the scope of Chapter 3. Article 310 applies to dc electrical hazards. Article 320 applies to capacitor electrical hazards. Article 330 covers electrical hazards from 1 Hz to 110 MHz, other than dc and 50/60 Hz. Article 350 applies to electrolytic cells. Article 360 applies to batteries and battery rooms. Article 370 applies to research and development laboratories. Article 380 applies to electrical double-layer capacitors. Article 390 applies to photovoltaic systems.

Supplemental Information

File Name	Description	Approved
70E_FR-106_Article_300.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 08 16:12:10 EDT 2024

Committee Statement

Committee Statement: Article 300 is revised to correlate with the reorganization of Chapter 3 user a separate revision.

Response Message: FR-106-NFPA 70E-2024

First Revision No. 81-NFPA 70E-2024 [Section No. 320.1]

360.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while working with exposed stationary storage batteries that exceed ~~100 volts, nominal, or exceed a short-circuit power of 1000 watts~~ one or more of the hazard thresholds listed in 360.3(A) .

Informational Note: See the following documents for additional information on best practices for safely working on stationary batteries:

(1) NFPA 1, *Fire Code*, Chapter 52, Stationary Storage Battery Systems, 2021

(2) *NFPA 70*, *National Electrical Code*, Article 480, Storage Batteries, 2020

(3) IEEE 450, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications*, 2020

(4) IEEE 937, *Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for Photovoltaic Systems*, 2019

(5) IEEE 1106, *IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications*, 2005 (R 2011)

(6) IEEE 1184, *IEEE Guide for Batteries for Uninterruptible Power Supply Systems*, 2015

(7) IEEE 1188, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications*, 1188a-2014

(8) IEEE 1657, *Recommended Practice for Personnel Qualifications for Installation and Maintenance of Stationary Batteries,* 2018

(9) OSHA 29 CFR 1910.305(j)(7), “Storage batteries”

(10) OSHA 29 CFR 1926.441, “Batteries and battery charging”

(11) DHHS (NIOSH) Publication No. 94-110, *Applications Manual for the Revised NIOSH Lifting Equation,* 1994

(12) IEEE/ASHRAE 1635, *Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications*, 2018

(13) NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*, 2020

(14) UL 9540, *Energy Storage Systems and Equipment*, 2020

(15) UL 9540A, *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, 2019

(16) UL 9540B, *Outline of Investigation for Large Scale Fire Test for Residential Battery Energy Storage Systems* , 2024

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 13:53:42 EDT 2024

Committee Statement

Committee Statement: The change improves the intent and ensures the scope covers all hazards as outlined in the hazard thresholds of the article.

This adds a reference to an informative UL standard related to an existing reference and update the reference dates.

Response Message: FR-81-NFPA 70E-2024

Public Input No. 122-NFPA 70E-2024 [Section No. 320.1]

Public Input No. 103-NFPA 70E-2024 [Section No. 320.1]

First Revision No. 91-NFPA 70E-2024 [New Section after 320.3]

360.4 Establishing a Lower Risk Work Condition in Batteries.

(A) General.

Each employer whose employees perform work on batteries shall establish, document, and implement a battery hazardous energy control program.

(1) Head Needed.

The battery hazardous energy control program shall specify procedures to safeguard workers from exposure to battery electrical hazards.

(2) Head Needed.

Employees performing work within the restricted approach boundary of a battery shall plan work to minimize exposure to electric shock and arc flash hazards.

(3) Head Needed.

Employees performing battery circuit manipulation shall plan work through a sectionalizing procedure or other risk reduction methods.

Exception 1: Work within the restricted approach boundary of an installed battery charger shall not be considered battery circuit manipulation.

Exception 2: A sectionalizing procedure shall not be required for batteries below 100 volts dc or 40 milliamperes.

Informational Note No. 1: Work within the restricted approach boundary of an installed battery charger is more appropriately controlled through complex lockout/tagout according to 120.5(A)(5) as it can be deenergized and an electrically safe work condition can be established.

Informational Note No. 2: Examples of battery circuit manipulation include bolting, unbolting, connecting, disconnecting, or otherwise increasing or decreasing the series or parallel combination of cells that make up a battery. This might involve work within the limited or restricted approach boundary.

(B) Battery Sectionalizing Principles.

(1) Persons Involved.

Each person who could be exposed directly or indirectly to a battery electrical hazard shall be involved in the sectionalizing procedure.

(2) Charger Mode.

The battery charger shall either be placed into bypass mode or turned off, deenergized, and locked out prior to sectionalizing the battery.

(3) Battery Disconnect.

The battery shall be disconnected from any electrical load it serves prior to sectionalizing the battery.

(4) Control Devices.

Control devices, such as push buttons or selector switches, shall not be used as the primary isolating device for the charger.

(5) Procedure.

A sectionalizing procedure shall be developed based on the existing battery system and shall use suitable documentation including up-to-date drawings and diagrams.

(6) Disconnecting Means.

The disconnecting means shall be identified in the sectionalizing procedure.

(7) Circuit Elements.

Bus bars or other circuit elements not uniquely or readily identifiable as a lockout/tagout device shall be permitted.

(8) Forms of Control.

Two forms of hazardous energy control, simple sectionalizing and complex sectionalizing, shall be permitted in battery systems.

(a) For simple sectionalizing, the qualified person shall be in charge.

(b) For complex sectionalizing, the person in charge shall have overall responsibility.

(C) Battery Sectionalizing Equipment.

(1) Requirements.

Battery sectionalizing equipment shall meet the requirements of lockout/tagout equipment specified in 120.4

(2) Non-Unique Circuit Elements.

Removal or disconnection of non-unique intercell busbars, wires, or other circuit elements shall be permitted for use as lockout devices in battery systems if the following conditions are met:

(1) The circuit elements are identified in the sectionalizing procedure.

(2) The visibility of the circuit element's presence or absent in the circuit is unobstructed.

(3) Once removed, the circuit elements are, individually or in groups, secured against reinstallation and tagged with REMOVED FOR SECTIONALIZING.

(4) Any similar circuit elements in the work area have been identified and either removed or secured against reinstallation and marked DO NOT USE.

Informational Note No. 1: Locked cabinets or boxes and nylon cable ties are commonly used to secure non-unique circuit elements against reinstallation and to attach the appropriate tag.

Informational Note No. 2: It is best practice to mark or tag both sides of a circuit element before removal or disconnection to ensure that it is reinstalled properly after completion of work.

(D) Battery Sectionalizing Procedure.

The employer shall maintain a copy of battery sectionalizing procedures required by this section available to all employees.

(1) General.

(a) The sectionalizing procedure shall require planning, including the requirements of 360.4(D) through 360.4(E) .

(b) Up-to-date battery circuit drawings shall be considered a primary reference source for identifying circuit elements to remove or disconnect in the sectionalizing procedure to reduce shock and arc flash hazard.

(c) When up-to-date battery circuit drawings are not available the employer shall be responsible for ensuring that an equally effective means of identifying circuit elements is employed.

(d) The plan shall identify persons who might be exposed to an electrical hazard and the PPE required during the execution of the job or task.

(e) The plan shall identify the person in charge and their responsibility in the sectionalizing procedure.

(f) The sectionalizing procedure shall identify the means and order that battery circuit connections or disconnections are to be made and any resulting changes in the following:

(1) Direct-current (dc) voltage

(2) Available short circuit power

(3) Thermal PPE

(4) Limited approach boundary

(5) Restricted approach boundary

(6) Electric shock PPE

(7) Arc flash incident energy

(8) Arc flash boundary

(9) Arc flash PPE

(2) Simple Battery Sectionalizing Procedure.

(a) A battery sectionalizing procedure that involves only a qualified person(s) sectionalizing a single battery with a single charger for the sole purpose of safeguards for personnel from exposure to battery electrical hazards shall be considered to be a simple battery sectionalizing procedure.

(b) Simple battery sectionalizing procedures shall not be required to be written for each application.

(c) Each worker shall be responsible for their own battery sectionalizing procedure.

(3) Complex Battery Sectionalizing Procedure.

(a) A complex battery sectionalizing procedure shall be permitted where one or more of the following exists:

(1) Any electrical work on a battery and its charger (non-battery electrical work covered by traditional LOTO)

(2) Multiple battery strings connected in parallel

(3) Multiple battery chargers connected in parallel

(4) Multiple single-string batteries with chargers located near each other

(5) Multiple energy sources (excluding the battery)

(6) Multiple crews

(7) Multiple crafts

(8) Multiple locations

(9) Multiple employers

(10) Multiple disconnecting means

(11) Multiple sequences

(12) Job or task that requires more than one work period

(b) All complex sectionalizing procedures shall require a written plan of execution that identifies the person in charge.

(c) The complex sectionalizing procedure shall vest primary responsibility in an authorized employee for employees working under the protection of a group lockout or tagout device such as an operation lock or lockbox.

(d) The person in charge shall be held accountable for safe execution of the complex sectionalizing procedure.

(e) Each authorized employee shall conduct the following:

(1) Affix a personal lock-out or tagout device to the group lockout device, group lockbox, or comparable mechanism when the employee begins work.

(2) Remove those devices when the employee stops working on the battery being serviced or maintained.

(f) All complex sectionalizing plans shall identify the method to account for all persons who might be exposed to electrical hazards in the course of the sectionalizing.

(E) Elements of Control.

(1) General.

The procedure shall not de-energize the batteries.

(a) The procedure shall not release the energy stored in the batteries.

(b) The procedure shall not require that the batteries be operated (charged or discharged) prior to or after sectionalizing.

Exception: *If the job or task involves one or more battery cells being removed for shipping, recycling, refurbishment, storage, or similar activity then the procedure shall be permitted to require that batteries be operated (charged or discharged) to achieve the state-of-charge required for such activities prior to sectionalizing.*

Informational Note No. 1: Discharging or disassembling batteries to a 'de-energized' state can be damaging to the battery, hazardous to the worker, or both.

Informational Note No. 2: Batteries are commonly required to be at a partial state-of-charge during shipping to reduce their potential fire hazard if damaged or short-circuited.

(2) Testing.

(a) Testing for absence of ac voltage shall be required if the shock risk assessment has identified the potential for a hazardous ac voltage from the battery circuit to the bonded enclosure.

(b) Testing for absence of voltage shall be required for all energy sources in the work area other than batteries.

(c) Testing for absence of voltage shall not be required to establish a lower risk work condition in batteries.

Informational Note No. 1: Batteries will retain voltage after sectionalizing. However, the voltage that a worker is exposed to, and risk of electrical injury will be substantially reduced.

Informational Note No. 2: Voltage and resistance testing with an appropriately rated meter can be helpful in double checking that the battery circuit is in the expected configuration at a given stage of sectionalizing.

(3) Process for Establishing and Verifying a Lower Risk Work Condition in Batteries.

Establishing and verifying a lower risk work condition in batteries shall include the following steps, which shall be performed in the order presented, if feasible:

(1) Determine the number, configuration, and voltage of batteries in series and parallel, and the number, configuration, and voltage of battery chargers.

(2) Determine if there are any batteries or chargers nearby that could be confused for the battery being worked on.

(3) Check applicable up-to-date drawings, diagrams, and identification tags.

(4) Isolate the battery bank from all loads and sources.

Informational Note: This might include placing battery chargers in bypass mode.

(5) Where possible, visually verify that all blades of the disconnecting devices are fully open or that drawout type circuit breakers are withdrawn to the test or fully disconnected position.

(6) Apply lockout/tagout devices to the battery charger disconnection means.

(7) Sectionalize the battery in accordance with a documented and established procedure.

(8) When required by 360.4(E)(2) , test for the absence of voltage with an adequately rated portable meter.

(4) Release for Return to Service.

(a) The procedure shall identify steps to be taken when the job or task requiring battery sectionalizing is completed.

(b) The procedure shall identify any wires or flexible circuit elements that could be reinstalled improperly resulting in a battery short circuit.

(c) Reinstallation of these circuit elements shall be identified in the procedure as having an elevated risk of short circuit.

(d) When returning a battery to service, employees shall wear the identified PPE prior to making any circuit connection that increases the risk of shock, thermal, or arc flash hazard.

Supplemental Information

File Name	Description	Approved
FR_91_attachment.docx	attachment for FR 91	
70E_FR-91_320.4-new.docx	For prod use	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 14:50:47 EDT 2024

Committee Statement

Committee Statement: The requirements in Article 120 to establish an electrically safe work condition are designed to reduce the risk when installing and modifying ac/dc power circuits. Electrical LOTO requires a worker to establish an electrically safe work condition by isolating equipment from its source of electric supply and locking the point of isolation to prevent unexpected energization. Batteries, however, are their own sources of electrical energy and cannot be deenergized like ac/dc power circuits. The requirements of LOTO are not directly applicable to battery systems as they are always energized. The principles of hazardous energy control on which LOTO programs are built can be applied to batteries requiring a worker to perform a battery sectionalizing procedure and establish a lower risk working condition. Sectionalizing a battery into lower voltage, lower energy, segments can substantially reduce contact thermal, electric shock, and arc flash hazards.

First and/or second level subdivision titles were added to comply with the NEC Style Manual.

Response Message: FR-91-NFPA 70E-2024

Public Input No. 114-NFPA 70E-2024 [New Section after 320.3]

First Revision No. 82-NFPA 70E-2024 [Section No. 320.3(A)(1)]

(A) ~~General Safety Hazards.~~ Electrical Hazard Thresholds.

Exposure levels shall not exceed ~~those identified in~~ the following ~~list~~ unless appropriate controls are implemented:

(1) ~~AC~~ Alternating current (ac) : 50 volts and 5 milliamperes

(2) ~~DC~~ Direct current (dc) : 100 volts and 40 milliamperes

(3) Thermal: 1000 watts short-circuit power

Informational Note No. 1: Available short-circuit power is calculated by multiplying the battery's nominal voltage by its available short-circuit current at the battery terminals, then dividing the result by ~~two~~ four .

Informational Note 2: See Department of Energy, *DOE Electrical Safety Handbook*, ~~DOE-HDBK-1092,~~ for electrical hazard thresholds.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 13:56:57 EDT 2024

Committee Statement

Committee Statement: The formula for maximum power calculates the power generated by the battery, not consumed by a load. The contact thermal hazard threshold should be based on the maximum power that could be consumed by a short-circuit load and turned into heat. According to the Maximum Power Transfer Theorem, the maximum power that can be transferred to a load resistor occurs when the load resistance exactly matches the source resistance. That means half of the power generated by the battery is used up by the internal resistance of the battery and so does not pose a hazard to the worker. The formula for how much power is dissipated into the load resistor is Pmax = V^2 / (4 Rload) = V * I / 4.

Response Message: FR-82-NFPA 70E-2024

Public Input No. 104-NFPA 70E-2024 [Section No. 320.3(A)(1)]

First Revision No. 83-NFPA 70E-2024 [Section No. 320.3(A)(2)]

Detail FR-84

(B) Battery Risk Assessment.

Prior to any work on a battery system, a risk assessment shall be performed ~~to identify the~~ and documented for chemical, contact thermal, ~~electrical~~ electric shock, and arc flash hazards ~~and assess the risks associated with the type of tasks to be performed~~ for the following reasons :

(1) To identify the hazards

(2) To estimate the likelihood of occurrence of injury or damage to health and potential severity of injury or damage to health

(3) To determine if additional protective measures are required, including the use of PPE

Informational Note No. 1: See Informative ~~Annex F~~ Figure F.7 for an example of a risk assessment method for work on batteries.

Informational Note No. 2: Battery systems commonly need multiple risk assessments based on the number of cells connected in series or parallel at the time when work is performed.

Detail FR-84

(1) Battery Chemical Assessment.

(a) *Estimate of Likelihood and Severity.* The estimate of likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health from chemical hazards shall take into consideration all the following:

(1) The design of the equipment

(2) The safety data sheet of the battery and electrolyte

(3) The equipment operating condition and the condition of maintenance

Informational Note: Many batteries are sealed, preventing the worker from exposure to chemical hazards of the electrolyte unless the battery has been damaged.

(b) *Additional Protective Measures.* The following shall apply when protective measures are taken:

(1) If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls identified in 110.3(H)(3).

(2) When the additional protective measures include the use of PPE, the following shall be determined:

a. Proper hand and eye/face protection based on performance characteristics relative to the task, conditions present, duration of use, and chemical hazards

b. Gloves and aprons appropriate for the chemical hazards

c. Portable or stationary eye wash facilities and equipment within the work area that are capable of drenching or flushing of the eyes and body for the duration necessary to mitigate injury from the chemical hazards

Informational Note No. 1: See ANSI/ISEA Z358.1, *American National Standard for Emergency Eye Wash and Shower Equipment*, for guidelines for the use and maintenance of eye wash facilities for vented batteries in non-telecom environments.

Informational Note No. 2: Where electrolyte is pumped or otherwise stored above atmospheric pressure, including head pressure in large storage tanks, additional protective equipment for the head, neck, and arms could be required to protect employees.

(2) Battery Contact Thermal Risk Assessment.

(a) *Estimate of Likelihood and Severity.* The estimate of likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health from contact thermal hazards shall take into consideration all the following:

(1) The available short-circuit power to which personnel will be exposed

(2) The work task and tools

Informational Note No. 1: Assembling a battery string or returning a battery to service commonly involves manipulating wires or flexible circuit elements that could be installed improperly, resulting in a battery short circuit.

Informational Note No. 2: Electrical measurements with undamaged, insulated probes and specific-gravity measurements on the electrolyte have a low likelihood of resulting in a short circuit.

(3) The design of the equipment including the spacing of exposed electrical conductors in relation to length of potential shorting materials used in the task

(4) The equipment operating condition and the condition of maintenance

(b) *Additional Protective Measures.* The following shall apply when protective measures are taken:

(1) If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls identified in 110.3(H)(3).

(2) When the additional protective measures include the use of PPE, the following shall be determined and made available to the employee:

a. Proper hand protection based on performance characteristics relative to the task, conditions present, duration of use, and available short-circuit power of the battery

b. Proper eye protection including safety goggles or safety glasses or face shield

c. Tools meeting the following criteria:

- Equipped with handles rated for the voltage on which they are used in accordance with 130.7(D)(1)
- Length of tools for work on batteries selected to minimize the likelihood of short circuit

(3) Employees shall keep battery terminals and all electrical conductors clear of unintended contact with tools, test equipment, liquid containers, and other foreign objects.

Informational Note: The PPE for contact thermal hazards might be covered by other hazard risk assessments.

Detail FR-86

(3) Battery Electric Shock Risk Assessment.

(a) *Estimate of Likelihood and Severity.* The estimate of likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health from battery shock hazards shall take into consideration all the following:

(1) The dc voltage to which personnel will be exposed

(2) The design of the equipment, including the grounding configuration and the spacing separation of exposed electrical conductors

(3) The potential for hazardous ac voltage on the battery enclosure or rack

(4) The equipment operating condition and the condition of maintenance

(b) *Additional Protective Measures.* The following shall apply when protective measures are taken:

(1) If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls identified in 110.3(H)(3).

(2) If protective measures include the use of shock protection PPE, they shall be selected so as not to conflict with PPE requirements for chemical hazards.

(3) Boundary requirements established in 130.4 shall apply when personnel approach exposed energized electrical conductors or circuit parts operating at not less than 100 volts and 40 milliamperes between battery terminals or between a single terminal and a grounded surface.

Detail FR-87

(4) Battery Arc Flash Risk Assessment.

(a) *General.* General requirements for arc flash risk assessment shall be as follows:

(1) An electric arc flash risk assessment shall be performed on stationary storage battery systems operating at 150 volts or more before a person interacts with the system in a matter likely to create an arc flash hazard.

(2) The requirements of 130.5 shall apply if it has been determined that the likelihood of an arc flash hazard exceeds an acceptable threshold.

(b) *Estimate of Likelihood and Severity.* The estimate of likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health from battery arc flash hazards shall take into consideration all the following:

(1) The dc voltage and available fault current to which personnel will be exposed

(2) The work task

(3) The design of the battery, including the grounding configuration, the separation distance of exposed electrical conductors, and any overcurrent protection devices and their operating times

(4) The equipment operating condition and the condition of maintenance

Informational Note: See Table 130.5(C)(3) and D.5 for more information on evaluating the likelihood and severity of a battery arc flash hazard.

(c) *Additional Protective Measures.* The following shall apply when protective measures are taken:

(1) If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk controls identified in 110.3(H)(3).

(2) If protective measures include the use of arc flash PPE, the following shall be determined:

a. The location of the gap where an arc could occur

b. The arc flash boundary

c. The PPE to be used within the arc flash boundary

Supplemental Information

File Name	Description	Approved
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Submitter Information Verification

Committee: EEW-AAA

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Committee Statement

Committee Statement: The changes to 320.3(A)(2) make the format consistent with 130.4 and 130.5 as well as the NEC Style Manual and includes the requirement for documenting risk assessments not covered elsewhere. Adding informational note 2 reminds users that to establish a lower risk working condition there are often intermediate steps where a worker is exposed to a different level of electrical risk. For example, one 800 V battery may be split

into two 400 V strings, four 200 V strings, eight 100 V strings, or sixteen 50 V strings. Each configuration requires a different electrical risk assessment and different PPE to work on safely.

Response Message: FR-83-NFPA 70E-2024

Public Input No. 105-NFPA 70E-2024 [Section No. 320.3(A)(2)]

First Revision No. 88-NFPA 70E-2024 [Section No. 320.3(A)(6)]

(F) Warning Signs.

The following warning signs or labels shall be posted in appropriate locations:

(1) Electrical hazard warnings indicating the electric shock hazard, ~~due to the battery voltage and the~~ arc flash hazard, ~~due to the prospective short-circuit current, and the thermal hazard~~ and contact thermal hazard based on the results of the battery risk assessment in 360.3(B) ~~.~~

Informational Note No.1: Because internal resistance, prospective short-circuit current, or both are not always provided on battery container labels or data sheets, and because many variables can be introduced into a battery layout, the battery manufacturer should be consulted for accurate data. Variables can include, but are not limited to, the following:

(1) Series connections

(2) Parallel connections

(3) Charging methodology

(4) Temperature

(5) Charge status

(6) ~~Dc~~ Direct-current (dc) distribution cable size and length

(7) Grounding configuration of the battery

(8) The potential for hazardous ac voltage on the battery enclosure or rack

Informational Note No. 2: See 130.5(H) for requirements for equipment labeling.

(2) Chemical hazard warnings, applicable to the worst case when multiple battery types are installed in the same space, indicating the following:

a. Potential presence of explosive gas (when applicable to the battery type)

b. Prohibition of open flame and smoking

c. Danger of chemical burns from the electrolyte (when applicable to the battery type)

(3) Notice for personnel to use and wear protective equipment and apparel appropriate to the hazard for the battery

(4) Notice prohibiting access to unauthorized personnel

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 14:21:28 EDT 2024

Committee Statement

Committee Statement: Information for the warning signs includes all electrical hazards identified in the risk assessments. Battery ground configuration is critical to understanding where shock hazards are in battery systems. Including the grounding configuration in the label will help workers avoid electrical hazards. Even if a battery is ungrounded on the DC bus, ac

voltage can be present that could pose a shock hazard. Existing requirements in this article do not make it clear that this voltage could be hazardous.

Response Message: FR-88-NFPA 70E-2024

Public Input No. 107-NFPA 70E-2024 [Section No. 320.3(A)(6)]

First Revision No. 89-NFPA 70E-2024 [Sections 320.3(B), 320.3(C)]

~~**(G)** Electrolyte Hazards.~~

~~**(1)** Battery Activities That Include Handling of Liquid Electrolyte.~~

~~The following protective equipment shall be available to employees performing any type of service on a battery with liquid electrolyte:~~

(0) ~~Goggles and face shield appropriate for the electrical hazard and the chemical hazard~~

(0) ~~Gloves and aprons appropriate for the chemical hazards~~

(0) ~~Portable or stationary eye wash facilities and equipment within the work area that are capable of drenching or flushing of the eyes and body for the duration necessary to mitigate injury from the electrolyte hazard.~~

~~Informational Note: See ANSI/ISEA Z358.1, *American National Standard for Emergency Eye Wash and Shower Equipment* , for guidelines for the use and maintenance of eye wash facilities for vented batteries in nontelecom environments.~~

~~**(2)** Activities That Do Not Include Handling of Electrolyte.~~

~~Employees performing any activity not involving the handling of electrolyte shall wear safety glasses.~~

~~Informational Note: Battery maintenance activities usually do not involve handling electrolyte. Batteries that are hermetically sealed (such as most lithium batteries) or immobilized electrolyte (such as valve-regulated lead acid batteries) present little or no electrolyte hazard. Most modern density meters expose a worker to a quantity of electrolyte too minute to be considered hazardous, if at all. Such work would not be considered handling electrolyte. However, if specific gravity readings are taken using a bulb hydrometer, the risk of exposure is higher — this could be considered to be handling electrolyte, and the requirements of 320.3(B)(1) would apply.~~

~~**(H)** Tools and Equipment.~~

~~**(1)** Handles.~~

~~Tools and equipment for work on batteries shall be equipped with insulated handles rated for the voltage on which they are used in accordance with 130.7(D)(1) .~~

~~**(2)** Contact.~~

~~Battery terminals and all electrical conductors shall be kept clear of unintended contact with tools, test equipment, liquid containers, and other foreign objects. The length and insulation of tools for work on batteries shall be selected to minimize the likelihood of inadvertent contact.~~

~~**(3)** Nonsparking Tools.~~

~~Nonsparking tools shall be required when the risk assessment required by 110.3(H) justifies their use.~~

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 14:26:25 EDT 2024

Committee Statement

Committee Statement: The content of Sections 320.3(B) and 320.3(C) are consolidated into the battery risk assessment to follow the organizational structure in Chapter 1. The requirement for non-sparking tools is eliminated since this requirement is based on the potential fire or explosion hazard in a poorly ventilated, flooded, lead acid battery system. The use of insulated tools is more important to protect workers from accidental short circuit.

Response Message: FR-89-NFPA 70E-2024

Public Input No. 112-NFPA 70E-2024 [Sections 320.3(B), 320.3(C)]

First Revision No. 90-NFPA 70E-2024 [Section No. 320.3(D)]

240.4 Cell Flame Arresters and Cell Ventilation.

When present, battery cell ventilation openings shall be unobstructed. Cell flame arresters shall be inspected for proper installation and unobstructed ventilation and shall be replaced when necessary in accordance with the manufacturer's instructions.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 14:31:18 EDT 2024

Committee Statement

Committee Statement: This language is moved from 320.3(D) because it involves maintenance of batteries and belongs in Article 240.

Response Message: FR-90-NFPA 70E-2024

Public Input No. 111-NFPA 70E-2024 [Section No. 320.3(D)]

First Revision No. 92-NFPA 70E-2024 [Article 330]

Article 330 Safety-Related Work Practices: Lasers

330.1 Scope.

This article covers safety-related work practices for maintaining lasers and their associated equipment.

Informational Note No. 1: See ANSI Z136.1, *Standard for Safe Use of Lasers* , for information on laser safety requirements for laser use.

Informational Note No. 2: See 21 CFR Part 1040, "Performance Standards for Light-Emitting Products," Sections 1040.10 "Laser products" and 1040.11, "Specific purpose laser products" for laser product requirements for laser manufacturers.

330.3 Electrical Hazard Thresholds.

Exposure levels shall not exceed those identified in the following list unless appropriate controls are implemented:

(0) AC: 50 volts and 5 milliamperes

(0) DC: 100 volts and 40 milliamperes

(0) Capacitor stored energy:

0. Less than 100 volts and greater than 100 joules of stored energy
0. Greater than or equal to 100 volts and greater than 1.0 joule of stored energy
0. Greater than or equal to 400 volts and greater than 0.25 joule of stored energy

Informational Note No. 1: See Department of Energy, *DOE Electrical Safety Handbook* , DOE-HDBK-1092, for information on electrical safety thresholds.

Informational Note No. 2: See 320.3 and Informative Annex R for information on capacitor hazards and controls.

330.4 Electrical Safety Training.

(A) Personnel to Be Trained.

Employers shall provide training for all personnel who work on or are near lasers or laser systems with user-accessible hazardous voltage, current, or stored energy (e.g., flashlamp-pumped lasers).

(B) Electrical Safety Training for Work on or with Lasers.

Training in electrical safe work practices shall include, but is not limited to, the following:

(0) Chapter 1 electrical safe work practices

(0) Electrical hazards associated with laser equipment

(0) Stored energy hazards, including capacitors and capacitor banks

(0) Ionizing radiation, including X-rays at voltages greater than 10 kV in a vacuum

(0) Assessing the listing status of electrical equipment and the need for field evaluation of nonlisted equipment

330.5 Safeguarding of Persons from Electrical Hazards Associated with Lasers and Laser Systems.

~~**(A)** Temporary Guarding.~~

~~Temporary guarding (e.g., covers, protective insulating barriers) shall be used to limit exposure to any electrical hazard when the permanent laser enclosure covers are removed for maintenance and testing.~~

~~**(B)** Work Requiring an Electrically Safe Work Condition.~~

~~Work that might expose employees to electrical hazards shall be performed with the equipment in an electrically safe work condition in accordance with 120.2 , 120.3 , and 110.2(B) .~~

~~**(C)** Energized Electrical Testing.~~

~~Energized electrical testing, troubleshooting, and voltage testing shall not require an energized work permit in accordance with 130.2(C) .~~

~~**(D)** Warning Signs and Labels.~~

~~Electrical safety warning signs and labels shall be posted as applicable on electrical equipment doors, covers, and protective barriers. The warning signs and labels shall adequately warn of the hazard using effective words, colors, and symbols. These signs and labels shall be permanently affixed to the equipment and shall be of sufficient durability to withstand the environment involved.~~

~~**(E)** Listing.~~

~~Laser system electrical equipment with the potential to expose workers to electrical hazards shall be listed or field evaluated prior to use.~~

~~**330.6** Responsibility for Electrical Safety.~~

~~All persons with access to hazardous voltage, current, or stored energy shall be responsible for the following:~~

(0) ~~Obtaining authorization for work with or on hazardous electrical equipment in lasers and laser systems~~

(0) ~~Use of Chapter 1 safety-related work practices~~

(0) ~~Reporting laser equipment failures, accidents, inadequate barriers, and inadequate signage to the employer~~

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 15:06:46 EDT 2024

Committee Statement

Committee Statement: There are no specific hazards or requirements in this article that are not already covered in other articles.

Response Message: FR-92-NFPA 70E-2024

Public Input No. 225-NFPA 70E-2024 [Article 330]

First Revision No. 93-NFPA 70E-2024 [Article 340]

Global FR-80

Article 330 ~~Safety-Related Work Practices: Power Electronic Equipment~~Electrical Hazards 1 Hz to 110 MHz (Not Including 50/60 Hz)

330.1 Scope.

This article covers the hazards and safety-related work ~~practices around power electronic~~ or equipment~~, including the following~~ that includes ac waveforms from 1 Hz to 3 kHz (sub RF) and 3 kHz to 110 MHz (RF). It does not cover power frequencies of 50/60 Hz. Typical equipment includes the following:

(1) Electric arc welding equipment

(2) High-power radio, radar, and television transmitting towers and antennas

(3) Industrial dielectric and radio frequency (RF) induction heaters

(4) Shortwave or RF diathermy devices

(5) Equipment that includes rectifiers and inverters such as the following:

   a. Motor drives

   b. Uninterruptible power supply systems

   c. Lighting controllers

(6) Generators producing sub RF (1 kHz to 3 kHz) and RF (3 kHz to 100 MHz) fields

(7) Ionizing radiation field generators including X-rays, magnetrons, klystrons, thyratrons, vacuum tubes, and similar high-voltage vacuum devices

(8) Nonionizing radiation field generating equipment, including the following:

   a. Antennas and RF transmission lines

   b. Radar equipment

   c. Industrial scientific and medical equipment

   d. RF induction and dielectric heaters

   e. Industrial microwave heaters and diathermy radiators

   f. Magnetic resonance imagers (MRIs)

   g. Large electromagnets

Informational Note: See the following standards for specific guidance on safety-related work practices around ~~power electronic~~ equipment containing sub RF and RF electrical hazards:

(1) IEEE C95.1, *IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz*, 2019

(2) International Electrotechnical Commission IEC TS 60479-1, *Effects of Current on Human Beings and Livestock, Part 1: General Aspects*

(2) ~~International Commission on Radiological Protection (ICRP) Publication 33, *Protection Against Ionizing Radiation from External Sources Used in Medicine*~~

330.3 Application.

The purpose of this article is to provide guidance for safety personnel in preparing specific safety-related work practices for sub RF and RF electrical hazards within their industry or laboratory.

330.4 Electrical Hazard Thresholds.

Exposure levels shall not exceed those identified in the following list unless appropriate controls are implemented:

(0) ~~DC (0 Hz to 1 Hz): 100 volts and 40 milliamperes~~

(0) ~~60/50 Hz power: 50 volts and 5 milliampere~~

(1) ~~AC~~Alternating current (ac) (1 Hz to 3 kHz): 50 volts and 3 milliamperes (not including 50/60 Hz)

(2) ~~AC~~Alternating current (ac) (3 kHz to 100 kHz): 1 x f mA, f in kHz

(3) ~~AC~~Alternating current (ac) (100 kHz to 3 MHz): 100 mA

(4) ~~AC~~Alternating current (ac) (3 MHz to 30 MHz):100 $(f/3)^{*0.3}$, f in MHz

(5) ~~AC~~Alternating current (ac) (30 MHz to 110 MHz): 200 mA

Informational Note No. 1: See IEEE Std C95.1-2019, *IEEE Standard for Safety Levels with Respect to Human Exposure to Electrical, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz*, for information regarding hazard thresholds for workers trained in sub RF and RF contact electric shock.

Informational Note No. 2: RF electric shock thresholds depend on current and frequency, not voltage.

330.5 Specific Measures for Personnel Safety.

The employer and employee shall implement the responsibilities, training requirements, and safe work practices in accordance with 110.5 for working with sub RF and RF hazards, with the exceptions in 330.5(A) and 330.5(B) .

Informational Note: Equipment that contains RF electrical hazards also could produce nonionizing radiation hazards — that is, RF electromagnetic fields (EM). Risk assessment should be performed to determine if there is a risk to EM exposure.

(A) Adequately Rated Meters.

Adequately rated meters used for safety purposes, including zero energy verification, shall be rated for the frequency of measurement.

(B) Use of Dielectric PPE.

Dielectric PPE shall be derated when used to protect against frequencies greater than 100 kHz.

~~**(B)** Employee Responsibility.~~

~~The employee shall be responsible for the following:~~

(0) ~~Understanding the hazards associated with the work~~

(0) ~~Being continuously alert and aware of the possible hazards~~

(0) ~~Using the proper tools and procedures for the work~~

(0) ~~Informing the employer of malfunctioning protective measures, such as faulty or inoperable enclosures and locking schemes~~

(0) ~~Examining all documents provided by the employer relevant to the work to identify the location of components that present an electrical hazard~~

(0) ~~Maintaining good housekeeping around the equipment and work space~~

(0) ~~Reporting any incident that resulted in, or could have resulted in, injury or damage to health~~

(0) ~~Using and appropriately maintaining the PPE and tools required to perform the work safely~~

Supplemental Information

File Name	Description	Approved
FR_93_attachment.docx	attachment for FR 93	
70E_FR-93_Article_340.docx	For prod use	

Submitter Information Verification

Committee: EEW-AAA
Submittal Date: Wed Aug 07 15:10:50 EDT 2024

Committee Statement

Committee Statement: Power electronics is a general term for circuits with active devices (e.g., IGBTs, SCRs, thyristors) that manage substantial power. Such power electronic devices also contain dc and capacitor hazards, which are covered elsewhere in 70E. The unique hazard introduced by the power electronics article is sub rf and rf electrical hazards. However, other circuits and devices create sub rf and rf electrical hazards so sub rf and rf electrical hazards should not be limited to power electronics. The sections redundant to other sections in the standard are removed and only those unique to sub RF and RF electrical hazards are included.

Response Message: FR-93-NFPA 70E-2024

Public Input No. 231-NFPA 70E-2024 [Article 340]

First Revision No. 94-NFPA 70E-2024 [Section No. 350.5 [Excluding any Sub-Sections]]

Each laboratory or R&D system application shall designate a ~~competent~~ qualified person as defined in this article to ensure the use of appropriate electrical safety-related work practices and controls.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 15:24:29 EDT 2024

Committee Statement

Committee Statement: Using qualified person is appropriate in this section. The term competent person is no longer defined.

Response Message: FR-94-NFPA 70E-2024

Public Input No. 166-NFPA 70E-2024 [Section No. 350.5 [Excluding any Sub-Sections]]

Public Input No. 44-NFPA 70E-2023 [Section No. 350.5 [Excluding any Sub-Sections]]

First Revision No. 95-NFPA 70E-2024 [Section No. 360.1]

320.1 Scope.

This article covers the electrical safety-related requirements for the practical safeguarding of employees while working with capacitors, other than electric double layer capacitors (EDLCs), supercapacitors, or hybrid supercapacitors, that present an electrical hazard.

Informational Note: See Informative Annex R for more information on working safely with capacitors.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 15:27:09 EDT 2024

Committee Statement

Committee Statement: The characteristics and hazards of conventional plate capacitors are unique and different than other classes of super capacitors and hybrids. This change clarifies Article 360 does not apply to electrical elements other than conventional capacitors.

Response Message: FR-95-NFPA 70E-2024

Public Input No. 182-NFPA 70E-2024 [Section No. 360.1]

First Revision No. 96-NFPA 70E-2024 [Section No. 360.3]

320.3 Stored Energy Hazard Thresholds.

Appropriate controls shall be applied where any of the following hazard thresholds are exceeded:

(1) Less than 100 volts and greater than 100 joules of stored energy (contact thermal hazard)

(2) Greater than or equal to 100 volts and greater than 1.0 joules of stored energy (electric shock hazard)

(3) Greater than or equal to 400 volts and greater than 0.25 joules of stored energy (electric shock hazard)

(4) Greater than or equal to 1.2 cal/cm ^{2} incident energy at the working distance (arc flash hazard)

(5) Greater than 100 joules of stored energy regardless of voltage (hearing acoustic hazard)

(6) Greater than 122 kJ of stored energy when dI/dt is greater than 109 amperes per second (lung collapse acoustic hazard)

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 15:29:02 EDT 2024

Committee Statement

Committee Statement: This revision adds thresholds for additional hazards covered in this article related to capacitors. The new thresholds correlate with the values in Informative Annex R.

Response Message: FR-96-NFPA 70E-2024

Public Input No. 188-NFPA 70E-2024 [Section No. 360.3]

First Revision No. 97-NFPA 70E-2024 [Section No. 360.4(B)]

(B) Performing a Risk Assessment for Capacitors.

~~The risk assessment process for capacitors shall follow the overall risk assessment procedures in Chapter 1 . If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk control identified in 110.3(H)(3) . When the additional protective measures include the use of PPE, the following shall be determined:~~

(0) ~~Capacitor voltage and stored energy for the worker exposure. An exposure shall be considered to exist when a conductor or circuit part that could potentially remain energized with hazardous stored energy is exposed.~~

(0) ~~Thermal hazard. The appropriate thermal PPE shall be selected and used if the stored energy of the exposed part is greater 100 joules.~~

(0) ~~Electric shock hazard. The appropriate electric shock PPE in accordance with 130.7 shall be selected and used if the voltage is greater than or equal to 100 volts.~~

(0) ~~Arc flash and arc blast hazard at the appropriate working distance. The appropriate protection for the arc flash and arc blast hazard shall be selected, as follows:~~

0. ~~Arc flash PPE in accordance with 130.7 shall be selected and used if the incident energy exceeds 1.2 cal/cm^2 (5 J/cm^2) at the working distance.~~
0. ~~Hearing protection shall be required where the stored energy exceeds 100 joules.~~
0. ~~The lung protection boundary shall be determined if stored energy is above 122 kJ. Employees shall not enter the lung protection boundary.~~
0. ~~Alerting techniques in accordance with 130.8(O) shall be used to warn employees of the hazards.~~

(0) ~~Required test and grounding method. Soft grounding shall be used for stored energy greater than 1000 joules. If capacitors are equipped with bleed resistors, or if using a soft grounding system, the required discharge wait time shall be determined where applicable.~~

(0) ~~Develop a written procedure that captures all of the required steps to place the equipment in an electrically safe work condition. Include information about the amount of stored energy available, how long to wait after de-energization before opening the enclosure, how to test for absence of voltage, and what to do if there is still stored energy present.~~

(1) Process.

The risk assessment process for capacitors shall follow the overall risk assessment procedures in Chapter 1.

(2) Protective Measures.

If additional protective measures are required, they shall be selected and implemented according to the hierarchy of risk control identified in 110.3(H)(3).

(3) PPE and Hazards.

When the additional protective measures include the use of PPE, the following shall be determined:

(1) Capacitor voltage and stored energy for the worker exposure~~.~~ : An exposure shall be considered to exist when a conductor or circuit part that could potentially remain energized with hazardous stored energy is exposed.

(2) Thermal hazard~~.~~ : The appropriate thermal PPE ~~shall be selected and used~~ if the stored energy of the exposed part is greater 100 joules.

(3) Electric shock hazard~~.~~ : The appropriate electric shock PPE in accordance with 130.7~~shall be selected and used~~ if the voltage is greater than or equal to 100 volts.

(4) Arc flash and arc blast hazard at the appropriate working distance~~.~~ : The appropriate protection for the arc flash and arc blast hazard ~~shall be selected,~~ as follows:

a. Arc flash PPE in accordance with 130.7~~shall be selected and used~~ if the incident energy exceeds 1.2 cal/cm^2 (5 J/cm^2) at the working distance.

b. Hearing protection ~~shall be required~~ where the stored energy exceeds 100 joules.

c. The lung protection boundary ~~shall be determined~~ if stored energy is above 122 kJ and dI/dt is greater than 109 A/sec . Employees shall not enter the lung protection boundary.

d. Alerting techniques in accordance with 130.8(O)~~shall be used~~ to warn employees of the hazards.

(5) Required test and grounding method~~.~~ meeting the following requirements: ~~Soft grounding shall be used for stored energy greater than 1000 joules. If capacitors are equipped with bleed resistors, or if using a soft grounding system, the required discharge wait time shall be determined where applicable.~~

a. Soft grounding shall be used for stored energy greater than 1000 joules.

b. If capacitors are equipped with bleed resistors, or if using a soft grounding system, the required discharge wait time shall be determined where applicable.

(6) Develop a written procedure that captures all of the required steps to place the equipment in an electrically safe work condition~~. Include~~ and includes information about the amount of stored energy available, how long to wait after de-energization before opening the enclosure, how to test for absence of voltage, and what to do if there is still stored energy present.

Informational Note No. 1: See Informative Annex R for more information on calculating capacitor stored energy, arc flash, and arc blast boundaries.

Informational Note No. 2: Heavy duty leather with a minimum thickness of 0.03 in. (0.7 mm) provides protection from thermal hazards.

Informational Note No. 3: For 320.4(B)(3)(4)c. only, the current risetime can be modeled using voltage, capacitance, and system impedances.

Supplemental Information

File Name	Description	Approved
70E_FR-97_360.4_B_.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 08 09:59:20 EDT 2024

Committee Statement

Committee Statement: The lung protection boundary was created in the 2021 NFPA 70E for large capacitor banks, that produce fast risetime, high currents. Such banks are almost always high voltage and very high power, on the order of 500 MW and above. Large, low-voltage banks could not produce such shock waves. The di/dt threshold of 10*9 A/s excludes such lower voltage, lower power capacitor banks.

The section was revised to comply with the NEC Style Manual.

First and/or second level subdivision titles were added to comply with the NEC Style Manual.

Response Message: FR-97-NFPA 70E-2024

Public Input No. 189-NFPA 70E-2024 [Section No. 360.4(B)]

First Revision No. 98-NFPA 70E-2024 [Section No. 360.5(B)]

(B) Safe Work Practices.

In order to place the capacitor(s) into an electrically safe work condition, a qualified person shall use the appropriate safe work practices and PPE and shall apply the following process for establishing and verifying an electrically safe work condition:

(1) Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.

(2) After properly interrupting the load current, open the disconnecting device(s) for each source.

(3) Wherever possible, visually verify that all blades of the disconnecting devices are fully open or that drawout-type circuit breakers are withdrawn to the fully disconnected position.

(4) Apply lockout/tagout devices in accordance with a documented and established policy.

(5) Determine capacitor discharge in accordance with the following: ~~If bleed resistors or automatic discharge systems are applicable, wait the prescribed time for the capacitors to discharge to less than the thresholds in~~ 320.3 ~~and proceed to step (6). For systems without bleed resistors or automatic discharge systems, discharge the capacitors with an adequately rated grounding device (e.g., ground stick). Soft grounding shall be performed above 1000 joules, and remote soft grounding shall be performed above 100 kJ.~~

   a. If bleed resistors or automatic discharge systems are applicable, wait the prescribed time for the capacitors to discharge to less than the thresholds in 320.3 and proceed to step (6).

   b. For systems without bleed resistors or automatic discharge systems, discharge the capacitors with an adequately rated grounding device (e.g., ground stick).

   c. ~~Soft grounding shall be performed~~ Perform soft grounding above 1000 joules~~,~~ and remote soft grounding ~~shall be performed~~ above 100 kJ.

   d. If the capacitor(s) are not referenced to ground through either terminal, use a shorting stick to discharge the capacitor from terminal to terminal.

   e. A hard shorting stick is permitted to be used up to 1000 joules, a soft shorting stick (containing a discharge resistor) is permitted to be used up to 100 kJ, and remote soft shorting is permitted above 100 kJ.

(6) Verify that the capacitors are discharged and grounded in accordance with the following: ~~For capacitors less than 1000 joules, verification shall be permitted to be done either by testing or by grounding. For capacitors between 1000 joules and less than 100 kJ, verification shall be done using testing or soft grounding, then hard grounding. Above 100 kJ, an engineered and redundant system shall be used for remote testing and grounding. An adequately rated grounding device (ground stick) or portable test instrument shall be used to test between each capacitor terminal and from each terminal to ground to assure that the capacitor is de-energized.~~

   a. For capacitors less than 1000 joules, verification shall be permitted to be done either by testing or by grounding.

   b. For capacitors between 1000 joules and less than 100 kJ, verification shall be done using testing or soft grounding, then hard grounding.

   c. Above 100 kJ, an engineered and redundant system shall be used for remote testing and grounding.

   d. An adequately rated grounding device (ground stick) or portable test instrument shall be used to test between each capacitor terminal and from each terminal to ground to assure that the capacitor is de-energized.

(7) When test instruments are used for testing the absence of voltage, verify the operation of the test instrument ~~shall be verified~~ on a known dc voltage source before and after each absence of voltage procedure is performed. ~~If voltage remains, determine and correct the cause, and repeat step (5) to discharge the capacitors. Where recharging can occur due to dielectric absorption or induced voltages, all the capacitor terminals shall be connected together and grounded with a bare or transparent-insulated wire.~~

(8) If voltage remains, determine and correct the cause, and repeat step (5) to discharge the capacitors.

(9) Determine the use of shorting wires in accordance with the following:

a. Where recharging can occur due to dielectric absorption or induced voltages, all the capacitor terminals shall be connected together and grounded with a bare or transparent-insulated wire.

b. For series capacitors, the shorting wires shall be attached across each individual capacitor~~, and to case~~ 's terminals .

(9) ~~For series capacitors the shorting wires shall be attached across each individual capacitor, and to case.~~

(10) For single capacitors or for a parallel capacitor bank, the grounding device shall be permitted to be left attached to the capacitor terminals for the duration of the work (e.g., a ground stick).

(11) For single, series, or parallel capacitors, an approved engineered discharge path that remains in place after zero energy is verified, shall be permitted to be used instead of additional shorting wires, as long as the engineered system is inspected after the zero-energy verification and before the work begins. The engineered system shall ensure that all capacitors are shorted and grounded.

~~For single capacitors or for a parallel capacitor bank, the grounding device shall be permitted to be left attached to the capacitor terminals for the duration of the work (e.g., a ground stick).~~

Exception: Lockout/tagout shall not be required for work on cord- and plug-connected equipment for which exposure to the hazards of unexpected energization of the equipment is controlled by the unplugging of the equipment from the energy source, provided that the plug is under the exclusive control of the employee performing the servicing and maintenance for the duration of the work.

Supplemental Information

File Name	Description	Approved
FR_98_attachment.docx	attachment for FR 98	
70E_FR-98_360.5_B_.docx	For prod use	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 08 10:15:50 EDT 2024

Committee Statement

Committee Statement: Although the shorting stick process for capacitors not referenced to ground through either terminal (i.e., floating) was covered in Annex R, it is important to recognize this design situation in Article 360 and to introduce the concept of shorting sticks.

For large capacitor banks, attaching a shorting wire manually across each capacitor adds additional worker hazards, such as crawling down deep into a tank, using ladders, and trying to get to inaccessible points. On these large banks well engineered, approved and tested automatic discharge systems are installed. They are inspected after each capacitor bank use, zero voltage procedures are still followed, and these systems are regularly tested and maintained. The requirement, as previously written, did not consider such large capacitor banks, and created additional hazards by requiring the manual placement of grounding straps.

Response Message: FR-98-NFPA 70E-2024 RESPONSE TO PI 190: The line about locking out the sources, but still not safe is to emphasize the stored energy nature of capacitors, and that energy discharge is required.

Public Input No. 197-NFPA 70E-2024 [Section No. 360.5(B)]

Public Input No. 190-NFPA 70E-2024 [Section No. 360.5(B)]

320.6 Ground or Shorting Sticks.

~~Ground sticks shall be provided for qualified persons to safely discharge any residual stored energy contained in capacitors or to hold the capacitor potential at 0 volts. The ground sticks shall be designed, constructed, installed, and periodically inspected so that the full energy and voltage of the capacitors can be safely discharged.~~

(A) General.

(1) Availability.

Ground or shorting sticks shall be provided for qualified persons to safely discharge any residual stored energy contained in capacitors or to hold the capacitor potential at 0 volts.

(2) Application.

The ground or shorting sticks shall be designed, constructed, installed, and periodically inspected so that the full energy and voltage of the capacitors can be safely discharged.

(3) Ungrounded Capacitors.

(a) If a capacitor is ungrounded one of the following shall apply:

(1) Two ground sticks shall be required.

(2) A single shorting stick shall be permitted to discharge the capacitor terminal to terminal.

(b) The shorted capacitor shall be brought to ground potential with a ground stick.

(B) Visual Inspection.

~~The ground stick shall be visually inspected for defects before each use. All mechanical connections shall be examined for loose connections. Resistors shall be visually inspected for cracks or other defects and electrically tested for proper resistance. The following shall occur if defects or contamination are found:~~

(0) ~~If any defect or contamination that could adversely affect the insulating qualities or mechanical integrity of the ground stick is present, the tool shall be removed from service.~~

(0) ~~If the defect or contamination exists on the ground stick, then it shall be replaced or repaired and tested before returning to service.~~

(0) ~~If the defect or contamination exists on the cable, then it shall be replaced or repaired and tested before returning to service.~~

(1) Frequency.

The ground or shorting stick shall be visually inspected for defects before each use.

(2) Connections.

All mechanical connections shall be examined for loose connections.

(3) Resistors.

Resistors shall be visually inspected for cracks or other defects and electrically tested for proper resistance.

(4) Defects or Contamination.

The following shall occur if defects or contamination are found:

(1) If any defect or contamination that could adversely affect the insulating qualities or mechanical integrity of the ground stick is present, the tool shall be removed from service.

(2) If the defect or contamination exists on the ground or shorting stick, ~~then~~ it shall be replaced or repaired and tested before returning to service.

(3) If the defect or contamination exists on the cable, ~~then~~ it shall be replaced or repaired and tested before returning to service.

(C) Electrical Testing.

All ground or shorting sticks shall be electrically tested as follows:

(1) The ground or shorting stick cable shall be tested to verify that the impedance is less than ~~0.~~ 1 ohm~~s~~ to ground every 2 years.

(2) The testing shall be documented.

Exception: The test shall be performed annually if the ground or shorting stick is utilized outdoors or in other adverse conditions.

(3) Soft grounding (High-Z) ground sticks with resistors shall be measured and compared to the specified value before each use.

(D) Storage and ~~Disposal~~ Removal .

Any residual charge from capacitors shall be removed by discharging before servicing or removal.

(1) All uninstalled capacitors capable of storing 10 joules or greater at their rated voltage shall be short-circuited with a conductor of ~~appropriate~~ a size determined by a qualified person .

(2) When an uninstalled capacitor is discovered without the shorting conductor attached to the terminals, it shall be treated as energized and charged to its full rated voltage until determined safe by a qualified person.

Informational Note: A capacitor that develops an internal open circuit could retain substantial charge internally even though the terminals are short-circuited. Such a capacitor can be hazardous to transport, because the damaged internal wiring could reconnect and discharge the capacitor through the short-circuiting conductor. Any capacitor that shows a significant change in capacitance after a fault could have this problem. Action should be taken to reduce the risk associated with this hazard when it is discovered.

(E) Hand Guard Distance.

The distance from the closest conductive point at the tip of the ground stick to the hand guard in front of the user's hand shall be a minimum of 36 cm (1.2 ft) for dc voltages less than or equal to 40 kV, and for 40 kV to 200 kV have a distance of $d = 0.03 \times V_{max}$ (kV).

(F) Dielectric PPE.

For ground sticks, dielectric PPE shall not be required if the ground stick is verified to be connected to a solid ground before use.

(G) Conductive Point Distance.

For shorting sticks, the closest conductive point at the tip of either shorting stick to the hand guard in front of the user's hand shall be a minimum of the restricted approach boundary.

Supplemental Information

File Name	Description	Approved
FR_99_attachment.docx	attachment for FR 99	

70E_FR-99_360.6.docx For prod use

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Thu Aug 08 10:34:33 EDT 2024

Committee Statement

Committee Statement: This section is revised to include the use of shorting sticks in addition to ground sticks. While shorting sticks are addressed in Informative Annex R, the safety concerns when using the safety devices justify regulating their use. Changing the resistance from 0.1 to 1 ohm aligns testing requirement of the ground stick cable. The new requirements are based on Informative Annex R.

The section was revised to comply with the NEC Style Manual.

First and/or second level subdivision titles were added to comply with the NEC Style Manual.

Response Message: FR-99-NFPA 70E-2024

Public Input No. 240-NFPA 70E-2024 [Section No. 360.6 [Excluding any Sub-Sections]]

Public Input No. 239-NFPA 70E-2024 [Section No. 360.6(B)]

Public Input No. 196-NFPA 70E-2024 [Section No. 360.6]

First Revision No. 69-NFPA 70E-2024 [Section No. A.3.9]

A.3.9 UL Publications.

Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 943, *Ground-Fault Circuit Interrupters*, ~~2006 (R 2012)~~ 2016, revised 2023 .

UL 943C, *Outline of Investigation for Special Purpose Ground-Fault Circuit-Interrupters*, 2012, revised 2015 .

UL 1436, *Outlet Circuit Testers and Other Similar Indicating Devices*, 2016.

UL RP 2986, *Recommended Practice for Measuring Incident Energy Exposure* , 2015.

ANSI/ZCSA/ UL 9540, *Energy Storage Systems and Equipment*, ~~2020~~ 2023 .

UL 9540A, *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, 2019.

UL 9540B, *Outline of Investigation for Large Scale Fire Test for Residential Battery Energy Storage Systems* , 2024.

UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements*, 2012, revised 2023 .

UL 61010-2-033, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use — Part 2-033: Particular Requirements for Hand-Held Multimeters and Other Meters, for Domestic and Professional use, Capable of Measuring Mains Voltage*, ~~2014~~ 2020 .

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 10:58:24 EDT 2024

Committee Statement

Committee Statement: The UL references have been updated to reflect the current editions. UL 9540B, Outline of Investigation for Large Scale Fire Test for Residential Battery Energy Storage Systems, was added as it now referenced within the body of the document.

Response Message: FR-69-NFPA 70E-2024

Public Input No. 123-NFPA 70E-2024 [Section No. A.3.9]

First Revision No. 70-NFPA 70E-2024 [Section No. C.2.1 [Excluding any Sub-Sections]]

Columns 2 through ~~5~~ 4 of Table 130.4(E)(a) and Table 130.4(E)(b) show various distances from the exposed energized electrical conductors or circuit parts. They include dimensions that are added to a basic minimum air insulation distance. Those basic minimum air insulation distances are based on OSHA's 29 CFR 1910.269, Table R-3.

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 11:02:52 EDT 2024

Committee Statement

Committee Statement: The references to the columns in Tables 130.4(E)(a) and (E)(b) have been editorially revised to reference Columns 2 through 4.

Response Message: FR-70-NFPA 70E-2024

Public Input No. 88-NFPA 70E-2024 [Section No. C.2.1 [Excluding any Sub-Sections]]

D.5 Direct-Current Incident Energy Calculations.

D.5.1 Dynamic Behavior of DC Arcs.

Direct-current arcs are similar to three-phase ac arcs in that continuously flowing current maintains the hot plasma, as compared to single-phase ac arcs, which cool at current zeros, which contributes to self-extinction. However, dc arcs have a unique difference to three-phase ac arcs. The spatially varying magnetic fields of the three phases of a three-phase arc combines to give a net zero effect on the motion of the arc. However, the magnetic field of a dc arc provides a continuous orthogonal force on the arc that causes the arc to move laterally and elongate *(see reference 1)* .

D.5.2 Arc Extinction Observations Provides Voltage/Gap Bounds.

If erosion and magnetic forces cause a dc arc to elongate to a threshold, the arc self-extinguishes. The extinction length is determined by the arc voltage and initial gap distance. Once the voltage drop in the arc exceeds the source voltage, the arc can no longer sustain.

An equation can be written, based on measurements, to provide a lower voltage bound for a given gap distance, below which, an arc cannot be sustain *(see references 1, 2, 3)* .

$$V_{min} = 1.06 \times g + 100 \quad \textbf{[D.5.2a]}$$

or

$$g_{min} = V - 100 \times 1.06 \quad \textbf{[D.5.2b]}$$

where:

V_{min} = voltage below which an arc can't be sustained

g = gap distance, cm (in.)

g_{min} = gap above which an arc can't be sustained, cm (in.)

V = system voltage

Table D.5.2 provides a maximum gap distance for various voltages above which an arc will extinguish.

Table D.5.2 Maximum Gap Distance.

System Voltage (volts)	Gap Distance, above which arc will quickly extinguish	
	cm	in.
150	0.47	0.18
250	1.4	0.55
550	4.2	1.7
600	4.7	1.8
1000	8.5	3.3

D.5.3 Maximum Power Method.

The following method of estimating dc arc flash incident energy ~~that follows was published in the *IEEE Transactions on Industry Applications* (see reference 4 of D.5.4). This method~~ is based on the concept that the maximum power possible in a dc arc will occur when the arcing voltage is one-half the system voltage. ~~Testing completed for Bruce Power (see reference 3 of D.5.5) has~~ Multiple tests have shown that this calculation is conservatively high in estimating the arc flash value *(see reference 4)* . This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \qquad \text{[D.5.4 3a]}$$

where:

I_{arc} = arcing current, amperes

I_{bf} = system bolted fault current, amperes

IE_m = estimated dc arc flash incident energy at the maximum power point, cal/cm^2

V_{sys} = nominal system voltage, volts

T_{arc} = arcing time, sec

D = working distance, cm

For exposures where the arc is in a box or enclosure, it would be prudent to consider additional PPE protection beyond the values shown in Table 130.7(C)(15)(b).

While IEEE 1584 *(see reference 5)* does not have arc-in-a-box/enclosure multipliers for dc panelboards and cabinets, reflected energy is reflected energy regardless of whether the initial source of the energy was ac or dc. Given that dc panelboards (fuse or breaker distribution boxes) are often of very similar dimensions to ac panelboards, the multiplier of 1.6 for calculated arc flash energy from a dc distribution panelboard found in IEEE 1584 for ac panelboards could be assumed to be prudent.

While there are larger dc distribution cabinets, most large dc enclosures contain batteries, and have quite a bit of depth to them relatively. Using typical distances of centralized large UPS battery cabinets, calculations show *(see reference 6)* that typical reflected energy at the typical calculation distance of 18 in. (455 mm) in front of the cabinet for low-voltage systems yields an approximate additional 3 percent to 4 percent energy. This essentially means that a multiplier for arc-in-a-box is generally not needed for incident energy of large dc battery cabinets at 18 in. (455 mm) in front of it. However, due to ratios of direct vs. reflected distance becoming closer the further the human is away from the box/enclosure, a multiplier for the arc flash boundary for these large dc battery cabinets might be prudent.

The following formula was derived *(see reference 3)* for the arc flash boundary distance multiplier from the large enclosure curves for ac switchgear in IEEE 1584.

$$K_{ab} = \left[0.55 \times In\left(d_{ab}\right)\right] - 0.6 \qquad \text{[D.5.3b]}$$

where:

K_{ab} = arc flash boundary distance multiplier for large dc battery cabinets

d_{ab} = calculated arc flash boundary (in.) without an arc-in-a-box/enclosure multiplier

~~**D.5.4** Detailed Arcing Current and Energy Calculations Method.~~

~~A thorough theoretical review of dc arcing current and energy was published in the *IEEE Transactions on Industry Applications*. Readers are advised to refer to that paper *(see reference 1)* for those detailed calculations.~~

~~References:~~

~~1. "DC-Arc Models and Incident-Energy Calculations," Ammerman, R.F., et al., *IEEE Transactions on Industry Applications*, Vol. 46, No. 5.~~

~~2. "Arc Flash Calculations for Exposures to DC Systems," Doan, D.R., *IEEE Transactions on Industry Applications*, Vol. 46, No. 6.~~

~~3. "DC Arc Hazard Assessment Phase II," Copyright Material, Kinectrics Inc., Report No. K-012623-RA-0002-R00.~~

~~**D.5.4** Short Circuit Current.~~

~~The determination of short circuit current is necessary in order to use Table 130.7(C)(15)(b). The arcing current is calculated at 50 percent of the dc short-circuit value. The current that a battery will deliver depends on the total impedance of the short-circuit path. A conservative approach in determining the short-circuit current that the battery will deliver at 25°C is to assume that the maximum available short-circuit current is 10 times the 1 minute ampere rating (to 1.75 volts per cell at 25°C and the specific gravity of 1.215) of the battery. A more accurate value for the short-circuit current for the specific application can be obtained from the battery manufacturer.~~

~~References:~~

~~1. IEEE 946, *Recommended Practice for the Design of DC Auxiliary Powers Systems for Generating Stations*.~~

D.5.4 Modified Maximum Power Method.

Repeated experiments by multiple companies *(see reference 3)* have shown that the maximum power method produces fairly accurate results at around 500 Vdc, where arc sustaining times average about 2 seconds. For lower voltages (which are quite common), the arc cannot sustain itself (even with close electrodes in an optimal configuration) for nearly that long, and the maximum sustaining time becomes lower and lower as the voltage goes down. Empirical derivation of a maximum sustaining time yields the formula in Equation D.5.4.

$$T_{arc} = 0.0043 \times V_{sys} \qquad \textbf{[D.5.4]}$$

Modifying the maximum power incident energy formula with this new value of T_{arc} yields results much closer to the values seen in actual testing and to the values produced by the iterative methods.

D.5.5 Stokes/Oppenlander Method.

This is an empirical method based on tests for dc arcs from 0.1 amperes to 1 kA *(see reference 7).*

D.5.6 Paukert Method.

This is an empirical method based on data of dc arc measurements from seven sources. It predicts high current arc characteristics *(see reference 8)*.

D.5.7 Kinectrics Physics Model.

This is a physics model based on mass and energy conservation principles. It is used to compute plasma temperature and resistance using discretized energy balance equations for finite elements across the radius of the arc. It is an iterative technique *(see reference 9).*

D.5.8 Ammerman/Sen Method.

This is a circuit/thermal model that assumes complete conversion of electrical arc energy into thermal energy. Arc power is determined from an iterative technique constrained by arc power and circuit characteristics *(see reference 2).*

D.5.9 Short Circuit Current and Clearing Time.

The short-circuit current of the source (battery, EDLC, or PV) needs to be obtained from the manufacturer. The circuit clearing time needs to be determined by analysis of the battery management system, solar management system, and/or fusing.

Clearing times from arc dynamics are still under study, but recent dc arc tests provide information to predict arc lifetime as a function of gap distance, voltage, and short-circuit current *(see references 1 and 3)* .

D.5.10 References.

(1) Gordon, L., "Modeling the Dynamic Behavior of DC Arcs," *IEEE Transactions on Industry Applications* , Vol. 60, No. 1, pp. 1946–1955, January/February 2024.

(2) Ammerman, R.F., Gammon, T., Sen, P.K., and Nelson, J.P., "DC arc models and incident energy calculations," in Proc. of Petroleum Chem. Ind. Conference, pp. 1–3, 2009.

(3) Ashton, C., "Modifying the DC Arc-Flash Max Power Formula to Give More Realistic Predictions of Maximum Arc-Flash Energy," in Proc. of IEEE Electrical Safety Workshop, Tucson, p. 71, March 2024.

(4) Doan, D.R., "Arc flash calculations for exposures to DC systems," *IEEE Transactions on Industry Applications* , Vol. 46, No. 6, pp. 2299–2302, November/December 2010.

(5) IEEE 1584, *Guide for Performing Arc Flash Calculations* , 2018.

(6) Rosewater, D.M., "Reducing Risk When Performing Energized Work on Batteries," in *IEEE Transactions on Industry Applications* , Vol. 60, No. 2, pp. 2732–2741, doi: 10.1109/TIA.2023.3332828, March-April 2024.

(7) Stokes, A. and Oppenlander, W., "Electric arcs in open air," *J. Phys. D: Appl. Phys.* , Vol. 24, pp. 26–35, 1991.

(8) Paukert, J., "The arc voltage and arc resistance of LV fault arcs," in Proc. 7th Int. Symp. Switching Arc Phenomena, pp. 49–51, 1993.

(9) Keyes, C. and Maurice, C., "DC arc hazard assessment phase II," *Kinectrics* , Toronto, ON, Canada, Tech. Rep. K-012623-RA-0001 -R00, July 2007.

Supplemental Information

File Name	Description	Approved
FR_71_attachement.docx	attachment for FR 71	
FR_71_D.5.docx	For prod use	

Submitter Information Verification

Committee: EEW-AAA

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Committee Statement

Committee Statement: The direct-current incident energy calculation models have been revised by including updated testing information, supporting references, dc to ac arc flash characteristic comparisons and additional considerations for direct-current incident energy calculations.

The term "nominal" was added before voltage in the Maximum Power Method, D.5.3. formula to clarify the voltage used.

Response Message: FR-71-NFPA 70E-2024

Public Input No. 215-NFPA 70E-2024 [Section No. D.5.3]

Public Input No. 81-NFPA 70E-2024 [Section No. D.5.1]

Public Input No. 115-NFPA 70E-2024 [New Section after D.5.1]

Public Input No. 78-NFPA 70E-2024 [Section No. D.5.1]

Public Input No. 222-NFPA 70E-2024 [New Section after D.5]

Public Input No. 208-NFPA 70E-2024 [Section No. D.5]

Public Input No. 224-NFPA 70E-2024 [Section No. D.5.2]

Public Input No. 223-NFPA 70E-2024 [New Section after D.5]

Public Input No. 213-NFPA 70E-2024 [Section No. D.5.1]

Public Input No. 55-NFPA 70E-2024 [Section No. D.5.1]

First Revision No. 72-NFPA 70E-2024 [Section No. F.3]

F.3 Hierarchy of Risk Control.

The purpose of specifying and adhering to a hierarchy of risk control methods is to identify the most effective individual or combination of preventive or protective measures to reduce the risk associated with a hazard. Each risk control method is considered less effective than the one before it. Table F.3 lists the hierarchy of risk control identified in this and other safety standards and provides examples of each.

Table F.3 The Hierarchy of Risk Control Methods

Risk Control Method	Examples
(1) Elimination	Conductors and circuit parts in an electrically safe working condition
(2) Substitution	Reduce ~~energy~~ the hazard by replacing 120 ~~V~~ volts control circuitry with 24 Vac or Vdc control circuitry
(3) Engineering controls	Guard energized electrical conductors and circuit parts to reduce the likelihood of electrical contact or arcing faults
(4) Awareness	Signs alerting of the potential presence of hazards
(5) Administrative controls	Procedures and job planning tools
(6) PPE	Electric shock and arc flash PPE

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 11:18:06 EDT 2024

Committee Statement

Committee Statement: The word “energy” was replaced with “hazard” to more accurately reflect the concern.

Response Message: FR-72-NFPA 70E-2024

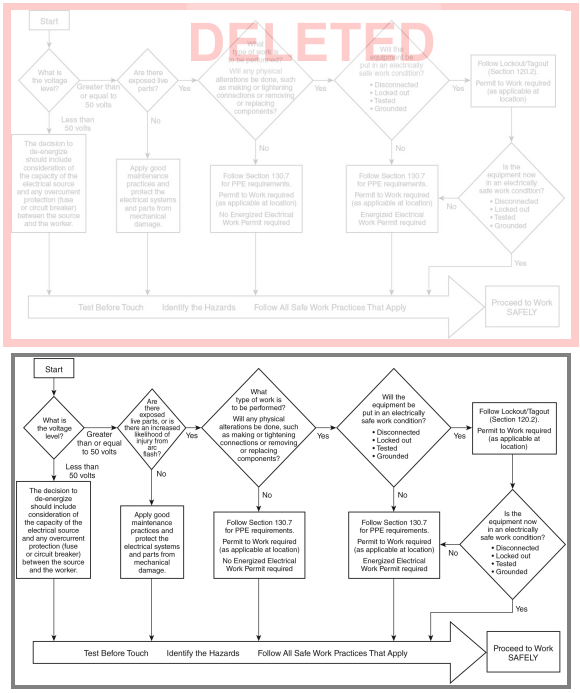
Public Input No. 74-NFPA 70E-2024 [Section No. F.3]

First Revision No. 73-NFPA 70E-2024 [Section No. J.2]

J.2 Energized Electrical Work Permit.

Figure J.2 illustrates items to consider when determining the need for an energized electrical work permit.

Figure J.2 Energized Electrical Work Permit Flow Chart.



Supplemental Information

File Name	Description	Approved
FR_73_attachment.docx	attachment for FR 73	

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 11:20:35 EDT 2024

Committee Statement

Committee Statement: The flow chart was revised to correlate with 130.2(A) which requires consideration of possible injury from an arc flash.

Response Message: FR-73-NFPA 70E-2024

Public Input No. 93-NFPA 70E-2024 [Section No. J.2]

First Revision No. 74-NFPA 70E-2024 [Annex K]

Informative Annex K General Categories of Electrical Hazards

This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

K.1 General.

Contact with or exposure to electricity continues to be one of the leading causes of workplace fatalities and injuries in the United States. Between 2011 and 2022, there were a total of 1,322 workplace fatalities involving electricity. According to the Occupational Safety and Health Administration (OSHA), an average of 113 Americans died in the workplace between 2011 and 2020 due to contact with electricity. Of these fatalities, 30 percent were in occupations that can be considered electrical occupations with employees who have received training on electrical safety and the relevant codes and standards of working around electricity. Seventy percent of the fatalities occurred in non-electrically related occupations. Working on or near energized equipment or parts was identified as the leading cause with 48 percent of the fatalities, closely followed by contact with overhead power lines with 41 percent. Electrical fatalities continue to stay consistent with an average 1.5 percent decrease in workplace electrical fatalities year over year. Electrical fatalities account for 6 percent of all workplace fatalities.

~~Electrical injuries represent a serious workplace health and safety issue to electrical and non-electrical workers. Data from the U.S. Bureau of Labor Statistics (BLS) indicate that there were nearly 6000 fatal electrical injuries to workers in the United States from 1992 through 2012. BLS data also indicate that there were 24,100 non-fatal electrical injuries from 2003 through 2012. From 1992 to 2013, the number of fatal workplace electrical injuries has fallen steadily and dramatically from 334 in 1992 to 139 in 2013. However, the trend with non-fatal electrical injuries is less consistent. Between 2003 and 2009, non-fatal injury totals ranged from 2390 in 2003 to 2620 in 2009, with a high of 2950 injuries in 2005. Non-fatal injury totals between 2010 through 2012 were the lowest over this 10-year period, with 1890 non-fatal injuries in 2010, 2250 in 2011, and 1700 in 2012.~~

~~There are two general categories of electric injury: electric shock and electrical burns. Electrical burns can be further subdivided into burns caused by radiant energy (arc burns), burns caused by exposure to ejected hot gases and materials (thermal burns), and burns caused by the conduction of electrical current through body parts (conduction burns). In addition, hearing damage can occur from acoustic energy, and traumatic injury can be caused by toxic gases and pressure waves associated with an arcing event.~~

About 98 percent of fatal occupational electric injuries are electric shock injuries. A corporate case study examining electrical injury reporting and safety practices found that 40 percent of electrical incidents involved 250 volts or less and were indicative of a misperception of electrical safety as a high-voltage issue. In addition, electrical incidents once again were found to involve a large share of non-electrical workers, with approximately one-half of incidents involving workers from outside electrical crafts. Research of electrical fatalities in construction found that the highest proportion of fatalities occurred in establishments with 10 or fewer employees and pointed out that smaller employers could have fewer formal training requirements and less structured training in safety practices.

There are two general categories of electrical hazards addressed extensively by the requirements of this standard: electric shock hazards and arc flash hazards. Each of these hazards are discussed separately in this informative annex. A third category of hazard is a thermal hazard related to the overheating of a conductor, circuit part, or other conductive object caused by electric current. This type of hazard is referred to but not specifically addressed by the requirements of this standard.

K.2 Electric Shock.

Over 40 percent of all electrical fatalities in the US involved overhead power line contact. This includes overhead power line fatalities from direct contact by a worker, contact through hand-carried objects, and contact through machines and vehicles. Comparing the ratio of total electrical fatalities to total electrical injuries (fatal and nonfatal), it was noticed that electrical injuries are more often fatal than many other injury categories. For example, from 2003 to 2009 there were 20,033 electrical injuries of which 1,573 were fatalities. One worker died for every 12.74 electrical injuries. For the same period there were 1,718,219 fall injuries of which 5,279 were fatalities — one worker died for every 325 injuries.

~~Of those, 1573 were electrical fatalities.~~ A more detailed look at the demographics for 168 electrical fatalities in 2009 showed that 99 percent of deaths were the result of electrocution, and 70 percent occurred while the worker was performing a constructing, repairing, or cleaning activity.

Shock injuries can be divided into the thermal effect of electric current on the human body and the effect of electric current on the body's nervous system. The thermal effect can result in skin burns that might require skin grafting and, if deep enough into subcutaneous tissue, might require amputation of the affected body part. The immediate effect on the nervous system can include loss of voluntary muscle control, asphyxiation, ventricular fibrillation, and cardiac arrest.

The long-term effects of shock injuries, known as electric shock sequela, are the topic of ongoing research. Sequela is an after-effect of a disease, condition, or injury; the plural is sequelae. These long-term effects can include psychological, neurological, and physical symptoms, which can occur and persist whether visible physical trauma occurred or not.

K.3 Arc Flash.

~~In the recently issued 29 CFR Subpart V, OSHA identified 99 injuries that involved burns from arcs from energized equipment faults or failures, resulting in 21 fatalities and 94 hospitalized injuries for the period January 1991 through December 1998.~~

~~Based on this data, OSHA estimated that an average of at least eight burn injuries from arcs occur each year involving employees doing work covered by OSHA rules, leading to 12 non-fatal injuries and two fatalities per year. Of the reports indicating the extent of the burn injury, 75 percent reported third-degree burns.~~

~~During the period involved, Federal OSHA only required non-fatal injuries to be reported when there were three or more workers hospitalized. OSHA found that there were six injuries for every fatality in California, which requires the reporting of every hospitalized injury.~~

~~Using that data, OSHA estimated that would be at least 36 injuries to every fatality, and probably many more. Also, many non-fatal electric shocks involve burns from associated electric arcs.~~

~~Starting January 1, 2015, Federal OSHA requires every hospitalized injury to be reported.~~

K.3.1 General.

In the recently issued 29 CFR Subpart V, OSHA identified 99 injuries that involved burns from arcs from energized equipment faults or failures, resulting in 21 fatalities and 94 hospitalized injuries for the period January 1991 through December 1998.

Based on this data, OSHA estimated that an average of at least eight burn injuries from arcs occur each year involving employees doing work covered by OSHA rules, leading to 12 nonfatal injuries and two fatalities per year. Of the reports indicating the extent of the burn injury, 75 percent reported third-degree burns.

During the period involved, ~~Federal~~ federal OSHA only required nonfatal injuries to be reported when there were three or more workers hospitalized. OSHA found that there were six injuries for every fatality in California, which requires the reporting of every hospitalized injury.

Using that data, OSHA estimated that would be at least 36 injuries to every fatality, and probably many more. Also, many nonfatal electric shocks involve burns from associated electric arcs.

~~Starting~~ Since January 1, 2015, ~~Federal~~ federal OSHA ~~requires~~ has required every hospitalized injury to be reported.

Four types of energies are released by an arcing event, each with different effects on the human body.

K.3.2 Thermal Energy.

The thermal energy developed by an arcing event is conveyed radiantly (infrared energy), convectively (plasma and hot gases), and conductively (molten metal) from the arc to a worker. Depending on the thermal density of this energy, skin burns can result from direct exposure to the arc thermal energy, and from clothing ignition and burning, which can transfer additional thermal energy to the skin. Internal burns can occur in the upper respiratory system such as the mouth, throat, and nose due to inhalation of hot gases produced by the arc plasma and hot gas, and by burning clothing.

The arc flash PPE requirements of this standard primarily address the thermal component of arc energy.

K.3.3 Mechanical Energy (Sudden Pressure Release).

At one time, it was proposed that the vaporization of copper or other metals by the arc produced life-threatening blast pressures. Recent research into arc blast phenomena does not support this theory. While it is true that copper expands several thousand times in volume when transitioning from metal to vapor, only a small amount of copper that is in or is immediately adjacent to the arc plasma stays in a vapor state. Beyond the plasma, the copper vapor drops below the vaporization temperature and condenses into molten copper or reacts chemically and becomes a copper compound.

Research has shown that what was considered to be arc blast pressure is primarily a function the instantaneous heating, expansion, and containment of the air surrounding the arc in an electrical equipment enclosure, which can cause the enclosure to fail. Enclosure failure can result in a sudden release of pressure and a mechanical transfer of energy caused by contact with ejected enclosure components.

Physical trauma can result from being struck by enclosure components. Most of the documented injuries have been from door ejections, broken parts of the equipment caused by the arcing event, and shattered insulators. Concussions and falls have also been recorded.

Research indicates that the pressures developed are substantially less than previously proposed, and that the pressure release is negligible for an open enclosure (i.e., if the enclosure door is open). Research has also shown that there is no correlation of pressure release to incident energy.

The release of mechanical energy should be considered in the risk assessment process. Protective measures could include operating equipment while standing to the side of the equipment or use of remote racking or other measures to prevent “line-of-fire” injuries.

The release of mechanical energy is normally prevented by arc-resistant equipment as such equipment contains and redirects any pressure away from the worker, provided the equipment is in the arc-resistant configuration.

See Hoagland et al. (2017 and 2020) for more information on the release of mechanical energy caused by an electric arc.

K.3.4 Acoustic (Sound) Energy.

The instantaneous conversion of metals and gases to plasma can produce sound pressure levels in excess of 130 dB. According to the Centers for Disease Control and Prevention (CDC), an instantaneous sound pressure level of 120 dB or higher can cause immediate harm to hearing.

The acoustic energy component of arc energy is addressed to a limited extent by the requirement in this standard to use hearing protection when within the arc flash boundary. See Gordon et al., “Modeling the Conversion of Electrical Energy to Acoustic Energy for Arcs and Applications for the Selection of PPE” for more information on the release of acoustic energy caused by an electric arc.

K.3.5 Light Energy.

The name of the phenomenon, arc flash, came from the intense light produced by an electric arc. The light emitted by an arc contains intense levels in the infrared (IR), visible (light), and ultraviolet (UV). These intense components impinging upon a worker and clothing are a significant portion of thermal injury discussed in K.3.2 , for some cases up to 50 percent. Documented test research indicates that the light intensity produced by an arcing event depends on a variety of factors such as voltage, current, arc length, and current risetime.

Tests also indicate that the relative luminosity (i.e., the brightness that is observed by someone in front of the arcing event) is affected by proximity to the arc, conductor configuration (vertical or horizontal), arc length, and whether the arc is in an enclosure, and if so, the enclosure dimensions.

The light energy component of arc energy is not currently specifically addressed by the requirements of this standard. However, AR PPE clothing protects from the light, especially the UV. AR rated face shields and suit hoods are also rated to block the arc UV.

See Lee et al. (2015) and Rau et al. (2017) for more information on the release of light energy caused by an electric arc.

~~**K.4** Arc Blast.~~

~~The tremendous temperatures of the arc cause the explosive expansion of both the surrounding air and the metal in the arc path. For example, copper expands by a factor of 67,000 times when it turns from a solid to a vapor. The danger associated with this expansion is one of high pressures, sound, and shrapnel. The high pressures can easily exceed hundreds or even thousands of pounds per square foot, knocking workers off ladders, rupturing eardrums, and collapsing lungs. Finally, material and molten metal are expelled away from the arc at speeds exceeding 1120 km/hr (700 mph), fast enough for shrapnel to completely penetrate the human body.~~

K.4 Other Information.

For additional information, the following documents are available:

Occupational Injuries From Electrical Shock and Arc Flash Events Final Report, ~~by~~ Richard Campbell~~,~~ and David Dini, ~~Sponsored by The~~ Fire Protection Research Foundation, Quincy, MA.

Occupational Electrical Injuries in the US, 2003–2009, by James Cawley and Brett C. Banner, ESFI.

Technical paper ESW 2012-24 presented at IEEE ESW conference, *Arc Flash Hazards, Incident Energy, PPE Ratings and Thermal Burn Injury — A Deeper Look*, by Tammy Gammon, Wei-Jen Lee, and Ben Johnson.

Technical Paper ESW 2015-17 presented at IEEE ESW conference, OSHA Subpart V, *Electric Power and Distribution*, April 11, 2014.

Hoagland, E. H., Maurice, C., Haines, A., and Maurice, A., "Arc Flash Pressure Measurement by the Physical Method, Effect of Metal Vapor on Arc Blast," *IEEE Transactions on Industry Applications* , 53(2): 1576–1582, 2017.

Hoagland, E. H., Maurice, C., Haines, A., and Maurice, A., "Arc Flash Pressure and Door Ejection Measurement," *IEEE Transactions on Industry Applications* , 56(4): 3297–3305, 2020.

Lee, W., Zhang, Z., Rau, S., Gammon, T., Johnson, B. C., and Beyreis, J., "Arc Flash Light Intensity Measurement System Design," *IEEE Transactions on Industry Applications* , 51(5): 4267–4274, 2015.

Rau, S., Zhang, Z., Lee, W., and Dini, D. A., "Arc Flash Visible Light Intensity as Viewed From Human Eyes," *IEEE Transactions on Industry Applications* , 53(5): 5068–5077, 2017.

Gordon, L. and Bradley, J., "Modeling the Conversion of Electrical Energy to Acoustic Energy for Arcs and Applications for the Selection of PPE," IEEE Paper No. ESW 2024-09 presented at the IEEE IAS Electrical Safety Workshop, Tucson, AZ, 2024.

Supplemental Information

File Name	Description	Approved
70E_FR-74_Annex_K.docx		

Submitter Information Verification

Committee: EEW-AAA

Submittal Date: Wed Aug 07 11:51:59 EDT 2024

Committee Statement

Committee Statement: Annex K was revised by updating the information regarding electrical injuries, updating the knowledge of electrical hazards and removing redundant information.

Response Message: FR-74-NFPA 70E-2024

Public Input No. 233-NFPA 70E-2024 [Annex K]

Public Input No. 99-NFPA 70E-2024 [Section No. K.1]

Public Input No. 69-NFPA 70E-2024 [Section No. K.2]

First Revision No. 75-NFPA 70E-2024 [Section No. L.1]

L.1 Application of Safeguards.

This informative annex ~~permits~~ provides a typical application of safeguards in electrolytic areas where electrical hazards exist. Take, for example, an employee working on an energized cell. The employee uses manual contact to make adjustments and repairs. Consequently, the exposed energized cell and grounded metal floor could present an electrical hazard. Safeguards for this employee can be provided in the following ways:

(1) Protective boots can be worn that isolate the employee's feet from the floor and that provide a safeguard from the electrical hazard.

(2) Protective gloves can be worn that isolate the employee's hands from the energized cell and that provide a safeguard.

(3) If the work task causes severe deterioration, wear, or damage to personal protective equipment (PPE), the employee might have to wear both protective gloves and boots.

(4) A permanent or temporary insulating surface can be provided for the employee to stand on to provide a safeguard.

(5) The design of the installation can be modified to provide a conductive surface for the employee to stand on. If the conductive surface is bonded to the cell, a safeguard will be provided by voltage equalization.

(6) Safe work practices can provide safeguards. If protective boots are worn, the employee should not make long reaches over energized (or grounded) surfaces such that his or her elbow bypasses the safeguard. If such movements are required, protective sleeves, protective mats, or special tools should be used. Training on the nature of electrical hazards and proper use and condition of safeguards is, in itself, a safeguard.

(7) The energized cell can be temporarily bonded to ground.

L.2 Nonelectrical Hazards for Consideration.

Electrolytic cells present nonelectrical hazards to the employee in which some arc-rated clothing materials might not be compatible with contamination and a potential chemical reaction. It might be necessary to provide PPE or safeguards to address both the arc flash and chemical hazards.

Submitter Information Verification

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Committee Statement

Committee Statement: The word "permits" was changed to "provides" as the annex material is providing a typical application of safeguards. Additional information was added to address non-electrical hazards of electrolytic cells.

Response Message: FR-75-NFPA 70E-2024

Public Input No. 174-NFPA 70E-2024 [Sections L.1, L.2]

First Revision No. 76-NFPA 70E-2024 [Section No. O.1]

O.1 Introduction.

~~This informative annex addresses the responsibilities of the facility owner or manager or the employer having responsibility for facility ownership or operations management to perform a risk assessment during the design of electrical systems and installations.~~

O.1.1

This informative annex covers employee safety-related design concepts for electrical equipment and installations in workplaces covered by the scope of this standard. This informative annex discusses design considerations that have impact on the application of the safety-related work practices only.

O.1.2

This informative annex does not discuss specific design requirements. The facility owner or manager or the employer should choose design options that eliminate hazards or reduce risk and enhance the effectiveness of safety-related work practices.

Supplemental Information

File Name	Description	Approved
70E_FR-76_O.1.docx		

Submitter Information Verification

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Committee Statement

Committee Statement: The modification to the introduction better reflects the content of Informative Annex O.

Response Message: FR-76-NFPA 70E-2024

Public Input No. 156-NFPA 70E-2024 [Annex O]

First Revision No. 77-NFPA 70E-2024 [Annex O [Title Only]]

Employee Safety-Related Design Concepts ~~and Facility Owner Responsibilities~~

Submitter Information Verification

Committee: EEW-AAA
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Committee Statement

Committee Statement: The modification to the title better reflects the content of Informative Annex O.
Response Message: FR-77-NFPA 70E-2024

First Revision No. 78-NFPA 70E-2024 [Section No. R.4.3]

R.4.3 Arc Blast Hazard.

Capacitors can have a significant arc blast hazard due to the very high short-circuit current involved. The effects of the acoustic ~~electric~~ shock wave can rupture eardrums and collapse lungs. While hearing protection should be used above 100 joules to mitigate against hearing damage, there is no PPE for protection against lung collapse, which becomes a hazard above 122 kJ.

Submitter Information Verification

Committee: EEW-AAA

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Committee Statement

Committee Statement: The word “electric” was removed as this section is concerned with acoustic shock waves.

Response Message: FR-78-NFPA 70E-2024

Public Input No. 57-NFPA 70E-2024 [Section No. R.4.3]

Public Input No. 175-NFPA 70E-2024 [Section No. R.4.3]