AGENDA

NFPA Technical Committee on Electrical Safety in the Workplace (EEW-AAA)
NFPA 70E Second Draft Meeting (A2026)

August 19 - 21, 2025
8 a.m. – 5 p.m. (ET)
Indianapolis, Indiana
To join the meeting, please contact scaldwell@nfpa.org

1. **Call to order.** Louis Barrios, Chair.
2. **Introductions.** See committee roster attached.
3. **Chair report.** Louis Barrios.
4. **Staff liaison report.** Christopher Coache.
5. **Previous meeting minutes.** July 30 - August 2, 2024, Memphis, TN. See attached.
6. **NFPA 70E Second Draft.**
   a. **Public Comments.** See attached.
   b. **Task group report(s).**
      i. **TG 1 Articles 90 and 100**. Rodney West, Chair.
      ii. **TG 2 Articles 105 and 110**. Mark McNellis, Chair.
      iii. **TG 3 Article 120**. Jason Wolf and Tom Norwood, Chairs.
      iv. **TG 4 Article 130 Sections .1, .2, 4, .8, .9, .10, .11 and .12**. Greg Steinman, Chair.
      v. **TG 5 Article 130 Section .5 and .7, and ac tables**. Jim Dollard, Chair.
      vi. **TG 6 Chapter 2**. Ron Widup, Chair.
      vii. **TG 7 Chapter 3 and dc tables**. Bobby Grey and Heath Garrison, Chairs.
      viii. **TG 8 Annexes**. Mark Hilbert, Chair.
      ix. **TG 9 Articles 90 and 100**. Rodney West, Chair.
7. **Presentation(s).**
      i. **PCs on 130.2(A)(2)**. Kyle Krueger, NECA.
8. **Other Business.**
9. **Future meetings.**
   a. **Next revision cycle planning.**
10. **Adjournment.**

Address List No Phone

07/22/2025
Christopher Coache
EEW-AAA

Electrical Safety in the Workplace
National Electrical Code®

Louis A. Barrios **U** 1/18/2001
Chair **EEW-AAA**
Retired
27803 Liberty Heights Lane
Fulshear, TX 77441
American Petroleum Institute
Alternate: Eric Glaude

Paul D. Barnhart **RT** 08/17/2018
Principal **EEW-AAA**
UL Solutions
12 Laboratory Drive
Research Triangle Park, NC 27709-3995
Alternate: Amanda H. Newsom

Jeffrey Paul Conkwright **U** 12/6/2017
Principal **EEW-AAA**
Eastern Kentucky University
521 Lancaster Avenue
Richmond, KY 40475

Daryld Ray Crow **M** 10/1/1995
Principal **EEW-AAA**
DRC Consulting, Ltd.
143 S. East Ridge Drive
St. George, UT 84790
The Aluminum Association, Inc.
Alternate: Karl M. Cunningham

James T. Dollard, Jr. **SE** 4/14/2005
Principal **EEW-AAA**
Self
26B Jones Avenue
Flourtown, PA 19031

Thomas B. Dyson **U** 08/11/2014
Principal **EEW-AAA**
Ameren Services
1901 Chouteau Avenue
St. Louis, MO 63103-3003
Edison Electric Institute

Ernest J. Gallo **U** 08/11/2014
Principal **EEW-AAA**
NEBScore, Inc.
37 Elmwood Road
Florham Park, NJ 07932
Alliance for Telecommunications Industry Solutions
Alternate: Trevor N. Bowmer

Bobby J. Gray **E** 4/5/2001
Principal **EEW-AAA**
Hoydar/Buck, Inc.
207 Lone Piper Drive
Chelan, WA 98816
Alternate: Larry D. Perkins

Jarod Guier **M** 04/09/2025
Principal **EEW-AAA**
Cintas Corporation
6800 Mason Boulevard
Mason, OH 45040

Donald Charles Hacke **IM** 08/08/2019
Principal **EEW-AAA**
Kone Inc.
325 - 19th Street
Moline, IL 61265
National Elevator Industry Inc.
Alternate: Sunny Kalola

William R. Harris **IM** 8/17/2015
Principal **EEW-AAA**
Barton Malow Company
26500 American Drive
Southfield, MI 48034

Palmer L. Hickman **L** 10/3/2002
Principal **EEW-AAA**
Electrical Training Alliance
5001 Howerton Way, Suite N
Bowie, MD 20715-4459
International Brotherhood of Electrical Workers
Alternate: Michael Anthony Alamprese

Address List No Phone

07/22/2025
Christopher Coache
EEW-AAA

Electrical Safety in the Workplace
National Electrical Code®

Mark R. Hilbert **E** 08/17/2018
Principal **EEW-AAA**
MR Hilbert Electrical Inspections & Training
32 Neal Hill Road
Center Tuftonboro, NH 03816-5070
International Association of Electrical Inspectors

Chaitanya Katekar **RT** 08/10/2022
Principal **EEW-AAA**
Intertek
Stafff Engineer
1809 10th Street, Suite 400
Plano, TX 75074

Scott Lubaczewski **L** 12/04/2024
Principal **EEW-AAA**
UAW-General Motors Joint Programs
5505 E. Thirteen Mile Road
Warren, MI 48092
International Union, United Automobile, Aerospace & Agricultural Implement Workers of America-UAW
Alternate: James Holton

Terrance L. McKinch **IM** 08/03/2016
Principal **EEW-AAA**
Nexamp
3278 South Duffield Road
Lennon, MI 48449

Mark McNellis **U** 7/28/2006
Principal **EEW-AAA**
Sandia National Laboratories
PO Box 5800, MS0984
Albuquerque, NM 87185
Alternate: Heath Garrison

Charles R. Miller **SE** 10/29/2012
Principal **EEW-AAA**
Lighthouse Educational Services
Charles R. Miller Electrical Education & Training
523 Five Oaks Boulevard
Lebanon, TN 37087
Alternate: Jim Phillips

Daleep C. Mohla **U** 01/14/2005
Principal **EEW-AAA**
DCM Electrical Consulting Services, Inc.
4702 Summer Lakes
Missouri City, TX 77459-3958
IEEE-IAS/PES JTCC
Alternate: Paul Dobrowsky

James K. Niemira **M** 12/8/2015
Principal **EEW-AAA**
S&C Electric Company
8940 Ewing Avenue
Evanston, IL 60203-1907

Thomas D. Norwood **SE** 10/4/2001
Principal **EEW-AAA**
Cadick Corporation
111 Hidden Lane
Red Oak, TX 75154
Alternate: Al Winfield

David A. Pace **U** 7/22/1999
Principal **EEW-AAA**
Olin Corporation
1638 Industrial Road
McIntosh, AL 36553
American Chemistry Council
Alternate: Roy K. Sparks, III

Duke W. Schamel **IM** 11/29/2023
Principal **EEW-AAA**
Electrical Service Solutions, Inc.
16835 Algonquin Street, #377
Huntington Beach, CA 92649
Independent Electrical Contractors, Inc.
Alternate: Eric Zane Simmons

James G. Stallcup **SE** 1/1/1991
Principal **EEW-AAA**
Grayboy, Inc.
6800 Meadow Creek
North Richland Hills, TX 76182

Address List No Phone

07/22/2025
Christopher Coache
EEW-AAA

Electrical Safety in the Workplace
National Electrical Code®

Gregory J. Steinman **M** 08/03/2016
Principal **EEW-AAA**
ABB Installation Products Inc.
860 Ridgelake Boulevard
Memphis, TN 38120
National Electrical Manufacturers Association
Alternate: Vincent Della Croce

Samuel B. Stonerock **SE** 10/20/2010
Principal **EEW-AAA**
Southern California Edison Company
3 Innovation Way
Pomona, CA 91768-2560
ASTM International

John M. Tobias **U** 10/18/2011
Principal **EEW-AAA**
US Department of the Army
CECOM, Attn: AMEL-SFS-I
3200 Raritan Avenue
Aberdeen Proving Grounds, MD 21005
Alternate: Dawn M. Carney

Rodney J. West **M** 7/29/2005
Principal **EEW-AAA**
Schneider Electric
5735 College Corner Road
Oxford, OH 45056-1070
Alternate: Scott Cavanaugh

Ron Widup **IM** 7/17/1998
Principal **EEW-AAA**
Shermco Industries
2425 East Pioneer Drive
Irving, TX 75061
InterNational Electrical Testing Association
Alternate: Daniel Hook

Jason Wolf **IM** 12/06/2017
Principal **EEW-AAA**
The ESCO Group
3450 3rd Street
Marion, IA 52302
National Electrical Contractor Association (NECA)
Alternate: Bradley Caldwell

Michael Anthony Alamprese **L** 03/20/2023
Alternate **EEW-AAA**
IBEW Local 11
6023 Garfield Avenue
Commerce, CA 90040
Principal: Palmer L. Hickman

Trevor N. Bowmer **U** 12/07/2022
Alternate **EEW-AAA**
Bunya Telecom Consulting, LLC
1792 Finntown Road
Waldoboro, ME 04572
Alliance for Telecommunications Industry Solutions
Principal: Ernest J. Gallo

Bradley Caldwell **IM** 08/23/2023
Alternate **EEW-AAA**
Morrow Meadows
231 Benton Court
City of Industry, CA 91789
National Electrical Contractor Association (NECA)
Principal: Jason Wolf

Dawn M. Carney **U** 12/02/2020
Alternate **EEW-AAA**
US Army Corps of Engineers
25997 Chamberlain Drive
Daphne, AL 36526
Principal: John M. Tobias

Scott Cavanaugh **M** 08/29/2024
Alternate **EEW-AAA**
Schneider Electric
6700 Tower Circle
Suite 500
Franklin, TN 37067
Principal: Rodney J. West

Karl M. Cunningham **M** 04/11/2018
Alternate **EEW-AAA**
Self Employed
6100 W. Ost-West Street
Homosassa, FL 34446
The Aluminum Association, Inc.
Principal: Daryld Ray Crow

Address List No Phone

07/22/2025
Christopher Coache
EEW-AAA

Electrical Safety in the Workplace
National Electrical Code®

Vincent Della Croce **M** 12/07/2022
Alternate **EEW-AAA**
Siemens
6167 NW East Deville Circle
Port Saint Lucie, FL 34986
National Electrical Manufacturers Association
Principal: Gregory J. Steinman

Paul Dobrowsky **U** 10/18/2011
Alternate **EEW-AAA**
Innovative Technology Services
5701 South Holley Road
Holley, NY 14470-9754
IEEE-IAS/PES JTCC
Principal: Daleep C. Mohla

Heath Garrison **U** 3/7/2013
Alternate **EEW-AAA**
National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
Principal: Mark McNellis

Eric Glaude **U** 8/2/2010
Alternate **EEW-AAA**
Chevron
1400 Smith Street
Houston, TX 77002
American Petroleum Institute
Principal: Louis A. Barrios

James Holton **L** 04/09/2025
Alternate **EEW-AAA**
International Union UAW Health and Safety Department
8000 East Jefferson
Detroit, MI 48442
Principal: Scott Lubaczewski

Daniel Hook **IM** 12/07/2021
Alternate **EEW-AAA**
CBS Field Services
2647 Wellington Street
Salt Lake City, UT 84106
InterNational Electrical Testing Association
Principal: Ron Widup

Sunny Kalola **IM** 08/10/2022
Alternate **EEW-AAA**
TK Elevator
788 Circle 75 Parkway, SE
Suite 500
Atlanta, GA 30339
National Elevator Industry Inc.
Principal: Donald Charles Hacke

Amanda H. Newsom **RT** 08/24/2021
Alternate **EEW-AAA**
UL LLC
12 Laboratory Drive
PO Box 13995
Research Triangle Park, NC 27709-3995
Principal: Paul D. Barnhart

Larry D. Perkins **E** 10/27/2009
Alternate **EEW-AAA**
US Department of Energy
104 Redbud Drive
Harriman, TN 37748
Principal: Bobby J. Gray

Jim Phillips **SE** 04/03/2019
Alternate **EEW-AAA**
Brainfiller, Inc.
PO Box 12024
Scottsdale, AZ 85267
Principal: Charles R. Miller

Eric Zane Simmons **IM** 08/24/2021
Alternate **EEW-AAA**
Helix Electric
6795 Flanders
San Diego, CA 92121
Independent Electrical Contractors, Inc.
Principal: Duke W. Schamel

Roy K. Sparks, III **U** 12/06/2017
Alternate **EEW-AAA**
Eli Lilly and Company
Lilly Technology Center South
1400 West Raymond Street
Drop Code 4005
Indianapolis, IN 46221-2004
American Chemistry Council
Principal: David A. Pace

Address List No Phone

07/22/2025
Christopher Coache
EEW-AAA

Electrical Safety in the Workplace
National Electrical Code®

Al Winfield **SE** 08/24/2021
Alternate **EEW-AAA**
Cadick Corporation
216 Port Road
Binghamton, NY 13901
Principal: Thomas D. Norwood

Daniel T. Roberts **SE** 08/24/2021
Nonvoting Member **EEW-AAA**
Electrical Safety Solutions
Electrical Safety Consultant
823 Constellation Drive
Mississauga, ON L5R 2V6 Canada
Canadian Standards Association
Alternate: Virginia Balitski

Virginia Balitski **SE** 08/24/2021
Alt. to Nonvoting Member **EEW-AAA**
Magna IV Engineering
1103 Parsons Road, SW
Edmonton, AB T6X 0X2 Canada
Canadian Standards Association
Principal: Daniel T. Roberts

David M. Wallis **O** 10/10/1998
Member Emeritus **EEW-AAA**
Consultant
9728 Denrob Court
Parkville, MD 21234-1861

Christopher Coache 3/13/2015
Staff Liaison **EEW-AAA**
National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471

MINUTES

NFPA Technical Committee on Electrical Safety in the Workplace (EEW-AAA)
NFPA 70E First Draft Meeting (A2026)

July 30-August 2, 2024
8:00 am – 5:00pm (Central)

Hybrid Meeting
The Central Station Memphis, Memphis, TN

1. **Call to order.** Louis Barrios, chair, called the meeting to order at 8:00 am on July 30.
2. **Introductions.** Attendees introduced themselves and identified their affiliation and NFPA staff took attendance.
3. **Chair report.** Louis Barrios welcomed attendees and provided an overview of the meeting.
4. **Staff liaison report.** Christopher Coache provided an overview of the standards development process and the revision cycle schedule.
   a. There were no declarations of a committee member representing another company, organization, or interest category.
5. **Previous meeting minutes.** The minutes from August 2022, Kansas City, Mo were approved without revision.
6. **NFPA 70E First Draft.**
   a. **Review of Public Inputs.** The Technical Committee reviewed the Public Inputs and developed First Revisions and Committee Inputs as necessary. These will be available in the First Draft Report at www.nfpa.org/70E.
   b. **Task group reports.** The following task groups provided their reports and recommendations.
      i. Task Group 1. Mark McNellis, Chair. Scope: PIs covering Article 105 and Article 110. The task group has been discharged with thanks. See attached.
      ii. Task Group 2. Tom Norwood, Chair. Scope: PIs covering Article 120. The task group has been discharged with thanks. See attached.
      iii. Task Group 3. Ron Widup, Chair. Scope: PIs covering Chapter 2. The task group has been discharged with thanks. See attached.
      iv. Task Group 4. Bobby Gray, Chair. Scope: PIs coving Chapter 3 and dc Tables 130.4(E)(b) and 130.7(C)(15)(b). The task group has been discharged with thanks. See attached.

v. Task Group 5. Greg Steinman, Chair. Scope: PIs covering 130.1, 130.2, 130.4, 130.8, 130.9, 130.10, 130.11, 130.12+ (ac) Table 130.4(E) (a). The task group has been discharged with thanks. See attached.

vi. Task Group 6. Jim Dollard, Chair. Scope: PIs covering 130.5, 130.7, 130.5(C), 130.5(G), 130.7(C)(7)(a), 130.7(C)(7)(b), 130.7(C)(14), 130.7(C)(15)(a), 130.7(C)(15)(c), 130.7E+ (ac) Tables. The task group has been discharged with thanks. See attached.

vii. Task Group 7. Mark Hilbert, Chair. Scope: PIs covering Annexes. The task group has been discharged with thanks. See attached.

viii. Task Group 8. Rod West, Chair. Scope: PIs coving Article 90 and Article 100. The task group has been discharged with thanks. See attached.

c. **Presentation(s).** The committee heard presentations from the following individuals.

i. **Reorganization of Chapter 3.** Lloyd B. Gordon, Specialized Electrical Safety Services. Presentation attached.

ii. **EDLC supercapacitors**. Lloyd B. Gordon, Specialized Electrical Safety Services. Presentation attached.

iii. **Reducing Risk When Performing Energized Work on Batteries**. David Rosewater, Sandia National Laboratories. Presentation attached.

iv. **DC Arc Flash**. Lloyd B. Gordon, Specialized Electrical Safety Services. Presentation attached.

v. **Digitization of NFPA 70E**. Troy Ruggiero, Boxlock. Presentation attached.

d. **New task groups.** The following task groups were appointed to work subsequent to the meeting:

i. **TG DC Tables**. TG Chair: Bobby Gray. Members: Ernie Gallo, Trevor Bowmer, Ray Crow, Heath Garrison, Mark McNellis, Larry Perkins. Non-TC members: Lloyd Gordon, David Rosewater, Bill Cantor, Steve Edley. Scope: Review and revise DC tables for Second Draft.

7. Other Business.

8. Future meetings. The next committee meeting will be July – August 2025. A meeting notification will be posted at www.nfpa.org/70Enext when the meeting is scheduled.

9. Adjournment. The meeting was adjourned at 10:00 am on August 2.

Attendees

✓	**Barrios, Louis**	Chair	American Petroleum Institute
✓	**Barnhart, Paul**	Principal	UL Solutions
	Chybowski, Steven	Principal	Rockwell Automation Inc.

	Conkwright, Jeffrey	Principal	Eastern Kentucky University
✓	**Crow, Daryld**	Principal	The Aluminum Association, Inc.
✓	**Dollard, James**	Principal	Self
	Dyson, Thomas	Principal	Edison Electric Institute
✓	**Gray, Bobby**	Principal	Hoydar/Buck, Inc.
✓	**Hacke, Donald**	Principal	National Elevator Industry Inc.
*	**Harris, William**	Principal	Barton Malow Company
✓	**Hickman, Palmer**	Principal	International Brotherhood of Electrical
✓	**Hilbert, Mark**	Principal	International Association of Electrical
	Katekar, Chaitanya	Principal	Intertek Testing Services
✓	**McNellis, Mark**	Principal	Sandia National Laboratories
✓	**Miller, Charles**	Principal	Lighthouse Educational Services
✓	**Mohla, Daleep**	Principal	IEEE-IAS/PES JTCC
✓	**Niemira, James**	Principal	S&C Electric Company
✓	**Norwood, Thomas**	Principal	Cadick Corporation
✓	**Pace, David**	Principal	American Chemistry Council
	Riddle, Larry	Principal	Amazon
✓	**Schamel, Duke**	Principal	Independent Electrical Contractors, Inc.
	Stallcup, James	Principal	Grayboy, Inc.
*	**Steinman, Gregory**	Principal	National Electrical Manufacturers
✓	**Stonerock, Samuel**	Principal	ASTM International
	Tobias, John	Principal	US Department of the Army
✓	**West, Rodney**	Principal	Schneider Electric
✓	**Widup, Ron**	Principal	InterNational Electrical Testing Association
✓	**Wolf, Jason**	Principal	National Electrical Contractor Association
	Bowmer, Trevor	Voting Alternate	Alliance for Telecommunications Industry
✓	**Alamprese, Michael**	Alternate	International Brotherhood of Electrical
✓	**Caldwell, Bradley**	Alternate	National Electrical Contractor Association
✓	**Carney, Dawn**	Alternate	US Army Corps of Engineers
✓	**Cunningham, Karl**	Alternate	The Aluminum Association, Inc.

	Della Croce, Vincent	Alternate	National Electrical Manufacturers
✓	**Dobrowsky, Paul**	Alternate	IEEE-IAS/PES JTCC
✓	**Garrison, Heath**	Alternate	National Renewable Energy Laboratory
✓	**Glaude, Eric**	Alternate	American Petroleum Institute
*	**Hook, Daniel**	Alternate	InterNational Electrical Testing Association
	Kalola, Sunny	Alternate	National Elevator Industry Inc.
*	**McKinch, Terrance**	Alternate	Signal Energy Constructors
*	**Newsom, Amanda**	Alternate	UL Solutions
	Perkins, Larry	Alternate	US Department of Energy
✓	**Phillips, Jim**	Alternate	Brainfiller, Inc.
	Simmons, Eric	Alternate	Independent Electrical Contractors, Inc.
*	**Sparks, Roy**	Alternate	American Chemistry Council
	Stallcup, James	Alternate	Grayboy, Inc.
✓	**Winfield, Al**	Alternate	Cadick Corporation
✓	**Roberts, Daniel**	Nonvoting Member	Canadian Standards Association
	Balitski, Virginia	Alt. to Nonvoting	Canadian Standards Association
✓	**Wallis, David**	Member Emeritus	Consultant
✓	**Coache, Christopher**	Staff Liaison	National Fire Protection Association

Guests:
Lloyd Gordon, Specialized Electrical Safety Services
Terry Becker, The Becker Electrical Safety
Scott Cavanaugh, Schnieder Electric
*Steve Edley, Atlas Power
*Kevin Arnold, Eaton
*Ernie Gallo
*Jim Pollard, Surewerx
Phil Allen, Grace Technologies
*Chaitanya Katekar, Intertek
Wayne Combs, General Motors
Scot Lubaczewski, United Auto Workers
Christel Hunter, Cerrowire
Thomas McGraw, General Motors
David Rosewater, Sandia
*Joseph Schomaker
Troy Ruggiero, BoxLock
Shelly DeGrate, Grace Technologies

*Wes Wheeler, NECA
*Chad Duffy, NFPA

*Participated by teleconference
Total number in attendance: 55

DOC #	70E
TG #/NAME	Articles 105 and 110
TG CHAIR	Mark McNellis
TG MEMBERS	Daniel Roberts, Dawn Carney, Al Winfield, Jennifer Martin, Ray Crow, Amanda Newsome, Bill Harris, Larry Riddle, Chaitanya Katekar, Jesse Duvuvei

All task group **proposed** motions, revisions, and entries displayed below are for consideration by the entire TC.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
105.2	COMMITTEE INPUT			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	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 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: • The title of Article 105 has been revised to more accurately reflect the content. • 105.1 has been revised to more accurately reflect the content of Article 105, which is mostly regarding employer and employee responsibilities. • 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 2.1.1: “The Introduction shall contain the scope, purpose, and administrative provisions.” 2.1.4.4 requires each Article to have a scope but does not require an Article to have a purpose.			

Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	ARTICLE 105 ~~Application of Safety-Related Work Practices and Procedures~~Employer and Employee Responsibilities **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. ~~**105.2 Purpose.** These practices and procedures are intended to provide for employee safety relative to electrical hazards in the workplace.~~ Informational Note: For general categories of electrical hazards, see Informative Annex K.

Response to PI 38 if the TC AGREES with the TG's approach to revise 105.1 and delete 105.2.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
105.2	38			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	**105.2 Purpose.** ~~These~~ The Article 105 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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	105.2 has been deleted as it is inaccurate, given the change in scope of Article 105, and it is unnecessary. Additionally, no other Article, other than Article 90 – Introduction, contains a Purpose section. In accordance with NEC Style Manual 2.1.1: "The Introduction shall contain the scope, purpose, and administrative provisions." 2.1.4.4 requires each Article to have a scope but does not require an Article to have a purpose.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			

Response to PI 38 if the TC DOES NOT AGREE with the TG's approach to revise 105.1 and delete 105.2.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
105.2	38			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	**105.2 Purpose.** ~~These~~ The Article 105 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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	105.2 has been edited to clarify that the intent of article 105 was to introduce and provide introduction to chapter one.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	105.2 Purpose. ~~These~~ The practices and procedures of Chapter One 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.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
105.3(A)	8			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	(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 ~~employees with~~ and document employee training in the employer's safety-related work practices and procedures.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			

Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
	The revision is made to correlate 105.3(A) with similar requirements throughout the standard to document employee training. Titles were provided to the second level subdivisions to comply with the NEC Style Manual Section 2.1.6.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	105.3 Responsibility. **(A) Employer Responsibility.** The employer shall have the following responsibilities: (1) Safety-Related Work Practices. Establish, document, and implement the safety-related work practices and procedures required by this standard. (2) Training. Provide ~~employees with~~and document employee training in the employer's safety-related work practices and procedures.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
105.5	39			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	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 for application of safety-related work practices and procedures. Article 110 provides general requirements for electrical safety-related work practices and procedures. Article 120 provides requirements for establishing and verifying an electrically safe work condition. Article 130 provides requirements for work involving electrical hazards.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	Statement: The revision is made to correlate the 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. "And verifying" is not added to the reference to Article 120 as the current language correlates with 120.1 Scope statement "This article cover requirements for establishing an electrically safe work condition." The word "provides" is replaced with "covers" in the references to Articles 105, 110, 120 and 130 to correlate with the scope statements in those Articles.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. **105.4 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 for work involving electrical hazards.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.2(B)	92			☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions show. (B) When Required. Energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts 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~~ restricted 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Use of the limited approach boundary to trigger the requirement to place electrical conductors and circuit parts into an electrically safe work condition has existed in the standard since the 2009 edition and existed in prior editions where the limited approach boundary was referred to as “working on or near.” Insufficient technical substantiation has been provided to revise the requirement to apply only when the employee is within the restricted approach boundary.
First Revision Text (FR) Clean current edition text is	**Must be in shown in track changes**.

provided to be revised. Do not delete for a resolve	

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.2(B)	116			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. (B) When Required. Energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts shall be put into an electrically safe work condition before an employee performs work if any of the following conditions exist: *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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other FRs, etc.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	Exception No. 4 Informational Note is not revised as it provides examples only of some situations when an employer must first demonstrate that de-energizing could introduce additional hazards or increased risk before permitting work to proceed with the equipment energized.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.2(B)	165			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	CDC Note: only identified revisions shown (B) When Required. Energized electrical conductors and circuit parts ~~operating at voltages equal to or greater than 50 volts~~ that present the risk of injury due to exposure to electrical hazards 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
	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 “or where an electrical hazard exists” has been added to the requirement to address situations where an electrical hazard might exist below 50 volts. The technical committee notes that 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.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. **(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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.2(B) Exception No. 2	Committee Input			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	110.2(B) Exception No. 2 to the requirement to create an electrically safe work condition is revised to clarify that insertion or removal (racking) of a circuit breaker might be included in creating an electrically safe work condition in accordance with 120.6(3).			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	Exception No. 2: An energized disconnecting means or isolating element shall be permitted to be operated, and draw-out type circuit breakers removed or inserted (racked) 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.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.2(B)	203			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC Note: only identified revisions shown (B) When Required. Energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts 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. *Exception No. 3: Racking in or out of circuit breakers shall be permitted while the equipment containing the circuit breaker being racked is energized and the employer can demonstrate that the*			

	equipment is in a normal operating condition and the circuit breaker cannot be racked while in the closed position.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
	The exception to permit insertion or removal (racking) of draw-out type circuit breakers in or out of energized equipment is not added as a general exception as it is up to the manufacturer to classify whether doing so is "normal operation." See First Revision to 110.2(B) Exception No. 2 that provides an exception for racking related to achieving an electrically safe work condition.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.2(B)	212			☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

CDC Note: only identified revisions shown

(B) When Required.

Energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts 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 it can be demonstrated that 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.~~
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	"Normal operating condition" is not deleted in 110.2(B) and relocated to Article 100 as the description does and must contain requirements to be useful. Per NEC Style Manual 2.1.2.5 Style "Definitions shall not contain requirements or recommendations."
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.2(B)	261			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC Note: only identified revisions shown (B) When Required. ~~Energized electrical~~ Electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts shall be ~~put~~ deenergized by putting them 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The phrase “put into an electrically safe work condition” is not revised as it is consistent with similar phrasing throughout the standard. See 130.1. The proposed revision is redundant and does not add clarity.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.2(B)	262			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC Note: only identified revisions shown (B) When Required. ~~Energized~~ All energized electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts 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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

	The use of “all” as a determiner (i.e. qualifier) before the subject “energized electrical conductors and circuit parts” is unnecessary as the requirement is clear as currently phrased.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.2(C)	30			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	(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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The first sentence in 110.2(C) regarding when an electrically safe work condition is considered to be established is not relocated to 120.6 as it provides the context for the second sentence regarding the use of safe work practices until the condition is established.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.2(C)	Committee Input			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
	This first revision is made to comply with the NEC Style Manual section 2.1.6.3 Subdivisions and 2.1.6.3.2 Subdivision Titles.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(C) Requirements Until Established. (1) When Considered to be 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.3(C)	117			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	(C) Condition of Maintenance. The electrical safety program shall include elements that consider condition of maintenance of electrical equipment and systems. Informational Note: See NFPA 70B, *Standard for Electrical Equipment Maintenance*, for more detail on evaluating condition of maintenance.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	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	**Technical reason for resolving or for not making some of the proposed changes.**			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. (B) 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 Assessing the Condition of Maintenance.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.3(I)(1)	216			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	Informational Note No. 2: An emergency response plan could include actions to be taken during an electrical injury emergency, contingency plans for when equipment is unintentionally de-energized while performing energized work due to additional hazards or increased risk, and roles and responsibilities during response efforts.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc. 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	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. (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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.3(L)(2)	Committee Input			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	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.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	(2) ~~Field Work~~Work Practices Audit. ~~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. 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.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.3(L)(3)	264			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	(3) Lockout/Tagout Program ~~and Procedure~~ Audit. The lockout/tagout program shall be audited to verify that the principles of the lockout/tagout program are in compliance with this standard. Audits shall be performed at intervals not to exceed 3 years. (4) **Lockout/Tagout Procedures 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:			

	(1) The lockout/tagout program and procedures (2) The lockout/tagout training (3) Worker execution of the lockout/tagout procedure
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
	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 Sections.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(3) Lockout/Tagout Program ~~and Procedure~~ 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 Procedures Audit. (a) The lockout/tagout ~~program and~~ procedures required by 120.2 through 120.~~6~~ 5 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 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

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New 110.3(M)	161			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	Point of Work. The electrical safety program shall include elements that consider how to determine the point of work in electrical equipment.			

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Determining the point of work is related to verifying the absence of voltage while establishing an electrically safe work condition. The requirement for a qualified worker to test for the absence of voltage at each point of work is adequately addressed in 120.6(7).
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.4(A)(1)(b)	13			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions shown (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. (b) A person shall be qualified for ~~certain~~ the equipment and tasks ~~to be performed~~ they will perform.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
	The revision to 110.4(A)(1)(b) in the 2024 edition was an attempt to replace 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.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. (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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.4(A)(1)	50			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown (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. (e) Employees shall be trained to select an appropriate test instrument and shall demonstrate how to use a device to verify the absence of ~~voltage~~ energy, 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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other FRs, etc.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The phrase “verify the absence of voltage” is not revised to “verify the absence of energy” as the term “energy” is too broad for the purposes of the application of this requirement. To be “qualified” to work on constant current lighting a person would have “knowledge related to the construction and operation of electrical equipment and installations” of such a system and would have “safety training to identify the hazards and reduce the associated risk,” including the correct method to verify that the system is in an electrically safe work condition.			
	Must be in shown in track changes.			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.4(A)(1)(e)	254			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions shown (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. (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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.
	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	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

New 110.4(D)	253			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	110.4(D) Secondary Hazard Training Several secondary hazards are created by electrical equipment including electric fields, magnetic fields, and rf fields (known as Nonionizing Radiation) and x-ray (known as Ionizing Radiation). Utility and facility transformers are large motors can be a significant hazard to any worker with medical electronics. Ionizing radiation is generated in any vacuum device that contains over 10 kV circuits, such as a MV vacuum breaker. As determined by management, training in Nonionizing Radiation and/or Ionizing Radiation safety shall be provided as needed.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The information on radiation hazards is not added to 110.4 as radiation hazards are addressed in Chapter 3.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	To create a revision, revise text above or paste final version here.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.5(A)	Committee Input			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	Revisions are made to comply with NEC Style Manual requiring titles for second level subdivisions.			

Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(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 employee'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

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.5(B)	Committee Input			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	Revisions are made to comply with NEC Style Manual requiring titles for second level subdivisions.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	(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. **(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

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.6(D)	243			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	(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. Exception No. 1 to (D): Permanently installed devices shall have terminations validated for proper connection to the intended voltage source before testing that source for the absence of voltage.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	A first revision is made to clarify 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	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	(D) Visual Inspection and Repair. (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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.6(E)	51			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	((E) Operation Verification. When test instruments are used for testing the absence of ~~voltage~~ energy on conductors or circuit parts operating at voltages equal to or greater than 50 volts, the operation of the test instrument shall be verified on any known ~~voltage~~ energy source before and after an absence of ~~voltage~~ energy test is performed. The energy source shall match the circuit type; voltage driven or current driven. Informational Note. The test instrument range/function used during the verification process should the same range/function used for the absence of energy test.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The phrase “verify the absence of voltage” is not revised to “verify the absence of energy” as the term “energy” is too broad for the purposes of the application of this requirement. To be “qualified” to work on constant current lighting a person would have “knowledge related to the construction and operation of electrical equipment and installations” of such a system and would have “safety training to identify the hazards and reduce the associated risk,” including the correct method of verify that the system is in an electrically safe work condition.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

110.6(E)	Committee Input			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	Section 110.6(E) is deleted in accordance with NEC Style Manual 4.1.2 to avoid repeating requirements in other articles. The requirement to verify the operation of a test instrument when testing for the absence of voltage is already addressed in 120.6(7).			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	~~(E) Operation Verification. When test instruments are used for testing the absence of voltage on conductors or circuit parts operating at voltages equal to or greater than 50 volts, the operation of the test instrument shall be verified on any known voltage source before and after an absence of voltage test is performed.~~			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.6(E)	167			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	(E) Operation Verification. When test instruments are used for testing the absence of voltage on conductors or circuit parts ~~operating at voltages equal to or greater than 50 volts~~ where an electrical hazard exists, the operation of the test instrument shall be verified on any known voltage source before and after an absence of voltage test is performed.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other FRs, etc.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	Response if CI to delete 110.6(E) is accepted: This section has been deleted by a previous action Response if CI to delete 110.6(E) is rejected:			

	The phrase “operating at voltages equal to or greater than 50 volts” is not revised to “that present the risk of injury due to exposure to electrical hazards” The context of the requirement in this section to verify the operation of a test instrument applies specifically to voltage and not to electrical hazards in general.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.6(E)	246			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	(E) Operation Verification. ~~When~~ All test instruments ~~are~~ and equipment used for testing the absence of voltage on conductors or circuit parts operating at voltages equal to or greater than 50 volts, the operation of the test instrument shall be verified on any known voltage source before and after an absence of voltage test is performed.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc. Response if CI to delete 110.6(E) is accepted: This section has been deleted by a previous action Response if CI to delete 110.6(E) is rejected: The revision to add “and equipment” to the requirement is not made as it is already addressed in 120.6(7).			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

110.7(D)	Committee Input			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	This revision is made to clarify that the provisions of 110.7(D) also applies to cord sets used in conductive or wet work locations. Note: 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	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	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.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.8	Committee Input			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
	The requirement to use GFCI protection in conductive or wet work locations is relocated 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	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	110.8 Ground-Fault Circuit-Interrupter (GFCI) Protection. **(A) General.** Employees shall be provided with listed ground-fault circuit-interrupter (GFCI) protective devices where required by applicable state, federal, or local codes and standards. Listed cord sets or devices incorporating listed GFCI protection for personnel identified for portable use shall be permitted. **(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.~~ (a) Cord sets (extension cords) and cord- and plug-connected tools used for maintenance 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. (b) 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 590.6(B)(2) of the National Electric Code (NFPA 70) for 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 590.6(B)(2) of the National Electric Code (NFPA 70) for information regarding implementation of an assured equipment grounding conductor program.~~ ~~(D)~~ (C) **Testing Ground-Fault Circuit-Interrupter Protection Devices.** GFCI protection devices shall be tested in accordance with the manufacturer's instructions.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
110.7(D)	171			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	(D) Conductive or Wet Work Locations. Portable cord-and-plug-connected electric equipment used in conductive or wet work locations shall be approved for use in those locations. ~~In~~ Ground fault circuit interrupter (GFCI) protection shall used where portable cord-and-plug connected electric equipment is used in work locations where employees are likely to contact ~~or be drenched~~ water or conductive liquids~~, ground-fault circuit-interrupter protection for personnel shall be used~~. Portable cord-and-plug connected electric equipment is prohibited from being used in work locations where employees are likely to be drenched with water or conductive liquids, whether using GFCI protection or not. 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.				
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other revisions, etc.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	Response if the TC accepts the CI for 110.7(D), which deletes the second sentence: The second sentence has not been revised as it has been deleted by a committee first revision.			

	Response if the TC rejects the CI for 110.7(D: The proposed edit is overly restrictive and gives no consideration to the rating of equipment.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. D) Conductive or Wet Work Locations. 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.

DOC #	70E
TG #/NAME	Article 120 Task Group
TG CHAIR	Thomas Norwood
TG MEMBERS	Bill Harris, Duke Schamel, Jason Wolf, Terrance Mckinch, Eric Simmons, Roy Sparks, Al Winfield, John Tobias#, Steve Chybowski#. #Unable to attend. Louis Barrios, David Wallis & Paul Dobrowsky also provided valuable input. *Non-committee member

All task group **proposed** motions, revisions, and entries displayed below are for consideration by the entire TC.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 120 and 120.1	4			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. Article 120 Establishing and Verifying an Electrically Safe Work Condition 120.1 Scope. This article covers requirements for establishing and verifying an electrically safe work condition.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.**			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	Verifying is inherent to the Electrically Safe Work Condition and therefore the proposed text is redundant and does not add clarity.			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. Article 120 Establishing an Electrically Safe Work Condition 120.1 Scope. This article covers requirements for establishing an electrically safe work condition.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
120.3(C)	18			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	(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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** The addition of eliminate aligns with the requirements of establishing an Electrically Safe Work Condition.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. (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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

120.4(C)	185			☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)

(C) Lockout Device.

The lockout device shall meet the following requirements:

(1) A lockout device shall include a lock — ~~either keyed or combination~~ physical mechanism which permits ready access to authorized personnel by means of physical key, numerical combination, or uniquely identifiable digital code/frequency.

(2) The lockout device shall include a method of identifying the individual who installed the lockout device.

(3) A lockout device shall be permitted to be only a lock, if the lock is readily identifiable as a lockout device, in addition to having a means of identifying the person who installed the lock, provided that all of the following conditions exist:

a. Only one circuit or piece of equipment is de-energized.

b. The lockout period does not extend beyond the work shift.

c. Employees exposed to the hazards associated with re-energizing the circuit or equipment are familiar with this procedure.

(4) Lockout devices shall be attached to prevent operation of the disconnecting means without resorting to undue force or the use of tools.

(4) Lockout devices shall be independently connected to a cloud network, local area network or private cloud network without the reliance on a worker's mobile device.

(5) Where a tag is used in conjunction with a lockout device, the tag shall contain a statement prohibiting unauthorized operation of the disconnecting means or unauthorized removal of the device.

(6) Lockout devices shall be suitable for the environment and for the duration of the lockout.

(7) Whether keyed, or combination, or digital access locks are used, the key, or combination, or digital code/frequency shall remain in the possession of the individual installing the lock or the person in charge, when provided by the established procedure.

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.

Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Insufficient substantiation was provided. As written, it creates conflicts within the document, for example list item 5 in the existing text cannot apply to keyed locks.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

	(A) Lockout Device.
	
	The lockout device shall meet the following requirements:
	
	1. A lockout device shall include a lock — either keyed or combination.
	2. The lockout device shall include a method of identifying the individual who installed the lockout device.
	3. A lockout device shall be permitted to be only a lock, if the lock is readily identifiable as a lockout device, in addition to having a means of identifying the person who installed the lock, provided that all of the following conditions exist:
	    1. Only one circuit or piece of equipment is de-energized.
	    2. The lockout period does not extend beyond the work shift.
	    3. Employees exposed to the hazards associated with re-energizing the circuit or equipment are familiar with this procedure.
	4. Lockout devices shall be attached to prevent operation of the disconnecting means without resorting to undue force or the use of tools.
	5. Where a tag is used in conjunction with a lockout device, the tag shall contain a statement prohibiting unauthorized operation of the disconnecting means or unauthorized removal of the device.
	6. Lockout devices shall be suitable for the environment and for the duration of the lockout.
	7. Whether keyed or combination locks are used, the key or combination shall remain in the possession of the individual installing the lock or the person in charge, when provided by the established procedure.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
120.4(D)	177			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	(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, and nonreleasable, ~~and equal to an all environmental tolerant nylon cable tie~~ ~~and equal to an all-environmental tolerant nylon cable tie~~ such as a cable tie,and shall 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** Specifying nylon is too restrictive, as other types of fasteners may be appropriate to attach tagout devices.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. (B) 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, and nonreleasable, such as a ~~and equal to an all-environmental tolerant nylon~~ cable tie and shall 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
120.5(A)(1)	63			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	(1) Locating Sources. Up-to-date single-line drawings shall be considered a primary reference source for such information. When up-to-date drawings are not available, the employer shall be responsible for ensuring that an equally effective means of locating all sources of energy is employed. Informational Note: ~~Locating sources~~ ~~Locating sources~~ Determining sources of supply could include identifying situations where a ~~neutral~~ grounded ~~neutral~~ conductor continues to carry current after phase conductors have been ~~de-enrgized~~ ~~de-energized.~~ placed into an electrically safe work condition. This could occur if single or three phase loads remain energized or could become energized and are fed from an alternate source with a shared neutral connection within the work location, or during abnormal conditions.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	Changing neutral conductor to grounded conductor does not add clarity or useability and is inconsistent with the parent text. Replacing “de-energized” with “placed into an electrically safe work condition” is technically incorrect, as a conductor can be			

	de-energized but still not be an electrically safe work condition.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. (1) Locating Sources. Up-to-date single-line drawings shall be considered a primary reference source for such information. When up-to-date drawings are not available, the employer shall be responsible for ensuring that an equally effective means of locating all sources of energy is employed. Informational Note: Locating sources of supply could include identifying situations where a neutral conductor continues to carry current after phase conductors have been de-energized.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
120.5(A)(5)	187			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown (5) Complex Lockout/Tagout. (d) Each authorized employee shall affix a personal lockout or tagout device to the group lockout device, group lockbox, or comparable mechanism when he or she begins work and shall remove those devices when he or she stops working on the machine or equipment being serviced or maintained. In the event that a digital lockout device is used, a single lockout device that follows the same rules for lockout/tagout where the device or system can identify the person in charge and records the status of any authorized employee or employees working under the protection of the group lockout device.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			

Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The proposed text is not a complete statement and attempts to add requirements for digital locks which are not currently in the NFPA 70E. Insufficient substantiation was provided.			
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
120.5(A)(5)	266			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown (5) Complex Lockout/Tagout. (a) A complex lockout/tagout procedure shall be ~~permitted~~ required ~~permitted~~ where one or more of the following exists: (1) Multiple energy source (2) Multiple crews (3) Multiple crafts (4) Multiple locations (5) Multiple employers (6) Multiple disconnecting means (7) Particular sequences (8) Job or task that continues for more than one work period			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The proposed text is too restrictive. This standard intends for the complex LO/TO method to be permissive instead of a mandatory requirement.			
	Must be in shown in track changes.			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	(5) Complex Lockout/Tagout. 1. A complex lockout/tagout procedure shall be permitted where one or more of the following exists: 1. Multiple energy source 2. Multiple crews 3. Multiple crafts 4. Multiple locations 5. Multiple employers 6. Multiple disconnecting means 7. Particular sequences 8. Job or task that continues for more than one work period 2. All complex lockout/tagout procedures shall require a written plan of execution that identifies the person in charge. 3. The complex lockout/tagout 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. The person in charge shall be held accountable for safe execution of the complex lockout/tagout. 4. Each authorized employee shall affix a personal lockout or tagout device to the group lockout device, group lockbox, or comparable mechanism when he or she begins work and shall remove those devices when he or she stops working on the machine or equipment being serviced or maintained. 5. All complex lockout/tagout plans shall identify the method to account for all persons who might be exposed to electrical hazards in the course of the lockout/tagout.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
120.5(B)(4)	226			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: Could not identify a revision in PI (4) Responsibility. The procedure shall identify the person who is responsible for verifying that the lockout/tagout procedure is implemented and who is responsible for ensuring that the task is completed prior to removing locks/tags. A mechanism to accomplish lockout/tagout for multiple (complex) jobs/tasks where required, including the person responsible for coordination, shall be included.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			

Response	**Technical reason for resolving or for not making some of the proposed changes.** This public input did not provide a suggested revision as required in section 4.3.4.1(c) of the NFPA regulations.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. 4) Responsibility. The procedure shall identify the person who is responsible for verifying that the lockout/tagout procedure is implemented and who is responsible for ensuring that the task is completed prior to removing locks/tags. A mechanism to accomplish lockout/tagout for multiple (complex) jobs/tasks where required, including the person responsible for coordination, shall be included.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
120.5(B)(6)	52			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	(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 exposed conductor or circuit part(s) within the defined boundary of the work area (4) Requirement to retest for absence of ~~voltage~~ ~~voltage~~ energy 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			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
	Technical reason for resolving or for not making some of the proposed changes.			

Response	Changing this to energy makes the requirement less clear for most applications. To be “qualified” to work on constant current lighting a person would have “knowledge related to the construction and operation of electrical equipment and installations” of such a system and would have “safety training to identify the hazards and reduce the associated risk,” including the correct method to verify that the system is in an electrically safe work condition.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
120.5(B)(6)	75			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	(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~~ ~~before touching every~~ each exposed conductor or circuit ~~part(s)~~ part for absence of voltage before touching it when it is within the defined boundary of the work area (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
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other FRs, etc. First Revision. The proposed change aligns list item 3 with list item 4.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(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 each~~before touching every~~ exposed conductor or circuit part~~(s)~~ for absence of voltage before touching it when it is within the defined boundary of the work area 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

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
120.5(B)(8)	227			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: could not identify a revision in PI (8) Shift Change. A method shall be identified in the procedure to transfer responsibility for lockout/tagout to another person or to the person in charge when the job or task extends beyond one shift.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	This public input did not provide a suggested revision as required in section 4.3.4.1(c) of the NFPA regulations.			
First Revision Text (FR) Clean current edition text is provided to be revised.	**Must be in shown in track changes.**			
	(8) Shift Change. A method shall be identified in the procedure to transfer responsibility for lockout/tagout to another person or to the person in charge when the job or task extends beyond one shift.			

Do not delete for a resolve	

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
120.5(B)(12)	228			☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	CDC NOTE: could not identify a revision in PI (12) Removal of Lockout/Tagout Devices. The procedure shall identify the details for removing locks or tags when the installing individual is unavailable. When locks or tags are removed by someone other than the installer, the employer shall attempt to locate that person prior to removing the lock or tag. When the lock or tag is removed because the installer is unavailable, the installer shall be informed prior to returning to work.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	This public input did not provide a suggested revision as required in section 4.3.4.1(c) of the NFPA regulations.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(12) Removal of Lockout/Tagout Devices. The procedure shall identify the details for removing locks or tags when the installing individual is unavailable. When locks or tags are removed by someone other than the installer, the employer shall attempt to locate that person prior to removing the lock or tag. When the lock or tag is removed because the installer is unavailable, the installer shall be informed prior to returning to work.

DOC #	70E
TG #/NAME	Chapter 2
TG CHAIR	Ron Widup
TG MEMBERS	Ron Widup, Karl Cunningham, Donald Hacke, Daniel Hook, Roy Sparks, James Stallcup, Sr., Vincent Della Croce, (Louis Barrios attended the TG call)

All task group **proposed** motions, revisions, and entries displayed below are for consideration by the entire TC.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Chapter 2	259		132, 133, 134, 135, 137, 138, 136	☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	DELETE CHAPTER 2			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** To create a revision, indicate if all or any articles of Chapter 2 are to be deleted.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.** NFPA 70B became a standard in 2023 and requires more time to mature as a standard before considering the deletion of the safety-related maintenance requirements in NFPA 70E. *(Note to TC: There are a total of 8 PIs that seek to delete all, or elements of, Chapter 2 due to NFPA 70B becoming a standard. They are PIs 259, 132, 133, 134, 135, 137, 138, and 136.*)			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
205.1	143			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	205.1 Scope. This article covers general safety-related maintenance requirements for electrical equipment.			
First Revision Text (FR) Clean current edition text is provided to be revised.	**Must be in shown in track changes** 205.1 Scope. This article covers general safety-related maintenance requirements for electrical equipment.			

Do not delete for a resolve	
Statement	**Technical reason for revision.**
	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. *(Note to TC: There are a total of 10 PIs that seek to add the term “safety-related” to the scope statements in Chapter 2. They are PIs 143, 146, 147, 148, 149, 150, 151, 152, 153, 154. This is action 1 of 10.*)
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
205.2	132		259	☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	~~205.2 Qualified Persons.~~ ~~Employees who perform maintenance on electrical equipment and installations shall be qualified persons as required in Chapter 1 and shall be trained in, and familiar with, the specific maintenance procedures and tests required.~~ ~~205.3 Single-Line Diagram.~~ ~~A single-line diagram, where provided for the electrical system, shall be maintained in a legible condition and shall be kept current.~~ ~~205.4 General Maintenance Requirements.~~ ~~Electrical equipment shall be maintained in accordance with manufacturers' instructions or industry consensus standards to reduce the risk associated with failure. The equipment owner or the owner’s designated representative shall be responsible for maintenance of the electrical equipment and documentation.~~ ~~Informational Note No. 1: Common industry practice is to apply test or calibration decals to equipment to indicate the test or calibration date and overall condition of equipment that has been tested and maintained in the field. These decals provide the employee immediate indication of last maintenance date and if the tested device or system was found acceptable on the date of test. This local information can assist the employee in the assessment of overall electrical equipment maintenance status.~~ ~~Informational Note No. 2: Noncontact diagnostic methods in addition to scheduled maintenance activities of electrical equipment can assist in the identification of electrical anomalies.~~				

	~~205.5 Overcurrent Protective Devices.~~ ~~Overcurrent protective devices shall be maintained in accordance with the manufacturers' instructions or industry consensus standards. Maintenance, tests, and inspections shall be documented.~~
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** 205.2 Qualified Persons. Employees who perform maintenance on electrical equipment and installations shall be qualified persons as required in Chapter 1 and shall be trained in, and familiar with, the specific maintenance procedures and tests required. 205.3 Single-Line Diagram. A single-line diagram, where provided for the electrical system, shall be maintained in a legible condition and shall be kept current. 205.4 General Maintenance Requirements. Electrical equipment shall be maintained in accordance with manufacturers' instructions or industry consensus standards to reduce the risk associated with failure. The equipment owner or the owner's designated representative shall be responsible for maintenance of the electrical equipment and documentation. Informational Note No. 1: Common industry practice is to apply test or calibration decals to equipment to indicate the test or calibration date and overall condition of equipment that has been tested and maintained in the field. These decals provide the employee immediate indication of last maintenance date and if the tested device or system was found acceptable on the date of test. This local information can assist the employee in the assessment of overall electrical equipment maintenance status. Informational Note No. 2: Noncontact diagnostic methods in addition to scheduled maintenance activities of electrical equipment can assist in the identification of electrical anomalies. 205.5 Overcurrent Protective Devices. Overcurrent protective devices shall be maintained in accordance with the manufacturers' instructions or industry consensus standards. Maintenance, tests, and inspections shall be documented.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	NFPA 70B became a standard in 2023 and requires more time to mature as a standard before considering the deletion of the safety-related maintenance requirements in NFPA 70E.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
205.7	133		259	☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	~~205.7 Grounding and Bonding.~~ ~~Equipment, raceway, cable tray, and enclosure bonding and grounding shall be maintained to ensure electrical continuity.~~			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	205.7 Grounding and Bonding. Equipment, raceway, cable tray, and enclosure bonding and grounding shall be maintained to ensure electrical continuity.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	NFPA 70B became a standard in 2023 and requires more time to mature as a standard before considering the deletion of the safety-related maintenance requirements in NFPA 70E.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
210.1	146			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	210.1 Scope. This article covers safety-related maintenance requirements for substations, switchgear assemblies, switchboards, panelboards, motor control centers, and disconnect switches.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	210.1 Scope. This article covers safety-related maintenance requirements for substations, switchgear assemblies, switchboards, panelboards, motor control centers, and disconnect switches.			

Statement	**Technical reason for revision.**
	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	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
210.2	134		259	☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	~~210.2 Enclosures.~~ ~~Enclosures shall be kept free of material that would expose employees to an electrical hazard.~~			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** 210.2 Enclosures. Enclosures shall be kept free of material that would expose employees to an electrical hazard.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	NFPA 70B became a standard in 2023 and requires more time to mature as a standard before considering the deletion of the safety-related maintenance requirements in NFPA 70E.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
210.4	135		259	☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	~~210.4 Conductors.~~			

	~~Current-carrying conductors (buses, switches, disconnects, joints, and terminations) and bracing shall be maintained to perform as follows:~~ ~~(1) Conduct rated current without overheating~~ ~~(2) Withstand available fault current~~
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**
	210.4 Conductors. Current-carrying conductors (buses, switches, disconnects, joints, and terminations) and bracing shall be maintained to perform as follows: 1. Conduct rated current without overheating 2. Withstand available fault current
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	NFPA 70B became a standard in 2023 and requires more time to mature as a standard before considering the deletion of the safety-related maintenance requirements in NFPA 70E.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
215.1	147			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	215.1 Scope. This article covers safety-related maintenance requirements for premises wiring.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	215.1 Scope. This article covers safety-related maintenance requirements for premises wiring.			
	Technical reason for revision.			

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	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
220.1	148			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	220.1 Scope. This article covers safety-related maintenance requirements for controllers, which includes electrical equipment that governs the starting, stopping, direction of motion, acceleration, speed, and protection of rotating equipment and other power utilization apparatus in the workplace.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** 220.1 Scope. This article covers safety-related maintenance requirements for controllers, which includes electrical equipment that governs the starting, stopping, direction of motion, acceleration, speed, and protection of rotating equipment and other power utilization apparatus in the workplace.			
Statement	**Technical reason for revision.** 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	**Technical reason for resolving or for not making some of the proposed changes.**			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
225.1	149			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	225.1 Scope. This article covers safety-related maintenance requirements for fuses and circuit breakers.			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**
	225.1 Scope. This article covers safety-related maintenance requirements for fuses and circuit breakers.
Statement	**Technical reason for revision.**
	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	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
225.2	136		259	☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	~~225.2 Fuses.~~ ~~Fuses shall be maintained free of breaks or cracks in fuse cases, ferrules, and insulators. Fuse clips shall be maintained to provide adequate contact with fuses. Fuseholders for current-limiting fuses shall not be modified to allow the insertion of fuses that are not current-limiting. Non-current limiting fuses shall not be modified to allow their insertion into current-limiting fuseholders.~~ ~~225.3 Molded-Case Circuit Breakers.~~ ~~Molded-case circuit breakers shall be maintained free of cracks in cases and cracked or broken operating handles.~~			
	Must be in shown in track changes			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	225.2 Fuses. Fuses shall be maintained free of breaks or cracks in fuse cases, ferrules, and insulators. Fuse clips shall be maintained to provide adequate contact with fuses. Fuseholders for current-limiting fuses shall not be modified to allow the insertion of fuses that are not current-limiting. Non-current limiting fuses shall not be modified to allow their insertion into current-limiting fuseholders. 225.3 Molded-Case Circuit Breakers. Molded-case circuit breakers shall be maintained free of cracks in cases and cracked or broken operating handles.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	NFPA 70B became a standard in 2023 and requires more time to mature as a standard before considering the deletion of the safety-related maintenance requirements in NFPA 70E.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
230.1	150			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	230.1 Scope. This article covers safety-related maintenance requirements for rotating equipment.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	230.1 Scope. This article covers safety-related maintenance requirements for rotating equipment.			
Statement	**Technical reason for revision.**			
	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.			
	Technical reason for resolving or for not making some of the proposed changes.			

Response	

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 235	137		151, 259	☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)

~~Article 235 Hazardous (Classified) Locations~~

~~235.1 Scope.~~

~~This article covers maintenance requirements in those areas identified as hazardous (classified) locations.~~

~~Informational Note No. 1: These locations need special types of equipment and installation to ensure safe performance under conditions of proper use and maintenance. It is important that inspection authorities and users exercise more than ordinary care with regard to installation and maintenance. The maintenance for specific equipment and materials is covered elsewhere in Chapter 2 and is applicable to hazardous (classified) locations. Other maintenance will ensure that the form of construction and of installation that makes the equipment and materials suitable for the particular location are not compromised.~~

~~Informational Note No. 2: The maintenance needed for specific hazardous (classified) locations depends on the classification of the specific location. The design principles and equipment characteristics — for example, use of positive pressure ventilation, explosionproof, nonincendive, intrinsically safe, and purged and pressurized equipment — that were applied in the installation to meet the requirements of the area classification must also be known. With this information, the employer and the inspection authority are able to determine whether the installation as maintained has retained the condition necessary for a safe workplace.~~

~~235.2 Maintenance Requirements for Hazardous (Classified) Locations.~~

~~Equipment and installations in these locations shall be maintained such that the following criteria are met:~~

~~(1) No energized parts are exposed.~~

~~*Exception to (1): Intrinsically safe and nonincendive circuits shall be permitted to be exposed.*~~

~~(2) There are no breaks in conduit systems, fittings, or enclosures from damage, corrosion, or other causes.~~

~~(3) All bonding jumpers are securely fastened and intact.~~

~~(4) All fittings, boxes, and enclosures with bolted covers have all bolts installed and bolted tight.~~

~~(5) All threaded conduit are wrenchtight and enclosure covers are tightened in accordance with the manufacturer's instructions.~~

~~(6) There are no open entries into fittings, boxes, or enclosures that would compromise the protection characteristics.~~

~~(7) All close-up plugs, breathers, seals, and drains are securely in place.~~

	~~(8) Marking of luminaires (lighting fixtures) for maximum lamp wattage and temperature rating is legible and not exceeded.~~ ~~(9) Required markings are secure and legible.~~
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	NFPA 70B became a standard in 2023 and requires more time to mature as a standard before considering the deletion of the safety-related maintenance requirements in NFPA 70E.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
235.1	151		137	☒~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	235.1 Scope. This article covers safety-related maintenance requirements in those areas identified as hazardous (classified) locations.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
	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	**Technical reason for resolving or for not making some of the proposed changes.**
	Must be in shown in track changes

First Revision Text (FR)

Clean current edition text is provided to be revised.

Do not delete for a resolve

Article 235 Hazardous (Classified) Locations

235.1 Scope.

This article covers safety-related maintenance requirements in those areas identified as hazardous (classified) locations.

Informational Note No. 1: These locations need special types of equipment and installation to ensure safe performance under conditions of proper use and maintenance. It is important that inspection authorities and users exercise more than ordinary care with regard to installation and maintenance. The maintenance for specific equipment and materials is covered elsewhere in Chapter 2 and is applicable to hazardous (classified) locations. Other maintenance will ensure that the form of construction and of installation that makes the equipment and materials suitable for the particular location are not compromised.

Informational Note No. 2: The maintenance needed for specific hazardous (classified) locations depends on the classification of the specific location. The design principles and equipment characteristics — for example, use of positive pressure ventilation, explosionproof, nonincendive, intrinsically safe, and purged and pressurized equipment — that were applied in the installation to meet the requirements of the area classification must also be known. With this information, the employer and the inspection authority are able to determine whether the installation as maintained has retained the condition necessary for a safe workplace.

235.2 Maintenance Requirements for Hazardous (Classified) Locations.

Equipment and installations in these locations shall be maintained such that the following criteria are met:

1. No energized parts are exposed.

   Exception to (1): Intrinsically safe and nonincendive circuits shall be permitted to be exposed.

2. There are no breaks in conduit systems, fittings, or enclosures from damage, corrosion, or other causes.
3. All bonding jumpers are securely fastened and intact.
4. All fittings, boxes, and enclosures with bolted covers have all bolts installed and bolted tight.
5. All threaded conduit are wrenchtight and enclosure covers are tightened in accordance with the manufacturer’s instructions.
6. There are no open entries into fittings, boxes, or enclosures that would compromise the protection characteristics.
7. All close-up plugs, breathers, seals, and drains are securely in place.
8. Marking of luminaires (lighting fixtures) for maximum lamp wattage and temperature rating is legible and not exceeded.
9. Required markings are secure and legible.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
240.1	150			☒~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	240.1 Scope. This article covers safety-related maintenance requirements for batteries and battery rooms.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	240.1 Scope. This article covers safety-related maintenance requirements for batteries and battery rooms.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	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.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 245	138		153, 259	☐ Create First Revision ☒~~☐~~ Resolve
Proposed Text (from PI)	~~Article 245 Portable Electric Tools and Equipment~~ ~~245.1 Scope.~~ ~~This article covers maintenance requirements for portable electrical tools and equipment.~~ ~~245.2 Maintenance Requirements for Portable Electric Tools and Equipment.~~ ~~Attachment plugs, receptacles, cover plates, and cord connectors shall be maintained such that the following criteria are met:~~ ~~(1) There are no breaks, damage, or cracks exposing energized conductors and circuit parts.~~ ~~(2) There are no missing cover plates.~~ ~~(3) Terminations have no stray strands or loose terminals.~~			

	~~(4) There are no missing, loose, altered, or damaged blades, pins, or contacts.~~ ~~(5) Polarity is correct.~~
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.**
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	NFPA 70B became a standard in 2023 and requires more time to mature as a standard before considering the deletion of the safety-related maintenance requirements in NFPA 70E.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
245.1	153		138	☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	245.1 Scope. This article covers safety-related maintenance requirements for portable electrical tools and equipment.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.**
Statement	**Technical reason for revision.**
	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	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**
	Article 245 Portable Electric Tools and Equipment 245.1 Scope. This article covers safety-related maintenance requirements for portable electrical tools and equipment. 245.2 Maintenance Requirements for Portable Electric Tools and Equipment. Attachment plugs, receptacles, cover plates, and cord connectors shall be maintained such that the following criteria are met:

	1. There are no breaks, damage, or cracks exposing energized conductors and circuit parts. 2. There are no missing cover plates. 3. Terminations have no stray strands or loose terminals. 4. There are no missing, loose, altered, or damaged blades, pins, or contacts. 5. Polarity is correct.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
250.1	154			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	250.1 Scope. This article covers safety-related maintenance requirements for personal safety and protective equipment.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	250.1 Scope. This article covers safety-related maintenance requirements for personal safety and protective equipment.			
Statement	**Technical reason for revision.**			
	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	**Technical reason for resolving or for not making some of the proposed changes.**			

DOC #	70E
TG #/NAME	Chapter 3
TG CHAIR	Bobby Gray
TG MEMBERS	Heath Garrison, Mark McNellis, Trevor Bowmer, Ray Crow, Larry Perkins, Lloyd Gordon*, David Rosewater*, Bill Cantor*, Steve Edley*

All task group **proposed** motions, revisions, and entries displayed below are for consideration by the entire TC.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Global	130			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	Replace all references to "Soft Grounding" with "Capacitor Soft Discharging." References in the following Articles and Annexes should apply: 360.5(B) R.6.8, R.11.1, R.11.4, R.11.6, R.11.7, R.12.1, R.16.2			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The current language is consistent with the of the use of the phrase elsewhere in this Standard.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	To create a revision, revise text above or paste final version here.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Global	176			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	1. There is a need to establish a finger-safe terminals requirement internally and externally on large Lithium-Ion batteries for occupational safety. Currently most automotive propulsion lithium-ion batteries have exposed terminals undercover which pose hazards to assembly and service operators. 2. There should be a requirement to be able to segment large propulsion batteries (400-800VDC) into smaller segments and open circuit for service and safe repair/disassembly purposed.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The public input does not comply with the Regulations Governing the Development of NFPA Standards Paragraph 4.3.4.1.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	To create a revision, revise text above or paste final version here.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	41	163?		☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	~~**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)~~			

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	The defined term is not needed. The term elements are already covered in the "qualified person" definition.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	163			☐ Create First Revision ☐ Resolve

Proposed Text (from PI)	~~**Competent**~~ **Qualified Person, Research Laboratory (Research laboratory Qualified Person).** A person ~~who meets all the requirements of *qualified person*, and who, in addition, is~~ who 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)
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. 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)

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

100	191			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	**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)			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.**			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.**			
	Ground Stick. A device that is used to ensure that the capacitor is discharged by applying it to all terminals of the capacitor element. (360) Informational Note: This is also called a ground hook and could incorporate power-rated discharge resistors for high-energy applications.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	129			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	~~**Grounding, Soft (High-Z). (Soft Grounding)**~~ **Capacitor Soft Discharging** The practice of ~~connecting a capacitor to ground~~ discharging capacitors through a power resistor to avoid the hazards related with ~~hard grounding.~~ low impedance short circuiting. Informational Note: Capacitors ~~must~~ are either grounded or floating. Capacitors which are not grounded will not discharge unless the discharge resistor is connected between their terminals. ~~be discharged across their terminals or from their terminals to ground.~~ (360)			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.**			
Statement	**Technical reason for FR.**			

Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	Grounding, Soft (High-Z). (Soft Grounding) The practice of connecting a capacitor to ground through a power resistor to avoid the hazards related with hard grounding. (360)

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	128			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	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. ~~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 which are separated by a nonconductive, ion-permeable separator, an electrolyte ionically connecting both electrodes, and two current collectors directly attached to electrodes.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	To create a revision, revise text above or paste final version here.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.7(C)(15)(b)	198	198, 200, 201, 58		☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions show.

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, except capacitors 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.)	-	-

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

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 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.

Response

Technical reason for resolving or for not making some of the proposed changes.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.7(C)(15)(b)	155			☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions show.

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	-	-

	Parameters: Greater than 150 volts ~~and,~~ less than or equal to 600 volts, and where exposed conductor separation is less than 1mm / volt[a] ~~-~~	-	
	Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.)	-	-
	[a] 1mm / V assumes a theoretically infinite short circuit current.		
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.		
Statement	**Technical reason for revision.**		
Response	**Technical reason for resolving or for not making some of the proposed changes.**		
	The proposed addition addresses the likelihood of an arc flash hazard. This table is about selecting the proper PPE once it has been determined that an arc flash hazard exists. The revision would be better served in 130.5(C).		

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.7(C)(15)(b)	204			☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)

CDC NOTE: Only identified revisions shown

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

Equipment	Arc Flash PPArc Flash Boundary Category	
Storage batteries, dc switchboards, and other dc supply sources		
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~~ 3 kA	~~2~~1	~~900~~ 0.5 m~~m~~ (19 in~~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 23 — 0.91.8 m (36 ft) Available fault current greater than or equal to 7 kA and less than 10 kA 24 — 1.22.5 m (48 ft)
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The substantiation does not provide evidence of the integrity of the testing methods cited in the references. Additionally, there is not an evident link between the summarized data and the specific testing criteria supporting the conclusions to reduce the protection to the worker.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.7(C)(15)(b)	200	198, 200, 201, 58		☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions show. Table 130.7(C)(15)(b) Arc Flash PPE Categories for dc Systems 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 modelling 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
	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.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

Table 130.7(C)(15)(b)	201	198, 200, 201, 58		☒~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. Table 130.7(C)(15)(b) Arc Flash PPE Categories for dc Systems 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 may be higher and additional PPE protection beyond the value shown in this table should be considered.~~it would be prudent to consider additional PPE protection beyond the value shown in this table~~.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.** The revised language is clearer and explains why additional PPE may be needed.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.7(C)(15)(b)	202			☐ Create First Revision ☒~~☐~~ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. Table 130.7(C)(15)(b) Arc Flash PPE Categories for dc Systems Informational Note No. 4: The methods for estimating the dc arc flash incident energy that were used to determine the categories for this table assume a static arc with a constant length across the gap. These methods do not take into account the gap distance, the voltage, or the dynamic behavior of the arc. Recent tests have shown that arc lifetimes may be much less than 2 seconds, depending on the gap and voltage. Extinction by magnetic force arc elongation may also result in much lower incident energies for higher currents. Thus, this table significantly over estimates incident energies for the higher current. See Annex D.5 for discussion of these issues. The gap distance of the initial arc is a strong factor in the arc lifetime. See the following references for arc lifetimes and incident energies: (1) L. Gordon, "Modeling the Dynamic Behavior of DC Arcs", IEEE Trans. on Industry Applications, Vol. 60, No. 1, Jan/Feb 2024, pp 1946 - 1955. (2) Electric Power Research Institute (EPRI) Technical Report 3002014124, "DC Arc Flash on Photovoltaic (PV) Equipment, 2018. (3) W. Fechalos and P. Blake, "DC Arc-Flash in Stationary Battery Systems", proceedings of Battcon 2023, paper No. 18.			

(4) R. Veeraraghavan, "DC Arc-Flash Analysis," presentation for Symposium #1 (DC Arc Flash) at the 2017 winter meeting of the IEEE PES ESSB (Energy Storage and Stationary Battery committee, New Orleans, LA.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for FR.

Response

Technical reason for resolving or for not making some of the proposed changes.

The proposed information is addressing the methods used to develop the table in Informative Annex D, which is already referenced in Informational Note No. 1

First Revision Text (FR)

Clean current edition text is provided to be revised.

Do not delete for a resolve

Must be in shown in track changes.

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 25 kA available fault current; maximum of 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; maximum of 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; maximum of 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 of 0.33 sec (20 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	4.3 m (14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Maximum of 35 kA available fault current; maximum of up to 0.5 sec (30 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	6 m (20 ft)
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; minimum working distance 455 mm (18 in.)		
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Metal-clad switchgear, 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; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
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; 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; 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 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

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. (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. (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”). (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. (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. Informational Note No. 2 to Table 130.7(C)(15)(a): See Table 1 of IEEE 1584, *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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.7(C)(15)(b)	58	198, 200, 201, 58		☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. 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 125Vdc 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.			

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

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

Response

Technical reason for resolving or for not making some of the proposed changes.

First Revision Text (FR)

Clean current edition text is provided to be revised.

Do not delete for a resolve

Must be in shown in track changes.

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.

	(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 may be higher and ~~it would be prudent to consider~~ 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 Station Battery Systems,” 2018 IEEE Power & Energy Society General Meeting (PESGM), 2018, pp. 1–5. (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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Chapter 3	236			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown. PI 236 revised Chapter 3 as a whole. Recommend that the proposed revisions for each article be incorporated into the specific article. Do not revise Chapter 3 as single revision. I have pulled out the article revisions and placed them into the correct article in tables that follow. 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. ~~The~~ A. 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. 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 kHz, 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 lasers. Article 380 applies to power electronics. Article 390 applies to Research and Development Laboratories. Article 400 applies to electrical double-layer capacitors. Article 410 applies to photovoltaic systems.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	This First Revision is intended to be 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 proposed 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 will provide improved usability and make future additions to Chapter 3 more efficient in addressing only those unique circumstances for the added special equipment.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Must be in shown in track changes.

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	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. The employer shall provide safety-related work practices and employee training. The employee shall follow those work practices.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Article 310	Carry over from 236			☐ Create First Revision ☐ Resolve
Proposed Text (from PI)	Article 310 DC Electrical Hazards This article covers the electrical safety-related requirements for the practical safeguarding of employees while working with direct current (dc) that present an electrical hazard. 310.2 DC Electrical Hazard Thresholds (A) Electrical Thermal Hazard Thresholds For dc systems, hazardous power is considered greater than or equal to 1000 W. (B) Electrical Shock Thresholds. For dc systems, hazardous voltage is considered greater than or equal to 100 volts dc and 40 mA. (C) Electrical Arc Flash Hazard Thresholds. For dc systems, hazardous arc flash is considered for systems greater than or equal to 150 volts dc and greater than or equal to 1.2 cal/cm2 incident energy.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 310	Carry over from 236			☐ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown Article ~~310~~ 350 Safety-Related Work Practices for Electrolytic Cells			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. Article 310 Safety-Related Work Practices for Electrolytic Cells			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
310.1	173			☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)	310.1 Scope. The requirements of this article shall apply to the electrical safety-related work practices used in the types of electrolytic cell areas. ~~Informational Note No. 1: See Informative Annex L for a typical application of safeguards in the cell line working zone.~~ Informational Note No. 2: See *NFPA 70*, *National Electrical Code*, Article 668 for further information about electrolytic cells. Informational Note No. 3: See IEEE 463, *Electrical Safety Practices in Electrolytic Cell Line Working Zones*, for further information about electrical safety-related work practices in electrolytic cell lines.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The informational note provides information to the user of Article 310 and belongs in its current position.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	310.1 Scope. The requirements of this article shall apply to the electrical safety-related work practices used in the types of electrolytic cell areas. Informational Note No. 1: See Informative Annex L for a typical application of safeguards in the cell line working zone. Informational Note No. 2: See NFPA 70, National Electrical Code, Article 668 for further information about electrolytic cells. Informational Note No. 3: See IEEE 463, Electrical Safety Practices in Electrolytic Cell Line Working Zones, for further information about electrical safety-related work practices in electrolytic cell lines.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
310.5(D)(2)	172			☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)	(2) Personal Protective Equipment (PPE). PPE shall provide protection from electrical hazards. PPE shall include one or more of the following, as determined by authorized management: (1) Footwear for wet service (2) Gloves for wet service (3) Sleeves for wet service (4) Footwear for dry service (5) Gloves for dry service (6) Sleeves for dry service (7) Electrically insulated head protection (8) Protective clothing (9) Eye protection with nonconductive frames (10) Face shield (polycarbonate or similar nonmelting type) (a) *PPE.* Personal and other protective equipment shall be appropriate for conditions, as determined by authorized management. (b) *Testing of PPE.* PPE shall be verified with regularity and by methods that are consistent with the exposure of employees to electrical hazards. Informational Note: See Annex L for information on the application of safeguards in electrolytic areas where electrical hazards exist.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Moving the informational note from its current position in 310.1 does not add additional clarity or readability for the user.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(2) Personal Protective Equipment (PPE). PPE shall provide protection from electrical hazards. PPE shall include one or more of the following, as determined by authorized management: 1. Footwear for wet service 2. Gloves for wet service 3. Sleeves for wet service 4. Footwear for dry service 5. Gloves for dry service

	6. Sleeves for dry service 7. Electrically insulated head protection 8. Protective clothing 9. Eye protection with nonconductive frames 10. Face shield (polycarbonate or similar nonmelting type) 1. *PPE.* Personal and other protective equipment shall be appropriate for conditions, as determined by authorized management. 2. *Testing of PPE.* PPE shall be verified with regularity and by methods that are consistent with the exposure of employees to electrical hazards.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 320	Carry over from 236			☐ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown Article ~~320~~ 360 Safety Requirements Related to Batteries and Battery Rooms			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. Article 320 Safety Requirements Related to Batteries and Battery Rooms			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.1	103	122		☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions shown 320.1 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 320.3(A)(1)~~.~~.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** The change improves the intent and ensures the scope covers all hazards as outlined in the hazard thresholds of the article.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.1	122	103		☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	320.1 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. 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) ANSI/CAN/UL 9540, *Energy Storage Systems and Equipment*, ~~2020~~2023

(15) UL 9540A, *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, 2019

1. UL 9540B Outline of Investigation for Large Scale Fire Test for Residential Battery Energy Storage Systems, 2024.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for FR.

This addition adds a reference to an informative UL standard related to an existing reference and update the reference dates.

Response

Technical reason for resolving or for not making some of the proposed changes.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.1	139			☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions shown

320.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while working with exposed stationary or portable storage batteries that exceed 100 volts, nominal, or exceed a short-circuit power of 1000 watts.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

Response

Technical reason for resolving or for not making some of the proposed changes.

This change would include battery systems that are outside the scope of the NFPA 70E, per article 90.2, such as automobile batteries.

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

320.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while working with exposed stationary storage batteries that exceed one or more of the hazard thresholds listed in 320.3(A)(1)~~100 volts, nominal, or exceed a short-circuit power of 1000 watts~~.

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~~2023
15. UL 9540A, *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, 2019
16. ~~15.~~ UL 9540B *Outline of Investigation for Large Scale Fire Test for Residential Battery Energy Storage Systems*, 2024.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.3(A)(1)	104			☒~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	(1) Electrical Hazard Thresholds. 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~~ four. Informational Note 2: See Department of Energy, *DOE Electrical Safety Handbook*, DOE-HDBK-1092, for electrical hazard thresholds.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** The formula for maximum power calculates the power generated by the battery, not consumed by a load. The 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	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.3(A)(1)	140			☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)	(1) Electrical Hazard Thresholds. 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~~ 50 volts (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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The substantiation does not supersede the research data supporting the established threshold.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.3(A)(1)	242			☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)	(1) Electrical Hazard Thresholds. 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 for workers wearing jewelry or using small tools, 10 kW for work with large tools or other conductive objects that can bridge terminals to create a short circuit through the tool.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The proposed revision is too specific to be useful or enforceable.
	Must be in shown in track changes.

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	(1) Electrical Hazard Thresholds. 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.3(A)(2)	105		Note to Chris: We should consider elevating this to a section and PIs 108, 109, 110, and 113 all made subdivision level 1s (i.e.320.4(A), (B), (C), (D))	☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	(2) Battery Risk Assessment. Prior to any work on a battery system, a chemical, thermal, electrical shock, and arc flash 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~~ and documented: 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 1: See Informative Annex F Figure F.7 for an example of a risk assessment method for work on batteries. Informational Note 2: Batteries commonly have multiple electrical risk assessments based on the number of cells connected in series or parallel at the time when work is performed.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.**			
	Technical reason for revision.			

Statement	The recommended 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	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(2) Battery Risk Assessment. Prior to any work on a battery system, a chemical, thermal, electrical shock, and arc flash 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~~and documented:~~.~~ 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 2: Batteries commonly have multiple electrical risk assessments based on the number of cells connected in series or parallel at the time when work is performed.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New 320.3(A)(3)	108		108, 109, 110, 113	☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	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 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. ~~1.~~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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** 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	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. 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 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. (A) 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New 320.3(A)(3)	109		108, 109, 110, 113	☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	Battery 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 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 liklyhood 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 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). When the additional protective measures include the use of PPE, the following shall be determined and made available to the employee: 1. Proper hand protection based on performance characteristics relative to the task, conditions present, duration of use, and available short-circuit power of the battery. If hand protection required by the shock risk assessment and arc flash risk assessment is adequate for thermal hazard protection 2. Proper eye protection including safety goggles, safety glasses or face shield. 3. Tools equipped with handles rated for the voltage on which they are used in accordance with 130.7(D)(1). The length of tools for work on batteries shall be selected to minimize the likelihood of short circuit. 4. 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 thermal hazards might be covered by others hzard risk assessments.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
	Technical reason for revision.			

Statement	The proposed changes clarify the requirements for thermal risk assessment and PPE in involving batteries currently missing from the Standard.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	Battery 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 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 liklyhood 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 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). When the additional protective measures include the use of PPE, the following shall be determined and made available to the employee: 1. Proper hand protection based on performance characteristics relative to the task, conditions present, duration of use, and available short-circuit power of the battery. If hand protection required by the shock risk assessment and arc flash risk assessment is adequate for thermal hazard protection 2. Proper eye protection including safety goggles, safety glasses or face shield. 3. Tools equipped with handles rated for the voltage on which they are used in accordance with 130.7(D)(1). The length of tools for work on batteries shall be selected to minimize the likelihood of short circuit. 4. 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 thermal hazards might be covered by other hazard risk assessments.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New 320.3(A)(3)	110		108, 109, 110, 113	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	Battery Arc Flash Risk Assessment (A) General 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. 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 Informational note: See Table 130(C). 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 Informational note: see Annex D 3. The equipment operating condition and the condition of maintenance (C) Additional Protective Measures 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). If protective measures include the use of arc flash PPE, the following shall be determined: 1. The specific location of the gap where an arc could occur. 2. The arc flash boundary 3. The PPE to be used within the arc flash boundary
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** The proposed 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	**Technical reason for resolving or for not making some of the proposed changes.**

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	Battery Arc Flash Risk Assessment (A) General 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. 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) and Informative Annex D.5 for more information on evaluating the likelihood and severity of a battery arc flash hazard. (C) Additional Protective Measures 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). If protective measures include the use of arc flash PPE, the following shall be determined: 1. The specific location of the gap where an arc could occur. 2. The arc flash boundary 3. The PPE to be used within the arc flash boundary

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New 320.3(A)(3)	113		108, 109, 110, 113, 112	☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	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 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). 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 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** 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	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised.	**Must be in shown in track changes**. 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:

Do not delete for a resolve	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 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). 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 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.3(A)(5)	106			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	(5) ~~Abnormal Battery Conditions~~ Testing. (1) Instrumentation that provides alarms for early warning of abnormal conditions of battery operation, if present, shall be tested annually. (2) If practicable, ground-fault detectors and indicators installed in ungrounded or impedance grounded battery circuits exceeding 100 volts between conductors or to ground shall be tested annually or considered grounded for the purpose of the battery risk assessment. 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	The proposal introduces maintenance requirements that would be better served in Article 240.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(5) Abnormal Battery Conditions. 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.3(A)(6)	107			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions show (6) 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.~~, arc flash hazard, and thermal hazard according to the results of the battery risk assessment in 320.3(A)(2). 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 (6) Grounding configuration of the battery (6) 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	This change clarifies where the information for the labels is required to come from. Not just the battery voltage and available fault current but all electrical hazards identified in the risk assessment. 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. Current requirements in the standard do not make it clear that this voltage could be hazardous.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Must be in shown in track changes.

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	(6) 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 based on the results of the battery risk assessment in 320.3(A)(2). 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 7. Grounding configuration of the battery ~~6.~~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: 1. Potential presence of explosive gas (when applicable to the battery type) 2. Prohibition of open flame and smoking 3. 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

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.3(B)	112		113	☐ Create First Revision ☐ Resolve
Proposed Text (from PI)	~~Sections 320.3(B), 320.3(C)~~ ~~(B) 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:~~

~~(1) Goggles and face shield appropriate for the electrical hazard and the chemical hazard~~

~~(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 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.~~

~~(C) 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.~~

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	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. However, a well-ventilated battery room is not considered a

	classified environment and so non-sparking tools offer no additional protection to workers. Where non-sparking tools would offer any protection, the more appropriate control would be to eliminate the hazard by ventilating the space. The use of insulated tools is more important to protect workers from accidental short circuit.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	~~(B) 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:~~ ~~1. Goggles and face shield appropriate for the electrical hazard and the chemical hazard~~ ~~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 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.~~ ~~(C) 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.~~

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
320.3(D)	111			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	~~(D) 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.~~			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
	This subdivision is specific to maintenance and would be better served in Article 240.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	(D) 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.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New 320.4	114			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

320.X 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. The battery hazardous energy control program shall specify procedures to safeguard workers from exposure to battery electrical hazards. Employees performing work within the restricted approach boundary of a battery shall plan work to minimize exposure to shock and arc flash hazards. 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.

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.

Exception 2: A sectionalizing procedure is not required for batteries below 100 volts dc or 40 milliamperes.

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. Each person who could be exposed directly or indirectly to a battery electrical hazard shall be involved in the sectionalizing procedure.
2. The battery charger shall either be placed into bypass mode or turned off, deenergized, and locked out prior to sectionalizing the battery.
3. The battery shall be disconnected from any electrical load it serves prior to sectionalizing the battery.
4. Control devices, such as push buttons or selector switches, shall not be used as the primary isolating device for the charger.
5. 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. The disconnecting means shall be identified in the sectionalizing procedure.
7. Bus bars or other circuit elements not uniquely or readily identifiable as a lockout/tagout device shall be permitted.
8. Two forms of hazardous energy control shall be permitted in battery systems: simple sectionalizing and complex sectionalizing.

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. Battery sectionalizing equipment shall meet the requirements of lockout/tagout equipment specified in 120.4 with the following addition. 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 all of 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 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 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.

1. The sectionalizing procedure shall require planning, including the requirements of 320.4 (D)(1) through 320.4 (E)(4).

2. 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.

3. 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.

4. 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.

5. The plan shall identify the person in charge and their responsibility in the sectionalizing procedure.

6. 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:

    a. DC voltage,

    b. Available short circuit power,

    c. Thermal PPE,

d. Limited approach boundary,

e. Restricted approach boundary,

f. Shock PPE,

g. Arc flash incident energy,

h. Arc flash boundary, and

i. Arc flash PPE.

(2) Simple Battery Sectionalizing Procedure.

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. Simple battery sectionalizing procedures shall not be required to be written for each application. 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, or

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. The person in charge shall be held accountable for safe execution of the complex sectionalizing procedure.

(d) Each authorized employee shall affix a personal lock-out or tagout device to the group lockout device, group lockbox, or comparable mechanism when he or she begins work and shall remove those devices when he or she stops working on the battery being serviced or maintained.

(e) Al 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. The procedure shall not release the energy stored in the batteries. 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 1: Discharging or disassembling batteries to a 'de-energized' state can be damaging to the battery, hazardous to the worker, or both.

Informational Note 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 where 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 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 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 all of 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. Determine if there are any batteries or chargers nearby that could be confused for the battery being worked on. Check applicable up-to-date drawings, diagrams, and identification tags.

2. Isolate the battery bank from all loads and sources.

	Informational note: this may include placing battery chargers in bypass mode. 3. 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. 4. Apply lockout/tagout devices to the battery charger disconnection means. 5. Sectionalize the battery in accordance with a documented and established procedure. 6. When required by 320.4(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. ~~a.~~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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** 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 energy source and locking the point of isolation to prevent unexpected energization. It then requires a worker to test the circuit to verify zero energy within the work area before starting work. These requirements are based on sound and robust principles of electrical safety to eliminate or reduce the hazard as much as possible before work. 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 thermal, shock, and arc flash hazards The principles of battery sectionalizing are presented in [1]. [1] 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	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. **320.X 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. The battery hazardous energy control program shall specify procedures to safeguard workers from exposure to battery electrical hazards. Employees performing work within the restricted approach boundary of a battery shall plan work to minimize exposure to shock and arc flash hazards. 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. 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. Exception 2: A sectionalizing procedure is not required for batteries below 100 volts dc or 40 milliamperes. 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** 9. Each person who could be exposed directly or indirectly to a battery electrical hazard shall be involved in the sectionalizing procedure. 10. The battery charger shall either be placed into bypass mode or turned off, deenergized, and locked out prior to sectionalizing the battery. 11. The battery shall be disconnected from any electrical load it serves prior to sectionalizing the battery. 12. Control devices, such as push buttons or selector switches, shall not be used as the primary isolating device for the charger. 13. A sectionalizing procedure shall be developed based on the existing battery system and shall use suitable documentation including up-to-date drawings and diagrams. 14. The disconnecting means shall be identified in the sectionalizing procedure. 15. Bus bars or other circuit elements not uniquely or readily identifiable as a lockout/tagout device shall be permitted. 16. Two forms of hazardous energy control shall be permitted in battery systems: simple sectionalizing and complex sectionalizing. 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**

2. Battery sectionalizing equipment shall meet the requirements of lockout/tagout equipment specified in 120.4 with the following addition. 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 all of 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 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 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.

7. The sectionalizing procedure shall require planning, including the requirements of 320.4 (D)(1) through 320.4 (E)(4).
8. 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.
9. 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.
10. 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.
11. The plan shall identify the person in charge and their responsibility in the sectionalizing procedure.
12. 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:
    j. DC voltage,
    k. Available short circuit power,
    l. Thermal PPE,
    m. Limited approach boundary,
    n. Restricted approach boundary,
    o. Shock PPE,
    p. Arc flash incident energy,
    q. Arc flash boundary, and
    r. Arc flash PPE.

(2) Simple Battery Sectionalizing Procedure.

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. Simple battery sectionalizing procedures shall not be required to be written for each application. 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: 13. Any electrical work on a battery and its charger (non-battery electrical work covered by traditional LOTO), 14. Multiple battery strings connected in parallel, 15. Multiple battery chargers connected in parallel, 16. Multiple single-string batteries with chargers located near each other, 17. Multiple energy sources (excluding the battery), 18. Multiple crews, 19. Multiple crafts, 20. Multiple locations, 21. Multiple employers, 22. Multiple disconnecting means, 23. Multiple sequences, or 24. 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. The person in charge shall be held accountable for safe execution of the complex sectionalizing procedure. (d) Each authorized employee shall affix a personal lock-out or tagout device to the group lockout device, group lockbox, or comparable mechanism when he or she begins work and shall remove those devices when he or she stops working on the battery being serviced or maintained. (e) Al 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. The procedure shall not release the energy stored in the batteries. 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 1: Discharging or disassembling batteries to a ‘de-energized’ state can be damaging to the battery, hazardous to the worker, or both. Informational Note 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.** d. Testing for absence of ac voltage shall be required where the shock risk assessment has identified the potential for a hazardous ac voltage from the battery circuit to the bonded enclosure.

	e. Testing for absence of voltage shall be required for all energy sources in the work area other than batteries. f. Testing for absence of voltage shall not be required to establish a lower risk work condition in batteries. Informational note 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 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 all of the following steps, which shall be performed in the order presented, if feasible: 3. Determine the number, configuration, and voltage of batteries in series and parallel, and the number, configuration, and voltage of battery chargers. Determine if there are any batteries or chargers nearby that could be confused for the battery being worked on. Check applicable up-to-date drawings, diagrams, and identification tags. 4. Isolate the battery bank from all loads and sources. Informational note: this may include placing battery chargers in bypass mode. 7. 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. 8. Apply lockout/tagout devices to the battery charger disconnection means. 9. Sectionalize the battery in accordance with a documented and established procedure. 10. When required by 320.4(E)(2), test for the absence of voltage with an adequately rated portable meter. **(4) Release for Return to Service.** e. The procedure shall identify steps to be taken when the job or task requiring battery sectionalizing is completed. f. The procedure shall identify any wires or flexible circuit elements that could be reinstalled improperly resulting in a battery short circuit. g. Reinstallation of these circuit elements shall be identified in the procedure as having an elevated risk of short circuit. h. 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 330	Carry over from 236			☐ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown Article ~~330~~ 370 Safety-Related Work Practices: Lasers			

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 330	225			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	~~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:~~ ~~(1) AC: 50 volts and 5 milliamperes~~ ~~(2) DC: 100 volts and 40 milliamperes~~ ~~(3) Capacitor stored energy:~~ ~~a. Less than 100 volts and greater than 100 joules of stored energy~~ ~~b. Greater than or equal to 100 volts and greater than 1.0 joule of stored energy~~ ~~c. 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 360.3 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:~~

~~(1) Chapter 1 electrical safe work practices~~

~~(2) Electrical hazards associated with laser equipment~~

~~(3) Stored energy hazards, including capacitors and capacitor banks~~

~~(4) Ionizing radiation, including X-rays at voltages greater than 10 kV in a vacuum~~

~~(5) 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:~~

~~(1) Obtaining authorization for work with or on hazardous electrical equipment in lasers and laser systems~~

~~(2) Use of Chapter 1 safety-related work practices~~

~~(3) Reporting laser equipment failures, accidents, inadequate barriers, and inadequate signage to the employer~~

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	There are no specific hazards or requirements in this article that are not already covered in other articles.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

~~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:~~

~~1. AC: 50 volts and 5 milliamperes~~
~~2. DC: 100 volts and 40 milliamperes~~
~~3. Capacitor stored energy:~~
    ~~1. Less than 100 volts and greater than 100 joules of stored energy~~
    ~~2. Greater than or equal to 100 volts and greater than 1.0 joule of stored energy~~
    ~~3. 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 360.3 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:~~

1. ~~Chapter 1 electrical safe work practices~~
2. ~~Electrical hazards associated with laser equipment~~
3. ~~Stored energy hazards, including capacitors and capacitor banks~~
4. ~~Ionizing radiation, including X-rays at voltages greater than 10 kV in a vacuum~~
5. ~~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:~~ ~~1. Obtaining authorization for work with or on hazardous electrical equipment in lasers and laser systems~~ ~~2. Use of Chapter 1 safety-related work practices~~ ~~3.~~1. ~~Reporting laser equipment failures, accidents, inadequate barriers, and inadequate signage to the employer~~

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 340	Carry over from 236			☐ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown. PI shows 340 moving as Article 380 and as Article 330. PI 236 also proposes a reserved Article 340 Article ~~340~~ 380 Safety-Related Work Practices: Power Electronic Equipment Article ~~340~~ 330 ~~Safety-Related Work Practices: Power Electronic Equipment~~ Electrical Hazards 1 Hz to 110 MHz (not including dc and 50/60 Hz) Article 340 Electrical Hazards for Mixed Frequencies (RESERVED) This is reserved for addressing mixed frequencie, such as rectifed ac power, VFD modulated outputs, etc.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 340	231			☒~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	Article 340 ~~Safety-Related Work Practices: Power Electronic Equipment~~ Electrical Hazards 1 Hz to 110 MHz (not including 50/60 Hz) 340.1 Scope.			

This article covers the hazards and safety-related work practices ~~around power electronic equipment, including the following f~~or equipment 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 (not all inclusive):

(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:

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 60479-1, *Effects of Current on Human Beings and Livestock, Part 1: General Aspects*

~~(3) International Commission on Radiological Protection (ICRP) Publication 33, *Protection Against Ionizing Radiation from External Sources Used in Medicine*~~

340.3 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.

340.4 Electrical Hazard Thresholds.

Exposure levels shall not exceed those identified in the following list unless appropriate controls are implemented:

~~(1) DC (0 Hz to 1 Hz): 100 volts and 40 milliamperes~~

~~(2) 60/50 Hz power: 50 volts and 5 milliampere~~

(3) AC (1 Hz to 3 kHz): 50 volts and 3 milliamperes (not including 50/60 Hz)

(4) AC (3 kHz to 100 kHz): 1 x f mA, f in kHz

(5) AC (100 kHz to 3 MHz): 100 mA

(6) AC (3 MHz to 30 MHz):100 $(f/3)^{*0.3}$, f in MHz

(7) 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.

340.5 Specific Measures for Personnel Safety.

~~(A) Employer Responsibility.~~

~~The employer shall be responsible for the following:~~

~~(1) Proper training and supervision by properly qualified personnel, including the following:~~

~~a. Identification of associated hazards~~

~~b. Strategies to reduce the risk associated with the hazards~~

~~c. Methods of avoiding or protecting against the hazard~~

~~d. Necessity of reporting any incident that resulted in, or could have resulted in, injury or damage to health~~

~~(2) Properly installed equipment~~

~~(3) Proper access to the equipment~~

~~(4) Availability of the correct tools for operation and maintenance~~

~~(5) Proper identification and guarding of dangerous equipment~~

~~(6) Provision of complete and accurate circuit diagrams and other published information to the employee prior to the employee starting work (The circuit diagrams should be marked to indicate the components that present an electrical hazard.)~~

~~(7) Maintenance of clear and clean work areas around the equipment to be worked on~~

~~(8) Provision of adequate and proper illumination of the work area~~

~~(B) Employee Responsibility.~~

	~~The employee shall be responsible for the following:~~ ~~(1) Understanding the hazards associated with the work~~ ~~(2) Being continuously alert and aware of the possible hazards~~ ~~(3) Using the proper tools and procedures for the work~~ ~~(4) Informing the employer of malfunctioning protective measures, such as faulty or inoperable enclosures and locking schemes~~ ~~(5) Examining all documents provided by the employer relevant to the work to identify the location of components that present an electrical hazard~~ ~~(6) Maintaining good housekeeping around the equipment and work space~~ ~~(7) Reporting any incident that resulted in, or could have resulted in, injury or damage to health~~ ~~Using and appropriately maintaining the PPE and tools required to perform the work safely~~ The employer and employee shall implement the responsibilities, training requirements, and safe work practices per 110.5 for working with sub RF and RF hazards, with the following exceptions. (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. (C) Exposure to Electromagnetic Fields Informational Note: Equipment that contains RF electrical hazards also may produce nonionizing radiation hazards, i.e., RF electromagnetic fields (EM). Risk assessment shall be performed to determine if there is a risk to EM exposure. Informational Note 1 in item 340.1 above is the Standard for EM exposure.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	Power Electronics is a general term for circuits with active devices (e.g., IGBTs, SCRs, thyristers) that manage substantial power. Such power electronic devices also contain dc and capacitor hazards, which are covered elsewhere in 70E. The only unique new 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.
	Technical reason for resolving or for not making some of the proposed changes.

Response	

First Revision Text (FR)
 	
Clean current edition text is provided to be revised.
 	
Do not delete for a resolve
	Must be in shown in track changes.
	
	Article 340 Safety-Related Work Practices: Electrical Equipment~~Power Electronic~~ Equipment 1 Hz to 110 MHz (not including 50/60 Hz)
	
	340.1 Scope.
	
	This article covers the hazards and safety-related work practices ~~around power electronic equipment, including the following~~for equipment that includes ac waveforms from 1 Hz to 3 kHz (sub RF) and 3 kHz to 110 MHz (RF). It does not include power frequencies of 50/60 Hz. Typical equipment includes but not limited to:
	
	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:
	  1. Motor drives
	  2. Uninterruptible power supply systems
	  3. 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:
	  1. Antennas and RF transmission lines
	  2. Radar equipment
	  3. Industrial scientific and medical equipment
	  4. RF induction and dielectric heaters
	  5. Industrial microwave heaters and diathermy radiators
	  6. Magnetic resonance imagers (MRIs)
	  7. 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 60479-1, *Effects of Current on Human Beings and Livestock, Part 1: General Aspects*
	~~3. International Commission on Radiological Protection (ICRP) Publication 33, *Protection Against Ionizing Radiation from External Sources Used in Medicine*~~
	
	340.3 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.

340.4 Electrical Hazard Thresholds.

Exposure levels shall not exceed those identified in the following list unless appropriate controls are implemented:

~~1. DC (0 Hz to 1 Hz): 100 volts and 40 milliamperes~~
~~2. 60/50 Hz power: 50 volts and 5 milliampere~~
~~3.~~1. AC (1 Hz to 3 kHz): 50 volts and 3 milliamperes excluding 50/60 Hz
~~4.~~2. AC (3 kHz to 100 kHz): 1 x f mA, f in kHz
~~5.~~3. AC (100 kHz to 3 MHz): 100 mA
~~6.~~4. AC (3 MHz to 30 MHz):100 $(f/3)^{*0.3}$, f in MHz
~~7.~~5. 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.

340.5 Specific Measures for Personnel Safety.

The employer and employee shall implement the responsibilities, training requirements, and safe work practices per 110.5 for working with sub RF and RF hazards, with the following exceptions.

(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.

(C) Exposure to Electromagnetic Fields

Informational Note: Equipment that contains RF electrical hazards also may produce nonionizing radiation hazards, i.e., RF electromagnetic fields (EM).

~~(A) Employer Responsibility.~~
~~The employer shall be responsible for the following:~~

~~1. Proper training and supervision by properly qualified personnel, including the following:~~
~~1. Identification of associated hazards~~
~~2. Strategies to reduce the risk associated with the hazards~~
~~3. Methods of avoiding or protecting against the hazard~~
~~4. Necessity of reporting any incident that resulted in, or could have resulted in, injury or damage to health~~

	~~2. Properly installed equipment~~ ~~3. Proper access to the equipment~~ ~~4. Availability of the correct tools for operation and maintenance~~ ~~5. Proper identification and guarding of dangerous equipment~~ ~~6. Provision of complete and accurate circuit diagrams and other published information to the employee prior to the employee starting work (The circuit diagrams should be marked to indicate the components that present an electrical hazard.)~~ ~~7. Maintenance of clear and clean work areas around the equipment to be worked on~~ ~~8. Provision of adequate and proper illumination of the work area~~ ~~(B) Employee Responsibility.~~ ~~The employee shall be responsible for the following:~~ ~~1. Understanding the hazards associated with the work~~ ~~2. Being continuously alert and aware of the possible hazards~~ ~~3. Using the proper tools and procedures for the work~~ ~~4. Informing the employer of malfunctioning protective measures, such as faulty or inoperable enclosures and locking schemes~~ ~~5. Examining all documents provided by the employer relevant to the work to identify the location of components that present an electrical hazard~~ ~~6. Maintaining good housekeeping around the equipment and work space~~ ~~7. Reporting any incident that resulted in, or could have resulted in, injury or damage to health~~ ~~8.~~1. ~~Using and appropriately maintaining the PPE and tools required to perform the work safely~~

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 350	Carry over from 236			☐ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown Article ~~350~~ 390 Safety-Related Work Requirements: Research and Development Laboratories			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. Article 350 Safety-Related Work Requirements: Research and Development Laboratories

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
350.5	44	166	This is primary.	☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	350.5 Specific Measures and Controls for Personnel Safety. Each laboratory or R&D system application shall designate a qualified ~~competent~~ person ~~as defined in this article~~ to ensure the use of appropriate electrical safety-related work practices and controls.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** Using qualified person is appropriate in this section. The term “competent person” is no longer defined in Article 350.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
350.5	166	44	44 is the primary.	☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	350.5 Specific Measures and Controls for Personnel Safety. Each laboratory or R&D system application shall ~~designate a competent person as defined in this article~~ have a designated research laboratory qualified person as defined in article 100 to ensure the use of appropriate electrical safety-related work practices and controls.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.**			

Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	350.5 Specific Measures and Controls for Personnel Safety. Each laboratory or R&D system application shall designate a ~~competent~~ qt person as defined in this article to ensure the use of appropriate electrical safety-related work practices and controls.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Article 360	Carry over from 236			☐ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown. PI shows 340 moving as Article 310 and as Article 320. Article ~~360~~ 310 Safety-Related Requirements for Capacitors			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	Article 360 Safety-Related Requirements for Capacitors			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

360.1	182			☒☐ Create First Revision ☐ Resolve
Proposed Text (from PI)	360.1 Scope. This article covers the electrical safety-related requirements for the practical safeguarding of employees while working with conventional capacitors that present an electrical hazard. Informational Note 1: This article ~~It~~ does not cover electric double layer capacitors (EDLCs), supercapacitors, or hybrid supercapacitors. Informational Note 2: See Informative Annex R for more information on working safely with capacitors.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** 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	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. 360.1 Scope. This article covers the electrical safety-related requirements for the practical safeguarding of employees while working with conventional capacitors that present an electrical hazard. Informational Note 1: This article does not cover electric double layer capacitors (EDLCs), supercapacitors, or hybrid supercapacitors. Informational Note 2: See Informative Annex R for more information on working safely with capacitors.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
360.1	210			☐ Create First Revision ☒☐ Resolve
Proposed Text (from PI)	360.1 Scope.			

	This article covers the electrical safety-related requirements for the practical safeguarding of employees while working with capacitors that present an electrical hazard. It does not cover capacitors that are a part of NRTL listed products that include instructions that deal with the discharge of capacitors before working on the equipment. Informational Note 1: An example of instructions are the instructions on a variable frequency drive that instructs the user to turn the vfd off, lead the display blank out, and then wait a number of seconds before the door is opened. Informational Note 2: See Informative Annex R for more information on working safely with capacitors.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The concern is addressed in Chapter 2 requirements to follow manufacturer's instructions while maintaining electrical equipment.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	360.1 Scope. This article covers the electrical safety-related requirements for the practical safeguarding of employees while working with capacitors that present an electrical hazard. Informational Note: See Informative Annex R for more information on working safely with capacitors.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
360.3	188			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	360.3 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 (thermal hazard) (2) Greater than or equal to 100 volts and greater than 1.0 joule of stored energy (~~moderate~~ shock hazard) (3) Greater than or equal to 400 volts and greater than 0.25 joules of stored energy (~~high~~ shock hazard)			

	(4) Greater than 1.2 cal/cm^2 incident energy at the working distance (arc flash hazard) (5) Greater than 100 joules of stored energy irregardless of voltage (hearing acoustic hazard) (6) Greater than 122 kJ of stored energy when dI/dt is greater than 10^9 A/sec (lung collapse acoustic hazard)
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	This revision adds thresholds for additional hazards covered in this article related to capacitors.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	360.3 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 (thermal hazard) 2. Greater than or equal to 100 volts and greater than 1.0 joule of stored energy (shock hazard) 3. Greater than or equal to 400 volts and greater than 0.25 joules of stored energy (shock hazard) (4) Greater than 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 10^9 A/sec (lung collapse acoustic hazard)

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
360.4(B)	189			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown (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: (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 10^9 A/sec. ~~The current risetime can be modeled using voltage, capacitance, and system impedances.~~ 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. Informational Note: For 360.4(B)(4)(c); The current risetime can be modeled using voltage, capacitance, and system impedances.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	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 threshold of 10*9 A/s excludes such lower voltage, lower power capacitor banks. For justification see reference
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(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: 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: 1. 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. 2. Hearing protection shall be required where the stored energy exceeds 100 joules. 3. The lung protection boundary shall be determined if stored energy is above 122 kJ and dI/dt is greater than 10^9 A/sec. Employees shall not enter the lung protection boundary. 4. Alerting techniques in accordance with 130.8(O) shall be used to warn employees of the hazards. 5. 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. 6. 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. 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 360.4(B)(4)(3) only, the current risetime can be modeled using voltage, capacitance, and system impedances.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
360.5(B)	190	197		☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown (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: (4) Apply lockout/tagout devices in accordance with a documented and established policy. ~~(4) At this point, the sources that previously charged the capacitor(s) have been identified, isolated and locked out. However, the capacitors may still hold hazardous charge.~~			

	(5) If bleed resistors or automatic discharge systems are applicable, wait the prescribed time for the capacitors to discharge to less than the thresholds in 360.3 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. (6) If the capacitor(s) are not referenced to ground through either terminal, a shorting stick shall be used to discharge the capacitor from terminal to terminal. A hard shorting stick shall be permitted to be used up to 1000 joules, a soft shorting stick (containing a discharge resistor) shall be permitted to be used up to 100 kJ, and remote soft shorting shall be performed above 100 kJ.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** 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. 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.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
360.5(B)	197	190		☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions shown (8) For series capacitors or capacitors not connected to ground through either terminal the shorting wires shall be attached across each individual capacitor, and to ground~~case~~. (9) 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). (10) 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 capacitor are shorted and grounded. *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.*
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
	Technical reason for FR.

Statement	For large capacitor banks, attaching a shorting strap 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 written, did not consider such large capacitor banks, and created additional hazards by requiring the manual placement of grounding straps. Pictures and examples can be provided.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. (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. If bleed resistors or automatic discharge systems are applicable, wait the prescribed time for the capacitors to discharge to less than the thresholds in 360.3 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. ~~5.~~6.) If the capacitor(s) are not referenced to ground through either terminal, a shorting stick shall be used to discharge the capacitor from terminal to terminal. A hard shorting stick shall be permitted to be used up to 1000 joules, a soft shorting stick (containing a discharge resistor) shall be permitted to be used up to 100 kJ, and remote soft shorting shall be performed above 100 kJ. ~~6.~~7. Verify that the capacitors are discharged and grounded. 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. ~~7.~~8. When test instruments are used for testing the absence of voltage, 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. 9. For series capacitors or capacitors not connected to ground through either terminal, the shorting wires shall be attached across each individual capacitor, and to ~~case~~ground. 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). ~~8.~~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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
360.6	196	240, 196, 239		☒~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	360.6 Ground and 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. In the case that a capacitor is isolated or floating, two ground sticks are required, or a single shorting stick shall be permitted to be used to discharge the capacitor terminal to terminal. The shorted capacitor must still be brought to ground potential with a ground stick (A) Visual Inspection. The ground or shorting 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: (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 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. (B) Electrical Testing. All ground and 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 ohms to ground every 2 years. (2) The testing shall be documented. *Exception: The test shall be performed annually if the ground 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. **(C)** Storage and Disposal. 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 a size determined by a qualified person. ~~1.~~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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	Technical reason for resolving or for not making some of the proposed changes.

Response				
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
360.6	240	240, 196, 239		☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	360.6 Ground 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~~ to prevent ~~any~~ recharging. A. For a ground or shorting stick that will be used to remove the total capacitor or capacitor bank energy the ground or ~~/~~shorting stick shall be designed, constructed, installed, and periodically inspected so that the full energy and voltage of the capacitors can be safely discharged. B. For a ground or shorting stick that will be used to remove remnant charge the ground/shorting stick shall be designed, constructed, installed, and periodically inspected so that it will remove the remnant charge remaining after the installed energy removal system has discharged the bank and been verified remotely. C. For large energy storage, over 100 kV, the capacitor energy shall be removed and verified remotely. In this case, the ground/shorting stick is for visual indication that the system is in an electrically safe work condition and to add an additional method of preventing any recharging. In this case the the ground/shorting stick shall be designed, constructed, installed, and periodically inspected so that it provides and maintains a path to ground. D. 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 x V_{max} (kV). E. For ground sticks, dielectric PPE shall not be required as long as the ground stick is verified to be connected to a solid ground before use. F. 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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

360.6(B)	239	240, 196, 239		☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	(B) 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** 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.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. 360.6 Ground or Shorting Sticks. 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. 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. . If a capacitor is isolated or floating, two ground sticks are required, or a single shorting stick shall be permitted to be used to discharge the capacitor terminal to terminal. The shorted capacitor must still be brought to ground potential with a ground stick. (A) Visual Inspection. The ground or shorting 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:

	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. (B) 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 ohms 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. **(C)** Storage and Disposal. 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 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. D. 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 x V_{max} (kV). E. For ground sticks, dielectric PPE shall not be required as long as the ground stick is verified to be connected to a solid ground before use. F. 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Article	125			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	Article 390 Electrical Safety for Hybrid SuperCapacitors 380.1 Scope: This article covers electrical safety requirements for the practical safeguarding of employees while working with exposed hybrid supercapacitors that exceed 100 volts nominal or 10 kJ.			

	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 HSCs that exceed 100V or 10 kJ 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 HSCs shall be trained in, and familiar with, any electrical safety-related work practices necessary for their safety. (B) Performing a Risk Assessment for HSCs. The risk assessment process for HSCs 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: 1. The HSC system's 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 exposed. 2. Thermal hazard. The appropriate thermal PPE shall be selected and used if the stored energy of the exposed part is greater than 10 kJ. 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/cm2 (5 J/cm2) at the working distance. b. Acoustic Hazard. Hearing protection shall be required where the incident energy exceeds 4 cal/cm2 (16.7 J/cm2) at the working distance c. Alerting techniques in accordance with 130.8(O) shall be used to warn employees of the hazards. 380.3 Establishing an Electrically Safe Work Condition for HSCs. (A) Written Procedure. Where a conductor or circuit part is connected to an HSC system operating above 100V or 10 kJ, a written procedure shall be used to document the necessary steps and sequence to discharge the HSCs and place the equipment into an electrically safe work condition. The written procedure shall incorporate the results of the risk assessment performed in 380.2(B) and be in accordance with 120. (B) Storage and Disposal. Any residual charge from damaged HSCs shall be removed by discharging before removal. HSCs should be shipped at 30% state-of-charge (SOC) or less. HSCs should be stored at 30% SOC or less unless there are deluge sprinkler systems and early warning thermal detection fire detection technology installed in the facility, or they are stored outdoors in a metal shipping container at least 10 feet (3 m) away from other containers, building walls, roadways, walkways, etc.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	Technical reason for resolving or for not making some of the proposed changes.

Response	The content of the proposed article provides no new information not already found in Article 320 for hazards related to batteries.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Article	131			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	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 that fall within the scope of 380.1 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 EDLC's shall be trained in, and familiar with, any electrical safety-related work practices necessary for their safety. (B) Performing a Risk Assessment for EDLCs. The risk assessment process for EDLCs shall follow the overall risk assessment procedures in 110.3(H). 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). 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. The appropriate PPE for the hazards shall be determined meeting the following conditions: (1) (2) Thermal hazard. The appropriate thermal PPE shall be selected and used if the theoretical maximum power of the exposed part is greater than 1000W. (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 DC. (4) Arc flash at the appropriate working distance. The appropriate protection for the arc flash shall be selected, as follows: a. Arc flash PPE in accordance with 130.7 shall be selected and used if the voltage exceeds 150 volts DC and the incident energy exceeds 1.2 cal/cm2 (5 J/cm2) at the working distance.			

	b. Alerting techniques in accordance with 130.8(O) shall be used to warn employees of the hazards. 380.3 Establishing an Electrically Safe Work Condition for EDLCs. (A) Written Procedure. Where a conductor or circuit part is connected to an EDLC system operating within the scope of 380.1, a written procedure shall be used to document the necessary steps and sequence to safely work on that part. This may involve a procedure to discharge the EDLCs and place the equipment into an electrically safe work condition. 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. Unless a discharge method is provided by the manufacturer, an appropriately sized and safeguarded resistor shall be selected, and a method described to fully discharge the EDLC system. 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. The method shall also include a means to prevent residual charge build up on the EDLC system after it has been discharged. Informational Note: EDLC's 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) All uninstalled capacitors within the scope of 380.1 shall be short-circuited with a conductor of appropriate size after being discharged. (2) 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 (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	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 public input is to address the unique safety hazards associated with EDLC supercapacitors which have a combination of battery and capacitor hazards already identified in this code.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

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 that fall within the scope of 380.1 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 EDLC's shall be trained in, and familiar with, any electrical safety-related work practices necessary for their safety.

(B) Performing a Risk Assessment for EDLCs.

The risk assessment process for EDLCs shall follow the overall risk assessment procedures in 110.3(H). 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). 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. The appropriate PPE for the hazards shall be determined meeting the following conditions:

(1) Thermal hazard. The appropriate thermal PPE shall be selected and used if the theoretical maximum power of the exposed part is greater than 1000W.
(2) 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 DC.
(3) Arc flash at the appropriate working distance. The appropriate protection for the arc flash shall be selected, as follows:
a. Arc flash PPE in accordance with 130.7 shall be selected and used if the voltage exceeds 150 volts DC and the incident energy exceeds 1.2 cal/cm2 (5 J/cm2) at the working distance.
b. Alerting techniques in accordance with 130.8(O) shall be used to warn employees of the hazards.

380.3 Establishing an Electrically Safe Work Condition for EDLCs.

(A) Written Procedure.

	Where a conductor or circuit part is connected to an EDLC system operating within the scope of 380.1, a written procedure shall be used to document the necessary steps and sequence to safely work on that part. This may involve a procedure to discharge the EDLCs and place the equipment into an electrically safe work condition. 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. Unless a discharge method is provided by the manufacturer, an appropriately sized and safeguarded resistor shall be selected, and a method described to fully discharge the EDLC system. 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. The method shall also include a means to prevent residual charge build up on the EDLC system after it has been discharged. Informational Note: EDLC's 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) All uninstalled capacitors within the scope of 380.1 shall be short-circuited with a conductor of appropriate size after being discharged. (2) 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Article	245			☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)	Article 410 Safety-Related Requirements for Photovoltaic Systems 410.1 Scope. This article covers electrical safety requirements for the practical safeguarding of employees while working on DC Photovoltaic (PV) systems. 410.2 Energy Hazard Thresholds. Appropriate controls shall be applied where any of the following thresholds are exceeded: (1) DC thermal hazard: 1000 W for workers wearing jewelry or using small tools, 10 kW for using larger tools (2) DC shock hazard: 100 volts and 40 milliamperes (3) DC arc flash hazard: 150 volts and 1.2 cal/cm2 410.3 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. 410.4 Specific Work Procedures (1) No work shall be performed on exposed PV terminals greater than the shock or arc flash thresholds. (2) Before manipulating any connectors on an energized system (plugging or unplugging) a risk assessment shall be performed that determines the maximum open circuit voltage that would be generated and the maximum current to be interrupted. This risk assessmennt will determine if the action can be performed safely, and what PPE would be required. (3) Robust procedures for plugging and unplugging connectors on an energized PV system shall be developed that considers the possibility of making wrong connections and creating a short circuit, and the controls necessary to prevent such a situation.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	While the addition of new technologies and unique special equipment into Chapter 3 should be encouraged, redundancy must be avoided for overall usability of the Standard. This proposal does not present any new information that isn't already covered in existing Chapter 3 articles.
	Must be in shown in track changes.

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Article	142			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	Article 370 Safety-Related Work Practices for Solar Photovoltaic (PV) Energy Supply Stations 370.1 Scope This article covers electrical safety-related work practices used by employees while working on or with large-scale solar energy electric supply stations and installations[i], including exposed solar photovoltaic (PV) modules, their interconnected systems and equipment, where these pose an electrical hazard. The work practices covered apply to solar energy PV electric supply stations with a nameplate generating capacity of at least 5 MW. Informational Note: See Informative NFPA 70E Annex D for recognized methods for making a reasonable estimate of the arc flash incident heat energy associated with the electrical characteristics specific to solar photovoltaic energy sources. Informational Note: High daytime temperatures and high incident energy levels exist in every section of large-scale solar installations. See Informative NFPA 70E Annex O 0.2.4 (1), & (13) for safety-by-design methods used to reduce the risk of exposure to electrical hazards associated with photovoltaic sources and systems. Informational Note: See the following standards and documents for additional information with respect to safety related considerations associated with photovoltaic energy sources, including: 1. NFPA 70, National Electrical Code, Article 690, Solar Photovoltaic (PV) Systems, 2023 2. NFPA 70, National Electrical Code, Article 691, Large-Scale Photovoltaic (PV) Electric Supply Stations, 2023 3. IEEE 937, Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for Photovoltaic Systems, 2019 4. IEEE 1361, IEEE Guide for Selecting, Charging, Testing, and Evaluating Lead-Acid Batteries Used in Stand-Alone Photovoltaic (PV) Systems, 2014 5. IEEE 1526, IEEE Recommended Practice for Testing the Performance of Stand-Alone Photovoltaic Systems, 2020			

6. IEEE 1562, IEEE Recommended Practice for Sizing Stand-Alone Photovoltaic (PV) Systems, 2021

7. IEEE 2778, IEEE Guide for Solar Power Plant Grounding for Personnel Protection, 2020

8. IEEE Std C95.1, IEEE Standard for Safety Levels with Respect to Human Exposure to Electrical, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz, 2019

370.3 Safety Procedures

(A) General Safety Hazards (Associated with Solar Energy Installations)

(1) Electrical Hazard Thresholds.

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

(2) Photovoltaic System Risk Assessment.

Prior to working on a photovoltaic module or interconnected system, a risk assessment shall be performed to identify thermal, electrical shock, and arc flash hazards and assess the risks associated with the work to be performed.

(3) Electric Shock Risk Assessment.

An electric shock risk assessment shall be performed in accordance with 130.4.

(4) Arc Flash Risk Assessment.

The arc flash risk assessment method selected shall utilize an industry-recognized method for obtaining a reasonable estimate of the arc flash incident energy associated with photovoltaic sources of energy.

(1) Direct Current Arc Flash Hazard Estimation. For photovoltaic systems that output a direct current, arc flash risk analysis methods of estimation should account for the non-linear nature of solar/PV modules, including the arc impedance.

Informational Note: Paragraph D.5.2. Detailed Arcing and Energy Calculations Method under Informative Annex D contains information on industry-recognized and applicable methods of estimating the available incident energy and the arc flash boundary based upon the particular electrical characteristics of photovoltaic systems.

(5) Photovoltaic Array Requirements.

(1) Equipment operation and maintenance.

PV modules, systems and equipment shall be operated and maintained in accordance with the manufacturer's instructions.

(2) Personnel access and approach.

	The photovoltaic array, inclusive of any interconnected modules, shall be accessible only to authorized personnel. (3) Illumination. Employees shall ensure the use of sufficient illumination to perform the work safely. (4) Testing interconnected PV module cable connectors before disconnection. PV module cable connectors shall be tested for absence of load current prior to disconnecting. An adequately rated non-contact test instrument capable of measuring amperage ("amp clamp") shall be used to perform this test. The functionality of the test instrument shall be verified before and after this test has been performed. (6) Apparel. (1) Prohibited Clothing. Personnel shall not wear thermally or electrically conductive objects, clothing articles, jewelry and other like items during work on a PV module or system. (2) Protective Clothing and Equipment. Insulated protective equipment shall be worn by employees while working on or with interconnected PV modules or system components. (7) Abnormal Conditions. Work during abnormal conditions shall be addressed by procedure and shall include the following, where applicable: (1) Electrical Safety Plan. An electrical safety plan shall address abnormal conditions where these have been recognized to exist in the solar array. It shall be developed by a qualified and competent person. The plan shall cover the types of work to be performed on, or near, PV modules, systems and equipment as these relate to the abnormal conditions. A detailed job briefing that, at a minimum, includes each of the above requirements shall be conducted and reviewed with all persons involved with the work prior to commencing work during an abnormal condition. (2) Ground Fault Condition Testing. Where a ground fault condition is known to have occurred and has not been satisfactorily resolved, applicable tests shall be performed to demonstrate the absence of an active ground fault condition before working on or with the photovoltaic systems and equipment associated with the ground fault condition. (3) Active Faulting PV Equipment. Equipment that is actively faulting shall not be approached, operated or handled, except in emergency, and then only by qualified personnel trained in emergency procedures using adequately rated protective means in accordance with the applicable established emergency procedure. (4) Wet Conditions. Working on photovoltaic modules or interconnected systems and equipment while in a wet, damp or submersed condition shall not be permitted, unless the employer assesses the risk and ensures

	that safety-related work practices are used by employees to protect against the associated increased risk. The work practices used shall ensure that the insulating property of any insulated tools and equipment and personal protective equipment used to perform the work is not adversely affected. The work practices used shall not increase the risk of exposure to other electrical hazards. Informational Note: See Informative Annex K for more information on electrical hazards. 8. Warning Signs. Warning signs or labels shall be posted in appropriate locations, to include the following: 1. Permanent signage shall clearly designate areas where photovoltaic modules and interconnected equipment have been installed. 2. Electrical hazard warnings indicating the electric shock hazard due to the module voltage and the arc flash hazard due to the prospective short-circuit current, and the thermal hazard. 3. Notice for personnel to use and wear protective equipment and apparel appropriate to the hazard for the photovoltaic modules and system. 4. Notice prohibiting access to unauthorized personnel. (B) Photovoltaic Energy Source Hazards. (1) PV Module Material Hazards. Information on the materials used in the manufacture of photovoltaic modules shall be made available to employees who work on or with photovoltaic systems and equipment. (2) PV Electric Shock and Arc Flash Hazards. Working on a photovoltaic energy source or interconnected system, where hazardous voltage levels or arc flash hazards are recognized, shall be considered energized electrical work, and shall performed in accordance with the requirements of 130.2. (3) Non-electrical activities that include the handling of PV modules. The following protective equipment shall be available to employees performing any type of service on a PV module or system: (1) Safety glasses or goggles appropriate to the electrical and other hazards. (2) Appropriate cut-resistant gloves shall be worn as protection for the hands during activities that involve the handling of PV modules. (4) Activities that do not include PV module handling. Employees performing any activity not involving the handling of PV modules shall wear safety glasses. (C) Tools and Equipment. (1) Handles.

Tools and equipment for work on PV modules shall be equipment with insulation rated for the maximum voltage of the equipment on which they are used in accordance with 130.7(D)(1).

(2) Contact.

Bare or uncapped PV module electrical conductors shall be kept clear of unintended contact with tools, test equipment vegetation, structures, liquids and damp surfaces and other foreign objects. Conductors shall be capped, plugged or otherwise adequately insulated against contact when unattended.

370.4 Safety Training.

(A) General.

The training requirements of this chapter shall apply to employees exposed to electrical hazards associated with work on or near solar energy sources, including the interconnected photovoltaic equipment, collection systems and associated power conversion system.

(B) Training requirements.

Employees shall be trained to understand the specific electrical hazards associated with electrical energy from a photovoltaic module and arising from interconnecting multiple modules. Employees shall be trained in the safety-related work practices and requirements to provide protection from the electrical hazards associated with their respective job or task assignment.

370.5 Employee Training.

Employees who operate and maintain repair solar installations and equipment shall be trained in the operating characteristics of the PV modules and equipment with which they will work.

(A) Qualified Persons.

Only qualified personnel shall work with or on PV electrical supply installations/stations.

(1) Training.

Qualified persons shall be trained and knowledgeable in the operation of photovoltaic energy sources and equipment and specific work methods and shall be trained to avoid the electrical hazards that are present. Such persons shall be familiar with the proper use of precautionary techniques and PPE. Training for a qualified person shall include the following:

(1) Procedures.

Training in photovoltaic module safety requirements shall introduce any applicable procedures for installing, connecting, disconnecting, repairing, replacing, testing, handling, transport, storage and disposal of modules. Personnel shall complete training and demonstrate proficiency in safety-related work practices associated with performing any such activities before being assigned their tasks.

(2) Hazards.

Training in photovoltaic modules and equipment shall include the hazards of working with continuously or potentially energized equipment, the associated risk and applicable methods for avoiding such hazards and reducing risks appropriately and eliminating risks where feasible.

(3) PV energy systems.

	Qualified persons shall be trained in and knowledgeable of the basic principles of solar energy including photovoltaics, the types of PV systems and their components with which they will work, including the PV system design, and the applicable safety considerations when working with PV systems. (4) Unintentional Grounding of PV modules. Employees who work on or near solar installations and interconnecting collection systems and equipment shall be trained to understand the hazards associated with an unintentional grounded condition along the applicable precautionary techniques to prevent such a condition from occurring. (2) Unqualified Persons. (1) Training. Unqualified persons shall be trained to identify electrical hazards to which they could be exposed and the proper methods of avoiding the hazards. (2) In the solar array. Unqualified persons who may need to approach or enter the solar array shall be trained in, and be familiar with, applicable electrical safety-related work practices necessary to avoid electrical hazards they may encounter during their normal work activities. 370.6 Safeguarding of employees. Operation and maintenance of photovoltaic modules might require contact by employees with exposed energized surfaces of photovoltaic cells, circuit conductors, and their attachments. Safeguards such as safety-related work practices and other safeguards shall be used to protect employees from injury while working in the photovoltaic array. These safeguards shall be consistent with the nature and extent of the related electrical hazards. Safeguards might be different during daylight hours versus at night (for example, during non-daylight hours when irradiance conditions greatly reduce the output voltage and current from a solar module to levels that may be lower the thresholds indicated in 370.3(A)(1).) 370.7 Tools and Equipment. Tools and equipment used for installing, maintaining, servicing, repairing or replacement of solar installations, including interconnected PV equipment, shall conform to manufacturer's recommendations and meet the requirements of applicable codes and standards. 370.8 Responsibility for Electrical Safety. All personnel with access to hazardous voltage and current associated with PV energy sources shall be responsible for the following: (A)Obtaining authorization for work with or on energized electrical equipment in accordance with the requirements of 130.2. (B) Performing work in accordance with the applicable requirements of Chapter 1 safety-related work practices. (C) Reporting photovoltaic equipment incidents, damage, inadequate barriers and/or warning signs to the employer.

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	While the addition of safe electrical work practices for work involving alternative energy sources has merit, this submittal does not provide any unique circumstances that are not found currently in existing sections of this Standard.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Annex	127			☐ Create First Revision ☐ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions shown Informative Annex U Hybrid SuperCapacitors (HSCs) This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only. U.1 Introduction. HSCs (formerly known as Li-ion capacitors of LiCs) are a cross between a Li-ion battery (the cathode is graphite intercalated with lithium ions, similar to the anodes of most Li-ion batteries) and a supercap (EDLC). In an EDLC, both the anode and cathode are made of activated carbon, but in an HSC/LiC only the anode is made of activated carbon. These devices combine the high momentary power capability of an EDLC (or regular electrolytic capacitor), but have longer duration discharge gravimetric and volumetric energy densities approaching (but not quite as good as) those of conventional batteries. Because only one of the "plates" is made of activated carbon, the individual cell voltages (both nominal and charging) exceed those possible in an EDLC, and approach those of some types of Li-ion cells. U.2 Cell / Parallel Cell Pack Voltage Balancing Within a Module Because these hybrid supercapacitors typically use a flammable non-aqueous electrolyte, balancing the voltage of individual cells (or "packs"of parallel cells) within a module is critical for safety. This is typically done by an electronics board mounted inside the pack, which also helps to ensure that the HSC is not overcharged or overdischarged, or charged outside of its operating temperature window (similar to the functions performed by a BMS in a Li-ion battery or a cell balancing board in an EDLC module/pack). U.3 Higher Level BMS for Series Connections of Modules for Higher Voltage Applications While the individual balancing circuit boards in modules handle cell/pack voltage balancing within each module, when multiple modules are placed in series to achieve higher voltages for some larger energy storage applications, a higher level BMS is typically used to balance voltages between modules and act as an aggregation and communication/control point for the individual module boards.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Annex	Carry over from 131	131	This will be a task group FR from the chapter 3 group. It was embedded in 131, and needs pulled out.	☒~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	Annex T Informative Annex T EDLC Characteristics T.1 Introduction EDLC's are a category of supercapacitors having properties of both capacitors and electrochemical cells. They ~~that~~ 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. EDLC's 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. ~~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 a supersonic acoustic shock blast that can cause lung damage. This is due to several factors.~~ 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 which 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. T.2.1 Porous electrodes EDLC's use highly porous carbon-based electrodes to achieve high surface area. This increases the area available to hold charge, but 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. T2.2 Double layer charge separation In EDLC's, 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 electr~~on~~ic field in the dielectric in conventional capacitors. T2.3 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~~V~~. Most EDLC cells operate at less than 3~~V~~ volts DC~~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 (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	55	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$$ **[D.5.1]**

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).

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

Response

Technical reason for resolving or for not making some of the proposed changes.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	78	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)

D.5.1 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 2 of D.5.2)*. 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.~~3~~2)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.1]}$$

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} = system voltage, volts

T_{arc} = arcing time, sec

D = working distance, cm

Repeated experiments by multiple companies ~~*(see reference 4 of D.5.2 for a summary of all of those different tests as well as bibliographic reference to the published results of most of them)*~~ 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 *(see reference 4 of D.5.2)* of a maximum sustaining time yields the following formula: ***T_{arc} = 0.0043 x V_{sys}*** **D.5.2]** Modifying the maximum power incident energy formula with this new value of T_{arc} yields results much closer ~~*(see comparisons of values in reference 4 of D.5.2)*~~ to the values seen in actual testing, and to the values produced by the iterative methods. ~~*(such as the one detailed in reference 1 of D.5.2.)*~~ 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).
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	80	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☒~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	D.5.1 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 2 of D.5.2)*. 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.~~3~~2)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts. $I_{arc} = 0.5 \times I_{bf}$ $IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$ **[D.5.1]** 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} = 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 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 4 of D.5.2)* that typical reflected energy at the typical calculation distance of 18 inches in front of the cabinet for low voltage systems yields an approximate additional 3-4% energy. This essentially means that a mulitplier for arc-in-a-box is generally not needed for incident energy of large dc battery cabinets at 18" 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 4 of D.5.2)* for the arc-flash boundary distance multiplier from the large enclosure curves for ac switchgear in IEEE 1584.

$$K_{ab} = (0.55 \times \ln(d_{ab})) - 0.6 \quad \text{[D.5.3]}$$

where:

K_{ab} = arc-flash boundary distance multiplier for large dc battery cabinets

d_{ab} = calculated arc-flash boundary (in inches) without an arc-in-a-box/enclosure multiplier

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	81	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions show.

D.5.1 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 2 of D.5.2)*. 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.~~32~~)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	195			☐ Create First Revision ☒~~☐~~ Resolve

Proposed Text (from PI)	It is recommended that NFPA 70E provide a clear direction on arc flash incident energy calculation for batteries placed in battery rooms. The current NFPA 70E does classify if the batteries placed in battery rooms are to be considered open-air or enclosures when determining the arc flash incident energy using the maximum energy method. Classifying batteries placed in battery rooms as open-air or enclosed applications can have a significant impact on the incident energy level. The arc flash incident energy level available in an enclosure can be three (3) times greater than the available arc flash incident energy in an open-air application. AS/NZS 5139 Standard, Appendix F, uses a Multiplying Factor (MF) in determining the available arc flash incident energy for a DC system. The MF is 1 for open-air application, 1.5 for battery rooms (accounting for some incident energy reflections when batteries are placed near walls), and 3 for enclosure.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	There was no new proposed text or change, just in the substantiation, direction for the Tc to go do something.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	213	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☒~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	D.5.~~1~~ 2 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 2 of D.5.2)*. 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.5.3)* has~~ Multiple tests conducted in the past 12 years have shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts. $I_{arc} = 0.5 \times I_{bf}$ $IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$ **[D.5.1]** 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} = 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).
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

	$I_{arc} = 0.5 \times I_{bf}$ $IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$ **[D.5.1]** 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} = 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).

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New D.5.1	208	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	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 arcs combine 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. ~~All~~ Many of the methods discussed below assume a static arc, not changing shape in time, but staying in a direct line path between the two electrodes. A lateral magnetic force, plus electrode erosion, results in self extinction that is not predicted by any of the static models. This static assumption is true for models based on circuit theory and plasma physics that does not include dynamic arc behavior. Only an empirical model, based on sufficient data, might predict arc behavior. However, much of the data obtained for the empirical methods is from laboratory tests and does not represent actual systems, including geometry, electrode materials, and gap distances. This lack of accounting for the dynamic behavior of the arc is the primary reason that arc extinction times are not accounted for in the current models, and the models consistently give higher incident energy values than is measured. An example is that all of the below models will predict a higher incident energy for a higher current. However, tests show that the higher currents result in lower incident energy, due to a shorter arc lifetime due to the magnetic force rapidly elongating the arc. Testing of dc arcs has not yet been sufficient nor consistently documented, to create adequate empirically-based models. The difficulty in modeling behavior due to magnetic forces is taking into account the geometry of the conductors, and the lack of knowledge of the erosion effects is failure to document the electrode geometries and materials, and the initial and final gap distance.			

	Nevertheless, there is now sufficient data and dynamic behavior studies to place bounds on the use of the current models. ~~See reference #1.~~
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New D.5.1	115			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	D.5.1 Exposed Conductor Separation Batteries, PV, and other dc circuits commonly have equipment designs that separate exposed conductors to reduce the risk of short-circuit, shock, and arc flash. It is unlikely that a dc arc can be sustained in ungrounded or impedance grounded dc systems below 600 volts between exposed conductors with separation greater than 1 millimeter per volt (see reference [1]). [1] 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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

	Submitted agreed that this can be resolved till we can provide clearer language for this annex and the DC arc flash table.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New D.5.2	222	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☒~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)

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 measurement, to provide a lower voltage bound for a given gap distance, below which, an arc can't be sustain.

$V_{min}=1.06\times g+100$

Or

$$g_{min}=V-100x1.06$$

Where:

V_{min} = voltage below which an arc can't be sustained

g = gap distance

g_{min} = gap above which an arc can't be sustained

V = nominal system voltage

Table D.5.2-1 provides a maximum gap distance for various voltages, above which an arc will extinguish.

~~Using this equation gives the following~~

System voltage (volts)	**Gap Distance, above which arc will quickly extinguish** **cm (inch)**~~gap distance, above which arc will extinguish~~	~~David~~

150	0.47 cm (0.18)	~~15 cm~~
250	1.4 cm (0.55)	~~25 cm~~
550	4.2 cm (1.7)	~~55 cm~~
600	4.7 cm (1.8)	~~60 cm~~
1000	8.5 cm (3.3)	~~100 cm~~

Table D.5.2-1 Maximum gap that will sustain an arc vs voltage.

~~References: see # 1 and #2 in D.5.9 below.~~

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	To create a revision, revise text above or paste final version here.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.2	82	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☒~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	D.5.2 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. 4. "Modifying the DC Arc-Flash Max Power Formula to Give More Realistic Predictions of Maximum Arc-Flash Energy", proceedings of the IEEE IAS ESW, 2024. 5. IEEE 1584-2018, Guide for Performing Arc-Flash Hazard Calculations.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.2	224	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	D.5.~~2~~ 8 ~~Detailed~~ References for 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:~~ The following references for dc arc flash incident energy analysis are used for this Annex section, D.5 (1) L. Gordon, “Modeling the Dynamic Behavior of DC Arcs,” IEEE Trans. on Industry Applications, Vol. 60, No. 1, Jan/Feb 2024, pp 1946-1955. ~~1. “DC-Arc Models and Incident-Energy Calculations,” Ammerman, R.F., et al., *IEEE Transactions on Industry Applications*, Vol. 46, No. 5.~~ (2) R. F. Ammerman, T. Gammon, P. K. Sen, and J. P. Nelson, “DC arc models and incident energy calculations,” in Proc. Petroleum Chem. Ind. Conf.,2009, pp. 1–3. ~~2. “Arc Flash Calculations for Exposures to DC Systems,” Doan, D.R., *IEEE Transactions on Industry Applications*, Vol. 46, No. 6.~~ (3) D. R. Doan, “Arc flash calculations for exposures to DC systems,” IEEE Trans. on Industry Applications, Vol. 46, No. 6, Nov/Dec 2010, pp. 2299-2302. (4) C. Ashton, “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, March 2024, Tucson, pp. 71 – 77.

	(5) A. Stokes and W. Oppenlander, “Electric arcs in open air,” J. Phys. D: Appl. Phys., vol. 24, pp. 26–35, 1991. (6) J. Paukert, “The arc voltage and arc resistance of LV fault arcs,” in Proc. 7th Int. Symp. Switching Arc Phenomena, 1993, pp. 49–51 ~~3. “DC Arc Hazard Assessment Phase II,” Copyright Material, Kinectrics Inc., Report No. K-012623-RA-0002-R00.~~ (7) C.Keyes and C. Maurice, “DC arc hazard assessment phase II,”Kinectrics, Toronto, ON, Canada, Tech. Rep. K-012623-RA-0001-R00, Jul. 2007
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	D.5.2 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New D.5.3	223	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☒~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	D.5.3 Modified Maximum Power Method see reference #4 D.5.4 Stokes/Oppenlander Method This is an empirical method based on tests for dc arcs from 0.1 A to 1 kA. (see reference #5) D.5.5 Paukert Method This is an empirical method based on data of dc arc measurements from 7 sources. It predicts high current arc characteristics. (see reference #6) D.5.6 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 #7) D.5.7 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)
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.3	79	208, 55, 78, 222, 80, 223, 215, 213, 224, 82, 81		☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)	D.5.3 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~~Stationary Applications*.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	This was changed to max power method, so this reference is not longed applicable.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.3	215			☐ Create First Revision ☐ Resolve

Proposed Text (from PI)	D.5.~~3~~ 8 Short Circuit Current and Clearing Time. 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.*~~ 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.

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	D.5.3 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.

DOC #	70E
TG #/NAME	Article 130
TG CHAIR	Greg Steinman
TG MEMBERS	Alamprese, Bowmer, Caldwell, Conkwright, Dobrowsky, Dyson, Glaude, Pace, Wallis, Winfield,

All task group **proposed** motions, revisions, and entries displayed below are for consideration by the entire TC.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.1	1, 3 (move existing 130.2 to 130.3 while incorporating 130.1)	P.I. 1 & 3, 54	20, 35, 54	☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	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. MOVE THE FOLLOWING PARAGRAPHS AS NEW 130.2 130.2 General 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: (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) A **minimum of two qualified workers shall be present for work conducted within the limited approach boundary of exposed energized electrical conductors or circuit parts operating at voltages equal to or greater than 240 volts (AC) or 150 volts (DC). The second worker shall at a minimum be aware of the electrical hazards involved and knowledgeable of the planned work to observe the actions of the person performing the task, ensure their safety and in event of an emergency, assist using an appropriate mitigation means (e.g., contact release, isolation of the source of power, summoning emergency responders).** 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.1				☐ Create First Revision ☐ Resolve

First Revision (FR)	This section has a style issue.
Statement	**Technical reason for revision.** The section was revised to comply with the NEC Style Manual.

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.

MOVE THE FOLLOWING PARAGRAPHS AS NEW 130.2

130.2 General

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)

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) At least one person meeting the emergency response training requirements of 110.4(C) (1) shall be present wherever any employee is exposed to an electrical hazard.

(6) The person meeting ~~these~~ the emergency response training requirements shall be present in the vicinity of, but outside of, either the limited approach boundary or arc flash boundary, whichever is greater.

(B)

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.

Statement

Technical reason for revision.

130.1 contained more than the scope of Article 130. The deleted text was relocated to 130.2.

The 2 person requirement is to provide the immediate availability of emergency response if an employee is exposed to an electrical hazard.

Response

Technical reason for resolving or for not making some of the proposed changes.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

130.1	20		1, 35, 54	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

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 energized work is performed as permitted in accordance with the exceptions to 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.

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.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for FR.

Response

Technical reason for resolving or for not making some of the proposed changes.

Energized work is not defined, and this creates more confusion. It seems it would require that everyone turning on a "light switch" needs to be a qualified person. The existing definition of “Working on” clearly defines energized work.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.1	35		1, 3, 20, 54	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

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: 51. 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. Exception 1 – Unqualified persons may perform normal operation of equipment tasks in accordance with 110.B.2 exception 1. Unqualified persons shall be trained to be able to determine if all conditions in the exception are met. *Note 1 – It might make sense to place this at the end of all of 130.1? The scenario I'm picturing is throwing a switch in normal condition. 130.2 already has an allowance where it's not required in this instance, but 130.4 seems to always be required. 130.5 specifically points to this scenario as unlikely to result in an arc flash.* *Note 2 – An alternate wording I like would be to replace unqualified persons with "minimally qualified person" (or some similar phrase) which could be added as a new definition. My proposed definition is a stripped back version of "qualified person", for example: "One who has demonstrated skills and knowledge related to the operation of electrical equipment and has received safety training to identify the hazards associated".* 52. An energized electrical work permit shall be completed as required by 130.2. 53. An electric shock risk assessment shall be performed as required by 130.4. 54. 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The exception is not necessary because the definition of "Working on" does not include normal operation.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.2	2			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	This Public Input is only a recommendation to renumber this existing 130.2 as 130.3 to allow the text of existing 130.1 that is not part of the Article 130 scope to be relocated as 130.2.			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.** To create a revision, revise text above or paste final version here.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.** The NFPA publishing system automatically adjusts section numbers for the addition or deletion of sections created by a first revision.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.2(B)	9			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown (B) Elements of Work Permit. (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 (C)(15), Table 130.7(C)(15)(c), and 130.7(D)]* c. Arc flash boundary *[see 130.5(E)]*			
	Must be in shown in track changes.			

First Revision Text (FR)
 	
Clean current edition text is provided to be revised.
 	
Do not delete for a resolve
	(A) 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)]*
	    1. Voltage to which personnel will be exposed
	    2. Limited approach boundary *[see 130.4(F), Table 130.4(E)(a), and Table 130.4(E)(b)]*
	    3. Restricted approach boundary *[see 130.4(G), Table 130.4(E)(a), and Table 130.4(E)(b)]*
	    4. 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 (C)(15), and 130.7(D)]*
	6. Results of the arc flash risk assessment *[see 130.5(A)]*
	    1. Available incident energy at the working distance or arc flash PPE category *[see 130.5(F)]*
	    2. 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 (C)(15), Table 130.7(C)(15)(c), and 130.7(D)]*
	    3. 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.

Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Available Incident energy at a given point of work can be different depending on the source of energy and the mitigation systems that are employed to reduce the IE under maintenance conditions.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

New 130.2(C)(5)	255			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	130.2(C~~D~~) 130.2c Tasks done in compliance with 110.2(B) Exception No 1 and Exception No 2, shall be permitted without an energized electrical work permit.~~Tasks done in compliance with 110.2(B) Exception No 1, Exception No 2, or Exception No 5 shall be permitted without an energized electrical work permit.~~			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.** (C) Exemptions to Work Permit. Electrical work shall be permitted without an energized electrical work permit if a qualified person is provided with and uses appropriate safe work practices and PPE in accordance with Chapter 1 under any of the following conditions: 1. Testing, troubleshooting, or voltage measuring 2. Thermography, ultrasound, or visual inspections if the restricted approach boundary is not crossed 3. Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed 4. General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed 5. Tasks done in compliance with 110.2(B) Exception No 1 and Exception No 2.			
Statement	**Technical reason for revision.** The Sentence was added to help users understand the existing exceptions in 110.2(C). A new condition (5) was added to 130.2(C) that addresses compliance with 110.2(B) for exceptions number 1 and number 2 only. An energized electrical work permit is not needed for tasks already exempt from requiring an electrically safe work condition to be established per 110.2(B).			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.4(C)	179			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	(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: (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

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.5(C)				☐ Create First Revision ☐ Resolve

First Revision (FR)	This section has a style issue.
Statement	**Technical reason for revision.** The section was revised to comply with the NEC Style Manual.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.** (C) Additional Protective Measures. Additional protective measures shall comply with 130.5(C)(1) and 130.5(C)(2). (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). (2) 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
Statement	**Technical reason for revision.** The revised text clarifies which boundary requirements are involved.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

Table 130.4(E)(a)	73	214, TG note	120, 180, 214	☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. Table 130.4(E)(a) Electric Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems 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~~~~worker.~~ personnel.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
	The word "employee" was replaced with "personnel" to correlate to the existing word in 130.4E.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.4(E)(a)	214		73, 120, 180 Committee developed FR	☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown Table 130.4(E)(a) Electric Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for Alternating-Current Systems Notes: [e] ~~This includes circuits where the exposure does not exceed 120 volts nominal~~, ~~including line-to-neutral.~~ This voltage range applies to line to ground voltages up to 240V.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
	Note e was revised to indicate that the “line” vs. “phase” issue applies only at the lowest voltage range.			
	Technical reason for resolving or for not making some of the proposed changes.			

Response				
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.4(E)(a)	N/A			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
~~First Revision Text (FR)~~ ~~Clean current edition text is provided to be revised.~~ ~~Do not delete for a resolve~~	**Must be in shown in track changes.** ~~Informational Note: See 29CFR 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).~~			
Statement	**Technical reason for revision.** Create Committee FR: Add IN to note (d) to Table 130.4(E)(a) and note (b) to Table 130.4(E)(b) to direct users to more information on altitude impacts			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.**			

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 29CFR 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 240V.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Tables 130.4(E)(a)	120		73, 180, 214	☐ Create First Revision ☒~~☐~~ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions shown TABLE 130.4(E)(b) revision is handled by Gray.

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~~ 68 m (2 ft ~~2 in~~3 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.~~89 m (3 ft)	
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~~98 m (3 ft 3 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.~~2 m (4 ft)	
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~~42 m (4 ft 8 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~~64 m (5 ft 5 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~~94 m (6 ft 5 in.)
169.1 kV–242 kV	4.0 m (13 ft 0 in.)	4.0 m (13 ft 0 in.)~~2~~	3.~~1 m (6 ft 8 in~~08 m (10 ft 2 in.)
242.1 kV–362 kV	4.7 m (15 ft 4 in.)	4.7 m (15 ft 4 in.)	~~3~~5.~~5 m~~ 52 m (~~11 ft~~ 18 ft 2 in.)
362.1 kV–420 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)~~4~~	6.~~3 m (14 ft 0 in~~81 m (22 ft 5 in.)
420.1 kV–550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)~~5~~	8.~~1 m (16 ft 8 in~~24 m (27 ft 1 in.)
550.1 kV–800 kV	7.2 m (23 ft 9 in.)	7.2 m (23 ft 9 in.)~~6~~	11.~~9 m (22 ft 7 in~~38 m (37 ft 5 in.)

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.**
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	For work covered by 70E, the table is based on the person being at ground potential. Thus, all exposures are phase to ground exposures.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.4(E)(a)	180		73, 120, 214	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions shown 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]	Restricted Approach Boundary[b,d]; Includes Inadvertent Movement Adder	
Nominal System Voltage Range, Phase to Phase[a]	Exposed Movable Conductor[c]	Exposed Fixed Circuit Part	
Less than 50 V	Not specified	Not specified	Not specified
50 V–~~150 V~~240 V[e]	3.1 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
~~151 V~~ 241 V–750 V	3.1 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.31 m (1 ft 0 in.)

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	There are many unintended consequences creating correlation issues involving other provisions in 70E including Annex C 2.1.4.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.4(F)(3)	217			☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	(3) Entering the Limited Approach Boundary. ~~Where there is a need for an~~ Qualified persons shall be permitted to enter the limited approach boundary where it can be demonstrated that the work to be performed is in accordance 110.2(B). Exception: An unqualified person(s) shall be permitted to cross the limited approach boundary ~~, a qualified person shall advise the unqualified person~~ to perfom work in accordance with 110.2(B) when advised by a qualified person(s) of the possible hazards and continuously ~~escort the unqualified~~ escorted by a qualified person(s) while inside the limited approach boundary. ~~Under no circumstance shall unqualified person(s) be permitted to cross the restricted approach boundary.~~

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.**
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The committee affirms that the requirement "Under no circumstance shall unqualified person(s) be permitted to cross the restricted approach boundary" is needed.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130. 4(F)(3)				☐ Create First Revision ☐ Resolve

First Revision (FR)	This section has a style issue,
Statement	**Technical reason for revision.**
	The section was revised to comply with the NEC Style Manual.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.**
	(3) Entering the Limited Approach Boundary. The following shall apply where ~~Where~~ there is a need for an unqualified person(s) to cross the limited approach boundary: 1) ~~,~~ ~~a~~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 ~~1)~~2) ~~.~~ Under no circumstance shall unqualified person(s) be permitted to cross the restricted approach boundary.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.4(G)	218			☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	(G) Restricted Approach Boundary. No qualified person shall approach or take any conductive object closer to exposed energized electrical conductors or circuit parts than the restricted approach boundary set forth in Table 130.4(E)(a) and Table 130.4(E)(b), unless one of the following conditions applies:

	(1) The qualified person is insulated or guarded from energized electrical conductors or circuit parts operating at 50 volts or more. Insulating gloves and sleeves are considered insulation only with regard to the energized parts upon which work is performed. (2) The energized electrical conductors or circuit parts are insulated from the qualified person and from any other conductive object at a different potential. Under no circumstance shall unqualified person(s) be permitted to cross the restricted approach boundary.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The committee affirms the best location for this statement "Under no circumstance shall unqualified person(s) be permitted to cross the restricted approach boundary" is 130.4(F).

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130. 4(G)				☐ Create First Revision ☐ Resolve

First Revision (FR)	This section has a style issue.
Statement	**Technical reason for revision.**
	The section was revised to comply with the NEC Style Manual.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.**
	(G) Restricted Approach Boundary. No qualified person shall approach or take any conductive object closer to exposed energized electrical conductors or circuit parts than the restricted approach boundary set forth in Table 130.4(E)(a) and Table 130.4(E)(b), unless one of the following conditions applies: 1. The qualified person is insulated or guarded from energized electrical conductors or circuit parts operating at 50 volts or more. Informational Note: Insulating gloves and sleeves are considered insulation only with regard to the energized parts upon which work is performed. 2. The energized electrical conductors or circuit parts are insulated from the qualified person and from any other conductive object at a different potential.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.8	21			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	130.8 Other Precautions for ~~Personnel~~ Employee Activities.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.** 130.8 Other Precautions for Personnel Activities.			
Statement	**Technical reason for revision.** 			
Response	**Technical reason for resolving or for not making some of the proposed changes.** While consistent use of the term is desired, changing "personnel" to "employee" does not correct inconsistencies throughout the Standard, and is not the desired term.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.8(I)	66			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	(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~~ 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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** The word “silicone” was editorially corrected to “silicon”.			
	Technical reason for resolving or for not making some of the proposed changes.			

Response				
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.8(I)				☐ Create First Revision ☐ Resolve
First Revision (FR)	This section has a style issue.			
Statement	**Technical reason for revision.**			
	The section was revised to comply with the NEC Style Manual.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.**			
	(I) Housekeeping Duties. Housekeeping duties shall comply with both of the following: (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.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.8(K)	169			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	K) Anticipating Failure. ~~When~~ If there is evidence that electric equipment could fail and injure employees, the electric equipment shall be ~~de-energized~~placed in an electrically safe work condition, 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~~ placed in an electrically safe work condition 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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
	Technical reason for revision.			

Statement	This change aligns with the requirements of Section 110.2. The term "When" was revised to "If" to align with the style manual.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.8(K)				☐ Create First Revision ☐ Resolve

First Revision (FR)	This section has a style issue,
Statement	**Technical reason for revision.** The section was revised to comply with the NEC Style Manual.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.** K) Anticipating Failure. ~~When~~ The following shall apply if there is evidence that electric equipment could fail and injure employees: 1. ~~,~~ ~~t~~The electric equipment shall be ~~de-energized~~placed in an electrically safe work condition, unless the employer can demonstrate that de-energizing introduces additional hazards or increased risk or is infeasible because of equipment design or operational limitation. ~~1.~~2. Until the equipment is ~~de-energized or~~ placed in an electrically safe work condition 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.8(P)	29, 64 (same revision)	29, 64		☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	(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 of the alerting methods in 130.8(O), ~~or~~ shall be employed to prevent the employee from entering look-alike equipment.

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changess.**
	(P) Look-Alike Equipment. Where work is performed on equipment that is in an electrically safe work condition and the equipment 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.
Statement	**Technical reason for revision.**
	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	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.12	170			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	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~~ risk reduction methods 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~~ Examples of additional risk reduction methods that may be taken where conductors are de-energized in order to cut, remove, or reroute them include, but are not limited to~~, remotely~~ : (1) Marking or flagging of conductors, conductors are verified by two qualified employees remotely spiking the conductors~~, pulling conductors~~ (2) Pulling conductors that have been disconnected form energized parts to visually verify movement~~, remotely cutting the conductors, or other~~ (3) Remotely cutting the conductor (4) 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.			

	Informational Note No. 2: De-energizing is only one of several steps in lockout/tagout procedures and in establishing an electrically safe work condition.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changess.** 130.12 Cutting, Removing, or Rerouting of Electrical Conductors and Circuit Parts. Where electrical conductors or circuit parts are put into an electrically safe work condition in order to cut, remove, reroute, or otherwise work on them and the conductor terminations or other 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~~ 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 shall be taken prior to cutting, removing, rerouting, or otherwise work on the conductors or circuit parts. Informational Note No. 1: Examples of additional steps that can be taken ~~to verify~~ 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, but are not limited to: (1) remotely spiking the conductors, (2) pulling the conductors to visually verify movement of the conductors 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, or (~~4) other approved methods.~~ 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. [add existing IN #2 here as new IN#3] Informational Note No. ~~2~~3: De-energizing is only one of several steps in lockout/tagout procedures and in establishing an electrically safe work condition.
Statement	**Technical reason for FR.** The following changes were made: Change 'verify' 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.
	Technical reason for resolving or for not making some of the proposed changes.

Response	

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.4(E)(b)				☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes.** Informational Note: See 29CFR 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).			
Statement	**Technical reason for revision.** Added informational note to note (b) to Table 130.4(E)(b) to direct users to more information on altitude impacts			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

DOC #	70E
TG #/NAME	Sections 130.5 to 130.7 and ac tables
TG CHAIR	Jim Dollard
TG MEMBERS	Daniel Roberts, Sam Stonerock, David Wallace, Paul Barnhart, Paul Dobrowsky, Jim Phillips, Daleep Mohla, Palmer Hickman, Jason Wolfe, Eric Glaude, Vince Dela Croce

All task group **proposed** motions, revisions, and entries displayed below are for consideration by the entire TC.Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.5(B)	67			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. (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~~ being worked on, and the operating time of the protecting overcurrent device. (2) The electrical equipment operating condition and condition of maintenance Informational Note 1: 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). Informational Note 2: The protecting overcurrent device is typically located in an enclosure separate from the equipment being worked on.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.** 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	**Technical reason for resolving or for not making some of the proposed changes.**			
	Must be in shown in track changes.			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**(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~~ (2) The overcurrent protective device for the electrical equipment and its operating time and operating condition (~~2~~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).

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.5(C)	10		56, 67, 144, 145, 263	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions show.

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

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.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

This revision clarifies the application of this informational note and correlates the note with the related definition of fault current.

Response

Technical reason for resolving or for not making some of the proposed changes.

First Revision Text (FR)

Clean current edition text is provided to be revised.
Do not delete for a resolve

Must be in shown in track changes.

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

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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.5(C)	56		10, 67, 144, 145, 263	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions show.

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]
For ac systems, work on energized electrical conductors and circuit parts, including electrical testing.	Any	Yes
Working on control circuits with exposed energized electrical conductors and circuit parts, greater than ~~120~~ 125 volts.	-	-

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The two tasks, and voltage ranges in Table 130.5(C) referenced in this public input are completely different. The first addresses nominal voltage at 125 volts or below and the second addresses voltages greater than 120 volts which could include for example, control circuits at 277 volts.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.5(C)	144		10, 56, 67, 145, 263	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions shown

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]	
For ac systems, work on energized electrical conductors and circuit parts, including electrical testing.		Any	Yes
~~Insertion or removal of covers for battery intercell connector(s).~~		-	-

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

Response

Technical reason for resolving or for not making some of the proposed changes.

There are two completely separate suggested revisions seen in PI-144 and PI-145. The two requirements referenced here are not identical, as one applies to insertion and removal of covers that are not necessarily non-conductive, and does present a likelihood of occurrence. Only when the equipment is in normal condition, and the cover that is being removed is non-conductive, will the occurrence be considered to be unlikely.

First Revision Text (FR)

Clean current edition text is provided to be revised.
Do not delete for a resolve

Must be in shown in track changes.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.5(C)	145		10, 56, 67, 144, 263	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions shown

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]	
For ac systems, work on energized electrical conductors and circuit parts, including electrical testing.		Any	Yes
~~For dc systems, working on energized electrical conductors and circuit parts of series-connected battery cells, including electrical testing.~~		-	-

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

Response

Technical reason for resolving or for not making some of the proposed changes.

There are two completely separate suggested revisions seen in PI-144 and PI-145. The two requirements referenced here are not identical, as the first involves working on energized electrical conductors and circuit parts with the equipment in any condition, while the second is only conducting voltage testing with the equipment in normal condition. Working on equipment involves more than simple voltage testing.

First Revision Text (FR)
Clean current edition text is provided to be revised.
Do not delete for a resolve

Must be in shown in track changes.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.5(C)	263		10, 56, 67, 144, 145	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions shown

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]
Operation of a CB, switch, contactor, or starter.	Normal	No (c)

(c) While operation of a CB, switch, contactor, or starter under normal operating conditions does not have a liklihood of arc flash occurrence, use of basic PPE such as long-sleeve cotton shirt, long pants, leather gloves and safety glasses is recommended.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

Response

Technical reason for resolving or for not making some of the proposed changes.

The NFPA 70E standard provides adequate guidance to determine when PPE should be used as a protective measure. The standard does not recognize cotton garments as PPE. Providing recommendations in a table note is a violation of the NEC Style Manual as table notes are mandatory text.

First Revision Text (FR)

Clean current edition text is provided to be revised.
Do not delete for a resolve

Must be in shown in track changes.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.5(C)	Committee Input			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	This section has a style issue. I have a proposed revision to (A) below to get the ball rolling. 3.5.1.2 Multiple Requirements. Multiple requirements within a single subdivision shall be avoided. Additional subdivisions or lists shall be used to express independent requirements. 2.1.6.3 Subdivisions. Sections shall be permitted to be subdivided for clarity, with each subdivision representing either a rule or a part of a rule. 2.1.6.3.2 Subdivision Titles. First and second level subdivisions shall have titles. Third level subdivisions shall be permitted to have titles. If titles are provided for third level subdivisions in a section, each third level subdivision shall have a title.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	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	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

(C) Additional Protective Measures. Additional protective measures shall comply with 130.5(A)(1), 130.5(A)(2) and 130.5(A)(3).

(1) Hierarchy of Risk Control. 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). 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. 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). 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.	Any	Yes

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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.5(F)	100			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	(F) Arc Flash PPE. 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) 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.			

	Exception: Where the equipment manufacturer has performed testing to determine task specific incident energy information, that verified value shall be permitted for the selection of arc flash PPE. Informational Note: Incident energy released during an arc flash event can be measured in a lab using calorimeters. See UL RP 2986 Recommended Practice for Measuring Incident Energy Exposure for further information.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Testing of specific equipment configurations to determine possible incident arc energy levels is possible. However, the method of testing and the specific parameters under which the equipment is tested are critical variables that must be considered when applying the equipment and selecting PPE. Simply accepting the "verified value" stated by the manufacturer is not sufficient. All the parameters surrounding the "verified value" must be consistent with how the equipment was tested, and this must be confirmed prior to accepting the stated value for selection of PPE.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.5(F)	Committee Input			☒ Create First Revision ☐ Resolve
First Revision (FR)	This section has a style issue. I have a proposed revision to (F) below to get the ball rolling.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
	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	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	(F) Arc Flash PPE Selection Methods. **(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.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.5(H)	37		68	☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown (H) Equipment Labeling. Electrical equipment ~~such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling units and~~ that ~~are~~ is likely to require examination, adjustment, servicing, or maintenance while energized shall be marked with a label containing all the following information:			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
	Technical reason for resolving or for not making some of the proposed changes.			

Response	Deletion of the equipment identified in 130.5(H) will not improve clarity and could create confusion. No equipment list could possibly be all inclusive. The modifier “such as” and the equipment list presently provided is extremely useful to user of the standard
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.5(H)	68		37	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions shown

(H) Equipment Labeling.
Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be marked with a label containing all the following information:

(1) Statement noting that this electrical equipment is required (with some exception) to be put in an Electrically Safe Working Condition before any work can be performed

(1) Nominal system voltage

(2) Arc flash boundary

(3) At least one of the following:

a. Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) for the equipment, but not both

b. Minimum arc rating of clothing

c. Site-specific level of PPE

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for FR.

Response

Technical reason for resolving or for not making some of the proposed changes.

The proposed additional list item requiring a warning to place equipment in an electrically safe work condition is unnecessary. The requirement to place equipment in an electrically safe work condition is already adequately addressed in other sections of the standard.

First Revision Text (FR)
Clean current edition text is provided to be revised.
Do not delete for a resolve

Must be in shown in track changes.

(H) Equipment Labeling. Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be marked with a label containing all the following information:

1. Nominal system voltage
2. Arc flash boundary
3. At least one of the following:
    1. Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) for the equipment, but not both

	2. Minimum arc rating of clothing 3. Site-specific level of PPE Exception No. 1: Unless changes in electrical distribution system(s) render the label inaccurate, labels applied prior to the effective date of this edition of the standard shall be acceptable if they complied with the requirements for equipment labeling in the standard in effect at the time the labels were applied. Exception No. 2: In supervised industrial installations where conditions of maintenance and engineering supervision ensure that only qualified persons monitor and service the system, the information required in 130.5(H)(1) through 130.5(H)(3) shall be permitted to be documented in a manner that is readily available to persons likely to perform examination, servicing, maintenance, and operation of the equipment while energized. The method of calculating and the data to support the information for the label shall be documented. The data shall be reviewed for accuracy at intervals not to exceed 5 years. Where the review of the data identifies a change that renders the label inaccurate, the label shall be updated. The label shall be of sufficient durability to withstand the environment involved. The owner of the electrical equipment shall be responsible for the documentation, installation, and maintenance of the marked label.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New 130.5(I)	160			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	Point of Work Labeling Electrical equipment shall be marked with a label close by the air-gap isolator on the exterior of equipment such as switchboards, panelboards, industrial control panels, and motor control centers stating “ELECTRICAL ISOLATION POINT OF WORK LOCATION”. For other configurations where the “Electrical Isolation Point of Work” is non-obvious, then the qualified person shall do a risk assessment and determine another point of work location to isolate the electrical energy.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The requirement for a qualified worker to test for the absence of voltage at each point of work is adequately addressed in 120.6(7).			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	To create a revision, revise text above or paste final version here.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(A)	17			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	(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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
	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	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	(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.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(B)	15	Committee Input for 130.7(B)		☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	(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. Informational Note No1: See 130.7(C)(~~14) and~~ 7)(a), (c) and (d) and Table 130.7(C)(7)(a) and Table 130.7(~~E) for~~ C)(7)(b) 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** The existing informational note did not address requirements for periodic testing of electrical protective equipment and this revision modifies IN No. 1 to reference the applicable requirements. The existing reference in IN No.1 is relocated and modified as new IN 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	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. **(B) Care of Equipment.** Protective equipment shall comply with all of the following: (1) be maintained in a safe, clean, and reliable condition and in accordance with manufacturers' instructions. (2) ~~The protective equipment shall~~ be visually inspected before each use. (3) ~~Protective equipment shall~~ 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)~~ 7)(a), (c) and (d), Table 130.7(C)(7)(a) and Table 130.7(~~E)~~C)(7)(b) 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.
	Note self: see alternate suggestion by DR

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(C)(6)	98	275		☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	(6) Body Protection. Employees shall wear arc-rated clothing wherever there is possible exposure to an electric arc flash ~~above~~ equal to or greater than the threshold incident energy level for a second degree burn [1.2 cal/cm^2 (5 J/cm^2)].
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** 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	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. **(6) Body Protection.** Employees shall wear arc-rated clothing wherever there is possible exposure to ~~to an electric arc flash above the threshold incident energy level for a second degree burn~~incident energy of ~~[~~1.2 cal/cm2 (5 J/cm2)~~]~~ or more.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(C)(10)(c)	26	258	86, 121, 258	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions show.

(10) Arc Flash Protective Equipment.

(b) *Head Protection.*

(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.

Exception: Where face shields or hoods offer eye protection that meets the requirements of ANSI/ISEA Z87.1, safety glasses or goggles shall not be required to be worn under the face shield or hood.

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. Some newer faceshields or hoods offer rated eye protection in addition to arc flash protection.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

Response

Technical reason for resolving or for not making some of the proposed changes.

While face shields may be shown to meet ANSI/ISEA Z87.1, face shields do not necessarily provide protection from flying objects going under or around the face shield.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(C)(10)(d)	121	285	26, 86, 121, 258	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions shown (10) Arc Flash Protective Equipment. (d) *Hand Protection.* Gloves shall have an arc rating suitable for the arc flash exposure. Arc flash exposure for hands shall consider the actual working distance of the hands. (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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The requirement for suitably rated arc flash protection for the hands and the possibility that the hands could be closer than the assumed working distance that is used to determine incident energy is already addressed in 130.5(G), which states: “Arc-rated clothing and other PPE shall be used by the worker and selected on the basis of the incident energy exposure associated with the specific task. Recognizing that incident energy increases as the distance from the arc flash decreases, additional PPE shall be used for any parts of the body that are closer than the working distance at which the incident energy was determined.”
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(C)(10)(e)	86		26, 121, 258	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions shown (10) Arc Flash Protective Equipment. (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) The statement "shall be used in all exposures greater than 4 cal" is contradictory with Table 130.5(G) which states leather footwear is required above 1.2 cal. 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	This public input sought to delete the 4 cal/cm2 requirement in 130.7(C)(10) or modify the permissive table in 130.5(G). Neither of these suggestions are necessary or provide clarity. The use of Table 130.5(G) is permitted, it is not required. However, the threshold of 4 cal/cm2 for foot protection is required.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(C)(10)	Committee Input			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	This section has a style issue. I have a proposed revision to C(10) below to get the ball rolling.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
	The section was revised to comply with the NEC Style Manual section 3.5.1.2 Multiple Requirements			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			

(10) Arc Flash Protective Equipment.

(a) Arc Flash Suits.

(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.

(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.

(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.

	(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.* (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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(C)(12)	181			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	(12) Clothing and Other Apparel Not Permitted. Clothing and other apparel (such as hard hat liners and hair nets) made from materials that do not meet the requirements of 130.7(C)(11) regarding melting or made from materials that do not meet the flammability requirements shall not be permitted to be worn. Informational Note: Some flame-resistant fabrics, such as non-flame-resistant modacrylic and nondurable flame-retardant treatments of cotton, are not recommended for industrial electrical or utility applications. *Exception No. 1: Nonmelting, flammable (non-arc-rated) materials shall be permitted to be used as underlayers to arc-rated clothing, as described in 130.7(C)(11).* *Exception No. 2: Where the work to be performed inside the arc flash boundary exposes the worker to multiple hazards, such as the addition of airborne contaminants, ~~and the~~ a job risk assessment ~~identifies that the level of protection is adequate to address the arc flash hazard, non-arc-rated PPE shall be permitted.~~ shall be conducted to determine the proper risk control methiods needed to provide the worker proper protection form all hazards.*			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	Exception No. 2 is a very specific exception that permits non-arc rated PPE only when the protection is adequate to address the arc flash hazard. Where the arc flash hazard is low enough that non arc-rated PPE is acceptable, then other PPE (for example, dust masks or respirators) that don't meet the requirements of 130.7(C)(11) should be acceptable, but without the exception as currently written, they would not be acceptable.			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.
	(12) Clothing and Other Apparel Not Permitted. Clothing and other apparel (such as hard hat liners and hair nets) made from materials that do not meet the requirements of 130.7(C)(11) regarding melting or made from materials that do not meet the flammability requirements shall not be permitted to be worn. Informational Note: Some flame-resistant fabrics, such as non-flame-resistant modacrylic and nondurable flame-retardant treatments of cotton, are not recommended for industrial electrical or utility applications. Exception No. 1: Nonmelting, flammable (non-arc-rated) materials shall be permitted to be used as underlayers to arc-rated clothing, as described in 130.7(C)(11). Exception No. 2: Where the work to be performed inside the arc flash boundary exposes the worker to multiple hazards, such as airborne contaminants, and the risk assessment identifies that the level of protection is adequate to address the arc flash hazard, non-arc-rated PPE shall be permitted.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(C)(14)(b)	59		184	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions show.

(14) Standards for PPE.

(a) *General.* PPE shall conform to applicable state, federal, or local codes and standards.

Informational Note No. 1: See Informational Note Table 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 Informational Note Table 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:~~

~~(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~~ , Listing and Certification program by an International accredited independent third-party certification organization that Inspects the manufacturing facility where the certified product is manufactured and undergoes through annual recertification compliance.

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.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

PPE is important for worker safety. While most PPE manufacturers are reliable, merely relying upon self-certification by the PPE manufacturer is insufficient to ensure that the PPE provides the appropriate level of protection. As long as there are suppliers that value sales over integrity, there will be PPE on the market that may not actually meet the appropriate test requirements.

Response

Technical reason for resolving or for not making some of the proposed changes.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

(**14) Standards for PPE.**

(a) *General.* PPE shall conform to applicable state, federal, or local codes and standards.

Informational Note No. 1: See Informational Note Table 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 Informational Note Table 130.7(C)(14). (b) *Conformity Assessment.* All suppliers or manufacturers of PPE shall demonstrate conformity with an ~~appropriate~~ applicable product standard ~~by one of the following methods:~~through a listing and certification program by an internationally accredited independent third-party organization that includes regular inspections of the PPE at the facility where the certified PPE is manufactured as a condition of continued certification. ~~(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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(C)(14)(c)	184		59	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	CDC NOTE: only identified revisions shown (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) Product performance standards to which the product conforms (2) Conformity assessment method used by the supplier (3) Arc rating where appropriate for the equipment (4) One or more identifiers such as model, serial number, lot number, or traceability code (5) Care instructions
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.** This First Revision 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	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**. **(14) Standards for PPE.** *(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 by the supplier (~~2~~3) Product performance standards to which the product conforms (~~3~~4) Arc rating where appropriate for the equipment (~~4~~5) One or more identifiers such as model, serial number, lot number, or traceability code (~~5~~6) Care instructions

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

130.7(C)(15)	72		11, 12	☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: Could not identify proposed change. Statement has suggestions.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	This public input did not provide a suggested revision as required in section 4.3.4.1(c) of the NFPA regulations.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(C)(15)	11	12	12, 72	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions show.

(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:

(1) Power systems with greater than the estimated ~~maximum~~ available fault current

(2) Power systems with longer than the maximum fault clearing times

(3) Less than the minimum working distance

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

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

Response

Technical reason for resolving or for not making some of the proposed changes.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

(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.*

(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. 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:

(1) Power systems with greater than the estimated ~~maximum~~ available fault current

(2) Power systems with longer than the maximum fault clearing times

(3) Less than the minimum working distance

(b) *Direct Current (dc) Equipment.*

(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. 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:

(1) Power systems with greater than the estimated ~~maximum~~ available fault current

(2) Power systems with longer than the maximum arc duration

(3) Less than the minimum working distance

(c) Protective Clothing and Personal Protective Equipment (PPE).

(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. 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.7(C)(15)(a)	71		96, 234, 244	☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. Table 130.7(C)(15)(a) Arc Flash PPE Categories for Alternating Current (ac) Systems Informational Note No. 2 to Table 130.7(C)(15)(a): ~~See Table 1 of~~ IEEE 1584, *Guide for Performing Arc Flash Hazard Calculations*, for further information regarding list items (2) through (4) in Informational Note No. 1.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The reference to “Table 1” is not removed from Table 130.7(C)(15)(a) Informational Note No. 2 as IEEE 1584-2002 Table 1 is the source of the information provided in Table 130.7(C)(15)(a) Informational Note No. 1.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.7(C)(15)(a)	96		71, 234, 244	☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. Table 130.7(C)(15)(a) Arc Flash PPE Categories for Alternating Current (ac) Systems 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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.**			
	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.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
	Table 130.7(C)(15)(a) Arc Flash PPE Categories for Alternating Current (ac) Systems 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.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.7(C)(15)(a)	234		71, 96, 244	☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. Table 130.7(C)(15)(a) Arc Flash PPE Categories for Alternating Current (ac) Systems 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 short-time fault learing 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 short time fault clearing region.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.** List items (2) through (6) are modified for clarity and correlation with list item (1).			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision (FR)	**Must be in shown in track changes**. Table 130.7(C)(15)(a) Arc Flash PPE Categories for Alternating Current (ac) Systems 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 short time fault clearing 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 short time fault clearing region.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table 130.7(C)(15)(a)	244		71, 96, 234	☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions show. Table 130.7(C)(15)(a) Arc Flash PPE Categories for Alternating Current (ac) Systems 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. (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. (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”). (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. (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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The text that is recommended to be deleted must be retained to correlate with the separate revision made to Table 130.7(C)(15)(a) Notes.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose	MOTION

			revisions for this section	
Table 130.7(C)(15)(c)	19	269		☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions show.

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/cm² (16.75 J/cm²)**[a]	
	-	Arc-rated long-sleeve shirt and pants or arc-rated coverall
	-	Arc-rated face shield[b] or arc- rated arc flash suit hood
2	**Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm² (33.5 J/cm²)**[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

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

The modifiers “arc-rated” and “arc” are added to the table for correlation and clarity.

Response

Technical reason for resolving or for not making some of the proposed changes.

First Revision Text (FR)

Clean current edition text is provided to be revised.
Do not delete for a resolve

Must be in shown in track changes.

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/cm² (16.75 J/cm²)**[a]
	Arc-rated long-sleeve shirt and pants or arc-rated coverall
	Arc-rated face shield[b] or arc-rated flash suit hood
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[f]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[c]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[d]
	Leather footwear[e] (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]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[c]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[d]
	Leather footwear[e]
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]
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[f]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[c]
	Leather footwear[e]
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-rated gloves or rubber insulating gloves with protectors (SR)[d]
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[f]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[c]
	Leather footwear[e]

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. [c] 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] 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] 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. [f] 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(D)(1)	168			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	(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 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).
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.** This revision now 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, are 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	**Technical reason for resolving or for not making some of the proposed changes.**
	Must be in shown in track changes.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**(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. (5) ~~The i~~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).

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(D)(2)	186			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	(2) Barriers. Exposed energized electrical conductors or circuit parts ~~operating at 50 volts or more~~ where an electrical hazard exists 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.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The suggested revision seeks to modify the general rule in 110.2(B) which focuses the intent of the NFPA 70E Standard to electrical conductors and circuit parts operating at voltages equal to or greater than 50 volts. See 110.2(B) Exception No. 5 for specific reference to requirements for systems that operate at less than 50 volts. The deletion of “operating at 50 volts or more” in 130.7(D)(2) could create confusion.			
First Revision (FR)	**Must be in shown in track changes**.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
130.7(D)(2)	Committee Input			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
Statement	**Technical reason for revision.**			
	The section was revised to comply with the NEC Style Manual.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**.			
	(2) 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.			

CI/FR Table 130.7(C)(15)(a)

FR Statement:
This revison 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) 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	1	485 mm (19 in.)
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.)		

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated greater than 240 volts and up to 600 volts Parameters: Available fault current not exceeding ~~Maximum of~~ 25 kA ~~available fault current~~; fault clearing time not exceeding ~~maximum of~~ 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: Available fault current not exceeding ~~Maximum of~~ 65 kA ~~available fault current~~; fault clearing time not exceeding ~~maximum of~~ 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: Available fault current not exceeding ~~Maximum of~~ 42 kA fault clearing time not exceeding ~~available fault current; maximum of~~ 0.33 sec (20 cycles) ~~fault clearing time~~; minimum working distance 455 mm (18 in.)	4	4.3 m (14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Available fault current not exceeding ~~Maximum of~~ 35 kA ~~available fault current~~; fault clearing time not exceeding ~~maximum of up to~~ 0.5 sec (30 cycles) ~~fault clearing time~~; minimum working distance 455 mm (18 in.)	4	6 m (20 ft)
Other 600-volt class (277 volts through 600 volts, nominal) equipment Parameters: Available fault current not exceeding ~~Maximum of~~ 65 kA ~~available fault current~~; fault clearing time not exceeding ~~maximum of~~ 0.03 sec (2 cycles) ~~fault clearing time~~; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Available fault current not exceeding ~~Maximum of~~ 35 kA ~~available fault current~~; fault clearing time not exceeding ~~maximum of up to~~ 0.24 sec (15 cycles) ~~fault clearing time~~; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Metal-clad switchgear, 1 kV through 15 kV Parameters: Available fault current not exceeding ~~Maximum of~~ 35 kA ~~available fault current~~; fault clearing time not exceeding ~~maximum of up to~~ 0.24 sec (15 cycles) ~~fault clearing time~~; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Metal enclosed interrupter switchgear, fused or unfused type construction, 1 kV through 15 kV Parameters: Available fault current not exceeding ~~Maximum of~~ 35 kA ~~available fault current~~; fault clearing time not exceeding~~maximum of~~ 0.24 sec (15 cycles) ~~fault clearing time~~; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Other equipment 1 kV through 15 kV Parameters: Available fault current not exceeding ~~Maximum of~~ 35 kA ~~available fault current~~; fault clearing time not exceeding ~~maximum of up~~	4	12 m (40 ft)

Equipment	Arc Flash PPE Category	Arc Flash Boundary
~~to~~ 0.24 sec (15 cycles) ~~fault clearing time~~; minimum working distance 910 mm (36 in.)		
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 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

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.
(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.
(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”).
(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.
(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.

Informational Note No. 2 to Table 130.7(C)(15)(a): See Table 1 of IEEE 1584, *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.

DOC #	70E
TG #/NAME	Annexes
TG CHAIR	Mark Hilbert
TG MEMBERS	Paul Barnhart, Jeffrey Conkwright, Charlie Miller, Daleep Mohla, Jim Phillips, Virginia Balitski

All task group **proposed** motions, revisions, and entries displayed below are for consideration by the entire TC.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
A.3.9	123			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	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. ANSI/CAN/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.			
	Must be in shown in track changes .			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	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. UL 1436, Outlet Circuit Testers and Other Similar Indicating Devices, 2016. 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 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements, 2012. 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.
Statement	**Technical reason for revision.**
	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	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
C.2.1	88			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	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.			
	Must be in shown in track changes .			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	C.2.1 General Statement. 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.
Statement	**Technical reason for revision.** 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	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Table D.1	87			☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

CDC NOTE: Only identified changes shown

D.6	Marroquin, et al. ,High-Voltage Arc Flash Assessment and Applications (IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 56, NO. 3, MAY/JUNE 2020)	Calculates incident energy for high voltage system rated at greater than 1kV based on V.

V. Terzija and H. J. Konglin paper "Long arc in free air: Laboratory testing, modeling, simulation and model-parameters estimation," IEEE Proc.- Gener., Transmission and. Distribrution., vol. 149, no. 3, pp. 319–325, May 2002.

First Revision Text (FR)

Clean current edition text is provided to be revised.

Do not delete for a resolve

Must be in shown in track changes .

Table D.1 Limitation of Calculation Methods

Section	Source	Limitations/Parameters
D.2	Lee, "The Other Electrical Hazard: Electrical Arc Flash Burns"	Calculates incident energy and arc flash boundary for arc in open air; conservative over 600 volts and becomes more conservative as voltage increases
D.3	Doughty, et al., "Predicting Incident Energy to Better Manage the Electrical Arc Hazard on 600 V Power Distribution Systems"	Calculates incident energy for three-phase arc on systems rated 600 volts and below; applies to short-circuit currents between 16 kA and 50 kA

	D.4	IEEE 1584, *Guide for Performing Arc Flash Hazard Calculations*	Calculates incident energy and arc flash boundary for 208 volts to 15 kV; three-phase; 50 Hz to 60 Hz; 500 amperes to 106,000 amperes short-circuit current (208 volts to 600 volts); 200 amperes to 65,000 amperes short-circuit current (600 volts to 15,000 volts); and conductor gaps of 6.35 mm to 76.2 mm (0.25 in. to 3 in.) for 208 volts to 600 volts and 13 mm to 152 mm (0.75 in. to 10 in.) for 601 volts to 15,000 volts
	D.5	Doan, "Arc Flash Calculations for Exposure to DC Systems"	Calculates incident energy for dc systems rated up to 1000 volts dc
Statement	**Technical reason for revision.**		
Response	**Technical reason for resolving or for not making some of the proposed changes.**		

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	55	78, 81, 115, 208 213, 215, 222, 223, 224	78, 80, 81,195, 213	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

D.5.1 Maximum Power Method. See the attached document for Annex D.5 changes,

The following method of estimating dc arc flash incident energy that follows was published in the *IEEE Transactions on Industry Applications (see reference 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$$ **[D.5.1]**

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).
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	78		55, 80, 81, 195, 213	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

D.5.1 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 2 of D.5.2)*. 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.~~3~~2)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$$ **[D.5.1]**

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} = system voltage, volts

T_{arc} = arcing time, sec

D = working distance, cm

Repeated experiments by multiple companies *(see reference 4 of D.5.2 for a summary of all of those different tests as well as bibliographic reference to the published results of most of them)* 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 *(see reference 4 of D.5.2)* of a maximum sustaining time yields the following formula:

T_{arc} = 0.0043 x V_{sys} **D.5.2]**

Modifying the maximum power incident energy formula with this new value of T_{arc} yields results much closer *(see comparisons of values in reference 4 of D.5.2)* to the values seen in actual testing, and to the values produced by the iterative methods *(such as the one detailed in reference 1 of D.5.2.)*

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).

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for FR.

Response

Technical reason for resolving or for not making some of the proposed changes.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	80		55, 78, 81, 195, 213	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

D.5.1 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 2 of D.5.2)*. 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.~~3~~2)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$$ **[D.5.1]**

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} = 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 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 4 of D.5.2)* that typical reflected energy at the typical calculation distance of 18 inches in front of the cabinet for low voltage systems yields an approximate additional 3-4% energy. This essentially means that a mulitplier for arc-in-a-box is generally not needed for incident energy of large dc battery cabinets at 18" 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 4 of D.5.2)* for the arc-flash boundary distance multiplier from the large enclosure curves for ac switchgear in IEEE 1584.

$$K_{ab} = (0.55 \times \ln(d_{ab})) - 0.6 \quad \text{[D.5.3]}$$

where:

K_{ab} = arc-flash boundary distance multiplier for large dc battery cabinets

d_{ab} = calculated arc-flash boundary (in inches) without an arc-in-a-box/enclosure multiplier

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

Response

Technical reason for resolving or for not making some of the proposed changes.

IEEE 1584-2018 scope and application is limited to 3 phase ac. It specifically excludes DC. Utilizing guidance of a 3-phase model to DC application is inappropriate.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	81		55, 78, 80, 195, 213	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

CDC NOTE: only identified revisions show.

D.5.1 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 2 of D.5.2)*. 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.~~3~~2)* has shown that

	this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
	The reference to D.5.3 was editorially revised to D.5.2.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	195		55, 78, 80, 81, 213	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	It is recommended that NFPA 70E provide a clear direction on arc flash incident energy calculation for batteries placed in battery rooms. The current NFPA 70E does classify if the batteries placed in battery rooms are to be considered open-air or enclosures when determining the arc flash incident energy using the maximum energy method. Classifying batteries placed in battery rooms as open-air or enclosed applications can have a significant impact on the incident energy level. The arc flash incident energy level available in an enclosure can be three (3) times greater than the available arc flash incident energy in an open-air application. AS/NZS 5139 Standard, Appendix F, uses a Multiplying Factor (MF) in determining the available arc flash incident energy for a DC system. The MF is 1 for open-air application, 1.5 for battery rooms (accounting for some incident energy reflections when batteries are placed near walls), and 3 for enclosure.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	No recommended text has been provided as required by 4.3.4 of the NFPA Regulations Governing Committee Standards.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.1	213		55, 78, 80, 81, 195	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	D.5.~~1~~ 2 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 2 of D.5.2)*. 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.5.3)* has~~ Multiple tests conducted in the past 12 years have shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts. $I_{arc} = 0.5 \times I_{bf}$ $IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$ **[D.5.1]** 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} = 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).
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** . D.5.1 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 2 of D.5.2)*. 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.~~3~~2)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

	$I_{arc} = 0.5 \times I_{bf}$ $IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$ **[D.5.1]** 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).

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New D.5.1	208			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	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 arcs combine 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. All of the methods discussed below assume a static arc, not changing shape in time, but staying in a direct line path between the two electrodes. A lateral magnetic force, plus electrode erosion, results in self extinction that is not predicted by any of the static models. This static assumption is true for models based on circuit theory and plasma physics that does not include dynamic arc behavior. Only an empirical model, based on sufficient data, might predict arc behavior. However, much of the data obtained for the empirical methods is from laboratory tests and does not represent actual systems, including geometry, electrode materials, and gap distances. This lack of accounting for the dynamic behavior of the arc is the primary reason that arc extinction times are not accounted for in the current models, and the models consistently give higher incident energy values than is measured. An example is that all of the below models will predict a higher incident energy for a higher current. However, tests show that the higher currents result in lower incident energy, due to a shorter arc lifetime due to the magnetic force rapidly elongating the arc. Testing of dc arcs has not yet been sufficient nor consistently documented, to create adequate empirically-based models. The difficulty in modeling behavior due to magnetic forces is taking into account the geometry of the conductors, and the lack of knowledge of the erosion effects is failure to document the electrode geometries and materials, and the initial and final gap distance. Nevertheless, there is now sufficient data and dynamic behavior studies to place bounds on the use of the current models. See reference #1.				

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** . To create a revision, revise text above or paste final version here.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New D.5.1	115			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	D.5.1 Exposed Conductor Separation Batteries, PV, and other dc circuits commonly have equipment designs that separate exposed conductors to reduce the risk of short-circuit, shock, and arc flash. It is unlikely that a dc arc can be sustained in ungrounded or impedance grounded dc systems below 600 volts between exposed conductors with separation greater than 1 millimeter per volt (see reference [1]). [1] 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.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** . To create a revision, revise text above or paste final version here.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**

<table>
<tr><td>Section</td><td>This Public Input</td><td>Add other PIs included with this revision/resolve (CART)</td><td>For reference - these other PIs propose revisions for this section</td><td>MOTION</td></tr>
<tr><td>New D.5.2</td><td>222</td><td></td><td></td><td>☒ Create First Revision

☐ Resolve</td></tr>
<tr><td>Proposed Text (from PI)</td><td colspan="4">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 measurement, to provide a lower voltage bound for a given gap distance, below which, an arc can’t be sustain.

Vmin=1.06×g+100

Or

gmin=V-1001.06

Where:

V_{min} = voltage below which an arc can’t be sustained

g = gap distance

g_{min} = gap above which an arc can’t be sustained

V = system voltage

Using this equation gives the following

<table><tr><td>System voltage (volts)</td><td>gap distance, above which arc will extinguish</td><td>David</td></tr><tr><td>150</td><td>0.47 cm</td><td>15 cm</td></tr><tr><td>250</td><td>1.4 cm</td><td>25 cm</td></tr><tr><td>550</td><td>4.2 cm</td><td>55 cm</td></tr><tr><td>600</td><td>4.7 cm</td><td>60 cm</td></tr><tr><td>1000</td><td>8.5 cm</td><td>100 cm</td></tr></table>
References: see # 1 and #2 in D.5.9 below.</td></tr>
<tr><td>First Revision Text (FR)

Clean current edition text is provided to be revised.

Do not delete for a resolve</td><td colspan="4">Must be in shown in track changes .

To create a revision, revise text above or paste final version here.</td></tr>
<tr><td>Statement</td><td colspan="4">Technical reason for revision.</td></tr>
</table>

Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.2	82		244	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	D.5.2 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. 4. "Modifying the DC Arc-Flash Max Power Formula to Give More Realistic Predictions of Maximum Arc-Flash Energy", proceedings of the IEEE IAS ESW, 2024. 5. IEEE 1584-2018, Guide for Performing Arc-Flash Hazard Calculations.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	There is no test data or other substantiation provided for the addition of new references. Section 5.2 addresses arc flash calculations for DC. Inclusion of IEEE 1584-2018 as a reference is not appropriate as the scope of IEEE 1584-2018 excludes DC.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.2	224		82	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	D.5.~~2~~ 8 ~~Detailed~~ References for 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:~~ The following references for dc arc flash incident energy analysis are used for this Annex section, D.5 (1) L. Gordon, “Modeling the Dynamic Behavior of DC Arcs,” IEEE Trans. on Industry Applications, Vol. 60, No. 1, Jan/Feb 2024, pp 1946-1955. ~~1. “DC-Arc Models and Incident-Energy Calculations,” Ammerman, R.F., et al., *IEEE Transactions on Industry Applications*, Vol. 46, No. 5.~~ (2) R. F. Ammerman, T. Gammon, P. K. Sen, and J. P. Nelson, “DC arc models and incident energy calculations,” in Proc. Petroleum Chem. Ind. Conf.,2009, pp. 1–3. ~~2. “Arc Flash Calculations for Exposures to DC Systems,” Doan, D.R., *IEEE Transactions on Industry Applications*, Vol. 46, No. 6.~~ (3) D. R. Doan, “Arc flash calculations for exposures to DC systems,” IEEE Trans. on Industry Applications, Vol. 46, No. 6, Nov/Dec 2010, pp. 2299-2302. (4) C. Ashton, “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, March 2024, Tucson, pp. 71 – 77. (5) A. Stokes and W. Oppenlander, “Electric arcs in open air,” J. Phys. D: Appl. Phys., vol. 24, pp. 26–35, 1991. (6) J. Paukert, “The arc voltage and arc resistance of LV fault arcs,” in Proc. 7th Int. Symp. Switching Arc Phenomena, 1993, pp. 49–51 ~~3. “DC Arc Hazard Assessment Phase II,” Copyright Material, Kinectrics Inc., Report No. K-012623-RA-0002-R00.~~ (7) C.Keyes and C. Maurice, “DC arc hazard assessment phase II,”Kinectrics, Toronto, ON, Canada, Tech. Rep. K-012623-RA-0001-R00, Jul. 2007
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Must be in shown in track changes .

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	D.5.2 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New D.5.3	223			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	D.5.3 Modified Maximum Power Method see reference #4 D.5.4 Stokes/Oppenlander Method This is an empirical method based on tests for dc arcs from 0.1 A to 1 kA. (see reference #5) D.5.5 Paukert Method This is an empirical method based on data of dc arc measurements from 7 sources. It predicts high current arc characteristics. (see reference #6) D.5.6 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 #7) D.5.7 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)			
	Must be in shown in track changes .			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	To create a revision, revise text above or paste final version here.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.3	79		215	☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	D.5.3 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~~Stationary Applications*.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	Revising the informational note is not necessary as it has been removed as part of the Annex D.5 revisions.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
D.5.3	215		79	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	D.5.~~3~~ 8 Short Circuit Current and Clearing Time. 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.*~~ 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** .

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

F.3	74		238	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

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 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

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

The word “energy” was replaced with “hazard” to more accurately reflect the concern.

Response

Technical reason for resolving or for not making some of the proposed changes.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
F.3	238		74	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

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~~A change in process or workplace condition that removes the hazard or ensures that no worker can be exposed to a hazard under any foreseeable circumstances.
(2) Substitution	Reduce energy by replacing 120 V 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	Administrative controls change the way work is done by providing workers with relevant procedures or training, They're often used together with higher-level controls. They include: Procedures ~~and job planning tools~~, such as equipment inspections, planned preventive maintenance, checklists, lockout/tagout/tryout, changing work schedules, pre- and post-task reviews, and rotation of workers Training on topics such as hazard communication, permit-required work procedures, lockout/tagout/tryout, and safe work procedures
(6) PPE	Electric shock and arc flash PPE

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

Response

Technical reason for resolving or for not making some of the proposed changes.

The current wording is adequate and aligns with other requirements in the Standard such as 110.2(A)(1).

Must be in shown in track changes .

First Revision Text (FR)

Clean current edition text is provided to be revised.

Do not delete for a resolve

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 by replacing 120 V 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

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
G.2.0	229	230		☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

2.0 **Responsibility.**

All employees shall be instructed in the safety significance of the lockout/tagout procedure. All new or transferred employees and all other persons whose work operations are or might be in the area shall be instructed in the purpose and use of this procedure. *[Name(s) of the person(s) or the job title(s) of the employee(s) with responsibility]* shall ensure that appropriate personnel receive instructions on their roles and responsibilities. All persons installing a lockout/tagout device shall physically or digitally sign their names and the date on the tag *[or state how the name of the individual or person in charge will be available]*.

Must be in shown in track changes .

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	2.0 Responsibility. All employees shall be instructed in the safety significance of the lockout/tagout procedure. All new or transferred employees and all other persons whose work operations are or might be in the area shall be instructed in the purpose and use of this procedure. [Name(s) of the person(s) or the job title(s) of the employee(s) with responsibility] shall ensure that appropriate personnel receive instructions on their roles and responsibilities. All persons installing a lockout/tagout device shall sign their names and the date on the tag [or state how the name of the individual or person in charge will be available].
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The proposed text is not necessary at this time as there are no digital provisions in the body of the Standard.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
G.9.4	230	229		☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	9.4 All complex lockout/tagout plans identify the method to account for all persons who might be exposed to electrical hazards in the course of the lockout/tagout. One of the following methods is to be used: (1) Each individual shall install his or her own personal lockout or tagout device. (2) The person in charge shall lock his/her key in a lock box. (2) A connected lockout or tagout device that implements the lockout tagout procedures (3) The person in charge shall maintain a sign-in/sign-out log for all personnel entering the area. (4) Another equally effective methodology shall be used.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** .			

Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The proposed text is not necessary at this time as there are no digital provisions in the body of the Standard.

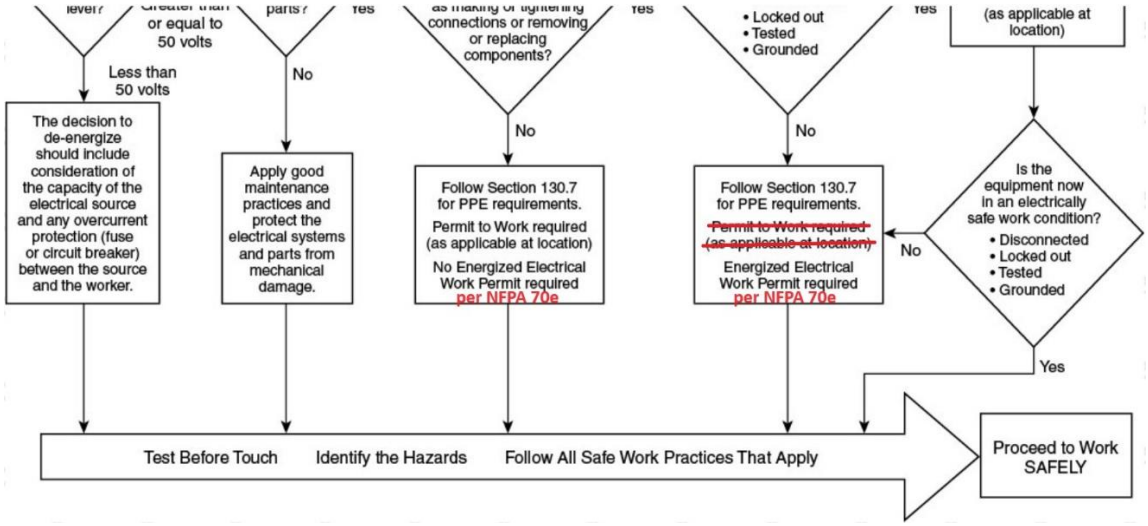
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
J.2	70		93	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

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.



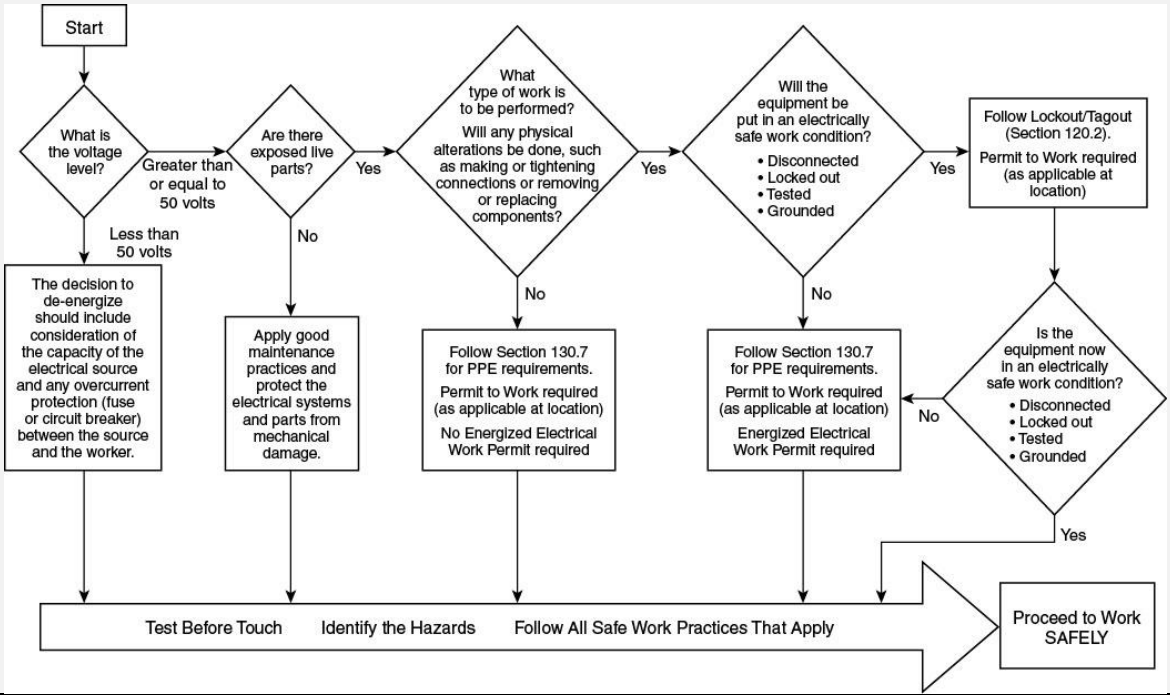
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	Technical reason for resolving or for not making some of the proposed changes.

Response	Per the flow chart, if an energized electrical work permit is required, it is typically issued in addition to the location permit to work.			
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
J.2	93		70	☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	The second requirement in the flow chart asks are there any exposed live parts. This should also ask if there is an increased likelihood of an arc flash injury so that it aligns with the requirements of 130.2 (A)(2)			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.** The flow chart was revised to correlate with 130.2(A) which requires consideration of possible injury from an arc flash.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** .			

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.



	Note to staff: please add “or an increased likelihood of injury from arc flash” after “parts” in the second diamond from the left in the top row.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Annex K	233		99, 69	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

K.1 General.

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 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 U.S. 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 1573 were fatalities. One worker died for every 12.74 electrical injuries. For the same period there were 1,718,219 fall injuries of which 5279 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: an after-effect of a disease, condition, or injury; plural: 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.

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 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.

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 vapour, only a small amount of copper that is in or is immediately adjacent to the arc plasma stays in a vapour state. Beyond the plasma, the copper vapour 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.

Informational Note: See Hoagland et al. (2017 and 2019) 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.

Informational Note: 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 acousticenergy 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 %. 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 which 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.

Informational Note: 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.5 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. 2017. Arc Flash Pressure Measurement by the Physical Method, Effect of Metal Vapor on Arc Blast, *IEEE Transactions on Industry Applications*, 53(2): 1576–1582.

Hoagland, E. H., Maurice, C., Haines, A., and Maurice, A. 2020. Arc Flash Pressure and Door Ejection Measurement, *IEEE Transactions on Industry Applications*, 56(4): 3297–3305.

Lee, W., Zhang, Z., Rau, S., Gammon, T., Johnson, B. C., and Beyreis, J. 2015. Arc Flash Light Intensity Measurement System Design, *IEEE Transactions on Industry Applications*, 51(5): 4267–4274.

Rau, S., Zhang, Z., Lee, W., and Dini, D. A. 2017. Arc Flash Visible Light Intensity as Viewed From Human Eyes, *IEEE Transactions on Industry Applications*, 53(5): 5068–5077.

Gordon, L, 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 2024 IEEE IAS Electrical Safety Workshop in Tucson, AZ.

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The proposed revisions contain unnecessary commentary.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
K.1	99	69	69, 233	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)

K.1 General.

~~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 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.~~ 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% 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. 70% 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% of the fatalities. Closely followed by contact with overhead power lines with 41%. Electrical fatalities continue to stay consistent with an average 1.5% decrease in workplace electrical fatalities year over year. Electrical fatalities account for 6% of all workplace fatalities. 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
K.2	69	99	99, 233	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	K.2 Electric Shock. Over 40 percent of all electrical fatalities in the U.S. 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 1573 were fatalities. One worker died for every 12.74 electrical injuries. For the same period there were 1,718,219 fall injuries of which 5279 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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.** Annex K was revised by updating the information regarding electrical injuries and removing redundant information.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** . K.1 General. Electrical injuries represent a serious workplace health and safety issue to electrical and non-electrical workers. 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% 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. 70% 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% of the fatalities. Closely followed by contact with overhead power lines with 41%. Declines in electrical fatalities continue to stay consistent with an average decrease of 1.5% in workplace electrical fatalities annually. Electrical fatalities account for 6% of all workplace fatalities. ~~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.

K.2 Electric Shock.

Over 40 percent of all electrical fatalities in the U.S. 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 1573 were fatalities. One worker died for every 12.74 electrical injuries. For the same period there were 1,718,219 fall injuries of which 5279 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.

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.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.5 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

New K.6	199			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	K.6 Technical paper ESW2022-12 presented at the IEEE ESW conference Who is Getting Hurt? Understanding the Cause of Fatal Electrical Injuries in the Workplace by Brett Brenner and Daniel Majano Electrical Safety Foundation International.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** .			
	To create a revision, revise text above or paste final version here.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	Referencing this paper does not contribute to the technical content in the annex.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
L.1	174			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	L.1 Application of Safeguards. This informative annex ~~permits a~~ provides 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 Non-Electrical Hazards for Consideration. Electrolytic cells present other non-electrical hazards to the employee in which standard arc-rated clothing of materials may not be appropriate due to contamination and a potential chemical reaction. Additional protective safeguards or PPE may be necessary to ensure employee safety.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** . 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.
Statement	**Technical reason for revision.** The word "permits" was changed to "provides" as the annex material is providing a typical application of safeguards.

Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Annex O	156			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown Informative Annex O Employee Safety-Related Design Concepts ~~and Facility Owner Responsibilities~~ *This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.* 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. O.1.1 This informative annex discusses design considerations that have impact on the application of the safety-related work practices only.				
	Must be in shown in track changes .			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	Informative Annex O Employee Safety-Related Design Concepts ~~and Facility Owner Responsibilities~~ This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only. 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. O.1.1 -This informative annex discusses design considerations that have impact on the application of the safety-related work practices only.
Statement	**Technical reason for revision.** The modification to the title and introduction better reflects the content of Annex O.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
R.4.3	57 (same revision)	175		☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	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.			
	Must be in shown in track changes .			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	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.
Statement	**Technical reason for revision.**
	The word “electric” was removed as this section is concerned with acoustic shock waves.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
Annex S	32			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	CDC NOTE: PI proposes deletion of Annex S. Just indicate if Annex S is to be deleted.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** .			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The informative annex is being retained as it describes items to consider with respect to the condition of maintenance. Section S.8 provides a reference to NFPA 70B.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
	273 (RBH)			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)				
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** .			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	It is not clear what text is proposed to be revised.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
A.3.9	CFR			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)				
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** .			
	Add a reference to UL 9540B *UL 9540B Outline of Investigation for Large Scale Fire Test for Residential Battery Energy Storage Systems, 2024.*			
Statement	**Technical reason for revision.**			
	A reference to UL 9540B was added as it now referenced within the body of the document.			

Response	**Technical reason for resolving or for not making some of the proposed changes.**

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 arcs combine 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 can't be sustain. *(see references 1, 2, 3)*

$V_{min} = 1.06 * g + 100$ **[D.5.2a]**

or

$g_{min} = V - 100 * 1.06$ **[D.5.2b]**

where:

V_{min} = voltage below which an arc can't be sustained

g = gap distance

g_{min} = gap above which an arc can't be sustained

V = system voltage

Table D.5.2-1 provides a maximum gap distance for various voltages, above which an arc will extinguish.

System Voltage (volts)	**Gap Distance, above which arc will quickly extinguish cm (inch)**
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 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.~~1~~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.5.2)~~. ~~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.5.3*~~2~~*)* 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.

[D.5.~~1~~3]

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$$

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 relaively. 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 inches in front of the cabinet for low voltage systems yields an approximate additional 3-4% 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 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.

$K_{ab} = (0.55 \times \ln(d_{ab})) - 0.6$ **[D.5.3b]**

where:

K_{ab} = arc-flash boundary distance multiplier for large dc battery cabinets

d_{ab} = calculated arc-flash boundary (in inches) without an arc-in-a-box/enclosure multiplier

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 following formula:

$T_{arc} = 0.0043 \times V_{sys}$ **[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 A to 1 kA *(see reference 7).*

D.5.6 Paukert Method

This is an empirical method based on data of dc arc measurements from 7 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.5.2 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.~~

D.5.10 References:

1. ~~"DC-Arc Models and Incident-Energy Calculations," Ammerman, R.F., et al., *IEEE Transactions on Industry Applications*, Vol. 46, No. 5.~~ L. Gordon, "Modeling the Dynamic Behavior of DC Arcs," IEEE Trans. on Industry Applications, Vol. 60, No. 1, Jan/Feb 2024, pp 1946-1955.

2. ~~"Arc Flash Calculations for Exposures to DC Systems," Doan, D.R., *IEEE Transactions on Industry Applications*, Vol. 46, No. 6.~~ R. F. Ammerman, T. Gammon, P. K. Sen, and J. P. Nelson, "DC arc models and incident energy calculations," in Proc. Petroleum Chem. Ind. Conf., 2009, pp. 1–3.

3. ~~"DC Arc Hazard Assessment Phase II," Copyright Material, Kinectrics Inc., Report No. K-012623-RA-0002-R00.~~ C. Ashton, "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, March 2024, Tucson, pp. 71

4. D. R. Doan, "Arc flash calculations for exposures to DC systems," IEEE Trans. on Industry Applications, Vol. 46, No. 6, Nov/Dec 2010, pp. 2299-2302.

5. IEEE 1584, Guide for Performing Arc Flash Calculations, New York, NY: IEEE, 2018.

6. 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.

7. A. Stokes and W. Oppenlander, "Electric arcs in open air," J. Phys. D: Appl. Phys., vol. 24, pp. 26–35, 1991.

8. J. Paukert, "The arc voltage and arc resistance of LV fault arcs," in Proc. 7th Int. Symp. Switching Arc Phenomena, 1993, pp. 49–51.

9. C.Keyes and C. Maurice, "DC arc hazard assessment phase II,"Kinectrics, Toronto, ON, Canada, Tech. Rep. K-012623-RA-0001 -R00 , Jul . 2007.

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.

DOC #	70E
TG #/NAME	Articles 90 and 100
TG CHAIR	Rod West
TG MEMBERS	Louis Barrios, Tom Dyson, Mark Hilbert, Daleep Mohla, Jim Niemira, Vincent Della Croce, Sunny Kalola, James Stallcup Jr Guests: Palmer Hickman, Mike Alamprese

All task group **proposed** motions, revisions, and entries displayed below are for consideration by the entire TC.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
90.1	60	61	61 (moves 90.3 to 90.1(B) and (C))	☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	90.1 Scope. Article 90 establishes the following: (A) Article 90 Scope. This article covers ~~the~~ use~~,~~ and application, and arrangement, and enforcement of this standard.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** FR with PI 60 and 61 in the cart. Change the title of 90.3 as shown: 90.3 ~~Workplaces Covered and Not Covered~~Scope of the Standard (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			

	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. (B) Workplaces Not Covered. This standard does not cover safety-related work practices for the following: 1. Installations in ships, watercraft other than floating buildings, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles 2. Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communications purposes 3. Installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations 4. Installations under the exclusive control of an electric utility where such installations: 1. Consist of service drops or service laterals, and associated metering, or 2. Are located in legally established easements or rights-of-way designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations, or 3. Are on property owned or leased by the electric utility for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy, or Are located by other written agreements either designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations. These written agreements shall be limited to installations for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy where legally established easements or rights-of-way cannot be obtained. These installations shall be limited to federal lands, Native American reservations through the U.S. Department of the Interior Bureau of Indian Affairs, military bases, lands controlled by port authorities and state agencies and departments, and lands owned by railroads.
Statement	**Technical reason for revision.**
	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. There are no changes to the provisions other than to the title and the addition of “s” to installations for clarity and consistency.

Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
90.3	61 (move to 90.1)	60	205, 220, 221	☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)

~~90.3 Workplaces Covered and Not Covered.~~

90.1(B) ~~(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) Installation 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

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.

90.1(C)~~(B)~~ Workplaces Not Covered.

This standard does not cover safety-related work practices for the following:

(1) Installations in ships, watercraft other than floating buildings, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles

(2) Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communications purposes

(3) Installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations

(4) Installations under the exclusive control of an electric utility where such installations:

a. Consist of service drops or service laterals, and associated metering, or

	b. Are located in legally established easements or rights-of-way designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations, or c. Are on property owned or leased by the electric utility for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy, or d. Are located by other written agreements either designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations. These written agreements shall be limited to installations for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy where legally established easements or rights-of-way cannot be obtained. These installations shall be limited to federal lands, Native American reservations through the U.S. Department of the Interior Bureau of Indian Affairs, military bases, lands controlled by port authorities and state agencies and departments, and lands owned by railroads.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
	n/a - Included with PI 60 above
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
90.3(A)	220		61	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	(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) Installation 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
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.

Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	The proposed text is unnecessary in 90.3(A). The present wording of 90.3(B) only excludes these types of installations that are under the exclusive control of a utility.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
90.3(B)	205		61, 221, 260	☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)

(B) Workplaces Not Covered.

This standard does not cover safety-related work practices for the following:

(1) Installations in ships, watercraft other than floating buildings, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles

(2) Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communications purposes

(3) Installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations

(4) Installations under the exclusive control of an electric utility where such installations comply with one of the following:

a. Consist of service drops or service laterals, and associated metering~~, or~~

b. Are located in legally established easements or rights-of-way designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations~~, or~~

c. Are on property owned or leased by the electric utility for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy~~, or~~ that are accessible only to qualifed employees.

Note: The types of installations covered by this paragraph include the generation, transmission, and distribution installations of electric utilities, as well as equivalent installations of industrial establishments.

d. Are located by other written agreements either designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations. These written agreements shall be limited to installations for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy where legally established easements or rights-of-way cannot be obtained. These installations shall be limited to federal lands, Native American reservations through the U.S. Department of the Interior Bureau of Indian Affairs, military bases, lands controlled

	by port authorities and state agencies and departments, and lands owned by railroads. e. Power generation, transmission, and distribution installations, includ
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Installations of generation, transmission, and distribution not under the exclusive control of the electric utility are covered by the scope of the Standard. Inadequate substantiation was provided to exclude these installations from the Scope.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
90.3(B)	221		61, 205, 260	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	(B) Workplaces Not Covered. This standard does not cover safety-related work practices for the following: (1) Installations in ships, watercraft other than floating buildings, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles (2) Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communications purposes (3) Installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations (4) Installations under the exclusive control of an electric utility where such installations: a. Consist of service drops or service laterals, and associated metering, or b. Are located in legally established easements or rights-of-way designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations, or c. Are on property owned or leased by the electric utility for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy, or d. Are located by other written agreements either designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations. These written agreements shall be limited to installations for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy where legally established easements or rights-of-way cannot be obtained. These installations shall be limited to federal lands, Native American reservations through the U.S. Department of the Interior Bureau of Indian Affairs, military bases, lands controlled by port authorities and state agencies and departments, and lands owned by railroads. ~~e~~(5)~~.~~ Installations of generation, transmission, and distribution equipment not under the control of an electric utility that operate exclusively for the purpose of supplying electricity to an electric utility.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.**
	Installations of generation, transmission, and distribution not under the exclusive control of the electric utility are covered by the scope of the Standard. Inadequate substantiation was provided to exclude these installations from the Scope.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

90.3(B)	260		61, 205, 221	☐ Create First Revision ☒ Resolve

Proposed Text (from PI)

(B) Workplaces Not Covered.

This standard does not cover safety-related work practices for the following:

(1) Installations in ships, watercraft other than floating buildings, railway rolling stock, or aircraft, ~~or automotive vehicles~~ other than mobile homes and recreational vehicles

(2) Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communications purposes

(3) Installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations

(4) Installations under the exclusive control of an electric utility where such installations:

a. Consist of service drops or service laterals, and associated metering, or

b. Are located in legally established easements or rights-of-way designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations, or

c. Are on property owned or leased by the electric utility for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy, or

d. Are located by other written agreements either designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations. These written agreements shall be limited to installations for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy where legally established easements or rights-of-way cannot be obtained. These installations shall be limited to federal lands, Native American reservations through the U.S. Department of the Interior Bureau of Indian Affairs, military bases, lands controlled by port authorities and state agencies and departments, and lands owned by railroads.

First Revision (FR)

See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table.

Statement

Technical reason for revision.

Response

Technical reason for resolving or for not making some of the proposed changes.

Inadequate substantiation has been provided to remove automotive vehicles, whether they be electric, internal combustion, or hybrid, from 90.3. The present provisions align with 90.2(D) of the NEC.

Must be in shown in track changes

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
90.4	62			☒ ~~☐~~ Create First Revision ☐ Resolve

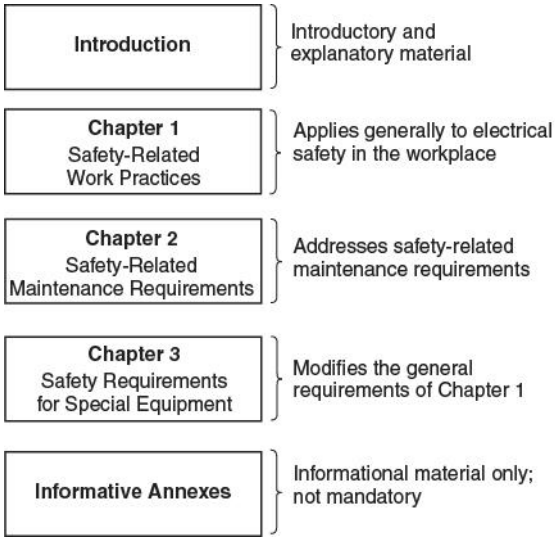
Proposed Text (from PI)

90.4 Standard Arrangement.

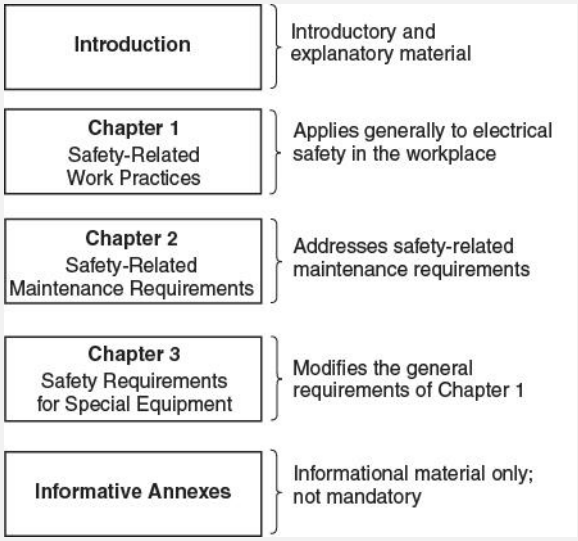
This standard is divided into the introduction and three chapters, as shown in Figure 90.4. Chapter 1 applies generally, Chapter 2 addresses safety-related maintenance requirements, and Chapter 3 ~~supplements or~~ modifies Chapter 1 with safety requirements for special equipment.

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

Figure 90.4 Standard Arrangement.



Must be in shown in track changes

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	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.  Figure 90.4, row 4 (Chapter 3) to read “Supplements or modifies the general requirements of Chapter 1”
Statement	**Technical reason for revision.** 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	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100 Scope	40			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	**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.			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**
	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.
Statement	**Technical reason for revision.**
	This first revision removes the word “proper” from this section. The resulting text is more closely aligned with the language found in the National Electrical Code.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	248			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	**Barrier.** A physical obstruction that is intended to prevent contact with equipment or energized electrical conductors and circuit parts. A barrier is a part of the design and is an engineering control to prevent injury.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	Barrier. A physical obstruction that is intended to prevent contact with equipment or energized electrical conductors and circuit parts.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The existing definition is clear and broad enough to encompass multiple methods intended to prevent contact with equipment or energized electrical conductors or			

	circuit parts. The additional proposed text to categorize a barrier as an engineering control is not necessary.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	249			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	**Barricade.** A physical obstruction such as tapes, cones, or A-frame-type wood or metal structures intended to provide a warning and to limit access. A barricade is a temporary method used during work to control access by an administrative control.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** Barricade. A physical obstruction such as tapes, cones, or A-frame-type wood or metal structures intended to provide a warning and to limit access.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.** The existing definition is clear and broad enough to encompass multiple methods to provide warning and limit access. The additional proposed text to categorize a barricade as an administrative control is not necessary.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	41	163	163	☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	~~**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)~~			

First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
	n/a - See below			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	163	41	41	☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	~~**Competent**~~ **Qualified Person, Research Laboratory (Research laboratory Qualified Person).** A person ~~who meets all the requirements of *qualified person*, and who, in addition, is~~ who 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)			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.**			
	The definition of competent person is deleted to correlate with other actions that removed the term from the standard.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	~~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)~~			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

100	42			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	~~**Electrical Safety.**~~ ~~Identifying hazards associated with the use of electrical energy and taking precautions to reduce the risk associated with those hazards.~~			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	~~Electrical Safety.~~ ~~Identifying hazards associated with the use of electrical energy and taking precautions to reduce the risk associated with those hazards.~~			
Statement	**Technical reason for revision.**			
	The definition is deleted as it does not correlate with other sections of the standard.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	49		7	☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	**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~~ electrical energy, and, if necessary, temporarily grounded for personnel protection.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The definition must be interpreted in its entirety to be properly applied. For example, the phrase “disconnecting a conductor or circuit part from energized			

	parts" is also included in the definition and addresses the concerns of the submitter. The phrase "tested for the absence of voltage" is widely used, understood, and correlates with the provisions found in this standard as well as OSHA and other regulations.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	7		49	☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	**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.
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.
Statement	**Technical reason for FR.** Must stand alone as reason for revision. TC does not feel, intend, agree, believe, etc. **DO NOT** refer to PI, submitter, substantiation, other PIs, other FRs, etc. A new informational note is added to raise awareness of the sections that provide the necessary steps to establish and verify an electrically safe work condition.
Response	**Technical reason for resolving or for not making some of the proposed changes.**
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** 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.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

100	43			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	**Enclosure.** The case or housing of apparatus —or the fence or walls surrounding an installation to prevent personnel from unintentionally contacting energized electrical conductors or circuit parts or to protect the equipment from physical damage.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** Enclosure. The case or housing of apparatus, —or the fence or walls surrounding an installation, that are intended to prevent personnel from unintentionally contacting energized electrical conductors or circuit parts or to protect the equipment from physical damage.			
Statement	**Technical reason for revision.** 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	**Technical reason for resolving or for not making some of the proposed changes.**			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	191			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	**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)			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** 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.			

Statement	**Technical reason for revision.**
	The definition is clarified to include “and to ground” to align with the actual application and use of a Ground Stick.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	129			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	~~**Grounding, Soft (High-Z). (Soft Grounding)**~~ **Capacitor Soft Discharging** The practice of ~~connecting a capacitor to ground~~ discharging capacitors through a power resistor to avoid the hazards related with ~~hard grounding.~~ short circuiting. Capacitors must either be discharged across their terminals or from their terminals to ground. (360)			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** Grounding, Soft (High-Z). (Soft Grounding) The practice of ~~connecting a capacitor to ground~~discharging capacitance by connecting to ground through a power resistor to avoid the hazards related with ~~hard grounding. (360)~~a low impedance short circuit. (360) Informational Note: Capacitors are either grounded or floating. Capacitors which are not grounded will not discharge unless the discharge resistor is connected between the terminals. COMMITTEE INPUT Grounding, Hard (Low-Z). (Hard Grounding) The practice of discharging capacitance by connecting to ground through a low impedance. (360) Informational Note: Capacitors are either grounded or floating. Capacitors which are not grounded will not discharge unless the discharge resistor is connected between the terminals.			
	Technical reason for FR.			

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	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	247			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	**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 shock wave ~~and high-velocity shrapnel~~(supersonic). (360)			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	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)			
Statement	**Technical reason for revision.**			
	The modified definition provides clarity by denoting that only the conventional capacitor can create a supersonic acoustic wave.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	250			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	**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, rf), 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.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** 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.~~
Statement	**Technical reason for revision.** The informational note is removed as it is incomplete and does not include all types of electric shock hazards.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	232			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	**Hazard, Electrical. (Electrical Hazard)** ~~A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn, or arc blast injury~~ A source of possible injury or damage to health associated with an electric shock hazard, an arc flash hazard, o a conduction thermal hazard. Informational Note 1: See Annex K for further information on the associated hazards. Informational Note 2: 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.			
	Must be in shown in track changes			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	Hazard, Electrical. (Electrical Hazard) A source of possible injury or damage to health ~~A dangerous condition~~ such that contact or equipment failure can result in electric shock~~,~~ arc flash burn, 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.
Statement	**Technical reason for revision.**
	The definition is modified to align with the other hazard definitions.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	251			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	**Incident Energy.** The amount of thermal energy impressed on a surface per unit area, a certain distance from the source, generated during an electrical arc event. Incident energy (density) is typically expressed in calories per square centimeter (cal/cm^2). The term "incident energy" is commonly used to refer to the incident energy density in arc flash discussions.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** 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).			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The current definition is consistent with other standards related to arc flash and is well understood. The addition of the word density is not necessary as the per unit area is included in the units of calories per square centimeter.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	47			☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	**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 one of the following: • ~~(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. 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.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** 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 one of the following: ~~(a) w~~ (1) Wiring from the service point or power source to the outlets~~; or (b) w~~ ~~(1)~~(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.
Statement	**Technical reason for revision.** This revision modifies the extracted definition of Premises Wiring (System) to match the 2023 National Electrical Code verbatim.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

100	5	SEE PI 6 BELOW	6	☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	**Qualified Person.** One who has ~~demonstrated skills~~ documented demonstration of and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	6	5	5	☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	**Qualified Person.** One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk. Informational Note: See 110.4(A)(1) for the training that a qualified person is to be trained and knowledgeable in.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for FR.**			
	Additional text and an informational note is added to the existing definition to help users locate provisions related to training and documentation requirements for qualified persons.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	Must be in shown in track changes			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	Qualified Person. One who has ~~demonstrated~~ documented demonstration of skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk. Informational Note: See 110.4 for training and associated documentation requirements for qualified persons.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	235			☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	**Risk.** A combination of the likelihood of ~~occurrence of injury or damage to health~~ exposure to a hazard and the severity of injury or damage to health that ~~results~~ may result from exposure to a hazard.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** Risk. A combination of the likelihood of ~~occurrence~~ exposure to a hazard and the severity of injury or damage to health ~~and the severity of injury or damage to health~~ that can result~~s from a hazard~~.
Statement	**Technical reason for revision.** The definition of Risk is clarified to emphasize the importance of likelihood of exposure to a hazard and better align with other occupational safety and health management standards such as ISO 45001.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	237			☒ ~~☐~~ Create First Revision ☐ Resolve

Proposed Text (from PI)	**Risk Assessment.** An overall process that identifies hazards, determines the likelihood of exposure to identified hazards, estimates the likelihood of occurrence of injury or damage to health, estimates the potential severity of injury or damage to health, ~~and~~ determines if protective measures are required, and assesses the effectiveness of selected protective measures. Informational Note: As used in this standard, *arc flash risk assessment* and *electric shock risk assessment* are types of risk assessments.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** Risk Assessment. An overall process that identifies hazards, estimates the likelihood of exposure to a hazard, ~~occurrence of injury or damage to health,~~ estimates the potential severity of injury or damage to health, and determines if protective measures are required. Informational Note: As used in this standard, arc flash risk assessment and electric shock risk assessment are types of risk assessments.
Statement	**Technical reason for revision.** The definition of Risk Assessment is clarified to emphasize the importance of likelihood of exposure to a hazard and better align with the definition of risk and with other occupational safety and health management standards such as ISO 45001.
Response	**Technical reason for resolving or for not making some of the proposed changes.** A risk assessment does not include determining the effectiveness of the selected protective measures. That is the function of the “monitor and review” step in risk management. See Annex F.1 Introduction to Risk Management and Figure F.1 Risk management Process

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	46			☒ ~~☐~~ Create First Revision ☐ Resolve
Proposed Text (from PI)	**~~Safeguarding~~ Safeguards for Personnel.** ~~Safeguards for personnel include the consistent~~ Consistent administrative enforcement of safe work practices~~. Safeguards~~ which can include training in safe work practices, cell line design, safety equipment, PPE, operating procedures, and work checklists. (310)			
	Must be in shown in track changes			

First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	~~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)~~
Statement	**Technical reason for revision.**
	The term and definition for “safeguarding” is deleted as it not necessary to define commonly defined terms or phrases. This first revision is related to a First Revision to change the terminology in 310.5(A).
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	164			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	Unqualified Person. A person ~~who is not a qualified person.~~ whose job duties may present risk of injury due to exposure to electrical hazards that have little or no experience with, or training in recognizing and protection from the hazards.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	Unqualified Person. A person who is not a qualified person.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
	Technical reason for revision.			

Statement	The proposed revision does not improve the clarity of the Standard. An unqualified person must be trained to recognize job task associated hazards, but not necessarily to the same level of a qualified person.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	252			☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	**Voltage (of a Circuit).** The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the ac circuit concerned, or the greatest dc difference of potential between any two conductors of the dc circuit. [**70:**100]
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** Voltage (of a Circuit). The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned. [70:100] Informational Note: Some systems, such as three-phase 4-wire, single-phase 3-wire, and 3-wire direct-current, may have various circuits of various voltages.
Statement	**Technical reason for revision.** The definition is accurate as stated. The rms value of a dc circuit is equal to the dc voltage.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
100	45			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	**Working Distance.**

	The distance between a person's face ~~and~~ or chest area and a prospective arc source, whichever is the lesser distance. Informational Note: See 130.5(G) for further information. Incident energy increases as the distance from the arc source decreases.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** Working Distance. The shortest distance between a person's face ~~and~~ or chest area and a prospective arc source. Informational Note: See 130.5(G) for further information. Incident energy increases as the distance from the arc source decreases.
Statement	**Technical reason for revision.** The definition is modified to clarify that the working distance is the lesser distance between a prospective arc source and the face or chest area of a person.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	91			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	Avoid Contact			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** To create a revision, revise text above or paste final version here.			
Statement	**Technical reason for revision.** This public input does not contain wording to be added, revised (and how revised), or deleted. See section 4.3.4 of the Regulations Governing the Development of NFPA Standards for public input contents.			

Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	97			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	Industrial Installation, Supervised. (Supervised Industrial Installation) The industrial portions of a facility where all of the following conditions are met: Conditions of maintenance and engineering supervision ensure that only qualified persons monitor and service the system. The premises wiring system has 2500 kVA or greater of load used in industrial process(es), manufacturing activities, or both, as calculated in accordance with Article 220. The premises has at least one service or feeder that is more than 150 volts to ground and more than 300 volts phase-to-phase. This definition excludes installations in buildings used by the industrial facility for offices, warehouses, garages, machine shops, and recreational facilities that are not an integral part of the industrial plant, substation, or control center.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	To create a revision, revise text above or paste final version here.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The term “Supervised Industrial Installation” is only used in 130.5 (H) Exception No. 2. The provisions of the exception outline the applicable installations and the proposed definition extracted from the NEC is not necessary.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

New Definition	118			☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	Field Work. Tasks performed by employees and contractors in the workplace.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	To create a revision, revise text above or paste final version here.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The proposed definition would not add clarity for users of the document. The term "field work" only appears once in section 110.3(L)(2) and the provisions of the section are clear.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	157		265	☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	Point of Work The specific location where work is being performed, the immediate vicinity where tasks are carried out, equipment is operated, and potential hazards exist. Ensuring safety at the point of work requires an electrical safety program with measures for mitigating risks, providing correct safety PPE and equipment, and training workers appropriately to assess the most feasible location for isolating electrical energy in order to maintain a safe working environment to prevent accidents or injuries.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

	Article 100 is used to define terms that are not commonly understood. The phrase “point of work” is clear and does not require further definition.			
Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	265		157	☐ Create First Revision ☒ Resolve
Proposed Text (from PI)	Point of Work The general location such as a panelboard, enclosure or industrial control panel where work such as testing, troubleshooting and voltage measuring will be conducted.			
First Revision (FR)	**See below for revised text. Do NOT use this revision field. Only use the revision field at end of this table**.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	Article 100 is used to define terms that are not commonly understood. The phrase “point of work” is clear and does not require further definition.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	To create a revision, revise text above or paste final version here.			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	162			☒ Create First Revision ☐ Resolve

Proposed Text (from PI)	Cell Line Working Zone (CLWZ), The space envelope wherein operation or maintenance is normally performed on or in proximity to exposed energized surfaces of electrolytic cell lines or their attachments. Unless specified as being greater, the minimum space envelope dimensions of the cell line working zone includes any space: a) Within 2.5 m (96 in) above energized surfaces of electrolytic cell lines or their energized attachments, b) Within 2.5 m (96 in) of access areas below energized surfaces of electrolytic cell lines or their energized attachments, c) Within 1.1 m (42 in) horizontally from energized surfaces or their energized attachments for electrolytic cell lines operating at 1000 V or less, and d) Within 1.5 m (60 in) horizontally from energized surfaces or their energized attachments for electrolytic cell lines operating above 1000 V.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** To create a revision, revise text above or paste final version here. 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 No. 3: See Article 310, 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.
Statement	**Technical reason for revision.** This first revision adds a new definition to improve the clarity and understanding of a term used in Article 310 and Annex L. A new informational note is also included to provide a resource for obtaining additional information related to electrolytic cell lines.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	192			☐ Create First Revision ☒ Resolve

Proposed Text (from PI)	Shorting, Hard (Low-Z) (Hard Shorting) The practice of discharging a capacitor from terminal to terminal through a low impedance, also called Low-Z (impedance). (360) Shorting, Soft (High-Z). (Soft Shorting) The practice of discharging a capacitor from terminal to terminal through a power resistor to avoid the hazards related with hard shorting, also called High-Z (impedance). (360)
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** To create a revision, revise text above or paste final version here.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.** The proposed definitions are not necessary as the terms are not used in the Standard and adding them would potentially set up conflicts with the defined terms of hard grounding and soft grounding.

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	194			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	Shorting Stick A device that is used to discharge a capacitor from terminal to terminal. (360)			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** To create a revision, revise text above or paste final version here. **Shorting Stick** A device that is used to discharge a capacitor from terminal to terminal. (360)			

Statement	**Technical reason for revision.**
	This FR adds a clear, concise definition for “Shorting Stick” to improve understanding of the term used in Chapter 3 and Annex R.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	206			☐ Create First Revision ☒ ~~☐~~ Resolve
Proposed Text (from PI)	Operation, Normal (Normal Operation) Operation of electrical equipment in a manner that performs the intended function of the equipment as specified by the equipment manufacturer. Informational Note: An example of normal operation includes opening and closing of switches, circuit breakers and contactors to de-energize or energize electrical equipment.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	To create a revision, revise text above or paste final version here.			
Statement	**Technical reason for revision.**			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			
	The conditions for normal operation are more appropriately located as requirements in 110.2(B).			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	211			☐ Create First Revision ☒ ~~☐~~ Resolve

Proposed Text (from PI)	Operating Condition, Normal An operating condition of electrical equipment that is assigned to equipment meeting the following: 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.
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** To create a revision, revise text above or paste final version here.
Statement	**Technical reason for revision.**
Response	**Technical reason for resolving or for not making some of the proposed changes.** The criteria that establish a normal operating condition are more appropriately located as requirements in 110.2(B).

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION

New Definition	241			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	Hazard, Thermal (Thermal Hazard) A source of possible injury or damage to health associated with current through conductive tools or jewelry in contact with the body from heating of the metal resulting in burns to the skin.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes**			
	To create a revision, revise text above or paste final version here. Hazard, Thermal (Thermal Hazard) A source of possible injury or damage to health (burns) associated with resistive heating of conductive metal tools or metal jewelry in contact with the body.			
Statement	**Technical reason for revision.**			
	This FR adds a new clear, concise definition for “thermal hazard” to improve understanding of the term.			
Response	**Technical reason for resolving or for not making some of the proposed changes.**			

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	126			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	CDC NOTE: only identified revisions shown Hybrid SuperCapacitor (HSC). Formerly known as a Li-ion capacitor (LiC) these cells (typically packaged into higher voltage modules with internal parallel cell packs connected in series, and usually with a cell balancing circuit board) consist of a cathode made of graphite intercalated with Lithium ions (similar to most Li-ion cells) and an anode made of activated carbon (both plates of an EDLC are made of activated carbon). They combine the high power attributes of EDLCs with better energy density characteristics that begin to approach the energy density characteristics of some batteries.			
First Revision Text (FR) Clean current edition text is	**Must be in shown in track changes**			
	To create a revision, revise text above or paste final version here. **Hybrid SuperCapacitor (HSC).**			

provided to be revised. Do not delete for a resolve	A type of EDLC that consists of a cathode made of graphite intercalated with Lithium ions and an anode made of activated carbon. It is a unique construction in which the single assembly is both a supercapacitor and a Li-ion battery.
Statement	**Technical reason for revision.** This FR adds a new detailed definition for “Hybrid SuperCapacitor” to improve understanding of the term.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Section	This Public Input	Add other PIs included with this revision/resolve (CART)	For reference - these other PIs propose revisions for this section	MOTION
New Definition	128			☒ Create First Revision ☐ Resolve
Proposed Text (from PI)	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. 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 electrodes which are separated by a nonconductive, ion-permeable separator, an electrolyte ionically connecting both electrodes, and two current collectors directly attached to electrodes.			
First Revision Text (FR) Clean current edition text is provided to be revised. Do not delete for a resolve	**Must be in shown in track changes** To create a revision, revise text above or paste final version here. 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. Informational Note: 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 electrodes which are separated by a nonconductive, ion-permeable separator, an electrolyte ionically connecting both electrodes, and two current collectors directly attached to electrodes.			

Statement	**Technical reason for revision.**
	A new definition and informational note is added to define the term electric double layer capacitor which is used in a new Chapter 3 article.
Response	**Technical reason for resolving or for not making some of the proposed changes.**

Proposal to 2027 NFPA 70E Committee Reorganization of Chapter 3

Chapter 3 Task Group

Presented by Lloyd B. Gordon

August 1, 2024

Chapter 3 Task Group – 2027 edition

- Bobby Gray
- Bill Cantor
- Lloyd Gordon
- Heath Garrison
- Mark McNellis

Goal

- Chapter 3 – Special Equipment has evolved little by little over the past 24 years by tacking on new articles at the end.
- Reorganization eliminates redundancy and flows from the specific hazards to applications

Evolution of NFPA 70E

- 1979
  - Part I – Installation Safety Requirements
- 1981
  - Part I – Installation Safety Requirements
  - Part II – Safety Related Work Practices
- 1983, 1988, 1995
  - Part I – Installation Safety Requirements
  - Part II – Safety Related Work Practices
  - Part III – Safety Related Maintenance Requirements
- 2000
  - Part I – Installation Safety Requirements
  - Part II – Safety Related Work Practices
  - Part III – Safety Related Maintenance Requirements
  - Part IV – Safety Requirements for Special Equipment
- 2004
  - Chapter 1 – Safety Related Work Practices
  - Chapter 2 – Safety Related Maintenance Requirements
  - **Chapter 3 – Safety Requirements for Special Equipment**
  - Chapter 4 – Installation Safety Requirements
- 2009, 2012, 2015, 2018, 2021
  - Chapter 1 – Safety Related Work Practices
  - Chapter 2 – Safety Related Maintenance Requirements
  - **Chapter 3 – Safety Requirements for Special Equipment**

Evolution of Chapter 3 – Special Equipment

2000/2004 – Part/Chapter III/3

- 300 – Introduction
- 310 – Electrolytic Cells
- 320 – Batteries and Battery Rooms
- 330 – Lasers
- 340 – Power Electronic Equipment

2009, 2012 (added DC), 2015

- 300 – Introduction
- 310 – Electrolytic Cells
- 320 – Batteries and Battery Rooms
- 330 – Lasers
- 340 – Power Electronic Equipment
- 350 – Research and Development Laboratories

2018

- 330 – Lasers – eliminated sections
- 340 – Power Electronic Equipment – cut in half
- 350 – Research and Development Laboratories
  - added ESA, increased equipment, thresholds

- 2021
  - 300 – Introduction
  - 310 – Electrolytic Cells
  - 320 – Batteries and Battery Rooms
  - 330 – Lasers
  - 340 – Power Electronic Equipment
  - 350 – Research and Development Laboratories
  - 360 – Capacitors (plus Annex R)
- 2027
  - 300 – Introduction
  - 305 – General
  - 310 – DC
  - 320 – Capacitors (previously 360)
  - 330 – RF and subRF (previously in 340)
  - 340 – R&D (previously 350)
  - 360 – Electrolytic Cells
  - 370 – Batteries and Battery Rooms
  - 380 - EDLCs
  - ~~330 – Lasers~~
  - ~~340 – Power Electronic Equipment~~

Observations – what happened over 21 years?

- Cells and Batteries were maintained and are in excellent form.
- Lasers and Power Electronics were full of errors, not maintained, redundant (some corrections in 2018).
- Concepts of AHJ (ESA) approval of special equipment and procedures added in 2009/2018 (350).
- Hazards formally added DC (2012), capacitors (2021), and RF (2024)
- Hazard thresholds were found in 310, 320, 330, 340, 350 and 360. Were not consistent.
- Equipment approval was found in 330, 340, and 350.
- Some material was redundant with Chapter 1.

Conclusions and Justifications

- Keep Cells and Batteries intact
  - Maintained and excellent
- Eliminate Lasers and Power Electronics
  - Hazards, controls, and special equipment now covered elsewhere
  - These two Articles no longer contain unique information
- Reorder to flow
  - Overall processes (applying to all special equipment)
    - training
  - Unique Hazards (non 60 Hz)
    - DC, capacitor, RF
  - Articles on special equipment
    - Cells, Batteries, EDLCs, PV

Proposed Revision for 2027

300 – Introduction	
305 – General Requirements	
310 – DC Electrical Hazards	
320 – Capacitor Electrical Hazards	(previously 360, a few PIs)
330 – RF and subRF Electrical Hazards	(previously in 340, PIs)
350 – Electrolytic Cells	very few changes (some from PIs)
360 – Batteries and Battery Rooms	changes from PIs
370 – R&D	
380 – EDLCs	separate PIs
390 – Photovoltaic	separate PIs

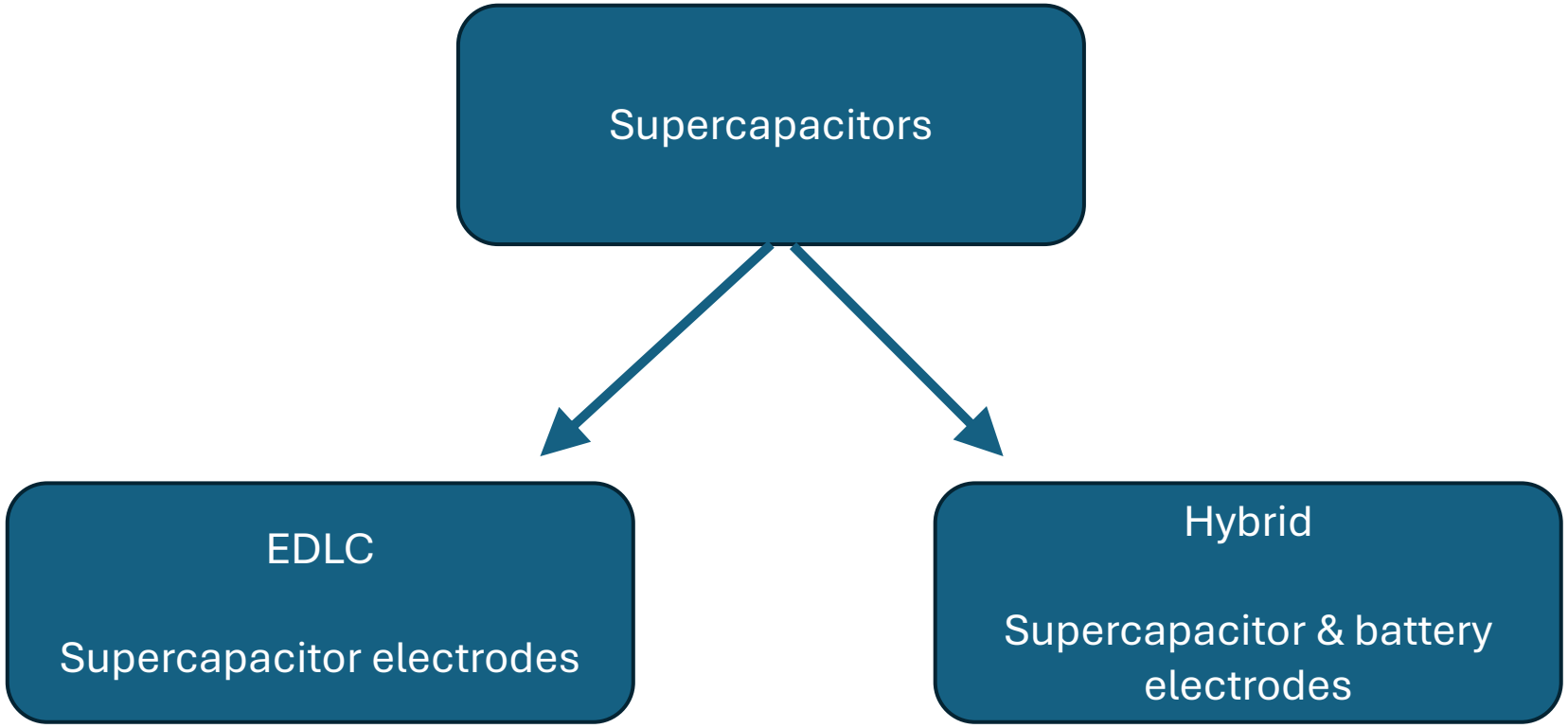
Additional Points

- NO new technical changes are introduced in the reorder that were not submitted as PIs.
- NO requirements are eliminated with the deletion of Lasers and Power Electronics, all previous requirements are covered in 305 through 330.
- Redundancy is eliminated (e.g., equipment approval, hazard thresholds, training).

Public Inputs 128 & 131
EDLC supercapacitors

Work group for EDLC Supercapacitors: Lloyd Gordon, Steve Edley, Dave Wright, Troy Brandon, Curtis Ashton

Supercapacitor Types



EDLC Supercapacitors

- Store energy in an electric charge
- Do not store energy electrochemically
- Can be placed in an electrically safe working condition by discharging to 0V.

Hybrid Supercapacitors

- Are a hybrid between EDLC and electrochemical batteries.
- Store energy in an electric charge and electrochemically
- Cannot be placed in an electrically safe working condition by discharging to 0V.

Why should EDLCs have their own Article?

- Unlike batteries or hybrid supercapacitors, EDLCs can be completely discharged and placed into an electrically safe working condition.
- Unlike conventional capacitors, neither EDLCs nor hybrid supercapacitors are capable of producing an acoustic shock wave that could impact human lungs. This is because during a short circuit, the rate of rise of current is far lower than the threshold required to do so.
- Further details can be found in the proposed new EDLC Characteristics Annex material.

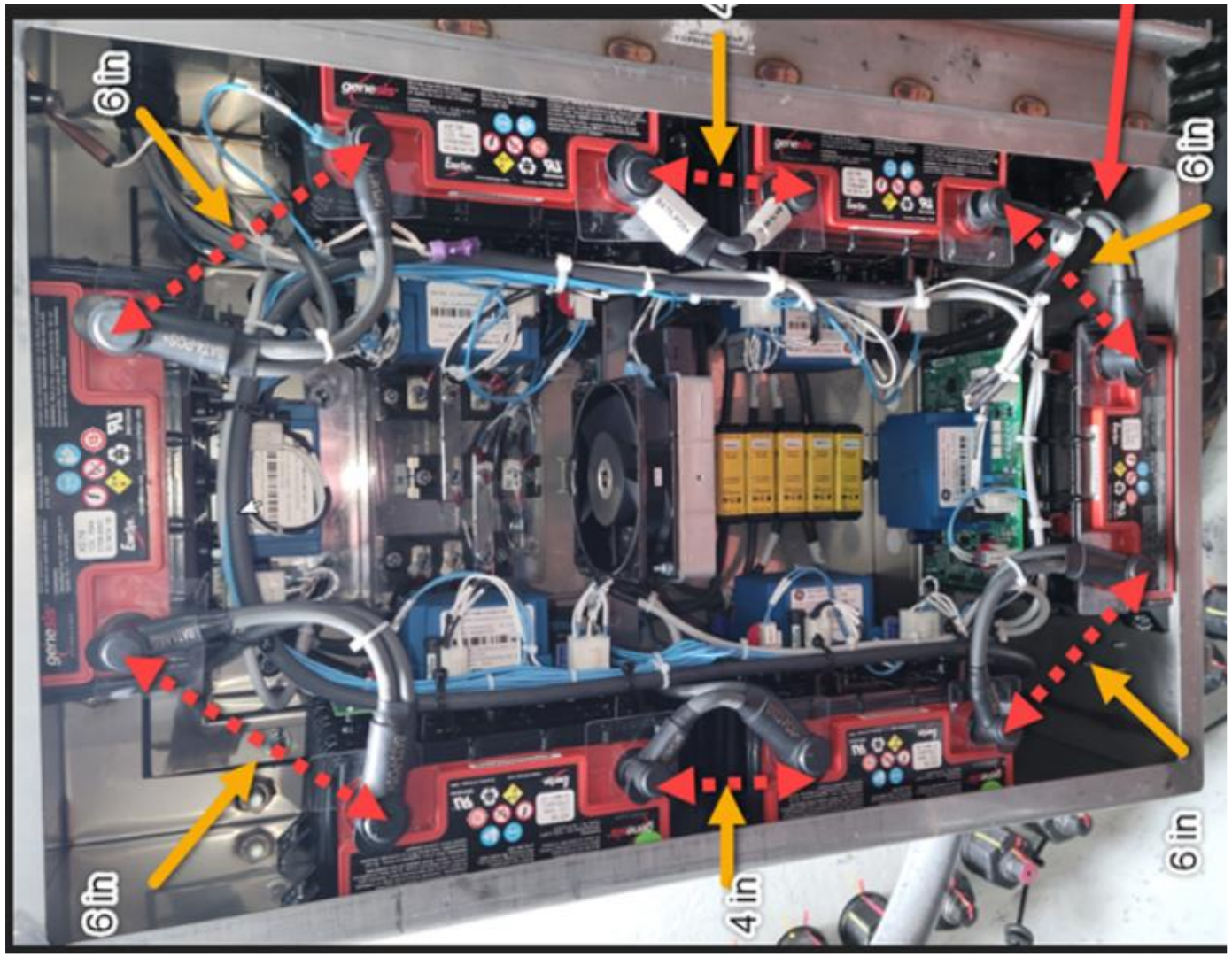
What is the history of applying Article 360 to supercapacitors?

- Article 360 was intended to address hazards associated with conventional capacitors.
- Article 360.4 (B)(4)(c) addresses lung protection boundary that should not be applied to supercapacitors.
- Without clarification Article 360 has been applied to supercapacitor systems with negative impact.
- Requires impractical PPE that can expose the worker to high risk due to the work environment.

Use of unnecessary PPE can expose the worker to high risk.

For wind turbine pitch boxes, the worker is very exposed.

Typical wind turbine pitch-box



This wind turbine pitch-box has 333kJ of energy when fully charged supercapacitors are installed.

Article 360.4(B) 4c states “if stored energy is above 122kJ employees shall not enter the lung protection boundary”

Impact of applying Article 360 to supercapacitors

- Inappropriately penalizes supercapacitor systems that are intended to be used instead of battery systems.
- Lost Benefits:
  - Inherently safe technology.
  - High round trip efficiency.
  - Exceptionally long life.

Reducing Risk When Performing Energized Work on Batteries

Presented by:
DAVID ROSEWATER

D. M. Rosewater, "Reducing Risk When Performing Energized Work on Batteries," in *IEEE Transactions on Industry Applications*, doi: 10.1109/TIA.2023.3332828.

U.S. DEPARTMENT OF ENERGY NNSA

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

SAND2024-

Sandia National Laboratories

Public Inputs

PI #	Section	Summary
105	320.3(A)(2)	Battery Risk Assessment
108	new after 320.3(A)(2)	Battery Electric Shock Risk Assessment
109	new after 320.3(A)(2)	Battery Thermal Risk Assessment
110	new after 320.3(A)(2)	Battery Arc Flash Risk Assessment
113	new after 320.3(A)(2)	Battery Chemical Risk Assessment
114	new after 320.3	Establishing a Lower Risk Work Condition in Batteries
115	New before D.5.1	Add Exposed Conductor Separation as the first way to assess dc arc flash
155	130.7(C)(15)	Adding the 1mm/volt rule to dc arc flash category method table 130.7(C)(15)(b)

The Need **The Process** **The Impact**

The Need

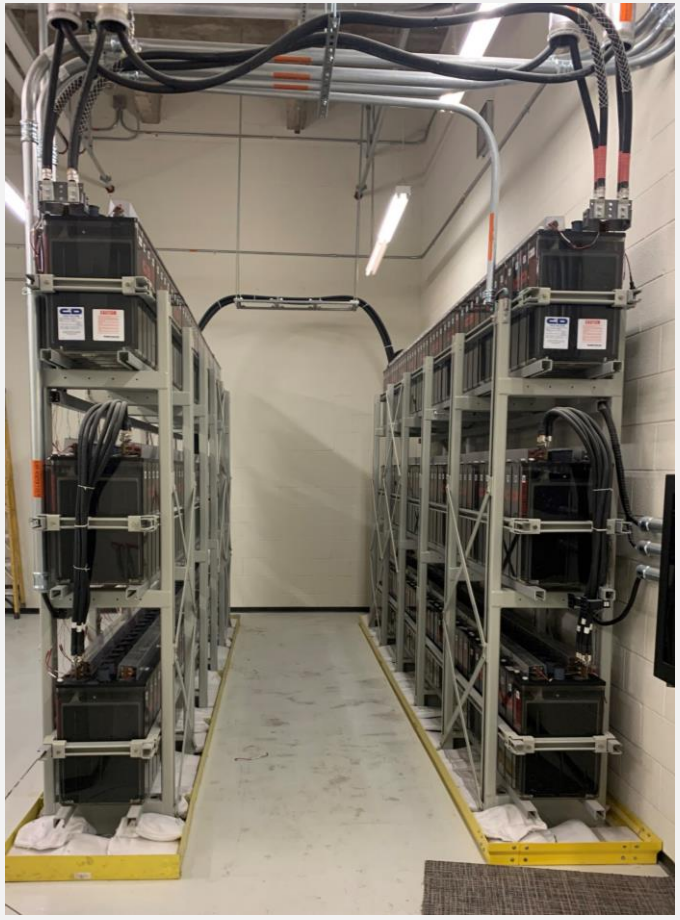
The U.S. will likely need more than 1 TWh* of energy storage to achieve net-zero by 2050 [2].

*Exact estimates depend on the modeling assumptions.

[2] E. Larson, C. Greig, J. Jenkins, E. Mayfield, A. Pascale, C. Zhang, J. Drossman, R. Williams, S. Pacala, R. Socolow, EJ Baik, R. Birdsey, R. Duke, R. Jones, B. Haley, E. Leslie, K. Paustian, and A. Swan, "Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Final report," *Princeton University*, Princeton, NJ, 29 October 2021

Why are batteries different?

Typical 480 V ac electrical service



Typical ~480 V dc batteries

The Process to Develop the PIs

The **Energy Facility Contractors Group (EFCOG)** organization arose from an initiative by contractor executives to work together to improve operations across the DOE complex; and a challenge from DOE leadership to tackle common problems facing DOE sites and laboratories. That remains the core of our mission today – to maximize DOE/NNSA mission success by achieving management and operational excellence. EFCOG has grown to an organization that has over 135 member companies representing the prime contractor community, as well as the small business community, that support the DOE/NNSA operations.

https://efcog.org/

Energy Storage and Stationary Battery Committee

The scope of the ESSB Committee is four-fold in purpose:

- Develop and publish standards that apply to the safety, performance and maintenance of energy storage and stationary battery systems, along with related DC systems and ancillary devices.
- Conduct or sponsor relevant technical sessions and webinars
- Seek experienced SME's from all areas of energy storage and stationary battery experience to help establish the ESSB Committee as a responsible and leading voice in energy storage and stationary batteries.
- Liaise with other technical committees, societies and groups

ESSB COMMITTEE

https://cmte.ieee.org/pes-essb/

D. M. Rosewater, "Reducing Risk When Performing Energized Work on Batteries," in *IEEE Transactions on Industry Applications*, doi: 10.1109/TIA.2023.3332828.

2732 IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 60, NO. 2, MARCH/APRIL 2024

Reducing Risk When Performing Energized Work on Batteries

David M. Rosewater, *Senior Member, IEEE*

***Abstract*—Electrical safety guidance in NFPA 70E for work on batteries can be substantially improved. Article 120, Establishing an Electrically Safe Work Condition was originally developed to manage electrical sources that can be de-energized, e.g., facility ac/dc power circuits. Some have inappropriately attempted to apply electrical safety practices intended for power distribution circuits to battery work. This includes attempts to de-energize batteries, verify zero energy, or establish an electrically safe work condition, none of which can be applied to batteries. However, the principles of the control of hazardous energy, including lockout tagout, can and need to be adapted to work on batteries. This paper explores the modifications required to develop a battery hazardous energy control procedure that can protect workers and avoid accidents. The paper also covers several physical properties and engineering controls common in battery systems that affect the battery risk assessment required by NFPA 70E. Lastly, the paper presents a list of changes proposed to electrical safety practices, including those outlined in NFPA 70E, that clarify how to control hazardous energy in batteries, helping to avoid future misapplication of power distribution circuit electrical safety practices to batteries.**

***Index Terms*—Batteries, energized work, risk assessment, work practices, workplace safety.**

I. Introduction

ELECTRICAL work on batteries is becoming more common with the proliferation of battery-based energy storage systems to support a transition to low-carbon energy sources. Large batteries have been in widespread use in power systems and electric vehicles for over a century, but their relative cost has historically limited their application to backup systems, and niche markets. Mobile applications have been limited to engine start batteries and naval vessels. This has led to a relatively small and stable workforce of specialized battery technicians who have established safety practices independent from the electrician and linemen trades. As batteries have fallen in cost they are more commonly installed in cars, homes, business, and utility applications by a new workforce of battery technicians. This new workforce needs specific guidance for how to safely assemble, maintain, repair, and disassemble battery systems.

Manuscript received 28 April 2023; revised 9 August 2023; accepted 14 October 2023. Date of publication 14 November 2023; date of current version 21 March 2024. Paper 2023-ESafC-0465.R1, approved for publication in the IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS by the Electrical Safety Committee of the IEEE Industry Applications Society. This work was supported by the US DOE Office of Electricity's, Energy Storage Program.

The author is with the Sandia National Laboratories, Albuquerque, NM 87185 USA (e-mail: dmrose@sandia.gov).

Color versions of one or more figures in this article are available at https://doi.org/10.1109/TIA.2023.3332828.

Digital Object Identifier 10.1109/TIA.2023.3332828

© 2023 The Authors. This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 License. For more information, see https://creativecommons.org/licenses/by-nc-nd/4.0/

The control of hazardous energy in electrical systems has been structured and regulated around lockout/tagout (LOTO) since before the OSHA first passed Code of Federal Regulations (CFR) Part 1910.147 in 1982 [3]. The LOTO system, in its current incarnation, is designed primarily for electricians installing and modifying ac/dc power circuits, though it can be applied to many hazardous energy sources [4]. Electrical LOTO requires a worker to establish an electrically safe work condition by isolating equipment from its energy source and locking the point of isolation to prevent unexpected energization. It then requires a worker to test the circuit to verify zero energy within the work area before starting work. These requirements are based on sound and robust principles of electrical safety to eliminate or reduce the hazard as much as possible before work. 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.

This paper presents a method to modify and supplement the requirements of the LOTO system to eliminate or reduce the hazards of battery systems as much as possible before performing energized electrical work. This method is built on contributions that clarify and refine the battery risk assessment required to identify required personnel protective equipment (PPE) and administrative work controls. Finally, it concludes with a discussion of how to modify existing workplace LOTO programs to cover energized work on batteries.

II. Battery Risk Assessment

Risk assessment aims to understand the likelihood and severity of potential accidents. Workers can then apply controls to make accidents less likely and/or less severe. This can be done through the hierarchy of controls presented in NFPA 70E 2024 Article 110.5(3) [4]: Elimination, Substitution, Engineering controls, Awareness, Administrative controls, and PPE.

Applied to batteries and battery systems, Article 320.3(A)(2) requires that a risk assessment shall be performed prior to any work on a battery system. This risk assessment shall identify the chemical, shock, arc flash, and thermal hazards. Additionally, this risk assessment shall assess the risks associated with the type of tasks to be performed.

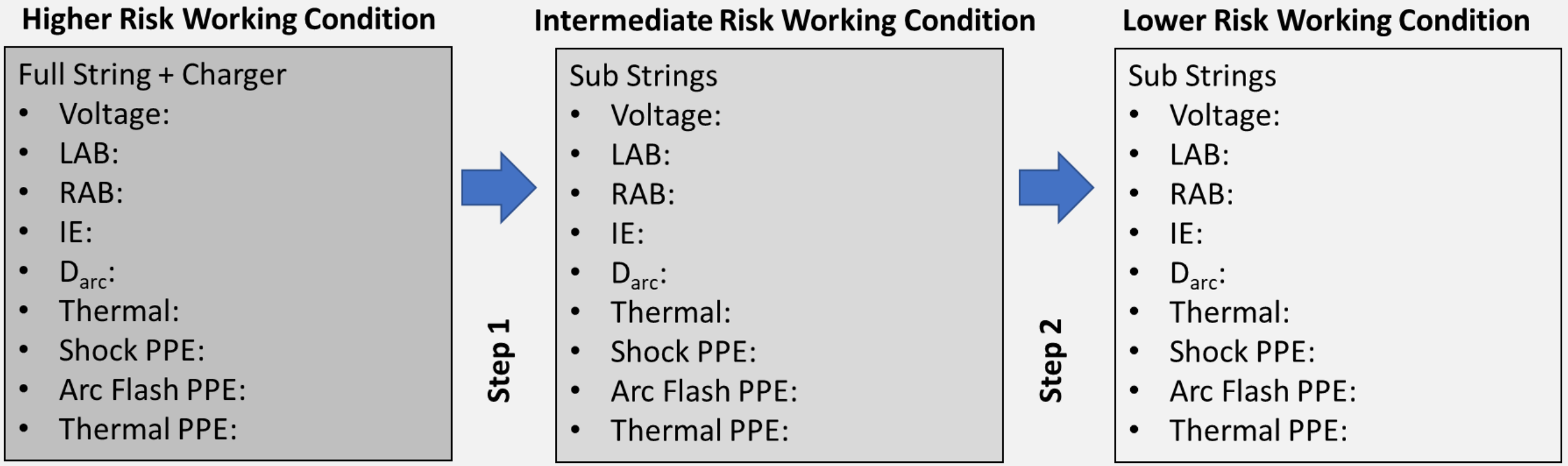
Historically, some employers require the preparation of an Energized Electrical Work Permit (EEWP) for any work on batteries. The requirements of a battery risk assessment are substantially like the requirements of an EEWP. An EEWP

We are asking for the following changes:

1. More specific requirements for battery risk assessment
2. The ability to establish a lower risk working condition in batteries

1) Battery Risk Assessment

A battery will have multiple risk assessments

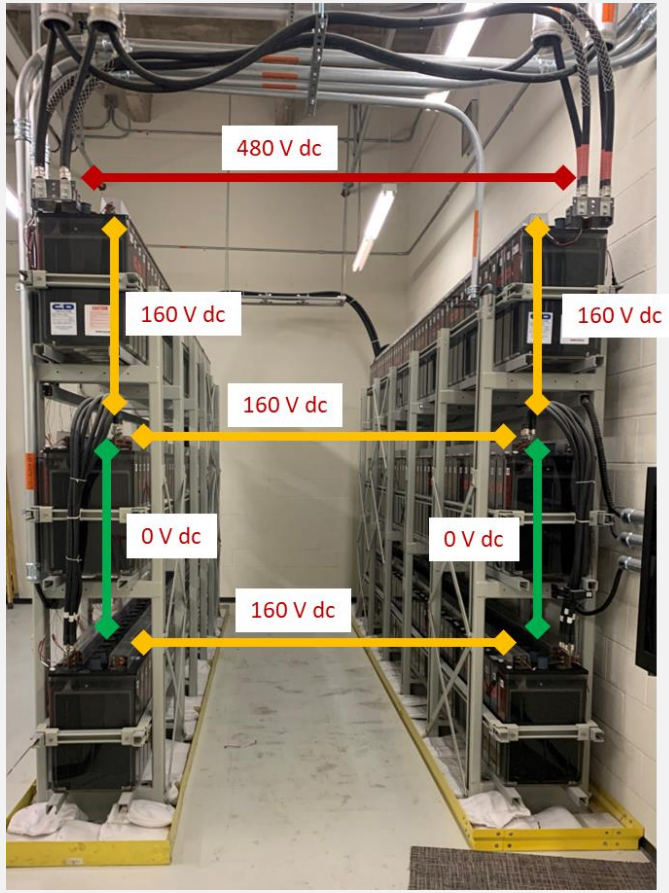


1) Battery Risk Assessment

The electrical hazards in batteries are mitigated by the physical separation of voltage and by their ability to operate ungrounded (or with high resistance to ground).

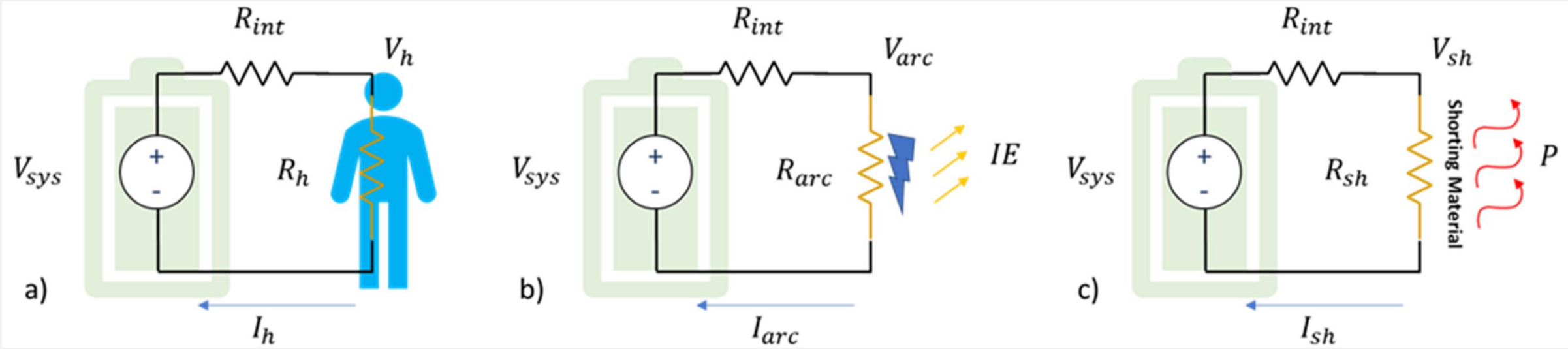
Typical 480 V ac electrical service
Exposed conductor gap < 20 mm

If exposed electrical conductors are farther than 1 mm / volt apart, then any arc that forms will extinguish itself within a matter of milliseconds.



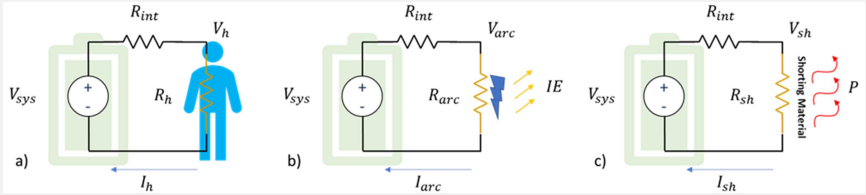
Typical ~480 V dc battery
Exposed conductor gap > 1 m

Battery Risk Assessment: Hazards



Shock Arc Flash Thermal

Battery Risk Assessment: Hazards



Shock

Shock risk assessment “Shall take into consideration …

The design of the equipment **including the spacing separation of exposed electrical conductors**.”

Arc Flash

Arc flash risk assessment “Shall take into consideration …

The design of the battery **including the separation distance of exposed electrical conductors**, and any overcurrent protection devices and their operating times.”

See new D.5.1

Thermal

Thermal risk assessment “Shall take into consideration …

The design of the equipment including the **spacing of exposed electrical conductors in relation to length of potential shorting materials used in the task**.”

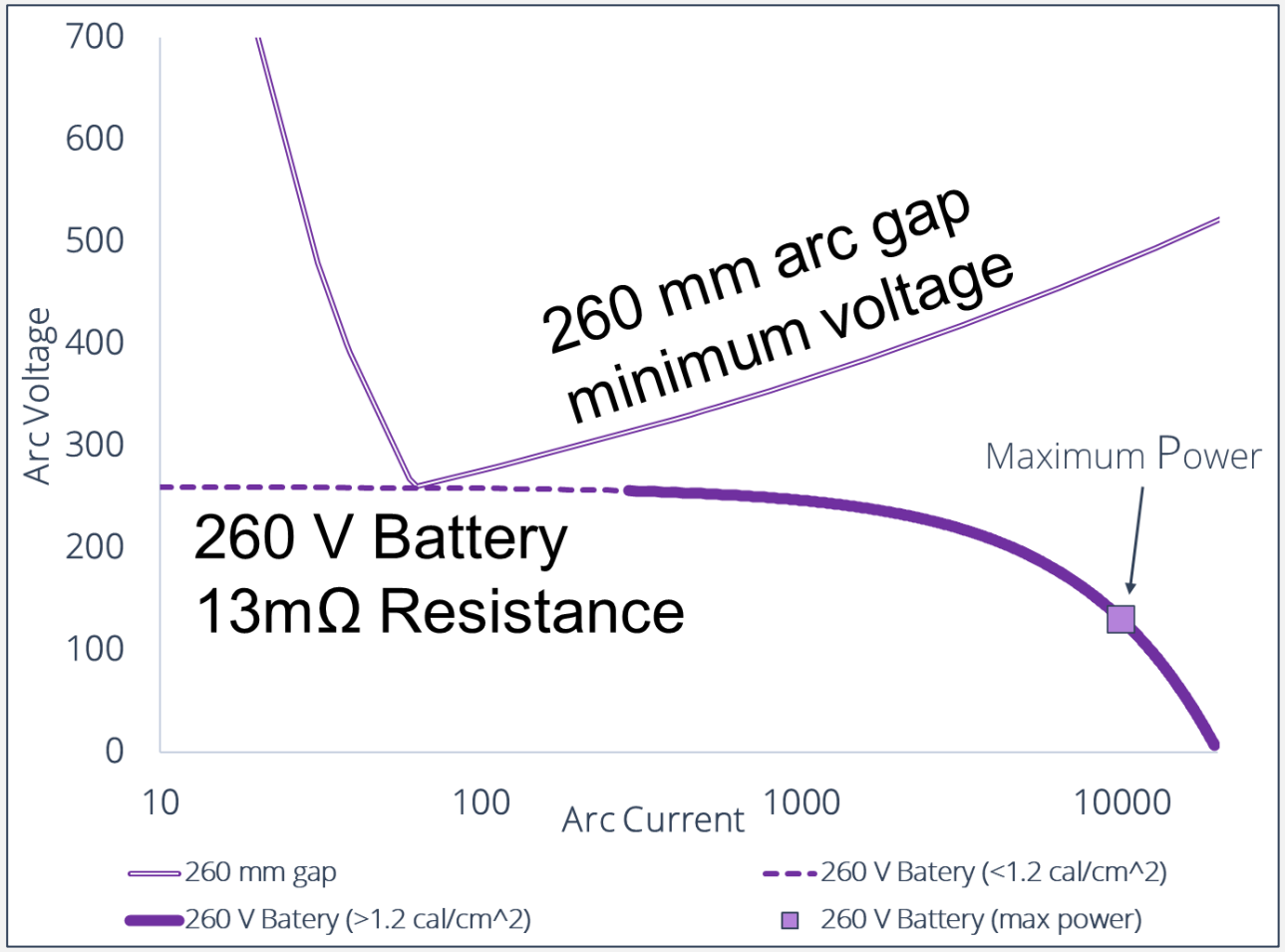
Battery Risk Assessment: 1 mm / V rule

Proposed Change to DC Arc Flash Category Method Table

Categories in Table 130.7(C)(15)(b) only apply when gap is less than 1mm/volt. Otherwise, there is a low likelihood of an arc flash due to equipment design.

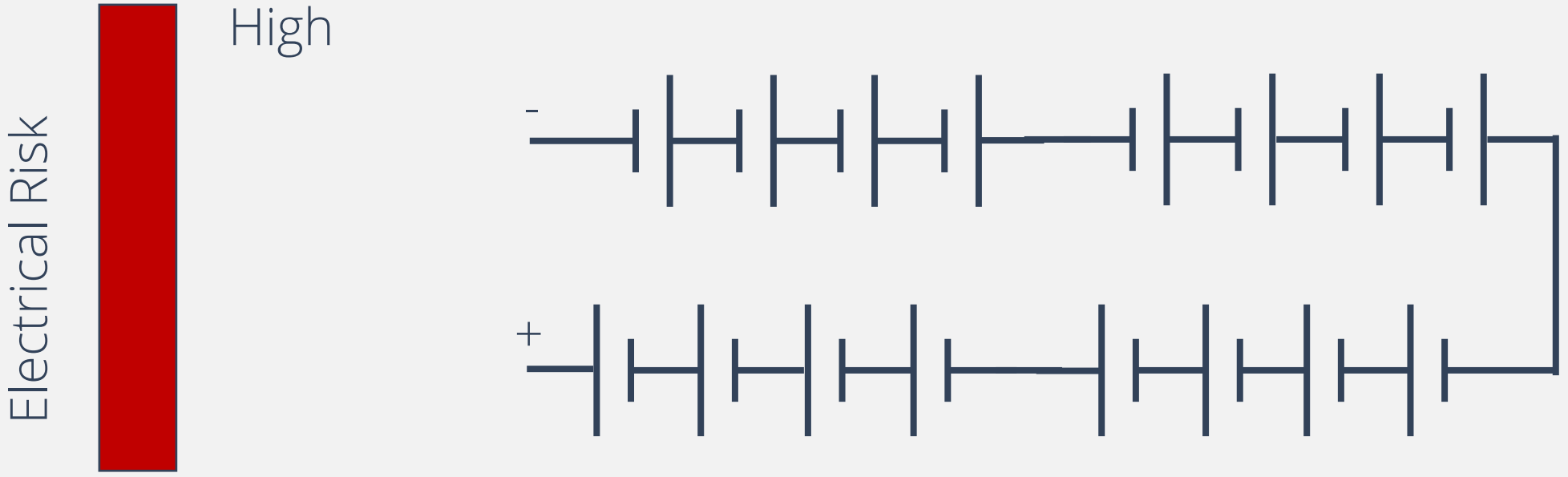
Proposed New Annex D Content

"It is unlikely that a dc arc can be sustained in ungrounded or impedance grounded dc systems below 600 volts between exposed conductors with separation greater than **1 millimeter per volt** … "



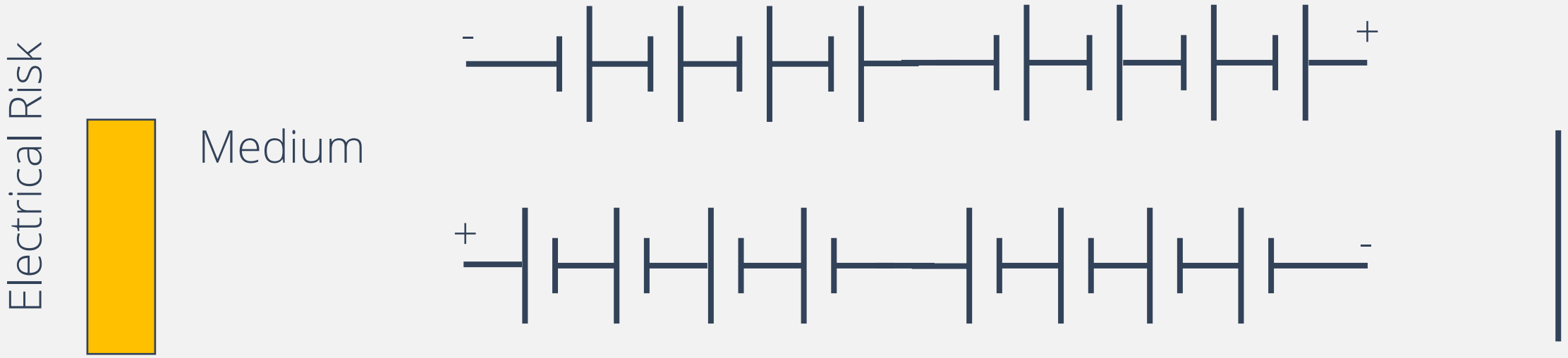
2) Establishing a Lower Risk Working Condition

As batteries cannot be de-energized, a battery sectionalizing procedure does not work to establish or verify an electrically safe work condition. Instead, it reduces the risk of injury by splitting a battery into lower voltage, lower energy segments.



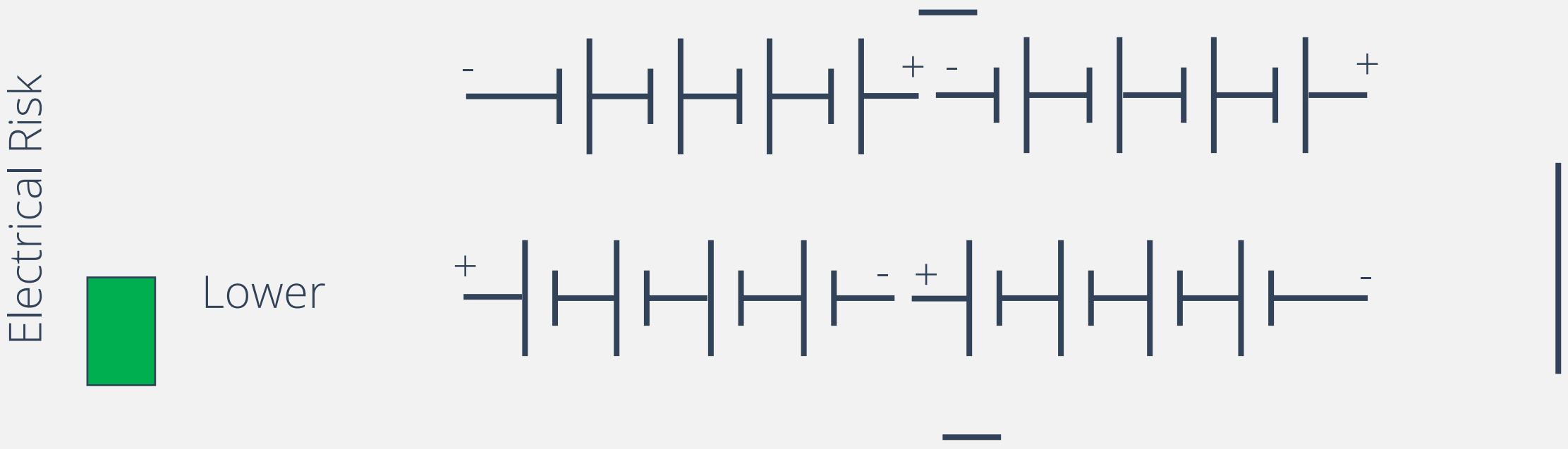
2) Establishing a Lower Risk Working Condition

As batteries cannot be de-energized, a battery sectionalizing procedure does not work to establish or verify an electrically safe work condition. Instead, it reduces the risk of injury by splitting a battery into lower voltage, lower energy segments.



2) Establishing a Lower Risk Working Condition

As batteries cannot be de-energized, a battery sectionalizing procedure does not work to establish or verify an electrically safe work condition. Instead, it reduces the risk of injury by splitting a battery into lower voltage, lower energy segments.



Conclusion

Summary of the PIs from :

1. More specific requirements for battery risk assessment
2. The Ability to Establishing a Lower Risk Working Condition in batteries

DC Arc Flash

2027 NFPA 70E First Draft Meeting

July 31, 2024

Presenter – Lloyd B. Gordon

Goal and Justification

- Goal
  - To update the DC Arc Flash Analysis Methods in the 2012 NFPA 70E, after 15 years.

- Justification
  - Current recommended methods over predict incident energy compared to all data on actual equipment, from 2 to 20 times greater.
  - Over 20 DC arc flash studies in the past 15 years provide data.
  - Publications, many peer-reviewed, will be summarized

- Accidents – Throughout the whole (a) Battery Energy Storage, (b) Standby Battery Systems, and (c) Electric Vehicle industries there is little to no documented dc arc flash accidents, and no fatalities. These communities are pleading for better methods for dc arc flash hazard analysis. Data does not support the high values calculated.

History - Table 130.7(C)(15)(b) – Arc Flash PPE Category Method and Annex D.5 Direct Current Incident Energy Calculations

- 2012 NFPA 70E
  - Key authors (2009 – 2010) – Bobby Gray, Lloyd Gordon, Dan Doan
  - Based on three references (2007 – 2010)

    (1) Maximum Power Transfer Theorem (circuit theory), Doan, 2007 IEEE publication

    (2) Ammerman (Iterative method), 2010, IEEE publication

    (3) Kinectrics model (limited laboratory data, unrealistic setup), 2007 internal publication
  - Limitations – all three assume static arc, use 2 s duration if no fuse
- 2027 NFPA 70E
  - Key contributors (2023 – 2024) – Lloyd Gordon, David Rosewater, Bill Cantor, Curtis Ashton, Navy, EPRI, etc.
  - Based on 15 years of new data (over 20 data sets) and modeling, many publications, select references
    - Gordon (2024 pub.), Cantor (2024 pub.), Ashton (2024 pub), Wetz (2024 draft), Gray (2020 pub)
    - Takes into account dynamic behavior, data from tests on equipment

Existing DC Arc Flash Calculation Models

- Iterative Model to come up with arc resistance
  - Stokes/Oppenlander, 1991
    - Commonly used by Software providers
  - Paukert, 1993
    - Commonly used by Software providers
  - Ammerman/Sen, 2009, Iterative, summary of previous methods
- Kinectrics Physics Model, 1995-2007, theoretical physics principles to predict arc resistance
- Doan Maximum Power Transfer Theorem, 2007, Simple Formulas (tends to significantly overestimate arc flash incident energy, especially at lower DC voltages)
    - Always used by Software providers
- All current models:
  - assume a static, fixed-length arc
  - use 2 seconds for arc lifetime, if no overcurrent protection
  - Over predict incident energy compared to tests

Simple Physics

- Single Phase, 60 Hz arcs –
  - Extinguish quickly because current passes through a current zero at 120 times per second, plasma cools off or dissipates.
- Three phase, 60 Hz arcs
  - Plasma remains continuously ionized due to three phases, which continuously feed plasma energy. Magnetic forces on the arcs cancel, no lateral arc movement.
- DC arcs
  - Plasma is continuously fed, similar to a 3-phase arc.
  - However, magnetic force is in one direction and elongates arc. The higher the current, the stronger the force on the arc, the quicker it extinguishes.

Accuracy of Existing DC Arc Flash Calculation Models

- Maximum Power Transfer Theorem, 2007 – LEAST ACCURATE
  - Assumes 50% of energy converted to arc flash energy
  - Assumes static arc, 2 s for no overcurrent protection
  - Overpredicts by 5 (550 V, 5 kA) to 225 (200 V, 5 kA) times
- Iterative Models to come up with arc resistance – MORE ACCURATE
  - Stokes/Oppenlander, Paukert, Ammerman
  - Better estimate of short circuit current
  - Assumes static arc, 2 s for no overcurrent protection
  - Overpredicts by 1 to 5 times
- Iterative Models with bounds accounting for arc dynamics from magnetic and erosion mechanisms – MOST ACCURATE

One of 15 examples of date - Sept. 2022 data
Mock battery bank, real breaker and cables

Laboratory Data	Max Power	Overest.
• 192 V, 5 kA, 2.8 cm gap – max 20 ms, max 0.02 cal/cm2	4.5 cal/cm^2	x225
• 250 V, 5 kA, 2.8 cm gap – max 60 ms, max 0.1 cal/cm2	5.5 cal/cm^2	x55
• 480 V		
• 5 kA, 2.8 cm gap – max 4.5 s, max 6 cal/cm2	11.5 cal/cm^2	x2
• 20 kA, 2.8 cm gap – max 0.3 s, max 2.6 cal/cm2	46 cal/cm^2	x18
• 5 kA, 8.3 cm gap (barrier) – max 20 ms, max 0.07 cal/cm2	11.5 cal/cm^2	x164

Conclusions, MUST take into account **gap distance and voltage, and barriers**
Higher currents leads to shorter lifetime 4 x current = 0.5 x incident energy

Photos

Simple barrier increased arc length, interrupted immediately, no incident energy

Maximum IE was for 480 V, 5 kA, IE was 6 cal/cm^2, 1 sec

Maximum damage was for 480V, 20 kA, but IE was only 2.6 cal/cm^2, 0.3 sec

References

- Journal Peer-Reviewed
  - L. Gordon, “Modeling the Dynamic Behavior of DC Arcs”, IEEE Trans. on Industry App., Vol. 60, No. 1, Jan/Feb 2024, pp 1946 – 1955. – Reviewed and analyzed 8 sets of DC arc flash data, 125 – 600 V.
  - R. F. Ammerman, T. Gammon, P. K. Sen, and J. P. Nelson, “DC arc models and incident energy calculations,” IEEE Trans. Ind. Appl., vol. 46, no. 5, pp. 1810–1819, Sep./Oct 2010. Reviewed data, showed MPT over predicts compared to other models.
  - T. Gammon, W. J. Lee, Z. Zhang, and B. C. Johnson, “A review of commonly used DC arc models,” IEEE Trans. Ind. Appl., vol. 51, no. 2, pp. 1398–1407, Mar./Apr. 2015. Reviewed data, showed MPT over predicts compared to other models.
  - A. D. Stokes and W. T. Oppenlander, “Electric arc in open air,” J. Phys. D: Appl. Phys., vol. 24, no. 1, 1991, Art. no. 26. Arc resistance model, significantly more accurate than MPT method.
  - A. C. Gaunce et al., “DC arc flash: Testing and modeling incidents in a 125-V substation battery backup system,” IEEE Trans. Ind. Appl., vol. 56, no. 3, pp. 2138–2147, May/Jun. 2020. Data supporting 150 V threshold for DC arc flash.

References

- Workshop Peer-Reviewed
  - C. Ashton, “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, March 2024, Tucson, pp. 71 – 77.
  - L. Gordon, “Modeling DC arc physics and applications for DC arc flash risk assessment,” in Proc. IEEE IAS Elect. Saf.Workshop, 2023, pp. 1–10.
  - J. Paukert, “The arc voltage and arc resistance of LV fault arcs,” in Proc. 7th Int. Symp. Switching Arc Phenomena, 1993, pp. 49–51.
  - K. S.Y. Cheng, C. Samson, and S.Cress, “DC arc-flash testing and analysis at 600 V,” in Proc. IEEE IAS Elect. Saf. Workshop, 2020, pp. 1–6.
  - K. Gray, S. Robert, and T. L. Gauthier, “Low voltage 100 –500 Vdc arc flash testing,” in Proc. IEEE IAS Elect. Saf. Workshop, 2020, pp. 1–7.
  - K. Gray, S. Robert, and R. Hallé, “Sustainability of an electric arc flash at a voltage of 240 Vac and 140 Vdc,” in Proc. IEEE IAS Elect. Saf. Workshop, 2023, pp. 1–6.

DC Arc Flash Studies (500 – 1000 tests)

- Bieder, 1956
- Amft, 1967
- Hall, 1978
- Sunabe, 1990
- Stokes, 1991
- Paukert, 1993
- Keyes, 2007
- Ammerman, 2010
- Cheng, 2011
- Hildreth, 2018
- Cheng, 2020
- Gaunce, 2020
- Gray, 2020
- Gray, 2023 Gordon 2023
- Gordon, 2024
- Gordon, 2024
- Ashton, 2024
- Cantor, 2024
- Wetz, 2024
- Marroquin, 2024

DC arc behavior – from several referred publications, necessary to explain changes to calculation methods

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 arcs combine 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)*.

Many of the methods discussed below assume a static arc, not changing shape in time, but staying in a direct line path between the two electrodes. A lateral magnetic force, plus electrode erosion, results in self extinction that is not predicted by any of the static models. This static assumption is true for models based on circuit theory and plasma physics that does not include dynamic arc behavior. Only an empirical model, based on sufficient data, might predict arc behavior. However, much of the data obtained for the empirical methods is from laboratory tests and does not represent actual systems, including geometry, electrode materials, and gap distances.

This lack of accounting for the dynamic behavior of the arc is the primary reason that arc extinction times are not accounted for in the current models, and the models consistently give higher incident energy values than is measured. An example is that all of the below models will predict a higher incident energy for a higher current. However, tests show that the higher currents result in lower incident energy, due to a shorter arc lifetime due to the magnetic force rapidly elongating the arc.

Effect of gap on arc lifetime - above a gap distance, determined by voltage, an arc extinguishes very quickly resulting in non hazard incident energy, published

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 can't be sustain. *(see references 1, 2, 3)*

$V_{min} = 1.06 * g + 100$ **[D.5.2a]**

or

$g_{min} = V - 100 * 1.06$ **[D.5.2b]**

where:

V_{min} = voltage below which an arc can't be sustained

g = gap distance

g_{min} = gap above which an arc can't be sustained

V = system voltage

Effect of gap on arc lifetime - above a gap distance, determined by voltage, an arc extinguishes very quickly resulting in non hazard incident energy, published

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 can't be sustain. *(see references 1, 2, 3)*

$V_{min} = 1.06 * g + 100$ **[D.5.2a]**

or

$g_{min} = V - 100 * 1.06$ **[D.5.2b]**

where:

V_{min} = voltage below which an arc can't be sustained

g = gap distance

g_{min} = gap above which an arc can't be sustained

V = system voltage

Box effect – data from recent tests to no support a significant box factor – This approach is from a recent publication.

- 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 relaively. 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 inches in front of the cabinet for low voltage systems yields an approximate additional 3-4% 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 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.
- $K_{ab} = (0.55 \times \ln(d_{ab})) - 0.6$ **[D.5.3b]**
-

- where:
- K_{ab} = arc-flash boundary distance multiplier for large dc battery cabinets
- d_{ab} = calculated arc-flash boundary (in inches) without an arc-in-a-box/enclosure multiplier

Modified Maximum – a modification of the PMT to account for arc extinction at low voltages, based on published data

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 following formula:

$$T_{arc} = 0.0043 \; x \; V_{sys} \qquad \textbf{[D.5.4]}$$

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.

Additional Models for DC arc flash hazard analysis – these alternate methods are already in use by some. All from published works.

D.5.5 Stokes/Oppenlander Method
This is an empirical method based on tests for dc arcs from 0.1 A to 1 kA *(see reference 7).*

D.5.6 Paukert Method
This is an empirical method based on data of dc arc measurements from 7 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).*

Updated discussion of Short Circuit Current and Clearing Time – Based on recent referred publications

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).*

Updated references – adds recent published works and analysis of many sets of dc tests (1, 3, 6) and additional methods

D.5.10 References

1. L. Gordon, “Modeling the Dynamic Behavior of DC Arcs,” IEEE Trans. on Industry Applications, Vol. 60, No. 1, Jan/Feb 2024, pp 1946-1955.
2. R. F. Ammerman, T. Gammon, P. K. Sen, and J. P. Nelson, “DC arc models and incident energy calculations,” in Proc. Petroleum Chem. Ind. Conf., 2009, pp. 1–3.
3. C. Ashton, “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, March 2024, Tucson, pp. 71 – 77.
4. D. R. Doan, “Arc flash calculations for exposures to DC systems,” IEEE Trans. on Industry Applications, Vol. 46, No. 6, Nov/Dec 2010, pp. 2299-2302.
5. IEEE 1584, Guide for Performing Arc Flash Calculations, New York, NY: IEEE, 2018.
6. 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.
7. A. Stokes and W. Oppenlander, “Electric arcs in open air,” J. Phys. D: Appl. Phys., vol. 24, pp. 26–35, 1991.
8. J. Paukert, “The arc voltage and arc resistance of LV fault arcs,” in Proc. 7th Int. Symp. Switching Arc Phenomena, 1993, pp. 49–51.
9. C.Keyes and C. Maurice, “DC arc hazard assessment phase II,”Kinectrics, Toronto, ON, Canada, Tech. Rep. K-012623-RA-0001 -R00 , Jul . 2007.

Thank you!

NFPA 70E:
BoxLock Public Input

Overview of comments provided by BoxLock (on behalf of Rosendin Electric, McCarthy Building Constructors, Kiewit Corp, and Oracle) regarding the digitization of NFPA 70E.

Automated Digital LOTO Logs Streamline Safety Audits and Training

Compliance and Safety: Ensuring adherence to OSHA standards and enhancing workplace safety by preventing accidental release of hazardous energy.

Accountability and Efficiency: Tracking lockout/tagout activities promotes accountability and improves operational efficiency by minimizing downtime.

Training and Improvement: Serving as a valuable resource for training employees and identifying opportunities for enhancing safety protocols.

Incident Investigation: Facilitating thorough investigations and audits by providing a clear record of LOTO activities, crucial for understanding and preventing workplace incidents.

Legal Protection: Offering crucial documentation in the event of legal actions or OSHA inspections, demonstrating adherence to safety procedures.

Recommended Overview of Enhancements

Section No. 120.4(C): Lockout Device

How digital LOTO devices ensure live status updates and monitoring, without the need for physical presence or individual mobile devices

Section No. 120.5(A)(5): Complex Lockout/Tagout

Utilizing a single connected lockout device with digital records ensures safety, accountability, and energy status accuracy for group lockout procedures

Section No. 120.5(B)(4): Disconnecting Responsibility

Leveraging digital LOTO devices ensure verification and task completion checks before releasing locks, which enhances coordination and safety

Section No. 120.5(B)(8): Shift Change

Digital transfers enable seamless handover of LOTO responsibilities between shifts, with verification from both the current and receiving workers

Section No. 120.5(B)(12): Removal of LOTO Devices

Using digital processes to automate consent allows for lock or tag removal without the installer's physical presence and provides a digital log of all actions

Sample Documents - Section No. G.2.0; No. G.9.4:
Introduces the option of a connected lockout tagout device that implements the appropriate procedures in the event that more digital LOTO solutions are incorporated

Public Comment No. 33-NFPA 70E-2025 [Global Input]

The Correlating Committee requests that the Technical Committee review the term “appropriate” in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 on unenforceable terms. This term is used in the following sections including but not limited to: 110.3(A), 110.3(L)(2)(b), 110.4(A)(1)(c)(4)d, 110.4(A)(1)(e), 130.5(C)(2)(1), 130.7(C)(14)(b) Informational Note No. 1, 130.7(C)(14)(c)(4), 330.4, 320.3, 320.4(B)(3)(4), 360.4(C)(2)(4) Informational Note No. 1, 380.2(B)(4),(1),(2) and (3), 380.3(C)(1), 390.2.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_1.pdf	70E_CN1	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 1 appeared in the First Draft Report.

The Correlating Committee requests that the Technical Committee review the term “appropriate” in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 on unenforceable terms. This term is used in the following sections including but not limited to: 110.3(A),110.3(L)(2)(b), 110.4(A)(1)(c)(4)d, 110.4(A)(1)(e),130.5(C)(2)(1), 130.7(C)(14)(b) Informational Note No. 1, 130.7(C)(14)(c)(4), 330.4, 320.3, 320.4(B)(3)(4), 360.4(C)(2)(4) Informational Note No. 1, 380.2(B)(4),(1),(2) and (3), 380.3(C)(1), 390.2.

Related Item

• Correlating Committee Note No. 1

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 03 13:01:04 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 1-NFPA 70E-2025 [Global Input]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:20:04 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the term “appropriate” in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 on unenforceable terms. This term is used in the following sections including but not limited to: 110.3(A), 110.3(L)(2)(b), 110.4(A)(1)(c)(4)d, 110.4(A)(1)(e),130.5(C)(2)(1), 130.7(C)(14)(b) Informational Note No. 1, 130.7(C)(14)(c)(4), 330.4, 320.3, 320.4(B)(3)(4), 360.4(C)(2)(4) Informational Note No. 1, 380.2(B)(4),(1),(2) and (3), 380.3(C)(1), 390.2.

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 74-NFPA 70E-2025 [Global Input]

The Correlating Committee requests that the Technical Committee review the extracted definitions and requirements from the 2026 NEC for correlation. For example, the term "overcurrent protective device (OCPD)" has been revised in the 2026 NEC and this would impact the 70E extracted definition of "switchboard" which uses the revised term "overcurrent protective device".

Additional Proposed Changes

File Name	Description	Approved
70E_CN_43.pdf	70E_CN43	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 43 appeared in the First Draft Report.

The Correlating Committee requests that the Technical Committee review the extracted definitions and requirements from the 2026 NEC for correlation. For example, the term "overcurrent protective device (OCPD)" has been revised in the 2026 NEC and this would impact the 70E extracted definition of "switchboard" which uses the revised term "overcurrent protective device".

Related Item

• Correlating Committee Note No. 43

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:51:25 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 43-NFPA 70E-2025 [Global Input]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 09:06:48 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the extracted definitions and requirements from the 2026 NEC for correlation. For example, the term "overcurrent protective device (OCPD)" has been revised in the 2026 NEC and this would impact the 70E extracted definition of "switchboard" which uses the revised term "overcurrent protective device".

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 77-NFPA 70E-2025 [Section No. 90.2]

90.2 Purpose.

The purpose of this standard is to provide a practical safe working area for employees relative to ~~the hazards arising from the use of electricity~~ employee exposure to electrical hazards .

Statement of Problem and Substantiation for Public Comment

The purpose of this standard is incorrectly the purpose of the NEC.The purpose of NFPA 70E is not to protect against "the use of electricity" but rather "exposure to electrical hazards in workplaces." This revised text comes from 110.1 and the deleted (due to its redundancy) 110.2 and correlates the purpose in 90.2 with the correct purpose of NFPA 70E - exposure to electrical hazards - not the use of electricity. This revision additionally correlates with what is covered and not covered by NFPA 70E, by scope - noting that "use of electricity" is not mentioned.

Related Item

• FR-31

Submitter Information Verification

Submitter Full Name: Palmer Hickman
Organization: Electrical Training Alliance
Street Address:
City:
State:
Zip:

Submittal Date: Wed Apr 23 14:31:06 EDT 2025
Committee: EEW-AAA

Public Comment No. 10-NFPA 70E-2025 [Section No. 90.3(B)]

(B) Workplaces Not Covered.

This standard does not cover safety-related work practices for the following:

(1) Installations in ships, watercraft other than floating buildings, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles

(2) Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communications purposes

(3) Installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations

(4) Installations not under the exclusive control of an electric utility , but are covered under OSHA 1910.269

(5) Installations under the exclusive control of an electric utility where such installations:

(6) Consist of service drops or service laterals, and associated metering, or

(7) Are located in legally established easements or rights-of-way designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations, or

(8) Are on property owned or leased by the electric utility for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy, or

(9) Are located by other written agreements either designated by or recognized by public service commissions, utility commissions, or other regulatory agencies having jurisdiction for such installations. These written agreements shall be limited to installations for the purpose of communications, metering, generation, control, transformation, transmission, or distribution of electric energy where legally established easements or rights-of-way cannot be obtained. These installations shall be limited to federal lands, Native American reservations through the US Department of the Interior Bureau of Indian Affairs, military bases, lands controlled by port authorities and state agencies and departments, and lands owned by railroads

.

a.

Statement of Problem and Substantiation for Public Comment

Many companies buy their power at 69kV, 138kV, even some at 345kV. This is where the service point is. This point is where the NESC stops, but where NFPA70E begins. Many companies struggle with this concept because they don't know how to resolve this. I have been in several meetings where companies have discussed having two "service points." The first, the actual one, where ownership transfers from the utility company to the customer. The second 'service point,' downstream of the actual service point, is the one where 1910.269 ends and 70E begins. There are no dielectric gloves rated for 345 kV. There is no PPE, for that matter, that will work at these levels. My first attempt at editing the scope of 70E called out the scope of .269 and added it to this section of 70E. This public comment simply calls out 1910.269 for consideration.

Related Item

• PI 205-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:

City:	
State:	
Zip:	
Submittal Date:	Sun Mar 23 14:46:28 EDT 2025
Committee:	EEW-AAA

Public Comment No. 123-NFPA 70E-2025 [Chapter 1]

~~Chapter 1~~ Chapter 1 Definitions and Safety-Related Work Practices

Article 100 Definitions

Scope. This article contains only those definitions essential to the 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.

Accessible (as applied to equipment).

Admitting close approach; not guarded by locked doors, elevation, or other effective means. [**70:**100]

Approved.

Acceptable to the authority having jurisdiction.

Arc Flash Suit.

A complete arc-rated clothing and equipment system that covers the entire body, except for the hands and feet.

Informational Note: An arc flash suit may include pants or overalls, a jacket or a coverall, and a beekeeper-type hood fitted with a face shield.

Arc Rating.

The value attributed to materials that describes their performance to exposure to an electrical arc discharge. The arc rating is expressed in cal/cm^2 and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakopen threshold (E_{BT}) (should a material system exhibit a breakopen response below the ATPV value). Arc rating is reported as either ATPV or E_{BT}, whichever is the lower value.

Informational Note No. 1: Arc-rated clothing or equipment indicates that it has been tested for exposure to an electric arc. Flame-resistant clothing without an arc rating has not been tested for exposure to an electric arc. All arc-rated clothing is also flame resistant.

Informational Note No. 2: See ASTM F1959/F1959M, *Standard Test Method for Determining the Arc Rating of Materials for Clothing*, which defines ATPV as the incident energy (cal/cm^2) on a material or a multilayer system of materials that results in a 50 percent probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a second degree skin burn injury based on the Stoll curve.

Informational Note No. 3: See ASTM F1959/F1959M, *Standard Test Method for Determining the Arc Rating of Materials for Clothing*, which defines E_{BT} as the incident energy (cal/cm^2) on a material or a material system that results in a 50 percent probability of breakopen. Breakopen is a material response evidenced by the formation of one or more holes of a defined size [an area of 1.6 cm^2 (0.5 in.^{2}) or an opening of 2.5 cm (1.0 in.) in any dimension] in the innermost layer of arc-rated material that would allow thermal energy to pass through the material.

Attachment Plug (Plug Cap) (Plug).

A device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle. [**70:**100]

Authority Having Jurisdiction (AHJ).

An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

> Informational Note: The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

Authorized Personnel.

The person in charge of the premises, or other persons appointed or selected by the person in charge of the premises who performs certain duties associated with stationary storage batteries. (320)

Automatic.

Performing a function without the necessity of human intervention.

Balaclava.

An arc-rated head-protective fabric that protects the neck and head except for a small portion of the facial area.

> Informational Note: Some balaclava designs protect the neck and head area except for the eyes while others leave the eyes and nose area unprotected.

Barricade.

A physical obstruction such as tapes, cones, or A-frame-type wood or metal structures intended to provide a warning and to limit access.

Barrier.

A physical obstruction that is intended to prevent contact with equipment or energized electrical conductors and circuit parts.

Battery.

A system consisting of two or more electrochemical cells connected in series or parallel and capable of storing electrical energy received and that can give it back by reconversion. (320)

Battery Effect.

A voltage that exists on the electrolytic cell line after the power supply is disconnected. (310)

> Informational Note: Electrolytic cells can exhibit characteristics similar to an electrical storage battery and an electric shock hazard could exist after the power supply is disconnected from the cell line.

Battery Room.

A room specifically intended for the installation of batteries that have no other protective enclosure. (320)

Bonded (Bonding).

Connected to establish electrical continuity and conductivity. [**70:**100]

Bonding Conductor or Jumper.

A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected. [**70:**100]

Boundary, Arc Flash. (Arc Flash Boundary)

When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm^2 (5 J/cm^2).

> Informational Note: According to the Stoll skin burn injury model, the onset of a second degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm^2 (5 J/cm^2) for one second.

Boundary, Hearing Protection. (Hearing Protection Boundary)

Worker distance at which a 1 percent probability of ear damage exists from a 20 kPa (3.0 psi) shock wave. (360)

Boundary, Limited Approach. (Limited Approach Boundary)

An approach limit at a distance from an exposed energized electrical conductor or circuit part within which an electric shock hazard exists.

Boundary, Lung Protection. (Lung Protection Boundary)

Worker distance at which a 1 percent probability of lung damage exists from a 70 kPa (10 psi) shock wave. (360)

Boundary, Restricted Approach. (Restricted Approach Boundary)

An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

Building.

A structure that stands alone or that is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors. [**70:**100]

Cabinet.

An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung. [**70:**100]

Cell.

The basic electrochemical unit, characterized by an anode and a cathode used to receive, store, and deliver electrical energy. (320)

Cell, Valve-Regulated Lead Acid (VRLA). (Valve-Regulated Lead Acid Cell)

A lead-acid cell that is sealed with the exception of a valve that opens to the atmosphere when the internal pressure in the cell exceeds atmospheric pressure by a pre-selected amount, and that provides a means for recombination of internally generated oxygen and the suppression of hydrogen gas evolution to limit water consumption. (320)

Cell, Vented. (Vented Cell)

A type of cell in which the products of electrolysis and evaporation are allowed to escape freely into the atmosphere as they are generated. (Also called "*flooded cell*.") (320)

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.

Charge Transfer.

Improper discharging of capacitor networks that results in transferring charge from one capacitor to another capacitor instead of fully discharging the stored energy. (360)

Circuit Breaker.

A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [**70:**100]

> Informational Note: The automatic opening means can be integral, direct acting with the circuit breaker, or remote from the circuit breaker.

Conductive.

Suitable for carrying electric current.

Conductor, Bare. (Bare Conductor)

A conductor having no covering or electrical insulation whatsoever. [**70:**100]

Conductor, Covered. (Covered Conductor)

A conductor encased within material of composition or thickness that is not recognized by *NFPA 70*, *National Electrical Code*, as electrical insulation. [**70:**100]

Conductor, Insulated. (Insulated Conductor)

A conductor encased within material of composition and thickness that is recognized by *NFPA 70*, *National Electrical Code*, as electrical insulation. [**70:**100]

Controller.

A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected. [**70:**100]

Current-Limiting Overcurrent Protective Device.

A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

Cutout.

An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

De-energized.

Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth.

Device.

A unit of an electrical system, other than a conductor, that carries or controls electric energy as its principal function. [**70:**100]

Dielectric Absorption.

The property of certain capacitors to recharge after being discharged. (360)

> Informational Note: A voltage recharge from 0.02 percent (polystyrene and polypropylene) up to 10 percent (some electrolytics) can occur a few minutes after the grounding or shorting device has been removed.

Discharge Time.

The time required to discharge a capacitor to below electrical hazard thresholds. (360)

Disconnecting Means.

A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [**70:**100]

Disconnecting (or Isolating) Switch (Disconnector, Isolator).

A mechanical switching device used for isolating a circuit or equipment from a source of power.

Dwelling Unit.

A single unit providing complete and independent living facilities for one or more persons, including permanent provisions for living, sleeping, cooking, and sanitation. [**70:**100]

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.

Electrical Safety Program.

A documented system consisting of electrical safety principles, policies, procedures, and processes that directs activities appropriate for the risk associated with electrical hazards.

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.

Electrolyte.

A solid, liquid, or aqueous immobilized liquid medium that provides the ion transport mechanism between the positive and negative electrodes of a cell. (320)

Enclosed.

Surrounded by a case, housing, fence, or wall(s) that prevents persons from unintentionally contacting energized parts.

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.

Energized.

Electrically connected to, or is, a source of voltage. [**70:**100]

Equipment.

A general term, including fittings, devices, appliances, luminaires, apparatus, machinery, and the like, used as a part of, or in connection with, an electrical installation. [**70:**100]

Equipment, Arc-Resistant. (Arc-Resistant Equipment)

Equipment designed to withstand the effects of an internal arcing fault and that directs the internally released energy away from the employee.

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.

Informational Note No. 2: See O.2.4(9) for information on arc-resistant equipment.

Exposed (as applied to energized electrical conductors or circuit parts).

Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated, or insulated.

Exposed (as applied to wiring methods).

On or attached to the surface or behind panels designed to allow access. [**70:**100]

Fault Current.

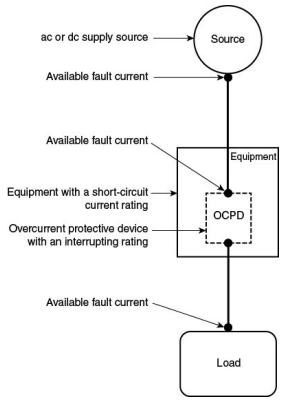
The amount of current delivered at a point on the system during a short-circuit condition.

Fault Current, Available. (Available Fault Current)

The largest amount of current capable of being delivered at a point on the system during a short-circuit condition.

Informational Note No. 1: See Figure Figure Informational Note 100.0 A short circuit can occur during abnormal conditions such as a fault between circuit conductors or a ground fault.

Figure Informational Note 100.0 Available Fault Current.



Informational Note No. 2: If the dc supply is a battery system, the term *available fault current* refers to the prospective short-circuit current.

Informational Note No. 3: The available fault current varies at different locations within the system due to the location of sources and system impedances.

Field Evaluated.

An evaluation of nonlisted or modified equipment in the field that is performed by persons or parties acceptable to the authority having jurisdiction. (330, 350)

Informational Note No. 1: The evaluation approval ensures that the equipment meets appropriate codes and standards or is similarly found suitable for a specified purpose.

Informational Note No. 2: See NFPA 791, *Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation*, for additional information on recommended practices and procedures for the field evaluation of nonlisted equipment.

Informational Note No. 3: See NFPA 790, *Standard for Competency of Third-Party Field Evaluation Bodies*, for requirements on evaluating third-party entities.

Fitting.

An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function. [**70:**100]

Fuse.

An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it.

Informational Note: A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Ground.

The earth. [**70:**100]

Ground Fault.

An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non–current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth. [**70:**100]

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.

Grounded Conductor.

A system or circuit conductor that is intentionally grounded. [**70:**100]

Grounded (Grounding).

Connected (connecting) to ground or to a conductive body that extends the ground connection. [**70:**100]

Grounded, Solidly. (Solidly Grounded)

Connected to ground without inserting any resistor or impedance device. [**70:**100]

Ground-Fault Circuit Interrupter (GFCI).

A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device. [**70:**100]

Informational Note: See UL 943, *Ground-Fault Circuit Interrupters*, for further information. Class A ground-fault circuit interrupters trip when the ground-fault current is 6 mA or higher and does not trip when the ground-fault current is less than 4 mA.

Grounding Conductor, Equipment (EGC). (Equipment Grounding Conductor)

The conductive path(s) that provides a ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both. [**70:**100]

Informational Note No. 1: It is recognized that the equipment grounding conductor also performs bonding.

Informational Note No. 2: See 250.118 of *NFPA 70*, *National Electrical Code*, for a list of acceptable equipment grounding conductors.

Grounding Electrode.

A conducting object through which a direct connection to earth is established. [**70:**100]

Grounding Electrode Conductor.

A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system. [**70:**100]

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

The practice of discharging 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.

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

The practice of discharging capacitance by connecting to ground through a power resistor to avoid the hazards related with 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.

Guarded.

Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger. [**70:**100]

Hazard.

A source of possible injury or damage to health.

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)

Hazard, Arc Flash. (Arc Flash Hazard)

A source of possible injury or damage to health associated with the release of energy caused by an electric arc.

> Informational Note No. 1: See 110.2(B) Exception No. 1 for further information regarding normal operation. The likelihood of occurrence of an arc flash incident increases when energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc. An arc flash incident is not likely to occur under normal operating conditions when enclosed energized equipment has been properly installed and maintained.
>
> Informational Note No. 2: See Table 130.5(C)(3) for examples of tasks that increase the likelihood of an arc flash incident occurring.

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.

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.

Hazard, Electrical. (Electrical Hazard)

A 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.

Hazardous.

Involving exposure to at least one hazard.

Incident Energy.

The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electrical arc event.

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

Incident Energy Analysis.

A component of an arc flash risk assessment used to predict the incident energy of an arc flash for a specified set of conditions.

Insulated.

Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

> Informational Note: When an object is said to be insulated, it is understood to be insulated for the conditions to which it is normally subject. Otherwise, it is, within the purpose of these rules, uninsulated.

Interrupter Switch.

A switch capable of making, carrying, and interrupting specified currents.

Interrupting Rating.

The highest current at rated voltage that a device is identified to interrupt under standard test conditions. [**70:**100]

> Informational Note: Equipment intended to interrupt current at other than fault levels may have its interrupting rating implied in other ratings, such as horsepower or locked rotor current.

Isolated (as applied to location).

Not readily accessible to persons unless special means for access are used. [**70:**100]

Labeled.

Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Laboratory.

A building, space, room, or group of rooms intended to serve activities involving procedures for investigation, diagnostics, product testing, or use of custom or special electrical components, systems, or equipment. (350)

Laser.

A device that produces radiant energy at wavelengths between 180 nm (nanometer) and 1 mm (millimeter) predominantly by controlled stimulated emission. Laser radiation can be highly coherent temporally, spatially, or both. (330)

Laser Energy Source.

Any device intended for use in conjunction with a laser to supply energy for the excitation of electrons, ions, or molecules. (330)

Laser Radiation.

All electromagnetic radiation emitted by a laser or laser system between 180 nm (nanometers) and 1 mm (millimeters) that is produced as a result of a controlled stimulated emission. (330)

Laser System.

A laser in combination with an appropriate laser energy source with or without additional incorporated components. (330)

Listed.

Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

> Informational Note: The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Luminaire.

A complete lighting unit consisting of a light source, such as a lamp or lamps, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light. A lampholder itself is not a luminaire. [**70:**100]

Maintenance, Condition of. (Condition of Maintenance)

The state of the electrical equipment considering the manufacturers' instructions, manufacturers' recommendations, and applicable industry codes, standards, and recommended practices.

Motor Control Center.

An assembly of one or more enclosed sections having a common power bus and principally containing motor control units. [**70:**100]

Outlet.

A point on the wiring system at which current is taken to supply utilization equipment. [**70:**100]

Overcurrent.

Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault. [**70:**100]

> Informational Note: A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore, the rules for overcurrent protection are specific for particular situations.

Overload.

Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. [**70:**100]

Panelboard.

A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front. [**70:**100]

Pilot Cell.

One or more cells chosen to represent the operating parameters of the entire battery (sometimes called "temperature reference" cell). (320)

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 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.

Protective Barrier.

Prevents user access to a hazardous voltage, current, or stored energy area. (330)

Protector.

A glove or mitten designed to be worn over rubber insulating gloves.

Qualified Person.

One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.

Raceway.

An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this standard. [**70:**100]

Radiation, Ionizing. (Ionizing Radiation)

Radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization of atoms or molecules through which it passes. (340)

Radiation, Nonionizing. (Nonionizing Radiation)

Static electric and magnetic (0 to 1 Hz), sub radiofrequency (1Hz to 3 kHz), radiofrequency (3 kHz to 300 GHz) fields, and infrared, visible light, and near ultraviolet (near UV) that cannot ionize an atom or molecule. (340)

Receptacle.

A contact device installed at the outlet for the connection of an attachment plug, or for the direct connection of electrical utilization equipment designed to mate with the corresponding contact device. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke. [**70:**100]

Research and Development (R&D).

An activity in an installation specifically designated for research or development conducted with custom or special electrical equipment. (350)

Resistor, Bleeder. (Bleeder Resistor)

A resistor or resistor network connected in parallel with a capacitor's terminals that dissipates the stored energy after power has been disconnected. (360)

Risk.

A combination of 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.

An overall process that identifies hazards, estimates the likelihood of occurrence of injury or damage to health, estimates the potential severity of injury or damage to health, and determines if protective measures are required.

> Informational Note: As used in this standard, *arc flash risk assessment* and *electric shock risk assessment* are types of risk assessments.

Service Drop.

The overhead conductors between the utility electric supply system and the service point. [**70:**100]

Service Lateral.

The underground conductors between the utility electric supply system and the service point. [**70:**100]

Service Point.

The point of connection between the facilities of the serving utility and the premises wiring. [**70:**100]

> Informational Note: The service point can be described as the point of demarcation between where the serving utility ends and the premises wiring begins. The serving utility generally specifies the location of the service point based on the conditions of service.

Short-Circuit Current, Prospective. (Prospective Short-Circuit Current)

The highest level of fault current that could theoretically occur at a point on a circuit. This is the fault current that can flow in the event of a zero impedance short circuit and if no protection devices operate. (320)

> Informational Note: Some batteries have built-in management devices to limit maximum short-circuit current. The determination of the prospective short-circuit current for these batteries assumes that the internal battery management system protection devices are operable.

Short-Circuit Current Rating.

The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding defined acceptance criteria. [**70:**100]

Shorting Stick.

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

Single-Line Diagram.

A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used in the circuit or system.

Special Permission.

The written consent of the authority having jurisdiction. [**70:**100]

Step Potential.

A ground potential gradient difference that can cause current flow from foot to foot through the body.

Structure.

That which is built or constructed. [**70:**100]

Switch, Isolating. (Isolating Switch)

A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means. [**70:**100]

Switchboard.

A large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments. These assemblies are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. [**70:**100]

Switchgear, Metal-Clad. (Metal-Clad Switchgear)

A switchgear assembly completely enclosed on all sides and top with sheet metal, having drawout switching and interrupting devices, and all live parts enclosed within grounded metal compartments.

Switchgear, Metal-Enclosed. (Metal-Enclosed Switchgear)

A switchgear assembly completely enclosed on all sides and top with sheet metal (except for ventilating openings and inspection windows), containing primary power circuit switching, interrupting devices, or both, with buses and connections. This assembly may include control and auxiliary devices. Access to the interior of the enclosure is provided by doors, removable covers, or both. Metal-enclosed switchgear is available in non-arc-resistant or arc-resistant constructions.

Switching Device.

A device designed to close, open, or both, one or more electric circuits.

Time Constant.

The time it takes for voltage to drop by ~63 percent (1/e) during discharge. (360)

Touch Potential.

A ground potential gradient difference that can cause current flow from hand to hand, hand to foot, or another path, other than foot to foot, through the body.

Ungrounded.

Not connected to ground or to a conductive body that extends the ground connection. [**70:**100]

Unqualified Person.

A person who is not a qualified person.

Utilization Equipment.

Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes. [**70:**100]

Voltage (of a Circuit).

The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned. [**70:**100]

> Informational Note: Some systems, such as three-phase 4-wire, single-phase 3-wire, and 3-wire direct-current, may have various circuits of various voltages.

Voltage, Nominal. (Nominal Voltage)

A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240 volts, 480Y/277 volts, 600 volts). [**70:**100]

> Informational Note No. 1: The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.
>
> Informational Note No. 2: See ANSI C84.1, *Electric Power Systems and Equipment — Voltage Ratings (60 Hz)*.

Voltage, Nominal (as applied to cell or battery). (Nominal Voltage)

The value assigned to a cell or battery of a given voltage class for the purpose of convenient designation; the operating voltage of the cell or system may vary above or below this value. (320)

> Informational Note: The most common cell voltages are 2.0 volts per cell for lead-acid batteries, 1.2 volts per cell for alkali batteries, and 3.2 to 3.8 volts per cell for Li-ion batteries. Nominal voltages might vary with different chemistries.

Working Distance.

The distance between a person's face and chest area and a prospective arc source.

Informational Note: See 130.5(G) for further information. Incident energy increases as the distance from the arc source decreases.

Working On (energized electrical conductors or circuit parts).

Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment (PPE) a person is wearing.

Informational Note: Examples of "working on" can include but are not limited to *diagnostic testing* (such as taking readings or measurements of electrical equipment, conductors, or circuit parts with approved test equipment that does not require making any physical change to the electrical equipment, conductors, or circuit parts) and *repair* or physical alteration of electrical equipment, conductors, or circuit parts (such as making or tightening connections, removing or replacing components, etc.).

Article 105 Employer and Employee Responsibilities

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.

105.3 Responsibility.

(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 training in the employer's safety-related work practices and procedures.

(B) Employee Responsibility.

The employee shall comply with the safety-related work practices and procedures provided by the employer.

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 standard. Article 105 covers employer and employee responsibilities for the application of safety-related work practices and procedures. Article 110 covers general requirements for electrical safety-related work practices and procedures. Article 120 covers requirements for establishing an electrically safe work condition. Article 130 covers requirements for work involving electrical hazards.

Article 110 General Requirements for Electrical Safety-Related Work Practices

110.1 Scope.

This article covers the general requirements for electrical safety-related work practices.

110.2 Electrically Safe Work Condition.

(A) Policy.

An employer shall establish, document, and implement an electrically safe work condition policy that does both of the following:

(1) Requires hazard elimination to be the first priority in the implementation of safety-related work practices

(2) Complies with 110.2(B)

Informational Note No. 1: See Informative Annex F for examples of hazard elimination. Elimination is the risk control method listed first in the hierarchy of risk control identified in 110.3(H)(3).

Informational Note No. 2: The electrically safe work condition policy could be documented in the employer's electrical safety program or in the employer's management system or similar documentation.

(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.

(C) Requirements Until Established.

(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.

110.3 Electrical Safety Program.

(A) General.

The employer shall implement and document an overall electrical safety program that directs activity appropriate to the risk associated with electrical hazards.

Informational Note No. 1: Safety-related work practices such as verification of proper maintenance and installation, alerting techniques, auditing requirements, and training requirements provided in this standard are administrative controls and part of an overall electrical safety program.

Informational Note No. 2: See Informative Annex P for information on implementing an electrical safety program within an employer's occupational health and safety management system.

Informational Note No. 3: See IEEE 3007.1, *Recommended Practice for the Operation and Management of Industrial and Commercial Power Systems*, which provides additional guidance for the implementation of the electrical safety program.

Informational Note No. 4: See IEEE 3007.3, *Recommended Practice for Electrical Safety in Industrial and Commercial Power Systems*, which provides additional guidance for electrical safety in the workplace.

(B) Inspection.

The electrical safety program shall include elements to verify that newly installed or modified electrical equipment or systems have been inspected to comply with applicable installation codes and standards prior to being placed into service.

(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.

(D) Awareness and Self-Discipline.

The electrical safety program shall be designed to provide an awareness of the potential electrical hazards to employees who work in an environment with the presence of electrical hazards. The program shall be developed to provide the required self-discipline for all employees who must perform work that may involve electrical hazards. The program shall instill safety principles and controls.

(E) Electrical Safety Program Principles.

The electrical safety program shall identify the principles upon which it is based.

Informational Note: See Informative Annex E for examples of typical electrical safety program principles.

(F) Electrical Safety Program Controls.

An electrical safety program shall identify the controls by which it is measured and monitored.

Informational Note: See Informative Annex E for examples of typical electrical safety program controls.

(G) Electrical Safety Program Procedures.

An electrical safety program shall identify the procedures to be utilized before work is started by employees exposed to an electrical hazard.

Informational Note: See Informative Annex E for an example of a typical electrical safety program procedure.

(H) Risk Assessment Procedure.

The electrical safety program shall include a risk assessment procedure and shall comply with 110.3(H)(1) through 110.3(H)(3).

(1) Elements of a Risk Assessment Procedure.

The risk assessment procedure shall address employee exposure to electrical hazards and shall identify the process to be used before work is started to carry out the following:

(1) Identify hazards

(2) Assess risks

(3) Implement risk control according to the hierarchy of risk control methods

Informational Note No. 1: The risk assessment procedure could include identifying when a second person could be required and the training and equipment that person should have.

Informational Note No. 2: See Informative Annex F for more information regarding risk assessment and the hierarchy of risk control.

(2) Human Error.

The risk assessment procedure shall address the potential for human error and its negative consequences on people, processes, the work environment, and equipment relative to the electrical hazards in the workplace.

Informational Note: See Informative Annex Q for further information. The potential for human error varies with factors such as tasks and the work environment.

(3) Hierarchy of Risk Control Methods.

The risk assessment procedure shall require that preventive and protective risk control methods be implemented in accordance with the following hierarchy:

(1) Elimination

(2) Substitution

(3) Engineering controls

(4) Awareness

(5) Administrative controls

(6) PPE

Informational Note No. 1: Elimination, substitution, and engineering controls are the most effective methods to reduce risk as they are usually applied at the source of possible injury or damage to health and they are less likely to be affected by human error. Awareness, administrative controls, and PPE are the least effective methods to reduce risk as they are not applied at the source and they are more likely to be affected by human error.

Informational Note No. 2: See Informative Annex F for more information regarding the hierarchy of risk control methods and examples of those methods.

(I) Job Safety Planning and Job Briefing.

Before starting each job that involves exposure to electrical hazards, the employee in charge shall complete a job safety plan and conduct a job briefing with the employees involved.

(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:

(4) A description of the job and the individual tasks

(5) Identification of the electrical hazards associated with each task

(6) An electric shock risk assessment in accordance with 130.4 for tasks involving an electric shock hazard

(7) An arc flash risk assessment in accordance with 130.5 for tasks involving an arc flash hazard

(8) Work procedures involved, special precautions, and energy source controls

(9) 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.

(2) Job Briefing.

The job briefing shall cover the job safety plan and the information on the energized electrical work permit, if a permit is required.

(3) Change in Scope.

Additional job safety planning and job briefings shall be held if changes occur during the course of the work that might affect the safety of employees.

Informational Note: See Figure I.1 for an example of a job briefing checklist.

(J) Incident Investigations.

The electrical safety program shall include elements to investigate electrical incidents.

Informational Note: Electrical incidents include events or occurrences that result in, or could have resulted in, a fatality, an injury, or damage to health. Incidents that do not result in fatality, injury, or damage to health are commonly referred to as a “close call” or “near miss.”

(K) Lockout/Tagout Program.

The electrical safety program shall include the information required by one of the following:

(1) A lockout/tagout program in accordance with 120.2(A)

(2) A reference to the employer’s lockout/tagout program established in accordance with 120.2(A)

(L) Auditing.

(1) Electrical Safety Program Audit.

The electrical safety program shall be audited to verify that the principles and procedures of the electrical safety program are in compliance with this standard. Audits shall be performed at intervals not to exceed 3 years.

(2) Work Practices Audit.

(a) 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.

(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 Procedure Audit.

(a) The lockout/tagout 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:

(4) The lockout/tagout procedures

(5) The lockout/tagout training

(6) Worker execution of the lockout/tagout procedure

(5) Documentation.

The audits required by 110.3(L) shall be documented.

110.4 Training Requirements.

(A) Electrical Safety Training.

The training requirements contained in 110.4(A) shall apply to employees exposed to an electrical hazard when the risk associated with that hazard is not reduced to a safe level by the applicable electrical installation requirements. Such employees shall be trained to understand the specific hazards associated with electrical energy. They shall be trained in safety-related work practices and procedural requirements, as necessary, to provide protection from the electrical hazards associated with their respective job or task assignments. Employees shall be trained to identify and understand the relationship between electrical hazards and possible injury.

Informational Note: See *NFPA 70*, *National Electrical Code*, for further information concerning installation requirements.

(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 with respect to certain equipment and tasks, 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:

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

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

(6) 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

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

(8) Perform the job safety planning

(9) Identify electrical hazards

(10) Assess the associated risk

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

(l) 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.

(m) Employees shall be trained to select an appropriate test instrument and shall demonstrate how to use a device to 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.

(n) 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.

(2) Unqualified Persons.

Unqualified persons shall be trained in, and be familiar with, any electrical safety-related practices necessary for their safety.

(3) Additional Training and Retraining.

Additional training and retraining in safety-related work practices and applicable changes in this standard shall be performed at intervals not to exceed 3 years. An employee shall receive additional training or retraining if any of the following conditions exists:

(1) The supervision or annual inspections indicate the employee is not complying with the safety-related work practices.

(2) New technology, new types of equipment, or changes in procedures necessitate the use of safety-related work practices different from those that the employee would normally use.

(3) The employee needs to review tasks that are performed less often than once per year.

(4) The employee needs to review safety-related work practices not normally used by the employee during regular job duties.

(5) The employee’s job duties change.

(4) Type of Training.

The training required by 110.4(A) shall be classroom, on-the-job, or a combination of the two. The type and extent of the training provided shall be determined by the risk to the employee.

Informational Note: Classroom training can include interactive electronic or interactive web-based training components.

(5) Electrical Safety Training Documentation.

The employer shall document that each employee has received the training required by 110.4(A). This documentation shall be in accordance with the following:

(1) Be made when the employee demonstrates proficiency in the work practices involved

(2) Be retained for the duration of the employee's employment

(3) Contain the content of the training, each employee's name, and dates of training

Informational Note No. 1: Content of the training could include one or more of the following: course syllabus, course curriculum, outline, table of contents, or training objectives.

Informational Note No. 2: Employment records that indicate that an employee has received the required training are an acceptable means of meeting this requirement.

(B) Lockout/Tagout Procedure Training.

(1) Initial Training.

Employees involved in the lockout/tagout procedures required by 120.3(B) shall be trained in the following:

(1) The lockout/tagout procedures

(2) Their responsibility in the execution of the procedures

(2) Retraining.

Retraining in the lockout/tagout procedures shall be performed as follows:

(1) When the procedures are revised

(2) At intervals not to exceed 3 years

(3) When supervision or annual inspections indicate that the employee is not complying with the lockout/tagout procedures

(3) Lockout/Tagout Training Documentation.

(a) The employer shall document that each employee has received the training required by 110.4(B).

(b) The documentation shall be made when the employee demonstrates proficiency in the work practices involved.

(c) The documentation shall contain the content of the training, each employee's name, and the dates of the training.

Informational Note: Content of the training could include one or more of the following: course syllabus, course curriculum, outline, table of contents, or training objectives.

(C) Emergency Response Training.

(1) Contact Release.

Employees exposed to electric shock hazards and those responsible for the safe release of victims from contact with energized electrical conductors or circuit parts shall be trained in methods of safe release. Refresher training shall occur annually.

(2) First Aid, Emergency Response, and Resuscitation.

(a) Employees responsible for responding to medical emergencies shall be trained in first aid and emergency procedures.

(b) Employees responsible for responding to medical emergencies shall be trained in cardiopulmonary resuscitation (CPR).

(c) Employees responsible for responding to medical emergencies shall be trained in the use of an automated external defibrillator (AED) if an employer's emergency response plan includes the use of this device.

(d) Training shall occur at a frequency that satisfies the requirements of the certifying body.

Informational Note: Employees responsible for responding to medical emergencies might not be first responders or medical professionals. Such employees could be a second person, a safety watch, or a craftsperson.

(3) Training Verification.

Employers shall verify at least annually that employee training required by 110.4(C) is current.

(4) Documentation.

The employer shall document that the training required by 110.4(C) has occurred.

110.5 Host and Contract Employers' Responsibilities.

(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.

(B) Contract Employer Responsibilities.

(1) Communicate Hazard Information to Employees.

(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

(C) Documentation.

Where the host employer has knowledge of hazards covered by this standard that are related to the contract employer's work, there shall be a documented meeting between the host employer and the contract employer.

Informational Note to 110.5: On multi-employer work sites (in all industry sectors), more than one employer can be responsible for identifying hazardous conditions and creating safe work practices.

110.6 Test Instruments and Equipment.

(A) Testing.

Only qualified persons shall perform tasks such as testing, troubleshooting, and voltage measuring on electrical equipment where an electrical hazard exists.

(B) Rating.

Test instruments, equipment, and their accessories shall be as follows:

(1) Rated for circuits and equipment where they are utilized

(2) Approved for the purpose

(3) Used in accordance with any instructions provided by the manufacturer

Informational Note: See UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use — Part 1: General Requirements*, and 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*, for rating and design requirements for voltage measurement and test instruments intended for use on electrical systems 1000 volts and below.

(C) Design.

Test instruments, equipment, and their accessories shall be designed for the environment to which they will be exposed and for the manner in which they will be utilized.

(D) Visual Inspection and Repair.

(1) Inspection.

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 until a person(s) qualified to perform the repairs and tests that are necessary to render the equipment safe has done so.

(E) Operation Verification.

When test instruments are used for testing the absence of voltage on conductors or circuit parts operating at voltages equal to or greater than 50 volts, the operation of the test instrument shall be verified on any known voltage source before and after an absence of voltage test is performed.

110.7 Portable Cord- and-Plug-Connected Electric Equipment.

This section applies to the use of cord- and plug-connected equipment, including cord- and plug-connected test instruments and cord sets (extension cords).

(A) Handling and Storage.

Portable equipment shall be handled and stored in a manner that will not cause damage. Flexible electric cords connected to equipment shall not be used for raising or lowering the equipment. Flexible cords shall not be fastened with staples or hung in such a fashion as could damage the outer jacket or insulation.

(B) Grounding-Type Equipment.

(a) A flexible cord used with grounding-type utilization equipment shall contain an equipment grounding conductor.

(b) Attachment plugs and receptacles shall not be connected or altered in a manner that would interrupt continuity of the equipment grounding conductor. Additionally, these devices shall not be altered in order to allow use in a manner that was not intended by the manufacturer.

(c) Adapters that interrupt the continuity of the equipment grounding conductor shall not be used.

(C) Visual Inspection and Repair of Portable Cord- and Plug-Connected Equipment and Flexible Cord Sets.

(a) *Frequency of Inspection.* Before each use, portable cord- and plug-connected equipment shall be visually inspected for external defects (such as loose parts or deformed and missing pins) and for evidence of possible internal damage (such as a pinched or crushed outer jacket).

Exception: Stationary cord- and plug-connected equipment that remain connected once they are put in place and are installed such that the cord and plug are not subject to physical damage during normal use shall not be required to be visually inspected until they are relocated or repaired.

(b) *Defective Equipment.* 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 necessary to render the equipment safe has done so.

(c) *Proper Mating.* When an attachment plug is to be connected to a receptacle, the relationship of the plug and receptacle contacts shall first be checked to ensure that they are of mating configurations.

(D) Conductive or Wet Work Locations.

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.

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.

(E) Connecting Attachment Plugs.

(a) Employees' hands shall not be wet when plugging and unplugging flexible cords and cord- and plug-connected equipment if energized equipment is involved.

(b) Energized plug and receptacle connections shall be handled only with insulating protective equipment if the condition of the connection could provide a conductive path to the employee's hand (e.g, if a cord connector is wet from being immersed in water).

(c) Locking-type connectors shall be secured after connection.

(F) Manufacturer's Instructions.

Portable equipment shall be used in accordance with the manufacturer's instructions and safety warnings.

110.8 Ground-Fault Circuit-Interrupter (GFCI) Protection.

(A) General.

Employees shall be provided with listed ground-fault circuit-interrupter (GFCI) protective devices where required by applicable state, federal, or local codes and standards. Listed cord sets or devices incorporating listed GFCI protection for personnel identified for portable use shall be permitted.

(B) Additional Circumstances Requiring GFCI Protection.

(1) 120-Volt Cord Circuits.

Cord sets (extension cords) and cord- and plug-connected tools used for maintenance 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.

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) Testing Ground-Fault Circuit-Interrupter Protection Devices.

GFCI protection devices shall be tested in accordance with the manufacturer's instructions.

110.9 Overcurrent Protection Modification.

Overcurrent protection of circuits and conductors shall not be modified, even on a temporary basis, beyond what is permitted by applicable portions of electrical codes and standards dealing with overcurrent protection.

Informational Note: See Article 240 of *NFPA 70*, *National Electrical Code*, for further information concerning electrical codes and standards dealing with overcurrent protection.

110.10 Equipment Use.

Equipment shall be used in accordance with the manufacturer's instructions.

Article 120 Establishing an Electrically Safe Work Condition

120.1 Scope.

This article covers requirements for establishing an electrically safe work condition.

120.2 Lockout/Tagout Program.

(A) General.

Each employer shall establish, document, and implement a lockout/tagout program. The lockout/tagout program shall specify lockout/tagout procedures to safeguard workers from exposure to electrical hazards. The lockout/tagout program and procedures shall also incorporate the following:

(1) Be applicable to the experience and training of the workers and conditions in the workplace

(2) Meet the requirements of 120.2 through 120.6

(3) Apply to fixed, permanently installed equipment, temporarily installed equipment, and portable equipment

(B) Employer Responsibilities.

The employer shall be responsible for the following:

(1) Providing the equipment necessary to execute lockout/tagout procedures

(2) Providing lockout/tagout training to workers in accordance with 110.4(B)

(3) Auditing the lockout/tagout program in accordance with 110.3(L)(4)

(4) Auditing execution of the lockout/tagout procedures in accordance with 110.3(L)(4)

Informational Note: See Informative Annex G for an example of a lockout/tagout program.

120.3 Lockout/Tagout Principles.

(A) Employee Involvement.

Each person who could be exposed directly or indirectly to a source of electrical energy shall be involved in the lockout/tagout procedure.

Informational Note: An example of direct exposure is the qualified electrician who works on the motor starter control, the power circuits, or the motor. An example of indirect exposure is the person who works on the coupling between the motor and compressor.

(B) Lockout/Tagout Procedure.

A lockout/tagout procedure shall be developed on the basis of the existing electrical equipment and system and shall use suitable documentation including up-to-date drawings and diagrams. The procedure shall meet the requirements of applicable codes, standards, and regulations for lockout and tagging of electrical sources.

(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.

(D) Electrical Circuit Interlocks.

Documentation, including up-to-date drawings and diagrams, shall be reviewed to ensure that no electrical circuit interlock operation can result in re-energizing the circuit being worked on.

(E) Control Devices.

Locks/tags shall be installed only on circuit disconnecting means. Control devices, such as push-buttons or selector switches, shall not be used as the primary isolating device.

(F) Identification.

The lockout/tagout device shall be unique and readily identifiable as a lockout/tagout device.

(G) Coordination.

The following items are necessary for coordinating the lockout/tagout procedure:

(1) The electrical lockout/tagout procedure shall be coordinated with all other employer's procedures for control of exposure to electrical energy sources such that all employer's procedural requirements are adequately addressed on a site basis.

(2) The procedure for control of exposure to electrical hazards shall be coordinated with other procedures for control of other hazardous energy based on similar or identical concepts.

(3) Electrical lockout/tagout devices shall be permitted to be similar to lockout/tagout devices for control of other hazardous energy sources, such as pneumatic, hydraulic, thermal, and mechanical, if such devices are used only for control of hazardous energy and for no other purpose.

(H) Forms of Control of Hazardous Electrical Energy.

Two forms of hazardous electrical energy control shall be permitted: simple lockout/tagout and complex lockout/tagout *[see 120.5]*. For the simple lockout/tagout, the qualified person shall be in charge. For the complex lockout/tagout, the person in charge shall have overall responsibility.

120.4 Lockout/Tagout Equipment.

(A) Lock Application.

Energy isolation devices for machinery or equipment installed after January 2, 1990, shall be capable of accepting a lockout device.

(B) Lockout/Tagout Device.

Each employer shall supply, and employees shall use, lockout/tagout devices and equipment necessary to execute the requirements of 120.4. Locks and tags used for control of exposure to electrical hazards shall be unique, shall be readily identifiable as lockout/tagout devices, and shall be used for no other purpose.

(C) Lockout Device.

The lockout device shall meet the following requirements:

(1) A lockout device shall include a lock — either keyed or combination.

(2) The lockout device shall include a method of identifying the individual who installed the lockout device.

(3) A lockout device shall be permitted to be only a lock, if the lock is readily identifiable as a lockout device, in addition to having a means of identifying the person who installed the lock, provided that all of the following conditions exist:

(4) Only one circuit or piece of equipment is de-energized.

(5) The lockout period does not extend beyond the work shift.

(6) Employees exposed to the hazards associated with re-energizing the circuit or equipment are familiar with this procedure.

(7) Lockout devices shall be attached to prevent operation of the disconnecting means without resorting to undue force or the use of tools.

(8) Where a tag is used in conjunction with a lockout device, the tag shall contain a statement prohibiting unauthorized operation of the disconnecting means or unauthorized removal of the device.

(9) Lockout devices shall be suitable for the environment and for the duration of the lockout.

(10) Whether keyed or combination locks are used, the key or combination shall remain in the possession of the individual installing the lock or the person in charge, when provided by the established procedure.

(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 comply with the following:

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

(5) Be nonreusable, attachable by hand, self-locking, and nonreleasable cable tie

(6) Be suitable for the environment where used

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

(8) 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.

120.5 Lockout/Tagout Procedures.

The employer shall maintain a copy of the procedures required by this section and shall make the procedures available to all employees.

(A) Planning.

The procedure shall require planning, including the requirements of 120.5(A)(1) through 120.5(B)(14).

(1) Locating Sources.

Up-to-date single-line drawings shall be considered a primary reference source for such information. When up-to-date drawings are not available, the employer shall be responsible for ensuring that an equally effective means of locating all sources of energy is employed.

Informational Note: Locating sources of supply could include identifying situations where a neutral conductor continues to carry current after phase conductors have been de-energized.

(2) Exposed Persons.

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.

(3) Person in Charge.

The plan shall identify the person in charge and his or her responsibility in the lockout/tagout.

(4) Simple Lockout/Tagout Procedure.

All lockout/tagout procedures that involve only a qualified person(s) de-energizing one set of conductors or circuit part source for the sole purpose of safeguarding employees from exposure to electrical hazards shall be considered to be a simple lockout/tagout. Simple lockout/tagout procedures shall not be required to be written for each application. Each worker shall be responsible for his or her own lockout/tagout.

Exception: Lockout/tagout is not 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.

(5) Complex Lockout/Tagout.

(a) A complex lockout/tagout procedure shall be permitted where one or more of the following exists:

(2) Multiple energy source

(3) Multiple crews

(4) Multiple crafts

(5) Multiple locations

(6) Multiple employers

(7) Multiple disconnecting means

(8) Particular sequences

(9) Job or task that continues for more than one work period

(j) All complex lockout/tagout procedures shall require a written plan of execution that identifies the person in charge.

(k) The complex lockout/tagout 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. The person in charge shall be held accountable for safe execution of the complex lockout/tagout.

(l) Each authorized employee shall affix a personal lockout or tagout device to the group lockout device, group lockbox, or comparable mechanism when he or she begins work and shall remove those devices when he or she stops working on the machine or equipment being serviced or maintained.

(m) All complex lockout/tagout plans shall identify the method to account for all persons who might be exposed to electrical hazards in the course of the lockout/tagout.

(B) Elements of Control.

The procedure shall identify elements of control.

(1) De-energizing Equipment (Shutdown).

The procedure shall establish the person who performs the switching and where and how to de-energize the load.

(2) Stored Energy.

The procedure shall include requirements for releasing stored electric or mechanical energy that might endanger personnel. All capacitors shall be discharged, and high-capacitance elements shall also be short-circuited and grounded before the associated equipment is touched or worked on. Springs shall be released or physical restraint shall be applied when necessary to immobilize mechanical equipment and pneumatic and hydraulic pressure reservoirs. Other sources of stored energy shall be blocked or otherwise relieved to the extent that the circuit cannot be unintentionally energized.

Informational Note: See 320.3, 320.5, and Informative Annex R for more information on methods and procedures to place capacitors in an electrically safe work condition.

(3) Disconnecting Means.

The procedure shall identify how to verify that the circuit is de-energized (open).

(4) Responsibility.

The procedure shall identify the person who is responsible for verifying that the lockout/tagout procedure is implemented and who is responsible for ensuring that the task is completed prior to removing locks/tags. A mechanism to accomplish lockout/tagout for multiple (complex) jobs/tasks where required, including the person responsible for coordination, shall be included.

(5) Verification.

The procedure shall verify that equipment cannot be restarted. The equipment operating controls, such as push-buttons, selector switches, and electrical interlocks, shall be operated or otherwise it shall be verified that the equipment cannot be restarted.

(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 exposed conductor or circuit parts within the defined boundary of the work area

(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

(7) Temporary Protective Grounding.

(a) 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) 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.

(8) Shift Change.

A method shall be identified in the procedure to transfer responsibility for lockout/tagout to another person or to the person in charge when the job or task extends beyond one shift.

(9) Coordination.

The procedure shall establish how coordination is accomplished with other jobs or tasks in progress, including related jobs or tasks at remote locations as well as the person responsible for coordination.

(10) Accountability for Personnel.

A method shall be identified in the procedure to account for all persons who could be exposed to hazardous energy during the lockout/tagout.

(11) Lockout/Tagout Application.

The procedure shall clearly identify when and where lockout applies, in addition to when and where tagout applies, and shall address the following:

(1) Lockout shall be defined as installing a lockout device on all sources of hazardous energy such that operation of the disconnecting means is prohibited, and forcible removal of the lock is required to operate the disconnecting means.

(2) Tagout shall be defined as installing a tagout device on all sources of hazardous energy, such that operation of the disconnecting means is prohibited. The tagout device shall be installed in the same position available for the lockout device.

(3) Where it is not possible to attach a lock to existing disconnecting means, the disconnecting means shall not be used as the only means to put the circuit in an electrically safe work condition.

(4) The use of tagout procedures without a lock shall be permitted only in cases where equipment design precludes the installation of a lock on an energy isolation device(s). When tagout is employed, at least one additional safety measure shall be employed. In such cases, the procedure shall clearly establish responsibilities and accountability for each person who might be exposed to electrical hazards.

> Informational Note: Examples of additional safety measures include the removal of an isolating circuit element such as fuses, blocking of the controlling switch, or opening an extra disconnecting device to reduce the likelihood of inadvertent energization.

(12) Removal of Lockout/Tagout Devices.

The procedure shall identify the details for removing locks or tags when the installing individual is unavailable. When locks or tags are removed by someone other than the installer, the employer shall attempt to locate that person prior to removing the lock or tag. When the lock or tag is removed because the installer is unavailable, the installer shall be informed prior to returning to work.

(13) Release for Return to Service.

The procedure shall identify steps to be taken when the job or task requiring lockout/tagout is completed. Before electric circuits or equipment are re-energized, tests and visual inspections shall be conducted to verify that all tools, mechanical restraints and electrical jumpers, short circuits, and temporary protective grounding equipment have been removed, so that the circuits and equipment are in a condition to be safely energized. When applicable, the employees responsible for operating the machines or process shall be notified when circuits and equipment are ready to be energized, and such employees shall provide assistance as necessary to safely energize the circuits and equipment. The procedure shall contain a statement requiring the area to be inspected to ensure that nonessential items have been removed. One such step shall ensure that all personnel are clear of exposure to dangerous conditions resulting from re-energizing the service and that blocked mechanical equipment or grounded equipment is cleared and prepared for return to service.

(14) Temporary Release for Testing/Positioning.

The procedure shall clearly identify the steps and qualified persons' responsibilities when the job or task requiring lockout/tagout is to be interrupted temporarily for testing or positioning of equipment; then the steps shall be identical to the steps for return to service.

Informational Note: See 110.6 for requirements when using test instruments and equipment.

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. 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. Before and after 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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Article 130 Work Involving Electrical Hazards

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.

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.

(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.

(2) Additional Person.

If an energized electrical work permit is required in accordance with 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.

130.3 Energized Electrical Work Permit.

(A) When Required.

When work is performed as permitted in accordance with 110.2(B), an energized electrical work permit shall be required and documented under any of the following conditions:

(1) When work is performed within the restricted approach boundary

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

(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)]*

(6) Voltage to which personnel will be exposed

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

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

(9) 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)]*

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

(11) Incident energy at the working distance or arc flash PPE category *[see 130.5(F)]*

(12) 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)]*

(13) Arc flash boundary *[see 130.5(E)]*

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

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

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

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

(C) Exemptions to Work Permit.

Electrical work shall be permitted without an energized electrical work permit if a qualified person is provided with and uses appropriate safe work practices and PPE in accordance with Chapter 1 under any of the following conditions:

(1) Testing, troubleshooting, or voltage measuring

(2) Thermography, ultrasound, or visual inspections if the restricted approach boundary is not crossed

(3) Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed

(4) General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed

130.4 Electric Shock Risk Assessment.

(A) General.

An electric shock risk assessment shall be performed:

(1) To identify electric shock hazards

(2) To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health

(3) To determine if additional protective measures are required

(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 shall take into consideration all of the following:

(1) The design of the electrical equipment

(2) The electrical equipment operating condition and the condition of maintenance

(C) Additional Protective Measures.

(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

(D) Documentation.

The results of the electric shock risk assessment shall be documented.

(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 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 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).

(F) Limited Approach Boundary.

(1) Approach by Unqualified Persons.

Unless permitted by 130.4(F)(3), no unqualified person shall be permitted to approach nearer than the limited approach boundary of energized conductors and circuit parts.

(2) Working at or Close to the Limited Approach Boundary.

Where one or more unqualified persons are working at or close to the limited approach boundary, the alerting methods in 130.8(O) shall be applied to warn the unqualified person(s) of the electrical hazard and to stay outside of the limited approach boundary.

(3) Entering the Limited Approach Boundary.

The following shall apply where there is a need for an unqualified person(s) to cross the limited 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.

(G) Restricted Approach Boundary.

No qualified person shall approach or take any conductive object closer to exposed energized electrical conductors or circuit parts than the restricted approach boundary set forth in Table 130.4(E)(a) and Table 130.4(E)(b), unless one of the following conditions applies:

(1) The qualified person is insulated or guarded from energized electrical conductors or circuit parts operating at 50 volts or more. Insulating gloves and sleeves are considered insulation only with regard to the energized parts upon which work is performed.

(2) The energized electrical conductors or circuit parts are insulated from the qualified person and from any other conductive object at a different potential.

130.5 Arc Flash Risk Assessment.

(A) General.

An arc flash risk assessment shall be performed:

(1) To identify arc flash hazards

(2) To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health

(3) To determine if additional protective measures are required, including the use of PPE

(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

(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).

(C) Additional Protective Measures.

(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).	-	-
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

Task	Operating Condition[a]	Likelihood of Occurrence[b]
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 fault currents could result in higher incident energy. If the fault current increases without a decrease in the fault clearing time of the overcurrent protective device, the incident energy will increase. If the 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.

(D) Documentation.

The results of the arc flash risk assessment shall be documented.

(E) Arc Flash Boundary.

(1) Incident Energy Analysis Method.

The arc flash boundary shall be the distance at which the incident energy equals 1.2 cal/cm^2 (5 J/cm^2).

Informational Note: See Informative Annex D for information on estimating the arc flash boundary.

(2) Arc Flash PPE Category Method.

The arc flash boundary shall be permitted to be determined by Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) when the requirements of these tables apply.

(F) Arc Flash PPE Selection Methods.

(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.

(G) Incident Energy Analysis Method.

The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. Arc-rated clothing and other PPE shall be used by the employee based on the incident energy exposure associated with the specific task. Recognizing that incident energy increases as the distance from the arc flash decreases, additional PPE shall be used for any parts of the body that are closer than the working distance at which the incident energy was determined.

The incident energy analysis shall take into consideration the characteristics of the overcurrent protective device and its fault clearing time, including its condition of maintenance.

The incident energy analysis shall be updated when changes occur in the electrical distribution system that could affect the results of the analysis. The incident energy analysis shall also be reviewed for accuracy at intervals not to exceed 5 years.

> Informational Note: Changes that could affect the results of the incident energy analysis include changes made by utilities or other entities, such as transformer sizing, as well as modifications to protective devices or changes to protective settings.

Table 130.5(G) identifies arc-rated clothing and other PPE requirements and shall be permitted to be used with the incident energy analysis method of selecting arc flash PPE.

> Informational Note No. 1: See Informative Annex D for information on estimating the incident energy.
>
> Informational Note No. 2: See Informative Annex H for information on selection of arc-rated clothing and other PPE.

Table 130.5(G) Selection of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method Is Used

Incident energy exposures equal to 1.2 cal/cm^2 up to and including 12 cal/cm^2
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Arc-rated long-sleeve shirt and pants or arc-rated coverall or arc flash suit (SR)
Arc-rated face shield and arc-rated balaclava or arc flash suit hood (SR)[b]
Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner, high-visibility apparel) (AN)[e]
Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[c]
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear[d]
Incident energy exposures greater than 12 cal/cm^2
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Arc-rated long-sleeve shirt and pants or arc-rated coverall or arc flash suit (SR)
Arc-rated arc flash suit hood
Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner, high-visibility apparel) (AN)[e]
Arc-rated gloves or rubber insulating gloves with protectors (SR)[c]
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear[d]

SR: Selection of one in group is required.

AN: As needed.

[a]Arc ratings can be for a single layer, such as an arc-rated shirt and pants or a coverall, or for an arc flash suit or a multi-layer system if tested as a combination consisting of an arc-rated shirt and pants, coverall, and arc flash suit.

[b]Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area are required by 130.7(C)(10)(c). Where the back of the head is inside the arc flash boundary, a balaclava or an arc flash hood shall be required for full head and neck protection.

[c]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.

[d]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.

[e]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.

(H) Equipment Labeling.

Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be marked with a label containing all the following information:

(1) Nominal system voltage

(2) Arc flash boundary

(3) At least one of the following:

(4) Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) for the equipment, but not both

(5) Minimum arc rating of clothing

(6) Site-specific level of PPE

Exception No. 1: Unless changes in electrical distribution system(s) render the label inaccurate, labels applied prior to the effective date of this edition of the standard shall be acceptable if they complied with the requirements for equipment labeling in the standard in effect at the time the labels were applied.

Exception No. 2: In supervised industrial installations where conditions of maintenance and engineering supervision ensure that only qualified persons monitor and service the system, the information required in 130.5(H)(1) through 130.5(H)(3) shall be permitted to be documented in a manner that is readily available to persons likely to perform examination, servicing, maintenance, and operation of the equipment while energized.

The method of calculating and the data to support the information for the label shall be documented. The data shall be reviewed for accuracy at intervals not to exceed 5 years. Where the review of the data identifies a change that renders the label inaccurate, the label shall be updated.

The label shall be of sufficient durability to withstand the environment involved.

The owner of the electrical equipment shall be responsible for the documentation, installation, and maintenance of the marked label.

130.7 Personal and Other Protective Equipment.

(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.

(B) Care of Equipment.

Protective equipment shall 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)(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 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.

(C) Personal Protective Equipment (PPE).

(1) General.

When an employee is working within the restricted approach boundary, the worker shall wear PPE in accordance with 130.4. When an employee is working within the arc flash boundary, he or she shall wear protective clothing and other PPE in accordance with 130.5. All parts of the body inside the arc flash boundary shall be protected.

Informational Note: Where the estimated incident energy exposure is greater than the arc rating of commercially available arc-rated PPE, then for the purpose of testing for the absence of voltage, the following examples of risk reduction methods could be used to reduce the likelihood of occurrence of an arcing event or the severity of exposure:

(1) Use of noncontact capacitive test instrument(s) or a permanently installed metering device(s) in the equipment for indication, before using a contact-type test instrument to test for the absence of voltage.

(2) If equipment design allows, observe visible gaps between the equipment conductors and circuit parts and the electrical source(s) of supply.

(3) Increase the working distance.

(4) Consider system design options to reduce the incident energy level.

(2) Movement and Visibility.

When arc-rated clothing is worn to protect an employee, it shall cover all ignitible clothing and shall allow for movement and visibility.

(3) Head, Face, Neck, and Chin (Head Area) Protection.

Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with energized electrical conductors or circuit parts or from flying objects resulting from electrical explosion. Employees shall wear nonconductive protective equipment for the face, neck, and chin whenever there is a danger of injury from exposure to electric arcs or flashes or from flying objects resulting from electrical explosion. If employees use hairnets or beard nets, or both, these items shall be arc rated.

Informational Note: See 130.7(C)(10)(b) and 130.7(C)(10)(c) for arc flash protective requirements.

(4) Eye Protection.

Employees shall wear protective equipment for the eyes whenever there is danger of injury from electric arcs, flashes, or from flying objects resulting from electrical explosion.

(5) Hearing Protection.

Employees inside the arc flash boundary shall wear hearing protection.

(6) Body Protection.

Employees shall wear arc-rated clothing wherever there is possible exposure to incident energy of 1.2 cal/cm^2 (5 J/cm^2).

(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:

(2) There shall be no activity performed that risks cutting or damaging the glove.

(3) The rubber insulating gloves shall be electrically retested before reuse.

(4) 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.

(e) *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).

(f) *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).

(g) *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).

(h) *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.

(8) Foot Protection.

Where insulated footwear is used as protection against step and touch potential, dielectric footwear shall be required. Insulated soles shall not be used as primary electrical protection.

Informational Note: Electrical hazard (EH) footwear can provide a secondary source of electric shock protection under dry conditions.

(9) Factors in Selection of Protective Clothing.

Clothing and equipment that provide worker protection from electric shock and arc flash hazards shall be used. If arc-rated clothing is required, it shall cover associated parts of the body as well as all flammable apparel while allowing movement and visibility.

Clothing and equipment required for the degree of exposure shall be permitted to be worn alone or integrated with flammable, nonmelting apparel. Garments that are not arc rated shall not be permitted to be used to increase the arc rating of a garment or of a clothing system.

Informational Note: Protective clothing includes shirts, pants, coveralls, jackets, and parkas worn routinely by workers who, under normal working conditions, are exposed to momentary electric arc and related thermal hazards. Arc-rated rainwear worn in inclement weather is included in this category of clothing.

(a) *Layering.* Nonmelting, flammable fiber garments shall be permitted to be used as underlayers in conjunction with arc-rated garments in a layered system. If nonmelting, flammable fiber garments are used as underlayers, the system arc rating shall be sufficient to prevent breakopen of the innermost arc-rated layer at the expected arc exposure incident energy level to prevent ignition of flammable underlayers. Garments that are not arc rated shall not be permitted to be used to increase the arc rating of a garment or of a clothing system.

Informational Note: A typical layering system might include cotton underwear, a cotton shirt and trouser, and an arc-rated coverall. Specific tasks might call for additional arc-rated layers to achieve the required protection level.

(b) *Outer Layers.* Garments worn as outer layers over arc-rated clothing, such as jackets, high-visibility apparel, or rainwear, shall also be made from arc-rated material. 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.

(c) *Underlayers.* Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric underlayers.

Exception: An incidental amount of elastic used on nonmelting fabric underwear or socks shall be permitted.

Informational Note No. 1: Arc-rated garments (e.g., shirts, trousers, and coveralls) worn as underlayers that neither ignite nor melt and drip in the course of an exposure to electric arc and related thermal hazards generally provide a higher system arc rating than nonmelting, flammable fiber underlayers.

Informational Note No. 2: Arc-rated underwear or undergarments used as underlayers generally provide a higher system arc rating than nonmelting, flammable fiber underwear or undergarments used as underlayers.

(d) *Coverage.* Clothing shall cover potentially exposed areas as completely as possible. Shirt and coverall sleeves shall be fastened at the wrists, shirts shall be tucked into pants, and shirts, coveralls, and jackets shall be closed at the neck.

(e) *Fit.* Tight-fitting clothing shall be avoided. Loose-fitting clothing provides additional thermal insulation because of air spaces. Arc-rated apparel shall fit properly such that it does not interfere with the work task.

(f) *Interference.* The garment selected shall result in the least interference with the task but still provide the necessary protection. The work method, location, and task could influence the protective equipment selected.

(10) Arc Flash Protective Equipment.

(a) *Arc Flash Suits.* 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:

(3) 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.

(4) An arc-rated hood shall be used when the anticipated incident energy exposure exceeds 12 cal/cm^2 (50.2 J/cm^2).

(e) *Face Protection.* Face protection shall meet the following requirements:

(6) Face shields shall have an arc rating suitable for the arc flash exposure.

(7) Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area shall be used.

(8) Face shields without an arc rating shall not be used.

(9) 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.

(j) *Hand Protection.* Hand protection shall meet the following requirements:

(11) 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).

(12) 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.

(m) *Foot Protection.* 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.

(11) Clothing Material Characteristics.

Arc-rated clothing shall meet the requirements described in 130.7(C)(12) and 130.7(C)(14).

Informational Note No. 1: Arc-rated materials, such as flame-retardant-treated cotton, meta-aramid, para-aramid, and poly-benzimidazole (PBI) fibers, provide thermal protection. These materials can ignite but will not continue to burn after the ignition source is removed. Arc-rated fabrics can reduce burn injuries during an arc flash exposure by providing a thermal barrier between the arc flash and the wearer.

Informational Note No. 2: Non-arc-rated cotton, polyester-cotton blends, nylon, nylon-cotton blends, silk, rayon, and wool fabrics are flammable. Fabrics, zipper tapes, and findings made of these materials can ignite and continue to burn on the body, resulting in serious burn injuries.

Informational Note No. 3: Rayon is a cellulose-based (wood pulp) synthetic fiber that is a flammable but nonmelting material.

Clothing consisting of fabrics, zipper tapes, and findings made from flammable synthetic materials that melt at temperatures below 315°C (600°F), such as acetate, acrylic, nylon, polyester, polyethylene, polypropylene, and spandex, either alone or in blends, shall not be used.

Informational Note: These materials melt as a result of arc flash exposure conditions, form intimate contact with the skin, and aggravate the burn injury.

Exception: Fiber blends that contain materials that melt, such as acetate, acrylic, nylon, polyester, polyethylene, polypropylene, and spandex, shall be permitted if such blends in fabrics are arc rated and do not exhibit evidence of melting and dripping during arc testing.

Informational Note: See ASTM F1959/F1959M, *Standard Test Method for Determining the Arc Rating of Materials for Clothing*, and ASTM F1506, *Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs*, for information on test methods used to determine the arc rating of fabrics.

(12) Clothing and Other Apparel Not Permitted.

Clothing and other apparel (such as hard hat liners and hair nets) made from materials that do not meet the requirements of 130.7(C)(11) regarding melting or made from materials that do not meet the flammability requirements shall not be permitted to be worn.

Informational Note: Some flame-resistant fabrics, such as non-flame-resistant modacrylic and nondurable flame-retardant treatments of cotton, are not recommended for industrial electrical or utility applications.

Exception No. 1: Nonmelting, flammable (non-arc-rated) materials shall be permitted to be used as underlayers to arc-rated clothing, as described in 130.7(C)(11).

Exception No. 2: Where the work to be performed inside the arc flash boundary exposes the worker to multiple hazards, such as airborne contaminants, and the risk assessment identifies that the level of protection is adequate to address the arc flash hazard, non-arc-rated PPE shall be permitted.

(13) Care and Maintenance of Arc-Rated Clothing and Arc-Rated Arc Flash Suits.

(a) *Inspection.* Arc-rated apparel shall be inspected before each use. Work clothing or arc flash suits that are contaminated or damaged to the extent that their protective qualities are impaired shall not be used. Protective items that become contaminated with grease, oil, or flammable liquids or combustible materials shall not be used.

(b) *Manufacturer's Instructions.* The garment manufacturer's instructions for care and maintenance of arc-rated apparel shall be followed.

(c) *Storage.* Arc-rated apparel shall be stored in a manner that prevents physical damage; damage from moisture, dust, or other deteriorating agents; or contamination from flammable or combustible materials.

(d) *Cleaning, Repairing, and Affixing Items.* When arc-rated clothing is cleaned, manufacturer's instructions shall be followed. When arc-rated clothing is repaired, the same arc-rated materials used to manufacture the arc-rated clothing shall be used to provide repairs.

Informational Note No. 1: The purpose of following manufacturer's instructions is to avoid the loss of protection and to remove contaminants such as hydrocarbons and metallic and disease-causing contaminants that could compromise safety.

Informational Note No. 2: See ASTM F1506, *Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs*, for additional guidance when trim, name tags, logos, or any combination thereof are affixed to arc-rated clothing.

Informational Note No. 3: See ASTM F1449, *Standard Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing*, and ASTM F2757, *Standard Guide for Home Laundering Care and Maintenance of Flame, Thermal, and Arc Resistant Clothing*, for additional guidance.

(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 arc-rated PPE shall be listed.

Informational Note No. 1: See 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:

(4) Name of manufacturer

(5) Conformity assessment method used

(6) Product performance standards to which the product conforms

(7) Arc rating where appropriate for the equipment

(8) One or more identifiers such as model, serial number, lot number, or traceability code

(9) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	

Subject	Document Title	Document Number
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

(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.* Alternating-current (ac) equipment shall meet the following requirements:

(2) 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) .

(3) An incident energy analysis shall be required in accordance with 130.5(G) for the following:

(4) Power systems with greater than the estimated maximum available fault current

(5) Power systems with longer than the maximum fault clearing times

(6) Less than the minimum working distance

(g) *Direct-Current (dc) Equipment.* Direct-current (dc) equipment shall meet the following requirements:

(8) 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) .

(9) An incident energy analysis shall be required in accordance with 130.5(G) for the following:

(10) Power systems with greater than the estimated maximum available fault current

(11) Power systems with longer than the maximum arc duration

(12) Less than the minimum working distance

(m) *Protective Clothing and Personal Protective Equipment (PPE).* Protective clothing and PPE shall meet the following requirements:

(14) 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.

(15) This clothing and equipment shall be used when working within the arc flash boundary.

(16) 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 ac Systems

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 volts and below	1	485 mm (19 in.)
Parameters: Available fault current not exceeding 25 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	-	-
Panelboards or other equipment rated greater than 240 volts and up to 600 volts	2	900 mm (3 ft)
Parameters: Available fault current not exceeding 25 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	-	-
600-volt class motor control centers (MCCs)	2	1.5 m (5 ft)
Parameters: Available fault current not exceeding 65 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	-	-
600-volt class motor control centers (MCCs)	4	4.3 m (14 ft)
Parameters: Available fault current not exceeding of 42 kA fault clearing time not exceeding 0.33 sec (20 cycles); 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)

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Parameters: 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: 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: 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: 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: 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: 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 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. 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, 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.

(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)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[e]
	-	Leather footwear[f] (AN)

Arc Flash PPE Category	PPE	
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)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[e]
	-	Leather footwear[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)[e]
	-	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Leather footwear[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 Flash PPE Category	PPE	
	Arc-rated arc flash suit pants (AR)	
	-	Arc-rated arc flash suit hood
	-	Arc-rated gloves or rubber insulating gloves with protectors (SR)[e]
	-	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Leather footwear[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.

[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.

[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.

[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.

[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.

(D) Other Protective Equipment.

(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.

Informational Note: See 130.4(E), Electric Shock Protection Boundaries.

(a) *Requirements for Insulated Tools.* The following requirements shall apply to insulated tools:

(2) Insulated tools shall be rated for the voltages on which they are used.

(3) Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.

(4) Insulated tools shall be protected from damage to the insulating material.

(5) Insulated tools and equipment shall be inspected prior to each use.

(6) 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).

(g) *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.

(h) *Ropes and Handlines.* Ropes and handlines used within the limited approach boundary shall be nonconductive.

(i) *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.

(j) *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.

(2) Barriers.

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.

(E) Standards for Other Protective Equipment.

Other protective equipment required in 130.7(D) shall conform to the 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 other protective equipment.

Table Informational Note 130.7(E) Standards on Other Protective Equipment

Subject	Document	Document Number
Arc Protective Blankets	Standard Test Method for Determining the Protective Performance of an Arc Protective Blanket for Electric Arc Hazards	ASTM F2676
Arc Protective Blankets — Selection, Care, and Use	Standard Guide for Selection, Care, and Use of Arc Protective Blankets	ASTM F3272
Blankets	Standard Specification for Rubber Insulating Blankets	ASTM D1048
Blankets — In-service Care	Standard Specification for In-Service Care of Insulating Blankets	ASTM F479
Covers	Standard Specification for Rubber Insulating Covers	ASTM D1049
Fiberglass Rods — Live Line Tools	Standard Specification for Fiberglass-Reinforced Plastic (FRP) Rod and Tube Used in Live Line Tools	ASTM F711
Insulated Hand Tools	Standard Specification for Insulated and Insulating Hand Tools	ASTM F1505
Ladders	American National Standard for Ladders — Wood — Safety Requirements	ANSI/ASC A14.1
	-	American National Standard for Ladders — Fixed — Safety Requirements ANSI/ASC A14.3
	-	American National Standard Safety Requirements for Job Made Wooden Ladders ANSI/ASC A14.4
	-	American National Standard for Ladders — Portable Reinforced Plastic — Safety Requirements ANSI/ASC A14.5
Line Hose	Standard Specification for Rubber Insulating Line Hoses	ASTM D1050

Subject	Document	Document Number	
Line Hose and Covers — In-service Care	Standard Specification for In-Service Care of Insulating Line Hose and Covers	ASTM F478	
Plastic Guard	Standard Test Methods and Specifications for Electrically Insulating Plastic Guard Equipment for Protection of Workers	ASTM F712	
Sheeting	Standard Specification for PVC Insulating Sheeting	ASTM F1742	
	-	Standard Specification for Rubber Insulating Sheeting	ASTM F2320
Safety Signs and Tags	Series of Standards for Safety Signs and Tags	ANSI Z535	
Shield Performance on Live Line Tool	Standard Test Method for Determining the Protective Performance of a Shield Attached on Live Line Tools or on Racking Rods for Electric Arc Hazards	ASTM F2522	
Temporary Protective Grounds — In-service Testing	Standard Specification for In-Service Test Methods for Temporary Grounding Jumper Assemblies Used on De-energized Electric Power Lines and Equipment	ASTM F2249	
Temporary Protective Grounds — Test Specification	Standard Specification for Temporary Protective Grounds to Be Used on De-energized Electric Power Lines and Equipment	ASTM F855	

130.8 Other Precautions.

(A) Alertness.

(1) Where Electrical Hazards Might Exist.

Employees shall be instructed to be alert at all times where electrical hazards might exist.

(2) When Impaired.

Employees shall not be permitted to work where electrical hazards exist while their alertness is recognizably impaired due to illness, fatigue, or other reasons.

(3) Changes in Scope.

Employees shall be instructed to be alert for changes in the job or task that could lead the person outside of the electrically safe work condition or expose the person to additional hazards that were not part of the original plan.

(B) Blind Reaching.

Employees shall be instructed not to reach blindly into areas that might contain exposed energized electrical conductors or circuit parts where an electrical hazard exists.

(C) Illumination.

(1) General.

Employees shall not enter spaces where electrical hazards exist unless illumination is provided that enables the employees to perform the work safely.

(2) Obstructed View of Work Area.

Where lack of illumination or an obstruction precludes observation of the work to be performed, employees shall not perform any task where an electrical hazard exists.

(D) Conductive Articles Being Worn.

Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear, or metal frame glasses) shall not be worn within the restricted approach boundary or where they present an electrical contact hazard with exposed energized electrical conductors or circuit parts.

(E) Conductive Materials, Tools, and Equipment Being Handled.

(1) General.

Conductive materials, tools, and equipment that are in contact with any part of an employee's body shall be handled in a manner that prevents unintentional contact with energized electrical conductors or circuit parts. Such materials and equipment shall include, but are not limited to, long conductive objects, such as ducts, pipes and tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, bull floats, and chains.

(2) Approach to Energized Electrical Conductors and Circuit Parts.

Means shall be employed to ensure that conductive materials approach exposed energized electrical conductors or circuit parts no closer than that permitted by 130.4(F).

(F) Confined or Enclosed Work Spaces.

When an employee works in a confined or enclosed space (such as a manhole or vault) where an electrical hazard exists, the employer shall provide, and the employee shall use, protective shields, protective barriers, or insulating materials as necessary to protect against electrical hazards.

(G) Doors and Hinged Panels.

Doors, hinged panels, and the like shall be secured to prevent their swinging into an employee and causing the employee to contact exposed energized electrical conductors or circuit parts where an electrical hazard exists if movement of the door, hinged panel, and the like is likely to create a hazard.

(H) Clear Spaces.

Working space required by other codes and standards shall not be used for storage. This space shall be kept clear to permit safe operation and maintenance of electrical equipment.

(I) Housekeeping Duties.

(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 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.

(J) Occasional Use of Flammable Materials.

Where flammable materials are present only occasionally, electric equipment capable of igniting them shall not be permitted to be used, unless measures are taken to prevent hazardous conditions from developing. Such materials shall include, but are not limited to, flammable gases, vapors, or liquids, combustible dust, and ignitible fibers or flyings.

Informational Note: See *NFPA 70*, *National Electrical Code*, for electrical installation requirements for locations where flammable materials are present on a regular basis.

(K) Anticipating Failure.

The following shall apply if there is evidence that electric equipment could fail and injure 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.

(L) Routine Opening and Closing of Circuits.

Load-rated switches, circuit breakers, or other devices specifically designed as disconnecting means shall be used for the opening, reversing, or closing of circuits under load conditions. Cable connectors not of the load-break type, fuses, terminal lugs, and cable splice connections shall not be permitted to be used for such purposes, except in an emergency.

(M) Reclosing Circuits After Protective Device Operation.

After a circuit is de-energized by the automatic operation of a circuit protective device, the circuit shall not be manually re-energized until a qualified person or persons determines the equipment and circuit can be safely energized. Manually reclosing circuit breakers or re-energizing circuits through replaced fuses shall be prohibited until the fault has been cleared.

Exception: When it is determined from the design of the circuit and the overcurrent devices involved that the automatic operation of a device was caused by an overload rather than a fault condition, examination of the circuit or connected equipment shall not be required before the circuit is re-energized.

(N) Safety Interlocks.

Only qualified persons following the requirements for working inside the restricted approach boundary as covered by 130.4(G) shall be permitted to defeat or bypass an electrical safety interlock over which the person has sole control, and then only temporarily while the qualified person is working on the equipment. The safety interlock system shall be returned to its operable condition when the work is completed.

(O) Alerting Techniques.

(1) Safety Signs and Tags.

Safety signs, safety symbols, or tags shall be used where necessary to warn employees about electrical hazards that might endanger them. Such signs and tags shall meet the requirements of applicable state, federal, or local codes and standards.

Informational Note No. 1: Safety signs, tags, and barricades used to identify energized “look-alike” equipment can be employed as an additional preventive measure.

Informational Note No. 2: See Table Informational Note 130.7(E), for a list of examples of standards that contain information on safety signs and tags.

(2) Barricades.

Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas containing energized conductors or circuit parts. Conductive barricades shall not be used where it might increase the likelihood of exposure to an electrical hazard. Barricades shall be placed no closer than the limited approach boundary given in Table 130.4(E)(a) and Table 130.4(E)(b). Where the arc flash boundary is greater than the limited approach boundary, barricades shall not be placed closer than the arc flash boundary.

(3) Attendants.

If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees. The primary duty and responsibility of an attendant providing manual signaling and alerting shall be to keep unqualified employees outside a work area where the unqualified employee might be exposed to electrical hazards. An attendant shall remain in the area as long as there is a potential for employees to be exposed to the electrical hazards.

(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) shall be employed to prevent the employee from entering look-alike equipment.

130.9 Work Within the Limited Approach Boundary or Arc Flash Boundary of Overhead Lines.

(A) Uninsulated and Energized.

Where work is performed in locations containing uninsulated energized overhead lines that are not guarded or isolated, precautions shall be taken to prevent employees from contacting such lines directly with any unguarded parts of their body or indirectly through conductive materials, tools, or equipment. Where the work to be performed is such that contact with uninsulated energized overhead lines is possible, the lines shall be de-energized and visibly grounded at the point of work or suitably guarded.

(B) Determination of Insulation Rating.

A qualified person shall determine if the overhead electrical lines are insulated for the lines' operating voltage.

(C) De-energizing or Guarding.

If the lines are to be de-energized, arrangements shall be made with the person or organization that operates or controls the lines to de-energize them and visibly ground them at the point of work. If arrangements are made to use protective measures, such as guarding, isolating, or insulation, these precautions shall prevent each employee from contacting such lines directly with any part of his or her body or indirectly through conductive materials, tools, or equipment.

(D) Employer and Employee Responsibility.

The employer and employee shall be responsible for ensuring that guards or protective measures are satisfactory for the conditions. Employees shall comply with established work methods and the use of protective equipment.

(E) Approach Distances for Unqualified Persons.

When unqualified persons are working on the ground or in an elevated position near overhead lines, the location shall be such that the employee and the longest conductive object the employee might contact do not come closer to any unguarded, energized overhead power line than the limited approach boundary in Table 130.4(E)(a), column 2 or Table 130.4(E)(b), column 2.

Informational Note: Objects that are not insulated for the voltage involved should be considered to be conductive.

(F) Vehicular and Mechanical Equipment.

(1) Elevated Equipment.

Where any vehicle or mechanical equipment structure will be elevated near energized overhead lines, it shall be operated so that the limited approach boundary distance of Table 130.4(E)(a), column 2 or Table 130.4(E)(b), column 2, is maintained. However, under any of the following conditions, the clearances shall be permitted to be reduced:

(1) If the vehicle is in transit with its structure lowered, the limited approach boundary to overhead lines in Table 130.4(E)(a), column 2 or Table 130.4(E)(b), column 2, shall be permitted to be reduced by 1.83 m (6 ft). If insulated barriers, rated for the voltages involved, are installed and they are not part of an attachment to the vehicle, the clearance shall be permitted to be reduced to the design working dimensions of the insulating barrier.

(2) If the equipment is an aerial lift insulated for the voltage involved, and if the work is performed by a qualified person, the clearance (between the uninsulated portion of the aerial lift and the power line) shall be permitted to be reduced to the restricted approach boundary given in Table 130.4(E)(a), column 4 or Table 130.4(E)(b), column 4.

(2) Equipment Contact.

Employees standing on the ground shall not contact the vehicle or mechanical equipment or any of its attachments unless either of the following conditions apply:

(1) The employee is using protective equipment rated for the voltage.

(2) The equipment is located so that no uninsulated part of its structure (that portion of the structure that provides a conductive path to employees on the ground) can come closer to the line than permitted in 130.9(F)(1).

(3) Equipment Grounding.

If any vehicle or mechanical equipment is capable of having parts of its structure elevated within the limited approach boundary of exposed movable conductors of energized overhead lines and is intentionally grounded, employees working on the ground near the point of grounding shall not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades, dielectric overshoe footwear, or insulation, shall be taken to protect employees from hazardous ground potentials (step and touch potential).

Informational Note: Upon contact of the elevated structure with the energized lines, hazardous ground potentials can develop within a few feet or more outward from the grounded point.

130.10 Underground Electrical Lines and Equipment.

Before excavation starts where there exists a reasonable possibility of contacting electrical lines or equipment, the employer shall take the necessary steps to contact the appropriate owners or authorities to identify and mark the location of the electrical lines or equipment. When it has been determined that a reasonable possibility of contacting electrical lines or equipment exists, appropriate safe work practices and PPE shall be used during the excavation.

130.11 Cutting or Drilling.

Before cutting or drilling into equipment, floors, walls, or structural elements where a likelihood of contacting energized electrical lines or parts exists, the employer shall perform a risk assessment to do the following:

(1) Identify and mark the location of conductors, cables, raceways, or equipment

(2) Establish and verify an electrically safe work condition

(3) Identify safe work practices, risk control methods, additional protective measures, and any required electric shock or arc flash PPE

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: 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.

Statement of Problem and Substantiation for Public Comment

The title of Chapter 1 needs to be changed to be technically correct as it contains definitions in Article 100 as well as topics apparently considered "Safety Related Work Practices" such as Article 105, 110, 120 and 130. Note that the title of Chapter 1 of the NEC is titled "General" which alternatively may be a more appropriate title for Chapter 1 of NFPA 70E as well since, per 90.4 and Figure 90.4, Chapter 1 applies generally and generally to electrical safety in the workplace, respectively.

Related Item

• FR-4 • PI-40

Submitter Information Verification

Submitter Full Name: Palmer Hickman
Organization: Electrical Training Alliance
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 27 13:33:55 EDT 2025
Committee: EEW-AAA

Public Comment No. 89-NFPA 70E-2025 [Chapter 1]

Chapter 1 Safety-Related Work Practices

Article 100 Definitions

Scope. This article contains only those definitions essential to the 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.

Accessible (as applied to equipment).

Admitting close approach; not guarded by locked doors, elevation, or other effective means. [**70:**100]

Approved.

Acceptable to the authority having jurisdiction.

Arc Flash Suit.

A complete arc-rated clothing and equipment system that covers the entire body, except for the hands and feet.

Informational Note: An arc flash suit may include pants or overalls, a jacket or a coverall, and a beekeeper-type hood fitted with a face shield.

Arc Rating.

The value attributed to materials that describes their performance to exposure to an electrical arc discharge. The arc rating is expressed in cal/cm^2 and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakopen threshold (E_{BT}) (should a material system exhibit a breakopen response below the ATPV value). Arc rating is reported as either ATPV or E_{BT}, whichever is the lower value.

Informational Note No. 1: Arc-rated clothing or equipment indicates that it has been tested for exposure to an electric arc. Flame-resistant clothing without an arc rating has not been tested for exposure to an electric arc. All arc-rated clothing is also flame resistant.

Informational Note No. 2: See ASTM F1959/F1959M, *Standard Test Method for Determining the Arc Rating of Materials for Clothing*, which defines ATPV as the incident energy (cal/cm^2) on a material or a multilayer system of materials that results in a 50 percent probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a second degree skin burn injury based on the Stoll curve.

Informational Note No. 3: See ASTM F1959/F1959M, *Standard Test Method for Determining the Arc Rating of Materials for Clothing*, which defines E_{BT} as the incident energy (cal/cm^2) on a material or a material system that results in a 50 percent probability of breakopen. Breakopen is a material response evidenced by the formation of one or more holes of a defined size [an area of 1.6 cm^2 (0.5 in.^{2}) or an opening of 2.5 cm (1.0 in.) in any dimension] in the innermost layer of arc-rated material that would allow thermal energy to pass through the material.

Attachment Plug (Plug Cap) (Plug).

A device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle. [**70:**100]

Authority Having Jurisdiction (AHJ).

An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

> Informational Note: The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

Authorized Personnel.

The person in charge of the premises, or other persons appointed or selected by the person in charge of the premises who performs certain duties associated with stationary storage batteries. (320)

Automatic.

Performing a function without the necessity of human intervention.

Balaclava.

An arc-rated head-protective fabric that protects the neck and head except for a small portion of the facial area.

> Informational Note: Some balaclava designs protect the neck and head area except for the eyes while others leave the eyes and nose area unprotected.

Barricade.

A physical obstruction such as tapes, cones, or A-frame-type wood or metal structures intended to provide a warning and to limit access.

Barrier.

A physical obstruction that is intended to prevent contact with equipment or energized electrical conductors and circuit parts.

Battery.

A system consisting of two or more electrochemical cells connected in series or parallel and capable of storing electrical energy received and that can give it back by reconversion. (320)

Battery Effect.

A voltage that exists on the electrolytic cell line after the power supply is disconnected. (310)

> Informational Note: Electrolytic cells can exhibit characteristics similar to an electrical storage battery and an electric shock hazard could exist after the power supply is disconnected from the cell line.

Battery Room.

A room specifically intended for the installation of batteries that have no other protective enclosure. (320)

Bonded (Bonding).

Connected to establish electrical continuity and conductivity. [**70:**100]

Bonding Conductor or Jumper.

A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected. [**70:**100]

Boundary, Arc Flash. (Arc Flash Boundary)

When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm^2 (5 J/cm^2).

> Informational Note: According to the Stoll skin burn injury model, the onset of a second degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm^2 (5 J/cm^2) for one second.

Boundary, Hearing Protection. (Hearing Protection Boundary)

Worker distance at which a 1 percent probability of ear damage exists from a 20 kPa (3.0 psi) shock wave. (360)

Boundary, Limited Approach. (Limited Approach Boundary)

An approach limit at a distance from an exposed energized electrical conductor or circuit part within which an electric shock hazard exists.

Boundary, Lung Protection. (Lung Protection Boundary)

Worker distance at which a 1 percent probability of lung damage exists from a 70 kPa (10 psi) shock wave. (360)

Boundary, Restricted Approach. (Restricted Approach Boundary)

An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

Building.

A structure that stands alone or that is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors. [**70:**100]

Cabinet.

An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung. [**70:**100]

Cell.

The basic electrochemical unit, characterized by an anode and a cathode used to receive, store, and deliver electrical energy. (320)

Cell, Valve-Regulated Lead Acid (VRLA). (Valve-Regulated Lead Acid Cell)

A lead-acid cell that is sealed with the exception of a valve that opens to the atmosphere when the internal pressure in the cell exceeds atmospheric pressure by a pre-selected amount, and that provides a means for recombination of internally generated oxygen and the suppression of hydrogen gas evolution to limit water consumption. (320)

Cell, Vented. (Vented Cell)

A type of cell in which the products of electrolysis and evaporation are allowed to escape freely into the atmosphere as they are generated. (Also called "*flooded cell*.") (320)

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.

Charge Transfer.

Improper discharging of capacitor networks that results in transferring charge from one capacitor to another capacitor instead of fully discharging the stored energy. (360)

Circuit Breaker.

A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [**70:**100]

> Informational Note: The automatic opening means can be integral, direct acting with the circuit breaker, or remote from the circuit breaker.

Conductive.

Suitable for carrying electric current.

Conductor, Bare. (Bare Conductor)

A conductor having no covering or electrical insulation whatsoever. [**70:**100]

Conductor, Covered. (Covered Conductor)

A conductor encased within material of composition or thickness that is not recognized by *NFPA 70*, *National Electrical Code*, as electrical insulation. [**70:**100]

Conductor, Insulated. (Insulated Conductor)

A conductor encased within material of composition and thickness that is recognized by *NFPA 70*, *National Electrical Code*, as electrical insulation. [**70:**100]

Controller.

A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected. [**70:**100]

Current-Limiting Overcurrent Protective Device.

A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

Cutout.

An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

De-energized.

Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth.

Device.

A unit of an electrical system, other than a conductor, that carries or controls electric energy as its principal function. [**70:**100]

Dielectric Absorption.

The property of certain capacitors to recharge after being discharged. (360)

> Informational Note: A voltage recharge from 0.02 percent (polystyrene and polypropylene) up to 10 percent (some electrolytics) can occur a few minutes after the grounding or shorting device has been removed.

Discharge Time.

The time required to discharge a capacitor to below electrical hazard thresholds. (360)

Disconnecting Means.

A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [**70:**100]

Disconnecting (or Isolating) Switch (Disconnector, Isolator).

A mechanical switching device used for isolating a circuit or equipment from a source of power.

Dwelling Unit.

A single unit providing complete and independent living facilities for one or more persons, including permanent provisions for living, sleeping, cooking, and sanitation. [**70:**100]

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.

Electrical Safety Program.

A documented system consisting of electrical safety principles, policies, procedures, and processes that directs activities appropriate for the risk associated with electrical hazards.

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.

Electrolyte.

A solid, liquid, or aqueous immobilized liquid medium that provides the ion transport mechanism between the positive and negative electrodes of a cell. (320)

Enclosed.

Surrounded by a case, housing, fence, or wall(s) that prevents persons from unintentionally contacting energized parts.

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.

Energized.

Electrically connected to, or is, a source of voltage. [**70:**100]

Energy Isolation Device.

A mechanical device that physically prevents the transmission or release of energy, including but not limited to the following: A manually operated electrical circuit breaker; a disconnect switch; a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors, and, in addition, no pole can be operated independently. Push buttons, selector switches and other control circuit type devices are not energy isolating devices.

Equipment.

A general term, including fittings, devices, appliances, luminaires, apparatus, machinery, and the like, used as a part of, or in connection with, an electrical installation. [**70:**100]

Equipment, Arc-Resistant. (Arc-Resistant Equipment)

Equipment designed to withstand the effects of an internal arcing fault and that directs the internally released energy away from the employee.

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.

Informational Note No. 2: See O.2.4(9) for information on arc-resistant equipment.

Exposed (as applied to energized electrical conductors or circuit parts).

Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated, or insulated.

Exposed (as applied to wiring methods).

On or attached to the surface or behind panels designed to allow access. [**70:**100]

Fault Current.

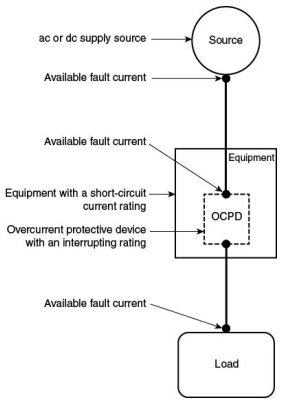
The amount of current delivered at a point on the system during a short-circuit condition.

Fault Current, Available. (Available Fault Current)

The largest amount of current capable of being delivered at a point on the system during a short-circuit condition.

Informational Note No. 1: See Figure Figure Informational Note 100.0 A short circuit can occur during abnormal conditions such as a fault between circuit conductors or a ground fault.

Figure Informational Note 100.0 Available Fault Current.



Informational Note No. 2: If the dc supply is a battery system, the term *available fault current* refers to the prospective short-circuit current.

Informational Note No. 3: The available fault current varies at different locations within the system due to the location of sources and system impedances.

Field Evaluated.

An evaluation of nonlisted or modified equipment in the field that is performed by persons or parties acceptable to the authority having jurisdiction. (330, 350)

Informational Note No. 1: The evaluation approval ensures that the equipment meets appropriate codes and standards or is similarly found suitable for a specified purpose.

Informational Note No. 2: See NFPA 791, *Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation*, for additional information on recommended practices and procedures for the field evaluation of nonlisted equipment.

Informational Note No. 3: See NFPA 790, *Standard for Competency of Third-Party Field Evaluation Bodies*, for requirements on evaluating third-party entities.

Fitting.

An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function. [**70:**100]

Fuse.

An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it.

Informational Note: A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Ground.

The earth. [**70:**100]

Ground Fault.

An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non–current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth. [**70:**100]

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.

Grounded Conductor.

A system or circuit conductor that is intentionally grounded. [**70:**100]

Grounded (Grounding).

Connected (connecting) to ground or to a conductive body that extends the ground connection. [**70:**100]

Grounded, Solidly. (Solidly Grounded)

Connected to ground without inserting any resistor or impedance device. [**70:**100]

Ground-Fault Circuit Interrupter (GFCI).

A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device. [**70:**100]

Informational Note: See UL 943, *Ground-Fault Circuit Interrupters*, for further information. Class A ground-fault circuit interrupters trip when the ground-fault current is 6 mA or higher and does not trip when the ground-fault current is less than 4 mA.

Grounding Conductor, Equipment (EGC). (Equipment Grounding Conductor)

The conductive path(s) that provides a ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both. [**70:**100]

Informational Note No. 1: It is recognized that the equipment grounding conductor also performs bonding.

Informational Note No. 2: See 250.118 of *NFPA 70*, *National Electrical Code*, for a list of acceptable equipment grounding conductors.

Grounding Electrode.

A conducting object through which a direct connection to earth is established. [**70:**100]

Grounding Electrode Conductor.

A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system. [**70:**100]

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

The practice of discharging 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.

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

The practice of discharging capacitance by connecting to ground through a power resistor to avoid the hazards related with 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.

Guarded.

Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger. [**70:**100]

Hazard.

A source of possible injury or damage to health.

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)

Hazard, Arc Flash. (Arc Flash Hazard)

A source of possible injury or damage to health associated with the release of energy caused by an electric arc.

> Informational Note No. 1: See 110.2(B) Exception No. 1 for further information regarding normal operation. The likelihood of occurrence of an arc flash incident increases when energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc. An arc flash incident is not likely to occur under normal operating conditions when enclosed energized equipment has been properly installed and maintained.
>
> Informational Note No. 2: See Table 130.5(C)(3) for examples of tasks that increase the likelihood of an arc flash incident occurring.

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.

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.

Hazard, Electrical. (Electrical Hazard)

A 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.

Hazardous.

Involving exposure to at least one hazard.

Incident Energy.

The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electrical arc event.

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

Incident Energy Analysis.

A component of an arc flash risk assessment used to predict the incident energy of an arc flash for a specified set of conditions.

Insulated.

Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

> Informational Note: When an object is said to be insulated, it is understood to be insulated for the conditions to which it is normally subject. Otherwise, it is, within the purpose of these rules, uninsulated.

Interrupter Switch.

A switch capable of making, carrying, and interrupting specified currents.

Interrupting Rating.

The highest current at rated voltage that a device is identified to interrupt under standard test conditions. [**70:**100]

> Informational Note: Equipment intended to interrupt current at other than fault levels may have its interrupting rating implied in other ratings, such as horsepower or locked rotor current.

Isolated (as applied to location).

Not readily accessible to persons unless special means for access are used. [**70:**100]

Labeled.

Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Laboratory.

A building, space, room, or group of rooms intended to serve activities involving procedures for investigation, diagnostics, product testing, or use of custom or special electrical components, systems, or equipment. (350)

Laser.

A device that produces radiant energy at wavelengths between 180 nm (nanometer) and 1 mm (millimeter) predominantly by controlled stimulated emission. Laser radiation can be highly coherent temporally, spatially, or both. (330)

Laser Energy Source.

Any device intended for use in conjunction with a laser to supply energy for the excitation of electrons, ions, or molecules. (330)

Laser Radiation.

All electromagnetic radiation emitted by a laser or laser system between 180 nm (nanometers) and 1 mm (millimeters) that is produced as a result of a controlled stimulated emission. (330)

Laser System.

A laser in combination with an appropriate laser energy source with or without additional incorporated components. (330)

Listed.

Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

> Informational Note: The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Lockout.

The placement of a lockout device on an energy isolating device, in accordance with an established procedure, ensuring that the energy isolating device and the equipment being controlled cannot be operated until the lockout device is removed.

Lockout Device.

A hardened device that utilizes a positive means such as a lock, either key or combination type, that physically restrains an energy isolating device in a safe position and prevents the energizing of a machine or equipment.

Lockout/Tagout (LOTO).

The combination use of both a Lockout Device with a Tagout Device to control hazardous electrical energy.

Luminaire.

A complete lighting unit consisting of a light source, such as a lamp or lamps, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light. A lampholder itself is not a luminaire. [**70:**100]

Maintenance, Condition of. (Condition of Maintenance)

The state of the electrical equipment considering the manufacturers' instructions, manufacturers' recommendations, and applicable industry codes, standards, and recommended practices.

Motor Control Center.

An assembly of one or more enclosed sections having a common power bus and principally containing motor control units. [**70:**100]

Outlet.

A point on the wiring system at which current is taken to supply utilization equipment. [**70:**100]

Overcurrent.

Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault. [**70:**100]

> Informational Note: A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore, the rules for overcurrent protection are specific for particular situations.

Overload.

Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. [**70:**100]

Panelboard.

A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front. [**70:**100]

Pilot Cell.

One or more cells chosen to represent the operating parameters of the entire battery (sometimes called "temperature reference" cell). (320)

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 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.

Protective Barrier.

Prevents user access to a hazardous voltage, current, or stored energy area. (330)

Protector.

A glove or mitten designed to be worn over rubber insulating gloves.

Qualified Person.

One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.

Raceway.

An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this standard. [**70:**100]

Radiation, Ionizing. (Ionizing Radiation)

Radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization of atoms or molecules through which it passes. (340)

Radiation, Nonionizing. (Nonionizing Radiation)

Static electric and magnetic (0 to 1 Hz), sub radiofrequency (1Hz to 3 kHz), radiofrequency (3 kHz to 300 GHz) fields, and infrared, visible light, and near ultraviolet (near UV) that cannot ionize an atom or molecule. (340)

Receptacle.

A contact device installed at the outlet for the connection of an attachment plug, or for the direct connection of electrical utilization equipment designed to mate with the corresponding contact device. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke. [**70:**100]

Research and Development (R&D).

An activity in an installation specifically designated for research or development conducted with custom or special electrical equipment. (350)

Resistor, Bleeder. (Bleeder Resistor)

A resistor or resistor network connected in parallel with a capacitor's terminals that dissipates the stored energy after power has been disconnected. (360)

Risk.

A combination of 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.

An overall process that identifies hazards, estimates the likelihood of occurrence of injury or damage to health, estimates the potential severity of injury or damage to health, and determines if protective measures are required.

> Informational Note: As used in this standard, *arc flash risk assessment* and *electric shock risk assessment* are types of risk assessments.

Service Drop.

The overhead conductors between the utility electric supply system and the service point. [**70:**100]

Service Lateral.

The underground conductors between the utility electric supply system and the service point. [**70:**100]

Service Point.

The point of connection between the facilities of the serving utility and the premises wiring. [**70:**100]

> Informational Note: The service point can be described as the point of demarcation between where the serving utility ends and the premises wiring begins. The serving utility generally specifies the location of the service point based on the conditions of service.

Short-Circuit Current, Prospective. (Prospective Short-Circuit Current)

The highest level of fault current that could theoretically occur at a point on a circuit. This is the fault current that can flow in the event of a zero impedance short circuit and if no protection devices operate. (320)

> Informational Note: Some batteries have built-in management devices to limit maximum short-circuit current. The determination of the prospective short-circuit current for these batteries assumes that the internal battery management system protection devices are operable.

Short-Circuit Current Rating.

The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding defined acceptance criteria. [**70:**100]

Shorting Stick.

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

Single-Line Diagram.

A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used in the circuit or system.

Special Permission.

The written consent of the authority having jurisdiction. [**70:**100]

Step Potential.

A ground potential gradient difference that can cause current flow from foot to foot through the body.

Structure.

That which is built or constructed. [**70:**100]

Switch, Isolating. (Isolating Switch)

A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means. [**70:**100]

Switchboard.

A large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments. These assemblies are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. [**70:**100]

Switchgear, Metal-Clad. (Metal-Clad Switchgear)

A switchgear assembly completely enclosed on all sides and top with sheet metal, having drawout switching and interrupting devices, and all live parts enclosed within grounded metal compartments.

Switchgear, Metal-Enclosed. (Metal-Enclosed Switchgear)

A switchgear assembly completely enclosed on all sides and top with sheet metal (except for ventilating openings and inspection windows), containing primary power circuit switching, interrupting devices, or both, with buses and connections. This assembly may include control and auxiliary devices. Access to the interior of the enclosure is provided by doors, removable covers, or both. Metal-enclosed switchgear is available in non-arc-resistant or arc-resistant constructions.

Switching Device.

A device designed to close, open, or both, one or more electric circuits.

Time Constant.

The time it takes for voltage to drop by ~63 percent (1/e) during discharge. (360)

Tagout.

The placement of a tagout device on an energy isolating device, in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

Tagout Device.

A prominent warning device, such as a tag and a means of attachment, which can be securely fastened to an energy isolating device in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed. Tags are essentially warning devices affixed to energy isolating devices, and do not provide the physical restraint on those devices that is provided by a lock where tags may evoke a false sense of security.

Touch Potential.

A ground potential gradient difference that can cause current flow from hand to hand, hand to foot, or another path, other than foot to foot, through the body.

Ungrounded.

Not connected to ground or to a conductive body that extends the ground connection. [**70:**100]

Unqualified Person.

A person who is not a qualified person.

Utilization Equipment.

Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes. [**70:**100]

Voltage (of a Circuit).

The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned. [**70:**100]

Informational Note: Some systems, such as three-phase 4-wire, single-phase 3-wire, and 3-wire direct-current, may have various circuits of various voltages.

Voltage, Nominal. (Nominal Voltage)

A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240 volts, 480Y/277 volts, 600 volts). [**70:**100]

Informational Note No. 1: The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Informational Note No. 2: See ANSI C84.1, *Electric Power Systems and Equipment — Voltage Ratings (60 Hz)*.

Voltage, Nominal (as applied to cell or battery). (Nominal Voltage)

The value assigned to a cell or battery of a given voltage class for the purpose of convenient designation; the operating voltage of the cell or system may vary above or below this value. (320)

Informational Note: The most common cell voltages are 2.0 volts per cell for lead-acid batteries, 1.2 volts per cell for alkali batteries, and 3.2 to 3.8 volts per cell for Li-ion batteries. Nominal voltages might vary with different chemistries.

Working Distance.

The distance between a person's face and chest area and a prospective arc source.

Informational Note: See 130.5(G) for further information. Incident energy increases as the distance from the arc source decreases.

Working On (energized electrical conductors or circuit parts).

Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment (PPE) a person is wearing.

Informational Note: Examples of "working on" can include but are not limited to *diagnostic testing* (such as taking readings or measurements of electrical equipment, conductors, or circuit parts with approved test equipment that does not require making any physical change to the electrical equipment, conductors, or circuit parts) and *repair* or physical alteration of electrical equipment, conductors, or circuit parts (such as making or tightening connections, removing or replacing components, etc.).

Article 105 Employer and Employee Responsibilities

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.

105.3 Responsibility.

(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 training in the employer's safety-related work practices and procedures.

(B) Employee Responsibility.

The employee shall comply with the safety-related work practices and procedures provided by the employer.

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 standard. Article 105 covers employer and employee responsibilities for the application of safety-related work practices and procedures. Article 110 covers general requirements for electrical safety-related work practices and procedures. Article 120 covers requirements for establishing an electrically safe work condition. Article 130 covers requirements for work involving electrical hazards.

Article 110 General Requirements for Electrical Safety-Related Work Practices

110.1 Scope.

This article covers the general requirements for electrical safety-related work practices.

110.2 Electrically Safe Work Condition.

(A) Policy.

An employer shall establish, document, and implement an electrically safe work condition policy that does both of the following:

(1) Requires hazard elimination to be the first priority in the implementation of safety-related work practices

(2) Complies with 110.2(B)

Informational Note No. 1: See Informative Annex F for examples of hazard elimination. Elimination is the risk control method listed first in the hierarchy of risk control identified in 110.3(H)(3).

Informational Note No. 2: The electrically safe work condition policy could be documented in the employer's electrical safety program or in the employer's management system or similar documentation.

(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.

Informational Note No. 3: The phrase *rated for the available fault current* means the available fault-current marking(s) related to the required short-circuit and interrupting ratings of the equipment. Values of available fault current for use in determining appropriate minimum short-circuit current and interrupting ratings of service equipment are available from electric utilities in published or other forms. [70:110.24]

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.

(C) Requirements Until Established.

(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.

110.3 Electrical Safety Program.

(A) General.

The employer shall implement and document an overall electrical safety program that directs activity appropriate to the risk associated with electrical hazards.

Informational Note No. 1: Safety-related work practices such as verification of proper maintenance and installation, alerting techniques, auditing requirements, and training requirements provided in this standard are administrative controls and part of an overall electrical safety program.

Informational Note No. 2: See Informative Annex P for information on implementing an electrical safety program within an employer's occupational health and safety management system.

Informational Note No. 3: See IEEE 3007.1, *Recommended Practice for the Operation and Management of Industrial and Commercial Power Systems*, which provides additional guidance for the implementation of the electrical safety program.

Informational Note No. 4: See IEEE 3007.3, *Recommended Practice for Electrical Safety in Industrial and Commercial Power Systems*, which provides additional guidance for electrical safety in the workplace.

(B) Inspection.

The electrical safety program shall include elements to verify that newly installed or modified electrical equipment or systems have been inspected to comply with applicable installation codes and standards prior to being placed into service.

(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.

(D) Awareness and Self-Discipline.

The electrical safety program shall be designed to provide an awareness of the potential electrical hazards to employees who work in an environment with the presence of electrical hazards. The program shall be developed to provide the required self-discipline for all employees who must perform work that may involve electrical hazards. The program shall instill safety principles and controls.

(E) Electrical Safety Program Principles.

The electrical safety program shall identify the principles upon which it is based.

Informational Note: See Informative Annex E for examples of typical electrical safety program principles.

(F) Electrical Safety Program Controls.

An electrical safety program shall identify the controls by which it is measured and monitored.

Informational Note: See Informative Annex E for examples of typical electrical safety program controls.

(G) Electrical Safety Program Procedures.

An electrical safety program shall identify the procedures to be utilized before work is started by employees exposed to an electrical hazard.

Informational Note: See Informative Annex E for an example of a typical electrical safety program procedure.

(H) Risk Assessment Procedure.

The electrical safety program shall include a risk assessment procedure and shall comply with 110.3(H)(1) through 110.3(H)(3).

(1) Elements of a Risk Assessment Procedure.

The risk assessment procedure shall address employee exposure to electrical hazards and shall identify the process to be used before work is started to carry out the following:

(1) Identify hazards

(2) Assess risks

(3) Implement risk control according to the hierarchy of risk control methods

Informational Note No. 1: The risk assessment procedure could include identifying when a second person could be required and the training and equipment that person should have.

Informational Note No. 2: See Informative Annex F for more information regarding risk assessment and the hierarchy of risk control.

(2) Human Error.

The risk assessment procedure shall address the potential for human error and its negative consequences on people, processes, the work environment, and equipment relative to the electrical hazards in the workplace.

Informational Note: See Informative Annex Q for further information. The potential for human error varies with factors such as tasks and the work environment.

(3) Hierarchy of Risk Control Methods.

The risk assessment procedure shall require that preventive and protective risk control methods be implemented in accordance with the following hierarchy:

(1) Elimination

(2) Substitution

(3) Engineering controls

(4) Awareness

(5) Administrative controls

(6) PPE

Informational Note No. 1: Elimination, substitution, and engineering controls are the most effective methods to reduce risk as they are usually applied at the source of possible injury or damage to health and they are less likely to be affected by human error. Awareness, administrative controls, and PPE are the least effective methods to reduce risk as they are not applied at the source and they are more likely to be affected by human error.

Informational Note No. 2: See Informative Annex F for more information regarding the hierarchy of risk control methods and examples of those methods.

(I) Job Safety Planning and Job Briefing.

Before starting each job that involves exposure to electrical hazards, the employee in charge shall complete a job safety plan and conduct a job briefing with the employees involved.

(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:

(4) A description of the job and the individual tasks

(5) Identification of the electrical hazards associated with each task

(6) An electric shock risk assessment in accordance with 130.4 for tasks involving an electric shock hazard

(7) An arc flash risk assessment in accordance with 130.5 for tasks involving an arc flash hazard

(8) Work procedures involved, special precautions, and energy source controls

(9) 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.

(2) Job Briefing.

The job briefing shall cover the job safety plan and the information on the energized electrical work permit, if a permit is required.

(3) Change in Scope.

Additional job safety planning and job briefings shall be held if changes occur during the course of the work that might affect the safety of employees.

Informational Note: See Figure I.1 for an example of a job briefing checklist.

(J) Incident Investigations.

The electrical safety program shall include elements to investigate electrical incidents.

Informational Note: Electrical incidents include events or occurrences that result in, or could have resulted in, a fatality, an injury, or damage to health. Incidents that do not result in fatality, injury, or damage to health are commonly referred to as a “close call” or “near miss.”

(K) Lockout/Tagout Program.

The electrical safety program shall include the information required by one of the following:

(1) A lockout/tagout program in accordance with 120.2(A)

(2) A reference to the employer’s lockout/tagout program established in accordance with 120.2(A)

(L) Auditing.

(1) Electrical Safety Program Audit.

The electrical safety program shall be audited to verify that the principles and procedures of the electrical safety program are in compliance with this standard. Audits shall be performed at intervals not to exceed 3 years.

(2) Work Practices Audit.

(a) 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.

(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 Procedure Audit.

(a) The lockout/tagout 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:

(4) The lockout/tagout procedures

(5) The lockout/tagout training

(6) Worker execution of the lockout/tagout procedure

(5) Documentation.

The audits required by 110.3(L) shall be documented.

110.4 Training Requirements.

(A) Electrical Safety Training.

The training requirements contained in 110.4(A) shall apply to employees exposed to an electrical hazard when the risk associated with that hazard is not reduced to a safe level by the applicable electrical installation requirements. Such employees shall be trained to understand the specific hazards associated with electrical energy. They shall be trained in safety-related work practices and procedural requirements, as necessary, to provide protection from the electrical hazards associated with their respective job or task assignments. Employees shall be trained to identify and understand the relationship between electrical hazards and possible injury.

Informational Note: See *NFPA 70*, *National Electrical Code*, for further information concerning installation requirements.

(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 with respect to certain equipment and tasks, 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:

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

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

(6) 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

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

(8) Perform the job safety planning

(9) Identify electrical hazards

(10) Assess the associated risk

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

(l) 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.

(m) Employees shall be trained to select an appropriate test instrument and shall demonstrate how to use a device to 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.

(n) 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.

(2) Unqualified Persons.

Unqualified persons shall be trained in, and be familiar with, any electrical safety-related practices necessary for their safety.

(3) Additional Training and Retraining.

Additional training and retraining in safety-related work practices and applicable changes in this standard shall be performed at intervals not to exceed 3 years. An employee shall receive additional training or retraining if any of the following conditions exists:

(1) The supervision or annual inspections indicate the employee is not complying with the safety-related work practices.

(2) New technology, new types of equipment, or changes in procedures necessitate the use of safety-related work practices different from those that the employee would normally use.

(3) The employee needs to review tasks that are performed less often than once per year.

(4) The employee needs to review safety-related work practices not normally used by the employee during regular job duties.

(5) The employee’s job duties change.

(4) Type of Training.

The training required by 110.4(A) shall be classroom, on-the-job, or a combination of the two. The type and extent of the training provided shall be determined by the risk to the employee.

Informational Note: Classroom training can include interactive electronic or interactive web-based training components.

(5) Electrical Safety Training Documentation.

The employer shall document that each employee has received the training required by 110.4(A). This documentation shall be in accordance with the following:

(1) Be made when the employee demonstrates proficiency in the work practices involved

(2) Be retained for the duration of the employee's employment

(3) Contain the content of the training, each employee's name, and dates of training

Informational Note No. 1: Content of the training could include one or more of the following: course syllabus, course curriculum, outline, table of contents, or training objectives.

Informational Note No. 2: Employment records that indicate that an employee has received the required training are an acceptable means of meeting this requirement.

(B) Lockout/Tagout Procedure Training.

(1) Initial Training.

Employees involved in the lockout/tagout procedures required by 120.3(B) shall be trained in the following:

(1) The lockout/tagout procedures

(2) Their responsibility in the execution of the procedures

(2) Retraining.

Retraining in the lockout/tagout procedures shall be performed as follows:

(1) When the procedures are revised

(2) At intervals not to exceed 3 years

(3) When supervision or annual inspections indicate that the employee is not complying with the lockout/tagout procedures

(3) Lockout/Tagout Training Documentation.

(a) The employer shall document that each employee has received the training required by 110.4(B).

(b) The documentation shall be made when the employee demonstrates proficiency in the work practices involved.

(c) The documentation shall contain the content of the training, each employee's name, and the dates of the training.

Informational Note: Content of the training could include one or more of the following: course syllabus, course curriculum, outline, table of contents, or training objectives.

(C) Emergency Response Training.

(1) Contact Release.

Employees exposed to electric shock hazards and those responsible for the safe release of victims from contact with energized electrical conductors or circuit parts shall be trained in methods of safe release. Refresher training shall occur annually.

(2) First Aid, Emergency Response, and Resuscitation.

(a) Employees responsible for responding to medical emergencies shall be trained in first aid and emergency procedures.

(b) Employees responsible for responding to medical emergencies shall be trained in cardiopulmonary resuscitation (CPR).

(c) Employees responsible for responding to medical emergencies shall be trained in the use of an automated external defibrillator (AED) if an employer's emergency response plan includes the use of this device.

(d) Training shall occur at a frequency that satisfies the requirements of the certifying body.

Informational Note: Employees responsible for responding to medical emergencies might not be first responders or medical professionals. Such employees could be a second person, a safety watch, or a craftsperson.

(3) Training Verification.

Employers shall verify at least annually that employee training required by 110.4(C) is current.

(4) Documentation.

The employer shall document that the training required by 110.4(C) has occurred.

110.5 Host and Contract Employers' Responsibilities.

(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.

(B) Contract Employer Responsibilities.

(1) Communicate Hazard Information to Employees.

(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

(C) Documentation.

Where the host employer has knowledge of hazards covered by this standard that are related to the contract employer's work, there shall be a documented meeting between the host employer and the contract employer.

Informational Note to 110.5: On multi-employer work sites (in all industry sectors), more than one employer can be responsible for identifying hazardous conditions and creating safe work practices.

110.6 Test Instruments and Equipment.

(A) Testing.

Only qualified persons shall perform tasks such as testing, troubleshooting, and voltage measuring on electrical equipment where an electrical hazard exists.

(B) Rating.

Test instruments, equipment, and their accessories shall be as follows:

(1) Rated for circuits and equipment where they are utilized

(2) Approved for the purpose

(3) Used in accordance with any instructions provided by the manufacturer

Informational Note: See UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use — Part 1: General Requirements*, and 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*, for rating and design requirements for voltage measurement and test instruments intended for use on electrical systems 1000 volts and below.

(C) Design.

Test instruments, equipment, and their accessories shall be designed for the environment to which they will be exposed and for the manner in which they will be utilized.

(D) Visual Inspection and Repair.

(1) Inspection.

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 until a person(s) qualified to perform the repairs and tests that are necessary to render the equipment safe has done so.

(E) Operation Verification.

When test instruments are used for testing the absence of voltage on conductors or circuit parts operating at voltages equal to or greater than 50 volts, the operation of the test instrument shall be verified on any known voltage source before and after an absence of voltage test is performed.

110.7 Portable Cord- and-Plug-Connected Electric Equipment.

This section applies to the use of cord- and plug-connected equipment, including cord- and plug-connected test instruments and cord sets (extension cords).

(A) Handling and Storage.

Portable equipment shall be handled and stored in a manner that will not cause damage. Flexible electric cords connected to equipment shall not be used for raising or lowering the equipment. Flexible cords shall not be fastened with staples or hung in such a fashion as could damage the outer jacket or insulation.

(B) Grounding-Type Equipment.

(a) A flexible cord used with grounding-type utilization equipment shall contain an equipment grounding conductor.

(b) Attachment plugs and receptacles shall not be connected or altered in a manner that would interrupt continuity of the equipment grounding conductor. Additionally, these devices shall not be altered in order to allow use in a manner that was not intended by the manufacturer.

(c) Adapters that interrupt the continuity of the equipment grounding conductor shall not be used.

(C) Visual Inspection and Repair of Portable Cord- and Plug-Connected Equipment and Flexible Cord Sets.

(a) *Frequency of Inspection.* Before each use, portable cord- and plug-connected equipment shall be visually inspected for external defects (such as loose parts or deformed and missing pins) and for evidence of possible internal damage (such as a pinched or crushed outer jacket).

Exception: Stationary cord- and plug-connected equipment that remain connected once they are put in place and are installed such that the cord and plug are not subject to physical damage during normal use shall not be required to be visually inspected until they are relocated or repaired.

(b) *Defective Equipment.* 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 necessary to render the equipment safe has done so.

(c) *Proper Mating.* When an attachment plug is to be connected to a receptacle, the relationship of the plug and receptacle contacts shall first be checked to ensure that they are of mating configurations.

(D) Conductive or Wet Work Locations.

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.

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.

(E) Connecting Attachment Plugs.

(a) Employees' hands shall not be wet when plugging and unplugging flexible cords and cord- and plug-connected equipment if energized equipment is involved.

(b) Energized plug and receptacle connections shall be handled only with insulating protective equipment if the condition of the connection could provide a conductive path to the employee's hand (e.g, if a cord connector is wet from being immersed in water).

(c) Locking-type connectors shall be secured after connection.

(F) Manufacturer's Instructions.

Portable equipment shall be used in accordance with the manufacturer's instructions and safety warnings.

110.8 Ground-Fault Circuit-Interrupter (GFCI) Protection.

(A) General.

Employees shall be provided with listed ground-fault circuit-interrupter (GFCI) protective devices where required by applicable state, federal, or local codes and standards. Listed cord sets or devices incorporating listed GFCI protection for personnel identified for portable use shall be permitted.

(B) Additional Circumstances Requiring GFCI Protection.

(1) 120-Volt Cord Circuits.

Cord sets (extension cords) and cord- and plug-connected tools used for maintenance 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.

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) Testing Ground-Fault Circuit-Interrupter Protection Devices.

GFCI protection devices shall be tested in accordance with the manufacturer's instructions.

110.9 Overcurrent Protection Modification.

Overcurrent protection of circuits and conductors shall not be modified, even on a temporary basis, beyond what is permitted by applicable portions of electrical codes and standards dealing with overcurrent protection.

Informational Note: See Article 240 of *NFPA 70*, *National Electrical Code*, for further information concerning electrical codes and standards dealing with overcurrent protection.

110.10 Equipment Use.

Equipment shall be used in accordance with the manufacturer's instructions.

Article 120 Establishing an Electrically Safe Work Condition

120.1 Scope.

This article covers requirements for establishing an electrically safe work condition.

120.2 Lockout/Tagout Program.

(A) General.

Each employer shall establish, document, and implement a lockout/tagout program. The lockout/tagout program shall specify lockout/tagout procedures to safeguard workers from exposure to electrical hazards. The lockout/tagout program and procedures shall also incorporate the following:

(1) Be applicable to the experience and training of the workers and conditions in the workplace

(2) Meet the requirements of 120.2 through 120.6

(3) Apply to fixed, permanently installed equipment, temporarily installed equipment, and portable equipment

(B) Employer Responsibilities.

The employer shall be responsible for the following:

(1) Providing the equipment necessary to execute lockout/tagout procedures

(2) Providing lockout/tagout training to workers in accordance with 110.4(B)

(3) Auditing the lockout/tagout program in accordance with 110.3(L)(4)

(4) Auditing execution of the lockout/tagout procedures in accordance with 110.3(L)(4)

Informational Note: See Informative Annex G for an example of a lockout/tagout program.

120.3 Lockout/Tagout Principles.

(A) Employee Involvement.

Each person who could be exposed directly or indirectly to a source of electrical energy shall be involved in the lockout/tagout procedure.

Informational Note: An example of direct exposure is the qualified electrician who works on the motor starter control, the power circuits, or the motor. An example of indirect exposure is the person who works on the coupling between the motor and compressor.

(B) Lockout/Tagout Procedure.

A lockout/tagout procedure shall be developed on the basis of the existing electrical equipment and system and shall use suitable documentation including up-to-date drawings and diagrams. The procedure shall meet the requirements of applicable codes, standards, and regulations for lockout and tagging of electrical sources.

(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.

(D) Electrical Circuit Interlocks.

Documentation, including up-to-date drawings and diagrams, shall be reviewed to ensure that no electrical circuit interlock operation can result in re-energizing the circuit being worked on.

(E) Control Devices.

Locks/tags shall be installed only on circuit disconnecting means. Control devices, such as push-buttons or selector switches, shall not be used as the primary isolating device.

(F) Identification.

The lockout/tagout device shall be unique and readily identifiable as a lockout/tagout device.

(G) Coordination.

The following items are necessary for coordinating the lockout/tagout procedure:

(1) The electrical lockout/tagout procedure shall be coordinated with all other employer's procedures for control of exposure to electrical energy sources such that all employer's procedural requirements are adequately addressed on a site basis.

(2) The procedure for control of exposure to electrical hazards shall be coordinated with other procedures for control of other hazardous energy based on similar or identical concepts.

(3) Electrical lockout/tagout devices shall be permitted to be similar to lockout/tagout devices for control of other hazardous energy sources, such as pneumatic, hydraulic, thermal, and mechanical, if such devices are used only for control of hazardous energy and for no other purpose.

(H) Forms of Control of Hazardous Electrical Energy.

Two forms of hazardous electrical energy control shall be permitted: simple lockout/tagout and complex lockout/tagout *[see 120.5]*. For the simple lockout/tagout, the qualified person shall be in charge. For the complex lockout/tagout, the person in charge shall have overall responsibility.

120.4 Lockout/Tagout Equipment.

(A) Lock Application.

Energy isolation devices for machinery or equipment installed after January 2, 1990, shall be capable of accepting a lockout device.

(B) Lockout/Tagout Device.

Each employer shall supply, and employees shall use, lockout/tagout devices and equipment necessary to execute the requirements of 120.4. Locks and tags used for control of exposure to electrical hazards shall be unique, shall be readily identifiable as lockout/tagout devices, and shall be used for no other purpose.

(C) Lockout Device.

The lockout device shall meet the following requirements:

(1) A lockout device shall include a lock — either keyed or combination.

(2) The lockout device shall include a method of identifying the individual who installed the lockout device.

(3) A lockout device shall be permitted to be only a lock, if the lock is readily identifiable as a lockout device, in addition to having a means of identifying the person who installed the lock, provided that all of the following conditions exist:

(4) Only one circuit or piece of equipment is de-energized.

(5) The lockout period does not extend beyond the work shift.

(6) Employees exposed to the hazards associated with re-energizing the circuit or equipment are familiar with this procedure.

(7) Lockout devices shall be attached to prevent operation of the disconnecting means without resorting to undue force or the use of tools.

(8) Where a tag is used in conjunction with a lockout device, the tag shall contain a statement prohibiting unauthorized operation of the disconnecting means or unauthorized removal of the device.

(9) Lockout devices shall be suitable for the environment and for the duration of the lockout.

(10) Whether keyed or combination locks are used, the key or combination shall remain in the possession of the individual installing the lock or the person in charge, when provided by the established procedure.

(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 comply with the following:

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

(5) Be nonreusable, attachable by hand, self-locking, and nonreleasable cable tie

(6) Be suitable for the environment where used

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

(8) 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.

120.5 Lockout/Tagout Procedures.

The employer shall maintain a copy of the procedures required by this section and shall make the procedures available to all employees.

(A) Planning.

The procedure shall require planning, including the requirements of 120.5(A)(1) through 120.5(B)(14).

(1) Locating Sources.

Up-to-date single-line drawings shall be considered a primary reference source for such information. When up-to-date drawings are not available, the employer shall be responsible for ensuring that an equally effective means of locating all sources of energy is employed.

Informational Note: Locating sources of supply could include identifying situations where a neutral conductor continues to carry current after phase conductors have been de-energized.

(2) Exposed Persons.

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.

(3) Person in Charge.

The plan shall identify the person in charge and his or her responsibility in the lockout/tagout.

(4) Simple Lockout/Tagout Procedure.

All lockout/tagout procedures that involve only a qualified person(s) de-energizing one set of conductors or circuit part source for the sole purpose of safeguarding employees from exposure to electrical hazards shall be considered to be a simple lockout/tagout. Simple lockout/tagout procedures shall not be required to be written for each application. Each worker shall be responsible for his or her own lockout/tagout.

Exception: Lockout/tagout is not 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.

(5) Complex Lockout/Tagout.

(a) A complex lockout/tagout procedure shall be permitted where one or more of the following exists:

(2) Multiple energy source

(3) Multiple crews

(4) Multiple crafts

(5) Multiple locations

(6) Multiple employers

(7) Multiple disconnecting means

(8) Particular sequences

(9) Job or task that continues for more than one work period

(j) All complex lockout/tagout procedures shall require a written plan of execution that identifies the person in charge.

(k) The complex lockout/tagout 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. The person in charge shall be held accountable for safe execution of the complex lockout/tagout.

(l) Each authorized employee shall affix a personal lockout or tagout device to the group lockout device, group lockbox, or comparable mechanism when he or she begins work and shall remove those devices when he or she stops working on the machine or equipment being serviced or maintained.

(m) All complex lockout/tagout plans shall identify the method to account for all persons who might be exposed to electrical hazards in the course of the lockout/tagout.

(B) Elements of Control.

The procedure shall identify elements of control.

(1) De-energizing Equipment (Shutdown).

The procedure shall establish the person who performs the switching and where and how to de-energize the load.

(2) Stored Energy.

The procedure shall include requirements for releasing stored electric or mechanical energy that might endanger personnel. All capacitors shall be discharged, and high-capacitance elements shall also be short-circuited and grounded before the associated equipment is touched or worked on. Springs shall be released or physical restraint shall be applied when necessary to immobilize mechanical equipment and pneumatic and hydraulic pressure reservoirs. Other sources of stored energy shall be blocked or otherwise relieved to the extent that the circuit cannot be unintentionally energized.

Informational Note: See 320.3, 320.5, and Informative Annex R for more information on methods and procedures to place capacitors in an electrically safe work condition.

(3) Disconnecting Means.

The procedure shall identify how to verify that the circuit is de-energized (open).

(4) Responsibility.

The procedure shall identify the person who is responsible for verifying that the lockout/tagout procedure is implemented and who is responsible for ensuring that the task is completed prior to removing locks/tags. A mechanism to accomplish lockout/tagout for multiple (complex) jobs/tasks where required, including the person responsible for coordination, shall be included.

(5) Verification.

The procedure shall verify that equipment cannot be restarted. The equipment operating controls, such as push-buttons, selector switches, and electrical interlocks, shall be operated or otherwise it shall be verified that the equipment cannot be restarted.

(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 exposed conductor or circuit parts within the defined boundary of the work area

(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

(7) Temporary Protective Grounding.

(a) 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) 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.

(8) Shift Change.

A method shall be identified in the procedure to transfer responsibility for lockout/tagout to another person or to the person in charge when the job or task extends beyond one shift.

(9) Coordination.

The procedure shall establish how coordination is accomplished with other jobs or tasks in progress, including related jobs or tasks at remote locations as well as the person responsible for coordination.

(10) Accountability for Personnel.

A method shall be identified in the procedure to account for all persons who could be exposed to hazardous energy during the lockout/tagout.

(11) Lockout/Tagout Application.

The procedure shall clearly identify when and where lockout applies, in addition to when and where tagout applies, and shall address the following:

(1) Lockout shall be defined as installing a lockout device on all sources of hazardous energy such that operation of the disconnecting means is prohibited, and forcible removal of the lock is required to operate the disconnecting means.

(2) Tagout shall be defined as installing a tagout device on all sources of hazardous energy, such that operation of the disconnecting means is prohibited. The tagout device shall be installed in the same position available for the lockout device.

(3) Where it is not possible to attach a lock to existing disconnecting means, the disconnecting means shall not be used as the only means to put the circuit in an electrically safe work condition.

(4) The use of tagout procedures without a lock shall be permitted only in cases where equipment design precludes the installation of a lock on an energy isolation device(s). When tagout is employed, at least one additional safety measure shall be employed. In such cases, the procedure shall clearly establish responsibilities and accountability for each person who might be exposed to electrical hazards.

> Informational Note: Examples of additional safety measures include the removal of an isolating circuit element such as fuses, blocking of the controlling switch, or opening an extra disconnecting device to reduce the likelihood of inadvertent energization.

(12) Removal of Lockout/Tagout Devices.

The procedure shall identify the details for removing locks or tags when the installing individual is unavailable. When locks or tags are removed by someone other than the installer, the employer shall attempt to locate that person prior to removing the lock or tag. When the lock or tag is removed because the installer is unavailable, the installer shall be informed prior to returning to work.

(13) Release for Return to Service.

The procedure shall identify steps to be taken when the job or task requiring lockout/tagout is completed. Before electric circuits or equipment are re-energized, tests and visual inspections shall be conducted to verify that all tools, mechanical restraints and electrical jumpers, short circuits, and temporary protective grounding equipment have been removed, so that the circuits and equipment are in a condition to be safely energized. When applicable, the employees responsible for operating the machines or process shall be notified when circuits and equipment are ready to be energized, and such employees shall provide assistance as necessary to safely energize the circuits and equipment. The procedure shall contain a statement requiring the area to be inspected to ensure that nonessential items have been removed. One such step shall ensure that all personnel are clear of exposure to dangerous conditions resulting from re-energizing the service and that blocked mechanical equipment or grounded equipment is cleared and prepared for return to service.

(14) Temporary Release for Testing/Positioning.

The procedure shall clearly identify the steps and qualified persons' responsibilities when the job or task requiring lockout/tagout is to be interrupted temporarily for testing or positioning of equipment; then the steps shall be identical to the steps for return to service.

Informational Note: See 110.6 for requirements when using test instruments and equipment.

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. 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. Before and after 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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Article 130 Work Involving Electrical Hazards

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.

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.

(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.

(2) Additional Person.

If an energized electrical work permit is required in accordance with 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.

130.3 Energized Electrical Work Permit.

(A) When Required.

When work is performed as permitted in accordance with 110.2(B), an energized electrical work permit shall be required and documented under any of the following conditions:

(1) When work is performed within the restricted approach boundary

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

(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)]*

(6) Voltage to which personnel will be exposed

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

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

(9) 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)]*

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

(11) Incident energy at the working distance or arc flash PPE category *[see 130.5(F)]*

(12) 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)]*

(13) Arc flash boundary *[see 130.5(E)]*

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

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

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

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

(C) Exemptions to Work Permit.

Electrical work shall be permitted without an energized electrical work permit if a qualified person is provided with and uses appropriate safe work practices and PPE in accordance with Chapter 1 under any of the following conditions:

(1) Testing, troubleshooting, or voltage measuring

(2) Thermography, ultrasound, or visual inspections if the restricted approach boundary is not crossed

(3) Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed

(4) General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed

130.4 Electric Shock Risk Assessment.

(A) General.

An electric shock risk assessment shall be performed:

(1) To identify electric shock hazards

(2) To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health

(3) To determine if additional protective measures are required

(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 shall take into consideration all of the following:

(1) The design of the electrical equipment

(2) The electrical equipment operating condition and the condition of maintenance

(C) Additional Protective Measures.

(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

(D) Documentation.

The results of the electric shock risk assessment shall be documented.

(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 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 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).

(F) Limited Approach Boundary.

(1) Approach by Unqualified Persons.

Unless permitted by 130.4(F)(3), no unqualified person shall be permitted to approach nearer than the limited approach boundary of energized conductors and circuit parts.

(2) Working at or Close to the Limited Approach Boundary.

Where one or more unqualified persons are working at or close to the limited approach boundary, the alerting methods in 130.8(O) shall be applied to warn the unqualified person(s) of the electrical hazard and to stay outside of the limited approach boundary.

(3) Entering the Limited Approach Boundary.

The following shall apply where there is a need for an unqualified person(s) to cross the limited 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.

(G) Restricted Approach Boundary.

No qualified person shall approach or take any conductive object closer to exposed energized electrical conductors or circuit parts than the restricted approach boundary set forth in Table 130.4(E)(a) and Table 130.4(E)(b), unless one of the following conditions applies:

(1) The qualified person is insulated or guarded from energized electrical conductors or circuit parts operating at 50 volts or more. Insulating gloves and sleeves are considered insulation only with regard to the energized parts upon which work is performed.

(2) The energized electrical conductors or circuit parts are insulated from the qualified person and from any other conductive object at a different potential.

130.5 Arc Flash Risk Assessment.

(A) General.

An arc flash risk assessment shall be performed:

(1) To identify arc flash hazards

(2) To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health

(3) To determine if additional protective measures are required, including the use of PPE

(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

(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).

(C) Additional Protective Measures.

(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).	-	-
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

Task	Operating Condition[a]	Likelihood of Occurrence[b]
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 fault currents could result in higher incident energy. If the fault current increases without a decrease in the fault clearing time of the overcurrent protective device, the incident energy will increase. If the 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.

(D) Documentation.

The results of the arc flash risk assessment shall be documented.

(E) Arc Flash Boundary.

(1) Incident Energy Analysis Method.

The arc flash boundary shall be the distance at which the incident energy equals 1.2 cal/cm^2 (5 J/cm^2).

Informational Note: See Informative Annex D for information on estimating the arc flash boundary.

(2) Arc Flash PPE Category Method.

The arc flash boundary shall be permitted to be determined by Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) when the requirements of these tables apply.

(F) Arc Flash PPE Selection Methods.

(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.

(G) Incident Energy Analysis Method.

The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. Arc-rated clothing and other PPE shall be used by the employee based on the incident energy exposure associated with the specific task. Recognizing that incident energy increases as the distance from the arc flash decreases, additional PPE shall be used for any parts of the body that are closer than the working distance at which the incident energy was determined.

The incident energy analysis shall take into consideration the characteristics of the overcurrent protective device and its fault clearing time, including its condition of maintenance.

The incident energy analysis shall be updated when changes occur in the electrical distribution system that could affect the results of the analysis. The incident energy analysis shall also be reviewed for accuracy at intervals not to exceed 5 years.

> Informational Note: Changes that could affect the results of the incident energy analysis include changes made by utilities or other entities, such as transformer sizing, as well as modifications to protective devices or changes to protective settings.

Table 130.5(G) identifies arc-rated clothing and other PPE requirements and shall be permitted to be used with the incident energy analysis method of selecting arc flash PPE.

> Informational Note No. 1: See Informative Annex D for information on estimating the incident energy.
>
> Informational Note No. 2: See Informative Annex H for information on selection of arc-rated clothing and other PPE.

Table 130.5(G) Selection of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method Is Used

Incident energy exposures equal to 1.2 cal/cm^2 up to and including 12 cal/cm^2
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Arc-rated long-sleeve shirt and pants or arc-rated coverall or arc flash suit (SR)
Arc-rated face shield and arc-rated balaclava or arc flash suit hood (SR)[b]
Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner, high-visibility apparel) (AN)[e]
Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[c]
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear[d]
Incident energy exposures greater than 12 cal/cm^2
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy[a]
Arc-rated long-sleeve shirt and pants or arc-rated coverall or arc flash suit (SR)
Arc-rated arc flash suit hood
Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner, high-visibility apparel) (AN)[e]
Arc-rated gloves or rubber insulating gloves with protectors (SR)[c]
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear[d]

SR: Selection of one in group is required.

AN: As needed.

[a]Arc ratings can be for a single layer, such as an arc-rated shirt and pants or a coverall, or for an arc flash suit or a multi-layer system if tested as a combination consisting of an arc-rated shirt and pants, coverall, and arc flash suit.

[b]Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area are required by 130.7(C)(10)(c). Where the back of the head is inside the arc flash boundary, a balaclava or an arc flash hood shall be required for full head and neck protection.

[c]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.

[d]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.

[e]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.

(H) Equipment Labeling.

Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be marked with a label containing all the following information:

(1) Nominal system voltage

(2) Arc flash boundary

(3) At least one of the following:

(4) Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b) for the equipment, but not both

(5) Minimum arc rating of clothing

(6) Site-specific level of PPE

Exception No. 1: Unless changes in electrical distribution system(s) render the label inaccurate, labels applied prior to the effective date of this edition of the standard shall be acceptable if they complied with the requirements for equipment labeling in the standard in effect at the time the labels were applied.

Exception No. 2: In supervised industrial installations where conditions of maintenance and engineering supervision ensure that only qualified persons monitor and service the system, the information required in 130.5(H)(1) through 130.5(H)(3) shall be permitted to be documented in a manner that is readily available to persons likely to perform examination, servicing, maintenance, and operation of the equipment while energized.

The method of calculating and the data to support the information for the label shall be documented. The data shall be reviewed for accuracy at intervals not to exceed 5 years. Where the review of the data identifies a change that renders the label inaccurate, the label shall be updated.

The label shall be of sufficient durability to withstand the environment involved.

The owner of the electrical equipment shall be responsible for the documentation, installation, and maintenance of the marked label.

130.7 Personal and Other Protective Equipment.

(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.

(B) Care of Equipment.

Protective equipment shall 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)(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 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.

(C) Personal Protective Equipment (PPE).

(1) General.

When an employee is working within the restricted approach boundary, the worker shall wear PPE in accordance with 130.4. When an employee is working within the arc flash boundary, he or she shall wear protective clothing and other PPE in accordance with 130.5. All parts of the body inside the arc flash boundary shall be protected.

Informational Note: Where the estimated incident energy exposure is greater than the arc rating of commercially available arc-rated PPE, then for the purpose of testing for the absence of voltage, the following examples of risk reduction methods could be used to reduce the likelihood of occurrence of an arcing event or the severity of exposure:

(1) Use of noncontact capacitive test instrument(s) or a permanently installed metering device(s) in the equipment for indication, before using a contact-type test instrument to test for the absence of voltage.

(2) If equipment design allows, observe visible gaps between the equipment conductors and circuit parts and the electrical source(s) of supply.

(3) Increase the working distance.

(4) Consider system design options to reduce the incident energy level.

(2) Movement and Visibility.

When arc-rated clothing is worn to protect an employee, it shall cover all ignitible clothing and shall allow for movement and visibility.

(3) Head, Face, Neck, and Chin (Head Area) Protection.

Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with energized electrical conductors or circuit parts or from flying objects resulting from electrical explosion. Employees shall wear nonconductive protective equipment for the face, neck, and chin whenever there is a danger of injury from exposure to electric arcs or flashes or from flying objects resulting from electrical explosion. If employees use hairnets or beard nets, or both, these items shall be arc rated.

Informational Note: See 130.7(C)(10)(b) and 130.7(C)(10)(c) for arc flash protective requirements.

(4) Eye Protection.

Employees shall wear protective equipment for the eyes whenever there is danger of injury from electric arcs, flashes, or from flying objects resulting from electrical explosion.

(5) Hearing Protection.

Employees inside the arc flash boundary shall wear hearing protection.

(6) Body Protection.

Employees shall wear arc-rated clothing wherever there is possible exposure to incident energy of 1.2 cal/cm^2 (5 J/cm^2).

(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:

(2) There shall be no activity performed that risks cutting or damaging the glove.

(3) The rubber insulating gloves shall be electrically retested before reuse.

(4) 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.

(e) *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).

(f) *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).

(g) *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).

(h) *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.

(8) Foot Protection.

Where insulated footwear is used as protection against step and touch potential, dielectric footwear shall be required. Insulated soles shall not be used as primary electrical protection.

Informational Note: Electrical hazard (EH) footwear can provide a secondary source of electric shock protection under dry conditions.

(9) Factors in Selection of Protective Clothing.

Clothing and equipment that provide worker protection from electric shock and arc flash hazards shall be used. If arc-rated clothing is required, it shall cover associated parts of the body as well as all flammable apparel while allowing movement and visibility.

Clothing and equipment required for the degree of exposure shall be permitted to be worn alone or integrated with flammable, nonmelting apparel. Garments that are not arc rated shall not be permitted to be used to increase the arc rating of a garment or of a clothing system.

Informational Note: Protective clothing includes shirts, pants, coveralls, jackets, and parkas worn routinely by workers who, under normal working conditions, are exposed to momentary electric arc and related thermal hazards. Arc-rated rainwear worn in inclement weather is included in this category of clothing.

(a) *Layering.* Nonmelting, flammable fiber garments shall be permitted to be used as underlayers in conjunction with arc-rated garments in a layered system. If nonmelting, flammable fiber garments are used as underlayers, the system arc rating shall be sufficient to prevent breakopen of the innermost arc-rated layer at the expected arc exposure incident energy level to prevent ignition of flammable underlayers. Garments that are not arc rated shall not be permitted to be used to increase the arc rating of a garment or of a clothing system.

Informational Note: A typical layering system might include cotton underwear, a cotton shirt and trouser, and an arc-rated coverall. Specific tasks might call for additional arc-rated layers to achieve the required protection level.

(b) *Outer Layers.* Garments worn as outer layers over arc-rated clothing, such as jackets, high-visibility apparel, or rainwear, shall also be made from arc-rated material. 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.

(c) *Underlayers.* Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric underlayers.

Exception: An incidental amount of elastic used on nonmelting fabric underwear or socks shall be permitted.

Informational Note No. 1: Arc-rated garments (e.g., shirts, trousers, and coveralls) worn as underlayers that neither ignite nor melt and drip in the course of an exposure to electric arc and related thermal hazards generally provide a higher system arc rating than nonmelting, flammable fiber underlayers.

Informational Note No. 2: Arc-rated underwear or undergarments used as underlayers generally provide a higher system arc rating than nonmelting, flammable fiber underwear or undergarments used as underlayers.

(d) *Coverage.* Clothing shall cover potentially exposed areas as completely as possible. Shirt and coverall sleeves shall be fastened at the wrists, shirts shall be tucked into pants, and shirts, coveralls, and jackets shall be closed at the neck.

(e) *Fit.* Tight-fitting clothing shall be avoided. Loose-fitting clothing provides additional thermal insulation because of air spaces. Arc-rated apparel shall fit properly such that it does not interfere with the work task.

(f) *Interference.* The garment selected shall result in the least interference with the task but still provide the necessary protection. The work method, location, and task could influence the protective equipment selected.

(10) Arc Flash Protective Equipment.

(a) *Arc Flash Suits.* 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:

(3) 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.

(4) An arc-rated hood shall be used when the anticipated incident energy exposure exceeds 12 cal/cm^2 (50.2 J/cm^2).

(e) *Face Protection.* Face protection shall meet the following requirements:

(6) Face shields shall have an arc rating suitable for the arc flash exposure.

(7) Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area shall be used.

(8) Face shields without an arc rating shall not be used.

(9) 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.

(j) *Hand Protection.* Hand protection shall meet the following requirements:

(11) 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).

(12) 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.

(m) *Foot Protection.* 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.

(11) Clothing Material Characteristics.

Arc-rated clothing shall meet the requirements described in 130.7(C)(12) and 130.7(C)(14).

Informational Note No. 1: Arc-rated materials, such as flame-retardant-treated cotton, meta-aramid, para-aramid, and poly-benzimidazole (PBI) fibers, provide thermal protection. These materials can ignite but will not continue to burn after the ignition source is removed. Arc-rated fabrics can reduce burn injuries during an arc flash exposure by providing a thermal barrier between the arc flash and the wearer.

Informational Note No. 2: Non-arc-rated cotton, polyester-cotton blends, nylon, nylon-cotton blends, silk, rayon, and wool fabrics are flammable. Fabrics, zipper tapes, and findings made of these materials can ignite and continue to burn on the body, resulting in serious burn injuries.

Informational Note No. 3: Rayon is a cellulose-based (wood pulp) synthetic fiber that is a flammable but nonmelting material.

Clothing consisting of fabrics, zipper tapes, and findings made from flammable synthetic materials that melt at temperatures below 315°C (600°F), such as acetate, acrylic, nylon, polyester, polyethylene, polypropylene, and spandex, either alone or in blends, shall not be used.

Informational Note: These materials melt as a result of arc flash exposure conditions, form intimate contact with the skin, and aggravate the burn injury.

Exception: Fiber blends that contain materials that melt, such as acetate, acrylic, nylon, polyester, polyethylene, polypropylene, and spandex, shall be permitted if such blends in fabrics are arc rated and do not exhibit evidence of melting and dripping during arc testing.

Informational Note: See ASTM F1959/F1959M, *Standard Test Method for Determining the Arc Rating of Materials for Clothing*, and ASTM F1506, *Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs*, for information on test methods used to determine the arc rating of fabrics.

(12) Clothing and Other Apparel Not Permitted.

Clothing and other apparel (such as hard hat liners and hair nets) made from materials that do not meet the requirements of 130.7(C)(11) regarding melting or made from materials that do not meet the flammability requirements shall not be permitted to be worn.

Informational Note: Some flame-resistant fabrics, such as non-flame-resistant modacrylic and nondurable flame-retardant treatments of cotton, are not recommended for industrial electrical or utility applications.

Exception No. 1: Nonmelting, flammable (non-arc-rated) materials shall be permitted to be used as underlayers to arc-rated clothing, as described in 130.7(C)(11).

Exception No. 2: Where the work to be performed inside the arc flash boundary exposes the worker to multiple hazards, such as airborne contaminants, and the risk assessment identifies that the level of protection is adequate to address the arc flash hazard, non-arc-rated PPE shall be permitted.

(13) Care and Maintenance of Arc-Rated Clothing and Arc-Rated Arc Flash Suits.

(a) *Inspection.* Arc-rated apparel shall be inspected before each use. Work clothing or arc flash suits that are contaminated or damaged to the extent that their protective qualities are impaired shall not be used. Protective items that become contaminated with grease, oil, or flammable liquids or combustible materials shall not be used.

(b) *Manufacturer's Instructions.* The garment manufacturer's instructions for care and maintenance of arc-rated apparel shall be followed.

(c) *Storage.* Arc-rated apparel shall be stored in a manner that prevents physical damage; damage from moisture, dust, or other deteriorating agents; or contamination from flammable or combustible materials.

(d) *Cleaning, Repairing, and Affixing Items.* When arc-rated clothing is cleaned, manufacturer's instructions shall be followed. When arc-rated clothing is repaired, the same arc-rated materials used to manufacture the arc-rated clothing shall be used to provide repairs.

Informational Note No. 1: The purpose of following manufacturer's instructions is to avoid the loss of protection and to remove contaminants such as hydrocarbons and metallic and disease-causing contaminants that could compromise safety.

Informational Note No. 2: See ASTM F1506, *Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs*, for additional guidance when trim, name tags, logos, or any combination thereof are affixed to arc-rated clothing.

Informational Note No. 3: See ASTM F1449, *Standard Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing*, and ASTM F2757, *Standard Guide for Home Laundering Care and Maintenance of Flame, Thermal, and Arc Resistant Clothing*, for additional guidance.

(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 arc-rated PPE shall be listed.

Informational Note No. 1: See 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:

(4) Name of manufacturer

(5) Conformity assessment method used

(6) Product performance standards to which the product conforms

(7) Arc rating where appropriate for the equipment

(8) One or more identifiers such as model, serial number, lot number, or traceability code

(9) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	

Subject	Document Title	Document Number
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

(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.* Alternating-current (ac) equipment shall meet the following requirements:

(2) 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) .

(3) An incident energy analysis shall be required in accordance with 130.5(G) for the following:

(4) Power systems with greater than the estimated maximum available fault current

(5) Power systems with longer than the maximum fault clearing times

(6) Less than the minimum working distance

(g) *Direct-Current (dc) Equipment.* Direct-current (dc) equipment shall meet the following requirements:

(8) 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) .

(9) An incident energy analysis shall be required in accordance with 130.5(G) for the following:

(10) Power systems with greater than the estimated maximum available fault current

(11) Power systems with longer than the maximum arc duration

(12) Less than the minimum working distance

(m) *Protective Clothing and Personal Protective Equipment (PPE).* Protective clothing and PPE shall meet the following requirements:

(14) 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.

(15) This clothing and equipment shall be used when working within the arc flash boundary.

(16) 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 ac Systems

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 volts and below	1	485 mm (19 in.)
Parameters: Available fault current not exceeding 25 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	-	-
Panelboards or other equipment rated greater than 240 volts and up to 600 volts	2	900 mm (3 ft)
Parameters: Available fault current not exceeding 25 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	-	-
600-volt class motor control centers (MCCs)	2	1.5 m (5 ft)
Parameters: Available fault current not exceeding 65 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	-	-
600-volt class motor control centers (MCCs)	4	4.3 m (14 ft)
Parameters: Available fault current not exceeding of 42 kA fault clearing time not exceeding 0.33 sec (20 cycles); 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)

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Parameters: 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: 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: 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: 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: 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: 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 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. 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, 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.

(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)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[e]
	-	Leather footwear[f] (AN)

Arc Flash PPE Category	PPE	
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)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[e]
	-	Leather footwear[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)[e]
	-	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Leather footwear[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 Flash PPE Category	PPE	
	Arc-rated arc flash suit pants (AR)	
	-	Arc-rated arc flash suit hood
	-	Arc-rated gloves or rubber insulating gloves with protectors (SR)[e]
	-	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Leather footwear[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.

[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.

[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.

[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.

[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.

(D) Other Protective Equipment.

(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.

Informational Note: See 130.4(E), Electric Shock Protection Boundaries.

(a) *Requirements for Insulated Tools.* The following requirements shall apply to insulated tools:

(2) Insulated tools shall be rated for the voltages on which they are used.

(3) Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.

(4) Insulated tools shall be protected from damage to the insulating material.

(5) Insulated tools and equipment shall be inspected prior to each use.

(6) 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).

(g) *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.

(h) *Ropes and Handlines.* Ropes and handlines used within the limited approach boundary shall be nonconductive.

(i) *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.

(j) *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.

(2) Barriers.

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.

(E) Standards for Other Protective Equipment.

Other protective equipment required in 130.7(D) shall conform to the 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 other protective equipment.

Table Informational Note 130.7(E) Standards on Other Protective Equipment

Subject	Document	Document Number
Arc Protective Blankets	Standard Test Method for Determining the Protective Performance of an Arc Protective Blanket for Electric Arc Hazards	ASTM F2676
Arc Protective Blankets — Selection, Care, and Use	Standard Guide for Selection, Care, and Use of Arc Protective Blankets	ASTM F3272
Blankets	Standard Specification for Rubber Insulating Blankets	ASTM D1048
Blankets — In-service Care	Standard Specification for In-Service Care of Insulating Blankets	ASTM F479
Covers	Standard Specification for Rubber Insulating Covers	ASTM D1049
Fiberglass Rods — Live Line Tools	Standard Specification for Fiberglass-Reinforced Plastic (FRP) Rod and Tube Used in Live Line Tools	ASTM F711
Insulated Hand Tools	Standard Specification for Insulated and Insulating Hand Tools	ASTM F1505
Ladders	American National Standard for Ladders — Wood — Safety Requirements	ANSI/ASC A14.1
	-	American National Standard for Ladders — Fixed — Safety Requirements ANSI/ASC A14.3
	-	American National Standard Safety Requirements for Job Made Wooden Ladders ANSI/ASC A14.4
	-	American National Standard for Ladders — Portable Reinforced Plastic — Safety Requirements ANSI/ASC A14.5
Line Hose	Standard Specification for Rubber Insulating Line Hoses	ASTM D1050

Subject	Document	Document Number	
Line Hose and Covers — In-service Care	Standard Specification for In-Service Care of Insulating Line Hose and Covers	ASTM F478	
Plastic Guard	Standard Test Methods and Specifications for Electrically Insulating Plastic Guard Equipment for Protection of Workers	ASTM F712	
Sheeting	Standard Specification for PVC Insulating Sheeting	ASTM F1742	
	-	Standard Specification for Rubber Insulating Sheeting	ASTM F2320
Safety Signs and Tags	Series of Standards for Safety Signs and Tags	ANSI Z535	
Shield Performance on Live Line Tool	Standard Test Method for Determining the Protective Performance of a Shield Attached on Live Line Tools or on Racking Rods for Electric Arc Hazards	ASTM F2522	
Temporary Protective Grounds — In-service Testing	Standard Specification for In-Service Test Methods for Temporary Grounding Jumper Assemblies Used on De-energized Electric Power Lines and Equipment	ASTM F2249	
Temporary Protective Grounds — Test Specification	Standard Specification for Temporary Protective Grounds to Be Used on De-energized Electric Power Lines and Equipment	ASTM F855	

130.8 Other Precautions.

(A) Alertness.

(1) Where Electrical Hazards Might Exist.

Employees shall be instructed to be alert at all times where electrical hazards might exist.

(2) When Impaired.

Employees shall not be permitted to work where electrical hazards exist while their alertness is recognizably impaired due to illness, fatigue, or other reasons.

(3) Changes in Scope.

Employees shall be instructed to be alert for changes in the job or task that could lead the person outside of the electrically safe work condition or expose the person to additional hazards that were not part of the original plan.

(B) Blind Reaching.

Employees shall be instructed not to reach blindly into areas that might contain exposed energized electrical conductors or circuit parts where an electrical hazard exists.

(C) Illumination.

(1) General.

Employees shall not enter spaces where electrical hazards exist unless illumination is provided that enables the employees to perform the work safely.

(2) Obstructed View of Work Area.

Where lack of illumination or an obstruction precludes observation of the work to be performed, employees shall not perform any task where an electrical hazard exists.

(D) Conductive Articles Being Worn.

Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear, or metal frame glasses) shall not be worn within the restricted approach boundary or where they present an electrical contact hazard with exposed energized electrical conductors or circuit parts.

(E) Conductive Materials, Tools, and Equipment Being Handled.

(1) General.

Conductive materials, tools, and equipment that are in contact with any part of an employee's body shall be handled in a manner that prevents unintentional contact with energized electrical conductors or circuit parts. Such materials and equipment shall include, but are not limited to, long conductive objects, such as ducts, pipes and tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, bull floats, and chains.

(2) Approach to Energized Electrical Conductors and Circuit Parts.

Means shall be employed to ensure that conductive materials approach exposed energized electrical conductors or circuit parts no closer than that permitted by 130.4(F).

(F) Confined or Enclosed Work Spaces.

When an employee works in a confined or enclosed space (such as a manhole or vault) where an electrical hazard exists, the employer shall provide, and the employee shall use, protective shields, protective barriers, or insulating materials as necessary to protect against electrical hazards.

(G) Doors and Hinged Panels.

Doors, hinged panels, and the like shall be secured to prevent their swinging into an employee and causing the employee to contact exposed energized electrical conductors or circuit parts where an electrical hazard exists if movement of the door, hinged panel, and the like is likely to create a hazard.

(H) Clear Spaces.

Working space required by other codes and standards shall not be used for storage. This space shall be kept clear to permit safe operation and maintenance of electrical equipment.

(I) Housekeeping Duties.

(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 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.

(J) Occasional Use of Flammable Materials.

Where flammable materials are present only occasionally, electric equipment capable of igniting them shall not be permitted to be used, unless measures are taken to prevent hazardous conditions from developing. Such materials shall include, but are not limited to, flammable gases, vapors, or liquids, combustible dust, and ignitible fibers or flyings.

Informational Note: See *NFPA 70*, *National Electrical Code*, for electrical installation requirements for locations where flammable materials are present on a regular basis.

(K) Anticipating Failure.

The following shall apply if there is evidence that electric equipment could fail and injure 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.

(L) Routine Opening and Closing of Circuits.

Load-rated switches, circuit breakers, or other devices specifically designed as disconnecting means shall be used for the opening, reversing, or closing of circuits under load conditions. Cable connectors not of the load-break type, fuses, terminal lugs, and cable splice connections shall not be permitted to be used for such purposes, except in an emergency.

(M) Reclosing Circuits After Protective Device Operation.

After a circuit is de-energized by the automatic operation of a circuit protective device, the circuit shall not be manually re-energized until a qualified person or persons determines the equipment and circuit can be safely energized. Manually reclosing circuit breakers or re-energizing circuits through replaced fuses shall be prohibited until the fault has been cleared.

Exception: When it is determined from the design of the circuit and the overcurrent devices involved that the automatic operation of a device was caused by an overload rather than a fault condition, examination of the circuit or connected equipment shall not be required before the circuit is re-energized.

(N) Safety Interlocks.

Only qualified persons following the requirements for working inside the restricted approach boundary as covered by 130.4(G) shall be permitted to defeat or bypass an electrical safety interlock over which the person has sole control, and then only temporarily while the qualified person is working on the equipment. The safety interlock system shall be returned to its operable condition when the work is completed.

(O) Alerting Techniques.

(1) Safety Signs and Tags.

Safety signs, safety symbols, or tags shall be used where necessary to warn employees about electrical hazards that might endanger them. Such signs and tags shall meet the requirements of applicable state, federal, or local codes and standards.

Informational Note No. 1: Safety signs, tags, and barricades used to identify energized “look-alike” equipment can be employed as an additional preventive measure.

Informational Note No. 2: See Table Informational Note 130.7(E), for a list of examples of standards that contain information on safety signs and tags.

(2) Barricades.

Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas containing energized conductors or circuit parts. Conductive barricades shall not be used where it might increase the likelihood of exposure to an electrical hazard. Barricades shall be placed no closer than the limited approach boundary given in Table 130.4(E)(a) and Table 130.4(E)(b). Where the arc flash boundary is greater than the limited approach boundary, barricades shall not be placed closer than the arc flash boundary.

(3) Attendants.

If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees. The primary duty and responsibility of an attendant providing manual signaling and alerting shall be to keep unqualified employees outside a work area where the unqualified employee might be exposed to electrical hazards. An attendant shall remain in the area as long as there is a potential for employees to be exposed to the electrical hazards.

(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) shall be employed to prevent the employee from entering look-alike equipment.

130.9 Work Within the Limited Approach Boundary or Arc Flash Boundary of Overhead Lines.

(A) Uninsulated and Energized.

Where work is performed in locations containing uninsulated energized overhead lines that are not guarded or isolated, precautions shall be taken to prevent employees from contacting such lines directly with any unguarded parts of their body or indirectly through conductive materials, tools, or equipment. Where the work to be performed is such that contact with uninsulated energized overhead lines is possible, the lines shall be de-energized and visibly grounded at the point of work or suitably guarded.

(B) Determination of Insulation Rating.

A qualified person shall determine if the overhead electrical lines are insulated for the lines' operating voltage.

(C) De-energizing or Guarding.

If the lines are to be de-energized, arrangements shall be made with the person or organization that operates or controls the lines to de-energize them and visibly ground them at the point of work. If arrangements are made to use protective measures, such as guarding, isolating, or insulation, these precautions shall prevent each employee from contacting such lines directly with any part of his or her body or indirectly through conductive materials, tools, or equipment.

(D) Employer and Employee Responsibility.

The employer and employee shall be responsible for ensuring that guards or protective measures are satisfactory for the conditions. Employees shall comply with established work methods and the use of protective equipment.

(E) Approach Distances for Unqualified Persons.

When unqualified persons are working on the ground or in an elevated position near overhead lines, the location shall be such that the employee and the longest conductive object the employee might contact do not come closer to any unguarded, energized overhead power line than the limited approach boundary in Table 130.4(E)(a), column 2 or Table 130.4(E)(b), column 2.

Informational Note: Objects that are not insulated for the voltage involved should be considered to be conductive.

(F) Vehicular and Mechanical Equipment.

(1) Elevated Equipment.

Where any vehicle or mechanical equipment structure will be elevated near energized overhead lines, it shall be operated so that the limited approach boundary distance of Table 130.4(E)(a), column 2 or Table 130.4(E)(b), column 2, is maintained. However, under any of the following conditions, the clearances shall be permitted to be reduced:

(1) If the vehicle is in transit with its structure lowered, the limited approach boundary to overhead lines in Table 130.4(E)(a), column 2 or Table 130.4(E)(b), column 2, shall be permitted to be reduced by 1.83 m (6 ft). If insulated barriers, rated for the voltages involved, are installed and they are not part of an attachment to the vehicle, the clearance shall be permitted to be reduced to the design working dimensions of the insulating barrier.

(2) If the equipment is an aerial lift insulated for the voltage involved, and if the work is performed by a qualified person, the clearance (between the uninsulated portion of the aerial lift and the power line) shall be permitted to be reduced to the restricted approach boundary given in Table 130.4(E)(a), column 4 or Table 130.4(E)(b), column 4.

(2) Equipment Contact.

Employees standing on the ground shall not contact the vehicle or mechanical equipment or any of its attachments unless either of the following conditions apply:

(1) The employee is using protective equipment rated for the voltage.

(2) The equipment is located so that no uninsulated part of its structure (that portion of the structure that provides a conductive path to employees on the ground) can come closer to the line than permitted in 130.9(F)(1).

(3) Equipment Grounding.

If any vehicle or mechanical equipment is capable of having parts of its structure elevated within the limited approach boundary of exposed movable conductors of energized overhead lines and is intentionally grounded, employees working on the ground near the point of grounding shall not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades, dielectric overshoe footwear, or insulation, shall be taken to protect employees from hazardous ground potentials (step and touch potential).

Informational Note: Upon contact of the elevated structure with the energized lines, hazardous ground potentials can develop within a few feet or more outward from the grounded point.

130.10 Underground Electrical Lines and Equipment.

Before excavation starts where there exists a reasonable possibility of contacting electrical lines or equipment, the employer shall take the necessary steps to contact the appropriate owners or authorities to identify and mark the location of the electrical lines or equipment. When it has been determined that a reasonable possibility of contacting electrical lines or equipment exists, appropriate safe work practices and PPE shall be used during the excavation.

130.11 Cutting or Drilling.

Before cutting or drilling into equipment, floors, walls, or structural elements where a likelihood of contacting energized electrical lines or parts exists, the employer shall perform a risk assessment to do the following:

(1) Identify and mark the location of conductors, cables, raceways, or equipment

(2) Establish and verify an electrically safe work condition

(3) Identify safe work practices, risk control methods, additional protective measures, and any required electric shock or arc flash PPE

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: 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.

Statement of Problem and Substantiation for Public Comment

The terms Lockout, Lockout Device, Tagout, Tagout Device, Lockout/Tagout, Energy Isolating Device are used throughout Article 120, however these critical terms related to controlling hazardous energy are not defined in Article 100. Therefore, to align with OSHA regulations for controlling hazardous energy, pursuant to 29CFR1910.147, Subpart J, they need to be defined in 70E. I'm aware Subpart J mainly addresses non electrical hazardous energy but Subpart J points to 29CFR1910.333 Subpart S, which is LOTO for electricity. Many employers will only develop one procedure to control all forms of hazardous energy, so using definitions that they will be familiar with from 1910.147 added to 70E will aid them.

A new Informational Note No. 3 is needed following 110.2(B) Exception No. 1 to clarify what "Rated for the available fault current" is and is not. The offered example was derived from the NEC 110.24 which is title "Available Fault Current"

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 88-NFPA 70E-2025 [New Section after 120.6]	Related to LOTO

Related Item

• lockout tagout

Submitter Information Verification

Submitter Full Name: George Cole
Organization: Pvngs Aps
Affiliation: E-Hazard
Street Address:
City:
State:
Zip:

Submittal Date: Fri May 16 21:18:19 EDT 2025

Committee:	EEW-AAA

Public Comment No. 19-NFPA 70E-2025 [Article 100]

Article 100 Definitions

Scope. This article contains only those definitions essential to the 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.

Accessible (as applied to equipment).

Admitting close approach; not guarded by locked doors, elevation, or other effective means. [**70:**100]

Approved.

Acceptable to the authority having jurisdiction.

Arc Flash Suit.

A complete arc-rated clothing and equipment system that covers the entire body, except for the hands and feet.

Informational Note: An arc flash suit may include pants or overalls, a jacket or a coverall, and a beekeeper-type hood fitted with a face shield.

Arc Rating.

The value attributed to materials that describes their performance to exposure to an electrical arc discharge. The arc rating is expressed in cal/cm^2 and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakopen threshold (E_{BT}) (should a material system exhibit a breakopen response below the ATPV value). Arc rating is reported as either ATPV or E_{BT}, whichever is the lower value.

Informational Note No. 1: Arc-rated clothing or equipment indicates that it has been tested for exposure to an electric arc. Flame-resistant clothing without an arc rating has not been tested for exposure to an electric arc. All arc-rated clothing is also flame resistant.

Informational Note No. 2: See ASTM F1959/F1959M, *Standard Test Method for Determining the Arc Rating of Materials for Clothing*, which defines ATPV as the incident energy (cal/cm^2) on a material or a multilayer system of materials that results in a 50 percent probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a second degree skin burn injury based on the Stoll curve.

Informational Note No. 3: See ASTM F1959/F1959M, *Standard Test Method for Determining the Arc Rating of Materials for Clothing*, which defines E_{BT} as the incident energy (cal/cm^2) on a material or a material system that results in a 50 percent probability of breakopen. Breakopen is a material response evidenced by the formation of one or more holes of a defined size [an area of 1.6 cm^2 (0.5 in.^{2}) or an opening of 2.5 cm (1.0 in.) in any dimension] in the innermost layer of arc-rated material that would allow thermal energy to pass through the material.

Attachment Plug (Plug Cap) (Plug).

A device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle. [**70:**100]

Authority Having Jurisdiction (AHJ).

An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

> Informational Note: The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

Authorized Personnel.

The person in charge of the premises, or other persons appointed or selected by the person in charge of the premises who performs certain duties associated with stationary storage batteries. (320)

Automatic.

Performing a function without the necessity of human intervention.

Avoid Contact

Means taking the necessary actions, such as using PPE, placing adequately rated insulating materials over or guarding the exposed energized conductors or circuit parts, to reduce the risk and likelihood of making inadvertent contact.

Balaclava.

An arc-rated head-protective fabric that protects the neck and head except for a small portion of the facial area.

> Informational Note: Some balaclava designs protect the neck and head area except for the eyes while others leave the eyes and nose area unprotected.

Barricade.

A physical obstruction such as tapes, cones, or A-frame-type wood or metal structures intended to provide a warning and to limit access.

Barrier.

A physical obstruction that is intended to prevent contact with equipment or energized electrical conductors and circuit parts.

Battery.

A system consisting of two or more electrochemical cells connected in series or parallel and capable of storing electrical energy received and that can give it back by reconversion. (320)

Battery Effect.

A voltage that exists on the electrolytic cell line after the power supply is disconnected. (310)

> Informational Note: Electrolytic cells can exhibit characteristics similar to an electrical storage battery and an electric shock hazard could exist after the power supply is disconnected from the cell line.

Battery Room.

A room specifically intended for the installation of batteries that have no other protective enclosure. (320)

Bonded (Bonding).

Connected to establish electrical continuity and conductivity. [**70:**100]

Bonding Conductor or Jumper.

A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected. [**70:**100]

Boundary, Arc Flash. (Arc Flash Boundary)

When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm^2 (5 J/cm^2).

> Informational Note: According to the Stoll skin burn injury model, the onset of a second degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm^2 (5 J/cm^2) for one second.

Boundary, Hearing Protection. (Hearing Protection Boundary)

Worker distance at which a 1 percent probability of ear damage exists from a 20 kPa (3.0 psi) shock wave. (360)

Boundary, Limited Approach. (Limited Approach Boundary)

An approach limit at a distance from an exposed energized electrical conductor or circuit part within which an electric shock hazard exists.

Boundary, Lung Protection. (Lung Protection Boundary)

Worker distance at which a 1 percent probability of lung damage exists from a 70 kPa (10 psi) shock wave. (360)

Boundary, Restricted Approach. (Restricted Approach Boundary)

An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

Building.

A structure that stands alone or that is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors. [**70:**100]

Cabinet.

An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung. [**70:**100]

Cell.

The basic electrochemical unit, characterized by an anode and a cathode used to receive, store, and deliver electrical energy. (320)

Cell, Valve-Regulated Lead Acid (VRLA). (Valve-Regulated Lead Acid Cell)

A lead-acid cell that is sealed with the exception of a valve that opens to the atmosphere when the internal pressure in the cell exceeds atmospheric pressure by a pre-selected amount, and that provides a means for recombination of internally generated oxygen and the suppression of hydrogen gas evolution to limit water consumption. (320)

Cell, Vented. (Vented Cell)

A type of cell in which the products of electrolysis and evaporation are allowed to escape freely into the atmosphere as they are generated. (Also called "*flooded cell*.") (320)

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.

Charge Transfer.

Improper discharging of capacitor networks that results in transferring charge from one capacitor to another capacitor instead of fully discharging the stored energy. (360)

Circuit Breaker.

A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [**70:**100]

> Informational Note: The automatic opening means can be integral, direct acting with the circuit breaker, or remote from the circuit breaker.

Conductive.

Suitable for carrying electric current.

Conductor, Bare. (Bare Conductor)

A conductor having no covering or electrical insulation whatsoever. [**70:**100]

Conductor, Covered. (Covered Conductor)

A conductor encased within material of composition or thickness that is not recognized by *NFPA 70*, *National Electrical Code*, as electrical insulation. [**70:**100]

Conductor, Insulated. (Insulated Conductor)

A conductor encased within material of composition and thickness that is recognized by *NFPA 70*, *National Electrical Code*, as electrical insulation. [**70:**100]

Controller.

A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected. [**70:**100]

Current-Limiting Overcurrent Protective Device.

A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

Cutout.

An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

De-energized.

Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth.

Device.

A unit of an electrical system, other than a conductor, that carries or controls electric energy as its principal function. [**70:**100]

Dielectric Absorption.

The property of certain capacitors to recharge after being discharged. (360)

> Informational Note: A voltage recharge from 0.02 percent (polystyrene and polypropylene) up to 10 percent (some electrolytics) can occur a few minutes after the grounding or shorting device has been removed.

Discharge Time.

The time required to discharge a capacitor to below electrical hazard thresholds. (360)

Disconnecting Means.

A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [**70:**100]

Disconnecting (or Isolating) Switch (Disconnector, Isolator).

A mechanical switching device used for isolating a circuit or equipment from a source of power.

Dwelling Unit.

A single unit providing complete and independent living facilities for one or more persons, including permanent provisions for living, sleeping, cooking, and sanitation. [**70:**100]

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.

Electrical Safety Program.

A documented system consisting of electrical safety principles, policies, procedures, and processes that directs activities appropriate for the risk associated with electrical hazards.

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.

Electrolyte.

A solid, liquid, or aqueous immobilized liquid medium that provides the ion transport mechanism between the positive and negative electrodes of a cell. (320)

Enclosed.

Surrounded by a case, housing, fence, or wall(s) that prevents persons from unintentionally contacting energized parts.

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.

Energized.

Electrically connected to, or is, a source of voltage. [**70:**100]

Equipment.

A general term, including fittings, devices, appliances, luminaires, apparatus, machinery, and the like, used as a part of, or in connection with, an electrical installation. [**70:**100]

Equipment, Arc-Resistant. (Arc-Resistant Equipment)

Equipment designed to withstand the effects of an internal arcing fault and that directs the internally released energy away from the employee.

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.

Informational Note No. 2: See O.2.4(9) for information on arc-resistant equipment.

Exposed (as applied to energized electrical conductors or circuit parts).

Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated, or insulated.

Exposed (as applied to wiring methods).

On or attached to the surface or behind panels designed to allow access. [**70:**100]

Fault Current.

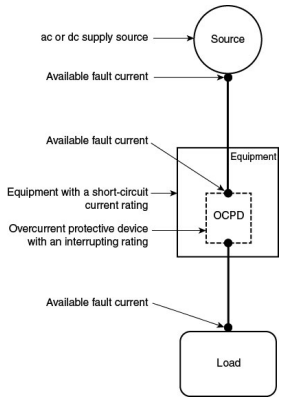
The amount of current delivered at a point on the system during a short-circuit condition.

Fault Current, Available. (Available Fault Current)

The largest amount of current capable of being delivered at a point on the system during a short-circuit condition.

Informational Note No. 1: See Figure Figure Informational Note 100.0 A short circuit can occur during abnormal conditions such as a fault between circuit conductors or a ground fault.

Figure Informational Note 100.0 Available Fault Current.



Informational Note No. 2: If the dc supply is a battery system, the term *available fault current* refers to the prospective short-circuit current.

Informational Note No. 3: The available fault current varies at different locations within the system due to the location of sources and system impedances.

Field Evaluated.

An evaluation of nonlisted or modified equipment in the field that is performed by persons or parties acceptable to the authority having jurisdiction. (330, 350)

Informational Note No. 1: The evaluation approval ensures that the equipment meets appropriate codes and standards or is similarly found suitable for a specified purpose.

Informational Note No. 2: See NFPA 791, *Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation*, for additional information on recommended practices and procedures for the field evaluation of nonlisted equipment.

Informational Note No. 3: See NFPA 790, *Standard for Competency of Third-Party Field Evaluation Bodies*, for requirements on evaluating third-party entities.

Fitting.

An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function. [**70:**100]

Fuse.

An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it.

Informational Note: A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Ground.

The earth. [**70:**100]

Ground Fault.

An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non–current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth. [**70:**100]

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.

Grounded Conductor.

A system or circuit conductor that is intentionally grounded. [**70:**100]

Grounded (Grounding).

Connected (connecting) to ground or to a conductive body that extends the ground connection. [**70:**100]

Grounded, Solidly. (Solidly Grounded)

Connected to ground without inserting any resistor or impedance device. [**70:**100]

Ground-Fault Circuit Interrupter (GFCI).

A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device. [**70:**100]

Informational Note: See UL 943, *Ground-Fault Circuit Interrupters*, for further information. Class A ground-fault circuit interrupters trip when the ground-fault current is 6 mA or higher and does not trip when the ground-fault current is less than 4 mA.

Grounding Conductor, Equipment (EGC). (Equipment Grounding Conductor)

The conductive path(s) that provides a ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both. [**70:**100]

Informational Note No. 1: It is recognized that the equipment grounding conductor also performs bonding.

Informational Note No. 2: See 250.118 of *NFPA 70*, *National Electrical Code*, for a list of acceptable equipment grounding conductors.

Grounding Electrode.

A conducting object through which a direct connection to earth is established. [**70:**100]

Grounding Electrode Conductor.

A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system. [**70:**100]

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

The practice of discharging 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.

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

The practice of discharging capacitance by connecting to ground through a power resistor to avoid the hazards related with 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.

Guarded.

Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger. [**70:**100]

Hazard.

A source of possible injury or damage to health.

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)

Hazard, Arc Flash. (Arc Flash Hazard)

A source of possible injury or damage to health associated with the release of energy caused by an electric arc.

> Informational Note No. 1: See 110.2(B) Exception No. 1 for further information regarding normal operation. The likelihood of occurrence of an arc flash incident increases when energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc. An arc flash incident is not likely to occur under normal operating conditions when enclosed energized equipment has been properly installed and maintained.
>
> Informational Note No. 2: See Table 130.5(C)(3) for examples of tasks that increase the likelihood of an arc flash incident occurring.

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.

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.

Hazard, Electrical. (Electrical Hazard)

A 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.

Hazardous.

Involving exposure to at least one hazard.

Incident Energy.

The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electrical arc event.

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

Incident Energy Analysis.

A component of an arc flash risk assessment used to predict the incident energy of an arc flash for a specified set of conditions.

Insulated.

Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

> Informational Note: When an object is said to be insulated, it is understood to be insulated for the conditions to which it is normally subject. Otherwise, it is, within the purpose of these rules, uninsulated.

Interrupter Switch.

A switch capable of making, carrying, and interrupting specified currents.

Interrupting Rating.

The highest current at rated voltage that a device is identified to interrupt under standard test conditions. [**70:**100]

> Informational Note: Equipment intended to interrupt current at other than fault levels may have its interrupting rating implied in other ratings, such as horsepower or locked rotor current.

Isolated (as applied to location).

Not readily accessible to persons unless special means for access are used. [**70:**100]

Labeled.

Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Laboratory.

A building, space, room, or group of rooms intended to serve activities involving procedures for investigation, diagnostics, product testing, or use of custom or special electrical components, systems, or equipment. (350)

Laser.

A device that produces radiant energy at wavelengths between 180 nm (nanometer) and 1 mm (millimeter) predominantly by controlled stimulated emission. Laser radiation can be highly coherent temporally, spatially, or both. (330)

Laser Energy Source.

Any device intended for use in conjunction with a laser to supply energy for the excitation of electrons, ions, or molecules. (330)

Laser Radiation.

All electromagnetic radiation emitted by a laser or laser system between 180 nm (nanometers) and 1 mm (millimeters) that is produced as a result of a controlled stimulated emission. (330)

Laser System.

A laser in combination with an appropriate laser energy source with or without additional incorporated components. (330)

Listed.

Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

> Informational Note: The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Luminaire.

A complete lighting unit consisting of a light source, such as a lamp or lamps, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light. A lampholder itself is not a luminaire. [**70:**100]

Maintenance, Condition of. (Condition of Maintenance)

The state of the electrical equipment considering the manufacturers' instructions, manufacturers' recommendations, and applicable industry codes, standards, and recommended practices.

Motor Control Center.

An assembly of one or more enclosed sections having a common power bus and principally containing motor control units. [**70:**100]

Outlet.

A point on the wiring system at which current is taken to supply utilization equipment. [**70:**100]

Overcurrent.

Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault. [**70:**100]

> Informational Note: A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore, the rules for overcurrent protection are specific for particular situations.

Overload.

Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. [**70:**100]

Panelboard.

A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front. [**70:**100]

Pilot Cell.

One or more cells chosen to represent the operating parameters of the entire battery (sometimes called "temperature reference" cell). (320)

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 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.

Protective Barrier.

Prevents user access to a hazardous voltage, current, or stored energy area. (330)

Protector.

A glove or mitten designed to be worn over rubber insulating gloves.

Qualified Person.

One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.

Raceway.

An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this standard. [**70:**100]

Radiation, Ionizing. (Ionizing Radiation)

Radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization of atoms or molecules through which it passes. (340)

Radiation, Nonionizing. (Nonionizing Radiation)

Static electric and magnetic (0 to 1 Hz), sub radiofrequency (1Hz to 3 kHz), radiofrequency (3 kHz to 300 GHz) fields, and infrared, visible light, and near ultraviolet (near UV) that cannot ionize an atom or molecule. (340)

Receptacle.

A contact device installed at the outlet for the connection of an attachment plug, or for the direct connection of electrical utilization equipment designed to mate with the corresponding contact device. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke. [**70:**100]

Research and Development (R&D).

An activity in an installation specifically designated for research or development conducted with custom or special electrical equipment. (350)

Resistor, Bleeder. (Bleeder Resistor)

A resistor or resistor network connected in parallel with a capacitor's terminals that dissipates the stored energy after power has been disconnected. (360)

Risk.

A combination of 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.

An overall process that identifies hazards, estimates the likelihood of occurrence of injury or damage to health, estimates the potential severity of injury or damage to health, and determines if protective measures are required.

> Informational Note: As used in this standard, *arc flash risk assessment* and *electric shock risk assessment* are types of risk assessments.

Service Drop.

The overhead conductors between the utility electric supply system and the service point. [**70:**100]

Service Lateral.

The underground conductors between the utility electric supply system and the service point. [**70:**100]

Service Point.

The point of connection between the facilities of the serving utility and the premises wiring. [**70:**100]

> Informational Note: The service point can be described as the point of demarcation between where the serving utility ends and the premises wiring begins. The serving utility generally specifies the location of the service point based on the conditions of service.

Short-Circuit Current, Prospective. (Prospective Short-Circuit Current)

The highest level of fault current that could theoretically occur at a point on a circuit. This is the fault current that can flow in the event of a zero impedance short circuit and if no protection devices operate. (320)

> Informational Note: Some batteries have built-in management devices to limit maximum short-circuit current. The determination of the prospective short-circuit current for these batteries assumes that the internal battery management system protection devices are operable.

Short-Circuit Current Rating.

The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding defined acceptance criteria. [**70:**100]

Shorting Stick.

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

Single-Line Diagram.

A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used in the circuit or system.

Special Permission.

The written consent of the authority having jurisdiction. [**70:**100]

Step Potential.

A ground potential gradient difference that can cause current flow from foot to foot through the body.

Structure.

That which is built or constructed. [**70:**100]

Switch, Isolating. (Isolating Switch)

A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means. [**70:**100]

Switchboard.

A large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments. These assemblies are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. [**70:**100]

Switchgear, Metal-Clad. (Metal-Clad Switchgear)

A switchgear assembly completely enclosed on all sides and top with sheet metal, having drawout switching and interrupting devices, and all live parts enclosed within grounded metal compartments.

Switchgear, Metal-Enclosed. (Metal-Enclosed Switchgear)

A switchgear assembly completely enclosed on all sides and top with sheet metal (except for ventilating openings and inspection windows), containing primary power circuit switching, interrupting devices, or both, with buses and connections. This assembly may include control and auxiliary devices. Access to the interior of the enclosure is provided by doors, removable covers, or both. Metal-enclosed switchgear is available in non-arc-resistant or arc-resistant constructions.

Switching Device.

A device designed to close, open, or both, one or more electric circuits.

Time Constant.

The time it takes for voltage to drop by ~63 percent (1/e) during discharge. (360)

Touch Potential.

A ground potential gradient difference that can cause current flow from hand to hand, hand to foot, or another path, other than foot to foot, through the body.

Ungrounded.

Not connected to ground or to a conductive body that extends the ground connection. [**70:**100]

Unqualified Person.

A person who is not a qualified person.

Utilization Equipment.

Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes. [**70:**100]

Voltage (of a Circuit).

The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned. [**70:**100]

> Informational Note: Some systems, such as three-phase 4-wire, single-phase 3-wire, and 3-wire direct-current, may have various circuits of various voltages.

Voltage, Nominal. (Nominal Voltage)

A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240 volts, 480Y/277 volts, 600 volts). [**70:**100]

> Informational Note No. 1: The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.
>
> Informational Note No. 2: See ANSI C84.1, *Electric Power Systems and Equipment — Voltage Ratings (60 Hz)*.

Voltage, Nominal (as applied to cell or battery). (Nominal Voltage)

The value assigned to a cell or battery of a given voltage class for the purpose of convenient designation; the operating voltage of the cell or system may vary above or below this value. (320)

> Informational Note: The most common cell voltages are 2.0 volts per cell for lead-acid batteries, 1.2 volts per cell for alkali batteries, and 3.2 to 3.8 volts per cell for Li-ion batteries. Nominal voltages might vary with different chemistries.

Working Distance.

The distance between a person's face and chest area and a prospective arc source.

Informational Note: See 130.5(G) for further information. Incident energy increases as the distance from the arc source decreases.

Working On (energized electrical conductors or circuit parts).

Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment (PPE) a person is wearing.

Informational Note: Examples of "working on" can include but are not limited to *diagnostic testing* (such as taking readings or measurements of electrical equipment, conductors, or circuit parts with approved test equipment that does not require making any physical change to the electrical equipment, conductors, or circuit parts) and *repair* or physical alteration of electrical equipment, conductors, or circuit parts (such as making or tightening connections, removing or replacing components, etc.).

Statement of Problem and Substantiation for Public Comment

The 2024 version of NFPA 70E uses the phrase 'Avoid Contact' as the Restricted Approach Boundary (RAB) for the ac voltage range of 50 vac to 150 vac in Table 130.4(E)(a) and in Table 130.4(E)(b) for dc voltages from 50 vdc to 300 vdc.
Unlike the other ac and dc voltage ranges listed in Table 130.4(E)(a) and Table 130.4(E)(b) respectively, which all contain a physical distance shown in metric and imperial measurements, the term 'Avoid Contact' is used in place of an actual measurement from the exposed energized part(s) at lower, albeit hazardous voltages. The use of 'Avoid Contact' as an electric shock protection boundary is extremely subjective and is often misunderstood by safety professionals and electrical workers alike to mean "Don't touch it" which is essentially nothing more than a warning to "Be Careful".
However, section 130.4(G) titled Restricted Approach Boundary, establishes two mandatory conditions before a qualified person is permitted to approach or take a conductive object closer to exposed energized parts than the RAB for voltages greater than 50 vac or 50 vdc, unless one of the two following conditions are met:
1. The qualified person is insulated or guarded from the energized conductors or circuit parts or
2. The energized conductors or circuit parts are insulated from the qualified person and from any conductive object at a different potential.

The purpose of the RAB is to prevent inadvertent or accidental contact with the energized parts through a predetermined air gap that serves as a safety buffer. This safety zone contains both an electrical component of air insulation and an ergonomic component to account for human errors. Consequently, crossing the RAB per section 130.4(G) must be treated the same as making intentional contact through the two conditions listed above.
Additionally, according to the column #4 in Tables 130.4(E)(a) and 1130.4(E)(b), the RAB includes an "Inadvertent Movement Factor", which is also known as the ergonomic component, but this is only true for those RABs with a physical distance. Whereas 'Avoid Contact' is the only RAB if crossed results in inadvertent contact with the energized part(s) followed by serious injury or death.
Additionally, OSHA regulations pursuant to 29CFR1910.269, Appendix B – Working On Exposed Energized Parts states in part states 'Avoid Contact' contains neither an electrical component nor an ergonomic component."
Please note, OSHA uses the term "Minimum Approach Distance" (MAD) rather than RAB to designate the shock boundary, furthermore the OSHA voltage range for 'Avoid Contact' is 50 to 300 volts. But the purpose for OSHA's MAD is identical to 70E's RAB.
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.269AppB
In OSHA's Final Rules to 1910.269, Subpart R, OSHA cited 26 fatalities of electric utility workers after inadvertent contact with 120 volts between 1984 to 1996.
According to more recent data from the Electrical Foundation International (ESFI) from 2011 to 2022, 30 workers lost their lives from voltages ranging between 110 to 120 volts with another 23 deaths from 208 to 240 volt systems. However, it is very likely that most of the fatal shocks listed as 208 or 240 volt systems were the result of a phase-to-ground contact, which would technically be a 120 volt shock.
For more background and details, please review the paper ESW2025-08 titled "Avoid Contact – The Shock Boundary Without a Distance" authored by George T. Cole, presented during the 2025 IEEE Electrical Safety Workshop conference in Jacksonville, FL, USA.

Related Item

• No related item as of this PI

Submitter Information Verification

Submitter Full Name: George Cole
Organization: PVNGS APS
Affiliation: PVNGS APS

Street Address:
City:
State:
Zip:
Submittal Date: Wed Mar 26 14:17:26 EDT 2025
Committee: EEW-AAA

Public Comment No. 90-NFPA 70E-2025 [Article 100]

Article 100 Definitions

Scope. This article contains only those definitions essential to the 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.

Accessible (as applied to equipment).

Admitting close approach; not guarded by locked doors, elevation, or other effective means. [**70:**100]

Approved.

Acceptable to the authority having jurisdiction.

Arc Flash Suit.

A complete arc-rated clothing and equipment system that covers the entire body, except for the hands and feet.

Informational Note: An arc flash suit may include pants or overalls, a jacket or a coverall, and a beekeeper-type hood fitted with a face shield.

Arc Rating.

The value attributed to materials that describes their performance to exposure to an electrical arc discharge. The arc rating is expressed in cal/cm^2 and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakopen threshold (E_{BT}) (should a material system exhibit a breakopen response below the ATPV value). Arc rating is reported as either ATPV or E_{BT}, whichever is the lower value.

Informational Note No. 1: Arc-rated clothing or equipment indicates that it has been tested for exposure to an electric arc. Flame-resistant clothing without an arc rating has not been tested for exposure to an electric arc. All arc-rated clothing is also flame resistant.

Informational Note No. 2: See ASTM F1959/F1959M, *Standard Test Method for Determining the Arc Rating of Materials for Clothing*, which defines ATPV as the incident energy (cal/cm^2) on a material or a multilayer system of materials that results in a 50 percent probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a second degree skin burn injury based on the Stoll curve.

Informational Note No. 3: See ASTM F1959/F1959M, *Standard Test Method for Determining the Arc Rating of Materials for Clothing*, which defines E_{BT} as the incident energy (cal/cm^2) on a material or a material system that results in a 50 percent probability of breakopen. Breakopen is a material response evidenced by the formation of one or more holes of a defined size [an area of 1.6 cm^2 (0.5 in.^{2}) or an opening of 2.5 cm (1.0 in.) in any dimension] in the innermost layer of arc-rated material that would allow thermal energy to pass through the material.

Attachment Plug (Plug Cap) (Plug).

A device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle. [**70:**100]

Authority Having Jurisdiction (AHJ).

An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

> Informational Note: The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

Authorized Personnel.

The person in charge of the premises, or other persons appointed or selected by the person in charge of the premises who performs certain duties associated with stationary storage batteries. (320)

Automatic.

Performing a function without the necessity of human intervention.

Balaclava.

An arc-rated head-protective fabric that protects the neck and head except for a small portion of the facial area.

> Informational Note: Some balaclava designs protect the neck and head area except for the eyes while others leave the eyes and nose area unprotected.

Barricade.

A physical obstruction such as tapes, cones, or A-frame-type wood or metal structures intended to provide a warning and to limit access.

Barrier.

A physical obstruction that is intended to prevent contact with equipment or energized electrical conductors and circuit parts.

Battery.

A system consisting of two or more electrochemical cells connected in series or parallel and capable of storing electrical energy received and that can give it back by reconversion. (320)

Battery Effect.

A voltage that exists on the electrolytic cell line after the power supply is disconnected. (310)

> Informational Note: Electrolytic cells can exhibit characteristics similar to an electrical storage battery and an electric shock hazard could exist after the power supply is disconnected from the cell line.

Battery Room.

A room specifically intended for the installation of batteries that have no other protective enclosure. (320)

Bonded (Bonding).

Connected to establish electrical continuity and conductivity. [**70:**100]

Bonding Conductor or Jumper.

A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected. [**70:**100]

Boundary, Arc Flash. (Arc Flash Boundary)

When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm^2 (5 J/cm^2).

> Informational Note: According to the Stoll skin burn injury model, the onset of a second degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm^2 (5 J/cm^2) for one second.

Boundary, Hearing Protection. (Hearing Protection Boundary)

Worker distance at which a 1 percent probability of ear damage exists from a 20 kPa (3.0 psi) shock wave. (360)

Boundary, Limited Approach. (Limited Approach Boundary)

An approach limit at a distance from an exposed energized electrical conductor or circuit part within which an electric shock hazard exists.

Boundary, Lung Protection. (Lung Protection Boundary)

Worker distance at which a 1 percent probability of lung damage exists from a 70 kPa (10 psi) shock wave. (360)

Boundary, Restricted Approach. (Restricted Approach Boundary)

An approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

Building.

A structure that stands alone or that is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors. [**70:**100]

Cabinet.

An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung. [**70:**100]

Cell.

The basic electrochemical unit, characterized by an anode and a cathode used to receive, store, and deliver electrical energy. (320)

Cell, Valve-Regulated Lead Acid (VRLA). (Valve-Regulated Lead Acid Cell)

A lead-acid cell that is sealed with the exception of a valve that opens to the atmosphere when the internal pressure in the cell exceeds atmospheric pressure by a pre-selected amount, and that provides a means for recombination of internally generated oxygen and the suppression of hydrogen gas evolution to limit water consumption. (320)

Cell, Vented. (Vented Cell)

A type of cell in which the products of electrolysis and evaporation are allowed to escape freely into the atmosphere as they are generated. (Also called "*flooded cell*.") (320)

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.

Charge Transfer.

Improper discharging of capacitor networks that results in transferring charge from one capacitor to another capacitor instead of fully discharging the stored energy. (360)

Circuit Breaker.

A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [**70:**100]

> Informational Note: The automatic opening means can be integral, direct acting with the circuit breaker, or remote from the circuit breaker.

Conductive.

Suitable for carrying electric current.

Conductor, Bare. (Bare Conductor)

A conductor having no covering or electrical insulation whatsoever. [**70:**100]

Conductor, Covered. (Covered Conductor)

A conductor encased within material of composition or thickness that is not recognized by *NFPA 70*, *National Electrical Code*, as electrical insulation. [**70:**100]

Conductor, Insulated. (Insulated Conductor)

A conductor encased within material of composition and thickness that is recognized by *NFPA 70*, *National Electrical Code*, as electrical insulation. [**70:**100]

Controller.

A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected. [**70:**100]

Current-Limiting Overcurrent Protective Device.

A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

Cutout.

An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

De-energized.

Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth.

Device.

A unit of an electrical system, other than a conductor, that carries or controls electric energy as its principal function. [**70:**100]

Dielectric Absorption.

The property of certain capacitors to recharge after being discharged. (360)

> Informational Note: A voltage recharge from 0.02 percent (polystyrene and polypropylene) up to 10 percent (some electrolytics) can occur a few minutes after the grounding or shorting device has been removed.

Discharge Time.

The time required to discharge a capacitor to below electrical hazard thresholds. (360)

Disconnecting Means.

A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [**70:**100]

Disconnecting (or Isolating) Switch (Disconnector, Isolator).

A mechanical switching device used for isolating a circuit or equipment from a source of power.

Dwelling Unit.

A single unit providing complete and independent living facilities for one or more persons, including permanent provisions for living, sleeping, cooking, and sanitation. [**70:**100]

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.

Electrical Safety Program.

A documented system consisting of electrical safety principles, policies, procedures, and processes that directs activities appropriate for the risk associated with electrical hazards.

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.

Electrolyte.

A solid, liquid, or aqueous immobilized liquid medium that provides the ion transport mechanism between the positive and negative electrodes of a cell. (320)

Enclosed.

Surrounded by a case, housing, fence, or wall(s) that prevents persons from unintentionally contacting energized parts.

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.

Energized.

Electrically connected to, or is, a source of voltage. [**70:**100]

Equipment.

A general term, including fittings, devices, appliances, luminaires, apparatus, machinery, and the like, used as a part of, or in connection with, an electrical installation. [**70:**100]

Equipment, Arc-Resistant. (Arc-Resistant Equipment)

Equipment designed to withstand the effects of an internal arcing fault and that directs the internally released energy away from the employee.

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.

Informational Note No. 2: See O.2.4(9) for information on arc-resistant equipment.

Equipotential Zone. (For Temporary Protective Grounding)(EPZ).

The state of maintaining a near identical electrical potential between two or more points in the work area, which minimizes electric shock exposure from step potential hazards and touch potential hazards.

Exposed (as applied to energized electrical conductors or circuit parts).

Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to electrical conductors or circuit parts that are not suitably guarded, isolated, or insulated.

Exposed (as applied to wiring methods).

On or attached to the surface or behind panels designed to allow access. [**70:**100]

Fault Current.

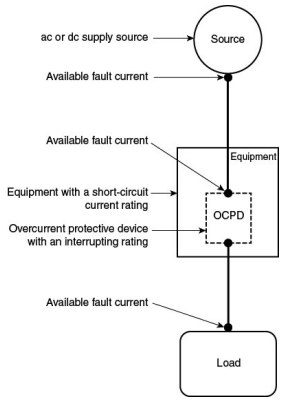
The amount of current delivered at a point on the system during a short-circuit condition.

Fault Current, Available. (Available Fault Current)

The largest amount of current capable of being delivered at a point on the system during a short-circuit condition.

Informational Note No. 1: See Figure Figure Informational Note 100.0 A short circuit can occur during abnormal conditions such as a fault between circuit conductors or a ground fault.

Figure Informational Note 100.0 Available Fault Current.



Informational Note No. 2: If the dc supply is a battery system, the term *available fault current* refers to the prospective short-circuit current.

Informational Note No. 3: The available fault current varies at different locations within the system due to the location of sources and system impedances.

Field Evaluated.

An evaluation of nonlisted or modified equipment in the field that is performed by persons or parties acceptable to the authority having jurisdiction. (330, 350)

Informational Note No. 1: The evaluation approval ensures that the equipment meets appropriate codes and standards or is similarly found suitable for a specified purpose.

Informational Note No. 2: See NFPA 791, *Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation*, for additional information on recommended practices and procedures for the field evaluation of nonlisted equipment.

Informational Note No. 3: See NFPA 790, *Standard for Competency of Third-Party Field Evaluation Bodies*, for requirements on evaluating third-party entities.

Fitting.

An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function. [**70:**100]

Fuse.

An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it.

Informational Note: A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Ground.

The earth. [**70:**100]

Ground Fault.

An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non–current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth. [**70:**100]

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.

Grounded Conductor.

A system or circuit conductor that is intentionally grounded. [**70:**100]

Grounded (Grounding).

Connected (connecting) to ground or to a conductive body that extends the ground connection. [**70:**100]

Grounded, Solidly. (Solidly Grounded)

Connected to ground without inserting any resistor or impedance device. [**70:**100]

Ground-Fault Circuit Interrupter (GFCI).

A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device. [**70:**100]

Informational Note: See UL 943, *Ground-Fault Circuit Interrupters*, for further information. Class A ground-fault circuit interrupters trip when the ground-fault current is 6 mA or higher and does not trip when the ground-fault current is less than 4 mA.

Grounding Conductor, Equipment (EGC). (Equipment Grounding Conductor)

The conductive path(s) that provides a ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both. [**70:**100]

Informational Note No. 1: It is recognized that the equipment grounding conductor also performs bonding.

Informational Note No. 2: See 250.118 of *NFPA 70*, *National Electrical Code*, for a list of acceptable equipment grounding conductors.

Grounding Electrode.

A conducting object through which a direct connection to earth is established. [**70:**100]

Grounding Electrode Conductor.

A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system. [**70:**100]

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

The practice of discharging 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.

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

The practice of discharging capacitance by connecting to ground through a power resistor to avoid the hazards related with 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.

Guarded.

Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger. [**70:**100]

Hazard.

A source of possible injury or damage to health.

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)

Hazard, Arc Flash. (Arc Flash Hazard)

A source of possible injury or damage to health associated with the release of energy caused by an electric arc.

> Informational Note No. 1: See 110.2(B) Exception No. 1 for further information regarding normal operation. The likelihood of occurrence of an arc flash incident increases when energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc. An arc flash incident is not likely to occur under normal operating conditions when enclosed energized equipment has been properly installed and maintained.
>
> Informational Note No. 2: See Table 130.5(C)(3) for examples of tasks that increase the likelihood of an arc flash incident occurring.

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.

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.

Hazard, Electrical. (Electrical Hazard)

A 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.

Hazardous.

Involving exposure to at least one hazard.

Incident Energy.

The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electrical arc event.

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

Incident Energy Analysis.

A component of an arc flash risk assessment used to predict the incident energy of an arc flash for a specified set of conditions.

Insulated.

Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

> Informational Note: When an object is said to be insulated, it is understood to be insulated for the conditions to which it is normally subject. Otherwise, it is, within the purpose of these rules, uninsulated.

Interrupter Switch.

A switch capable of making, carrying, and interrupting specified currents.

Interrupting Rating.

The highest current at rated voltage that a device is identified to interrupt under standard test conditions. [**70:**100]

> Informational Note: Equipment intended to interrupt current at other than fault levels may have its interrupting rating implied in other ratings, such as horsepower or locked rotor current.

Isolated (as applied to location).

Not readily accessible to persons unless special means for access are used. [**70:**100]

Labeled.

Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Laboratory.

A building, space, room, or group of rooms intended to serve activities involving procedures for investigation, diagnostics, product testing, or use of custom or special electrical components, systems, or equipment. (350)

Laser.

A device that produces radiant energy at wavelengths between 180 nm (nanometer) and 1 mm (millimeter) predominantly by controlled stimulated emission. Laser radiation can be highly coherent temporally, spatially, or both. (330)

Laser Energy Source.

Any device intended for use in conjunction with a laser to supply energy for the excitation of electrons, ions, or molecules. (330)

Laser Radiation.

All electromagnetic radiation emitted by a laser or laser system between 180 nm (nanometers) and 1 mm (millimeters) that is produced as a result of a controlled stimulated emission. (330)

Laser System.

A laser in combination with an appropriate laser energy source with or without additional incorporated components. (330)

Listed.

Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

> Informational Note: The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Luminaire.

A complete lighting unit consisting of a light source, such as a lamp or lamps, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light. A lampholder itself is not a luminaire. [**70:**100]

Maintenance, Condition of. (Condition of Maintenance)

The state of the electrical equipment considering the manufacturers' instructions, manufacturers' recommendations, and applicable industry codes, standards, and recommended practices.

Motor Control Center.

An assembly of one or more enclosed sections having a common power bus and principally containing motor control units. [**70:**100]

Outlet.

A point on the wiring system at which current is taken to supply utilization equipment. [**70:**100]

Overcurrent.

Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault. [**70:**100]

> Informational Note: A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore, the rules for overcurrent protection are specific for particular situations.

Overload.

Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. [**70:**100]

Panelboard.

A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front. [**70:**100]

Pilot Cell.

One or more cells chosen to represent the operating parameters of the entire battery (sometimes called "temperature reference" cell). (320)

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 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.

Protective Barrier.

Prevents user access to a hazardous voltage, current, or stored energy area. (330)

Protector.

A glove or mitten designed to be worn over rubber insulating gloves.

Qualified Person.

One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.

Raceway.

An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this standard. [**70:**100]

Radiation, Ionizing. (Ionizing Radiation)

Radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization of atoms or molecules through which it passes. (340)

Radiation, Nonionizing. (Nonionizing Radiation)

Static electric and magnetic (0 to 1 Hz), sub radiofrequency (1Hz to 3 kHz), radiofrequency (3 kHz to 300 GHz) fields, and infrared, visible light, and near ultraviolet (near UV) that cannot ionize an atom or molecule. (340)

Receptacle.

A contact device installed at the outlet for the connection of an attachment plug, or for the direct connection of electrical utilization equipment designed to mate with the corresponding contact device. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke. [**70:**100]

Research and Development (R&D).

An activity in an installation specifically designated for research or development conducted with custom or special electrical equipment. (350)

Resistor, Bleeder. (Bleeder Resistor)

A resistor or resistor network connected in parallel with a capacitor's terminals that dissipates the stored energy after power has been disconnected. (360)

Risk.

A combination of 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.

An overall process that identifies hazards, estimates the likelihood of occurrence of injury or damage to health, estimates the potential severity of injury or damage to health, and determines if protective measures are required.

> Informational Note: As used in this standard, *arc flash risk assessment* and *electric shock risk assessment* are types of risk assessments.

Service Drop.

The overhead conductors between the utility electric supply system and the service point. [**70:**100]

Service Lateral.

The underground conductors between the utility electric supply system and the service point. [**70:**100]

Service Point.

The point of connection between the facilities of the serving utility and the premises wiring. [**70:**100]

> Informational Note: The service point can be described as the point of demarcation between where the serving utility ends and the premises wiring begins. The serving utility generally specifies the location of the service point based on the conditions of service.

Short-Circuit Current, Prospective. (Prospective Short-Circuit Current)

The highest level of fault current that could theoretically occur at a point on a circuit. This is the fault current that can flow in the event of a zero impedance short circuit and if no protection devices operate. (320)

> Informational Note: Some batteries have built-in management devices to limit maximum short-circuit current. The determination of the prospective short-circuit current for these batteries assumes that the internal battery management system protection devices are operable.

Short-Circuit Current Rating.

The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding defined acceptance criteria. [**70:**100]

Shorting Stick.

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

Single-Line Diagram.

A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used in the circuit or system.

Special Permission.

The written consent of the authority having jurisdiction. [**70:**100]

Step Potential.

A ground potential gradient difference that can cause current flow from foot to foot through the body.

Structure.

That which is built or constructed. [**70:**100]

Switch, Isolating. (Isolating Switch)

A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means. [**70:**100]

Switchboard.

A large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments. These assemblies are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. [**70:**100]

Switchgear, Metal-Clad. (Metal-Clad Switchgear)

A switchgear assembly completely enclosed on all sides and top with sheet metal, having drawout switching and interrupting devices, and all live parts enclosed within grounded metal compartments.

Switchgear, Metal-Enclosed. (Metal-Enclosed Switchgear)

A switchgear assembly completely enclosed on all sides and top with sheet metal (except for ventilating openings and inspection windows), containing primary power circuit switching, interrupting devices, or both, with buses and connections. This assembly may include control and auxiliary devices. Access to the interior of the enclosure is provided by doors, removable covers, or both. Metal-enclosed switchgear is available in non-arc-resistant or arc-resistant constructions.

Switching Device.

A device designed to close, open, or both, one or more electric circuits.

Temporary Protective Grounding.

The intentional act of installing specialized conductors and clamps to all normally energized circuit parts and phases of a power system to ground and bond them together to conduct short circuit current for a specified duration of time by having sufficient current withstand rating which limits currents through the worker to acceptable levels. This is accomplished by limiting potential differences between any two or more accessible points at the worksite by developing an equipotential zone (EPZ).

Time Constant.

The time it takes for voltage to drop by ~63 percent (1/e) during discharge. (360)

Touch Potential.

A ground potential gradient difference that can cause current flow from hand to hand, hand to foot, or another path, other than foot to foot, through the body.

Ungrounded.

Not connected to ground or to a conductive body that extends the ground connection. [**70:**100]

Unqualified Person.

A person who is not a qualified person.

Utilization Equipment.

Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes. [**70:**100]

Voltage (of a Circuit).

The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned. [**70:**100]

> Informational Note: Some systems, such as three-phase 4-wire, single-phase 3-wire, and 3-wire direct-current, may have various circuits of various voltages.

Voltage, Nominal. (Nominal Voltage)

A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240 volts, 480Y/277 volts, 600 volts). [**70:**100]

> Informational Note No. 1: The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.
>
> Informational Note No. 2: See ANSI C84.1, *Electric Power Systems and Equipment — Voltage Ratings (60 Hz)*.

Voltage, Nominal (as applied to cell or battery). (Nominal Voltage)

The value assigned to a cell or battery of a given voltage class for the purpose of convenient designation; the operating voltage of the cell or system may vary above or below this value. (320)

Informational Note: The most common cell voltages are 2.0 volts per cell for lead-acid batteries, 1.2 volts per cell for alkali batteries, and 3.2 to 3.8 volts per cell for Li-ion batteries. Nominal voltages might vary with different chemistries.

Working Distance.

The distance between a person's face and chest area and a prospective arc source.

Informational Note: See 130.5(G) for further information. Incident energy increases as the distance from the arc source decreases.

Working On (energized electrical conductors or circuit parts).

Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment (PPE) a person is wearing.

Informational Note: Examples of "working on" can include but are not limited to *diagnostic testing* (such as taking readings or measurements of electrical equipment, conductors, or circuit parts with approved test equipment that does not require making any physical change to the electrical equipment, conductors, or circuit parts) and *repair* or physical alteration of electrical equipment, conductors, or circuit parts (such as making or tightening connections, removing or replacing components, etc.).

Statement of Problem and Substantiation for Public Comment

Temporary protective grounding (TPG) is the final and in some cases, the most important step, when establishing an electrically safety work condition per 120.6(8) because when installed correctly will prevent any hazardous voltage from developing by maintaining all conductive objects in the work area at the same electrical potential as the worker's body . The term Temporary protective grounding is used throughout this section but is not defined in article 100. Additionally, the most critical attribute TPGs is to minimize any differences of electrical potential if the line or equipment should become accidentally re-energized. This is somewhat explained in 120.6(8)(a) 'placement' but it does not use the term "equipotential zone (EPZ)" which is the technically correct term as used by OSHA, IEEE, NESC and several other standards.
Therefore, the new definitions of Temporary Protective Grounding (TPG) and Equipotential Zone (EPZ) were developed from technical information derived from 1910.269(n), IEEE 1048, IEEE 1246 and the NESC.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 88-NFPA 70E-2025 [New Section after 120.6]	ESWC and TPGs

Related Item

- Electrically safety work condition and temporary protective grounding

Submitter Information Verification

Submitter Full Name: George Cole
Organization: Pvngs Aps
Affiliation: E-Hazard
Street Address:
City:
State:
Zip:

Submittal Date: Fri May 16 22:40:12 EDT 2025
Committee: EEW-AAA

Public Comment No. 18-NFPA 70E-2025 [New Article after 100]

TITLE OF NEW CONTENT

Recommend adding a new definition to Article 100, defining and clarifying what 'Avoid Contact' means in context to the Restricted Approach Boundary.

The 2024 version of NFPA 70E uses the phrase ‘Avoid Contact’ as the Restricted Approach Boundary (RAB) for the ac voltage range of 50 vac to 150 vac in Table 130.4(E)(a) and in Table 130.4(E)(b) for dc voltages from 50 vdc to 300 vdc. Unlike the other ac and dc voltage ranges listed in Table 130.4(E)(a) and Table 130.4(E)(b) respectively, which all contain a physical distance shown in metric and imperial measurements, the term ‘Avoid Contact’ is used in place of an actual measurement from the exposed energized part(s) at lower, albeit hazardous voltages. The use of ‘Avoid Contact’ as an electric shock protection boundary is extremely subjective and is often misunderstood by safety professionals and electrical workers alike to mean “Don’t touch it” which is essentially nothing more than a warning to “Be Careful”. However, section 130.4(G) titled Restricted Approach Boundary, establishes two mandatory conditions before a qualified person is permitted to approach or take a conductive object closer to exposed energized parts than the RAB for voltages greater than 50 vac or 50 vdc, unless one of the two following conditions are met: 1. The qualified person is insulated or guarded from the energized conductors or circuit parts or 2. The energized conductors or circuit parts are insulated from the qualified person and from any conductive object at a different potential. The purpose of the RAB is to prevent inadvertent or accidental contact with the energized parts through a predetermined air gap that serves as a safety buffer. This safety zone contains both an electrical component of air insulation and an ergonomic component to account for human errors. Consequently, crossing the RAB per section 130.4(G) must be treated the same as making intentional contact through the two conditions listed above. Additionally, according to the column #4 in Tables 130.4(E)(a) and 1130.4(E)(b), the RAB includes an “Inadvertent Movement Factor”, which is also known as the ergonomic component, but this is only true for those RABs with a physical distance. Whereas ‘Avoid Contact’ is the only RAB if crossed results in inadvertent contact with the energized part(s) followed by serious injury or death. Additionally, OSHA regulations pursuant to 29CFR1910.269, Appendix B – Working On Exposed Energized Parts states in part states ‘Avoid Contact’ contains neither an electrical component nor an ergonomic component.” Please note, OSHA uses the term “Minimum Approach Distance” (MAD) rather than RAB to designate the shock boundary, furthermore the OSHA voltage range for ‘Avoid Contact’ is 50 to 300 volts. But the purpose for OSHA’s MAD is identical to 70E’s RAB. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.269AppB In OSHA's Final Rules to 1910.269, Subpart R, OSHA cited 26 fatalities of electric utility workers after inadvertent contact with 120 volts between 1984 to 1996. According to more recent data from the Electrical Foundation International (ESFI) from 2011 to 2022, 30 workers lost their lives from voltages ranging between 110 to 120 volts with another 23 deaths from 208 to 240 volt systems. However, it is very likely that most of the fatal shocks listed as 208 or 240 volt systems were the result of a phase-to-ground contact, which would technically be a 120 volt shock. For more background and details, please review the paper ESW2025-08 titled “Avoid Contact – The Shock Boundary Without a Distance” authored by George T. Cole, presented during the 2025 IEEE Electrical Safety Workshop conference in Jacksonville, FL, USA.

Statement of Problem and Substantiation for Public Comment

This proposed addition of a new definition for 'Avoid Contact' in context with the Restricted Approach Boundary will help minimize the confusion and misinterpretation that Avoid Contact means nothing more than "Don't Touch It" or "Be Careful" by safety professionals and electrical workers. Such misunderstanding by qualified electrical workers increases the risks and likelihood of electric shock because this false belief is based on nothing more than practicing good situational awareness to not touch an adjacent energized part(s) during work activities. However, if the worker implemented proactive actions as required by section 130.4(G) then this would provide the necessary barriers to prevent inadvertent contact at lower but very hazardous voltages, such as 120 vac or 135 vdc.

The 2024 version of NFPA 70E uses the phrase ‘Avoid Contact’ as the Restricted Approach Boundary (RAB) for the ac voltage range of 50 vac to 150 vac in Table 130.4(E)(a) and in Table 130.4(E)(b) for dc voltages from 50 vdc to 300 vdc.
Unlike the other ac and dc voltage ranges listed in Table 130.4(E)(a) and Table 130.4(E)(b) respectively, which all contain a physical distance shown in metric and imperial measurements, the term ‘Avoid Contact’ is used in place of an actual measurement from the exposed energized part(s) at lower, albeit hazardous voltages. The use of ‘Avoid Contact’ as an electric shock protection boundary is extremely subjective and is often misunderstood by safety professionals and electrical workers alike to mean “Don’t touch it” which is essentially nothing more than a warning to “Be Careful”.
However, section 130.4(G) titled Restricted Approach Boundary, establishes two mandatory conditions before a qualified person is permitted to approach or take a conductive object closer to exposed energized parts than the

RAB for voltages greater than 50 vac or 50 vdc, unless one of the two following conditions are met:
1. The qualified person is insulated or guarded from the energized conductors or circuit parts or
2. The energized conductors or circuit parts are insulated from the qualified person and from any conductive object at a different potential.

The purpose of the RAB is to prevent inadvertent or accidental contact with the energized parts through a predetermined air gap that serves as a safety buffer. This safety zone contains both an electrical component of air insulation and an ergonomic component to account for human errors. Consequently, crossing the RAB per section 130.4(G) must be treated the same as making intentional contact through the two conditions listed above.

Additionally, according to the column #4 in Tables 130.4(E)(a) and 1130.4(E)(b), the RAB includes an “Inadvertent Movement Factor”, which is also known as the ergonomic component, but this is only true for those RABs with a physical distance. Whereas ‘Avoid Contact’ is the only RAB if crossed results in inadvertent contact with the energized part(s) followed by serious injury or death.

Additionally, OSHA regulations pursuant to 29CFR1910.269, Appendix B – Working On Exposed Energized Parts states in part states ‘Avoid Contact’ contains neither an electrical component nor an ergonomic component.”

Please note, OSHA uses the term “Minimum Approach Distance” (MAD) rather than RAB to designate the shock boundary, furthermore the OSHA voltage range for ‘Avoid Contact’ is 50 to 300 volts. But the purpose for OSHA’s MAD is identical to 70E’s RAB.

https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.269AppB

In OSHA's Final Rules to 1910.269, Subpart R, OSHA cited 26 fatalities of electric utility workers after inadvertent contact with 120 volts between 1984 to 1996.

According to more recent data from the Electrical Foundation International (ESFI) from 2011 to 2022, 30 workers lost their lives from voltages ranging between 110 to 120 volts with another 23 deaths from 208 to 240 volt systems. However, it is very likely that most of the fatal shocks listed as 208 or 240 volt systems were the result of a phase-to-ground contact, which would technically be a 120 volt shock.

For more background and details, please review the paper ESW2025-08 titled “Avoid Contact – The Shock Boundary Without a Distance” authored by George T. Cole, presented during the 2025 IEEE Electrical Safety Workshop conference in Jacksonville, FL, USA.

Related Item

• Add new definition to article 100 for Avoid Contact

Submitter Information Verification

Submitter Full Name: George Cole
Organization: Pvngs Aps
Affiliation: PVNGS APS
Street Address:
City:
State:
Zip:

Submittal Date: Wed Mar 26 14:16:28 EDT 2025
Committee: EEW-AAA

Public Comment No. 12-NFPA 70E-2025 [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~~ electrical energy , 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.

Additional Proposed Changes

File Name	Description	Approved
PC_11_Supporting_Documents.pdf	File contains "NFPA_70E_Series_Circuit_R1 "	

Statement of Problem and Substantiation for Public Comment

The Technical Committee's statement does not adequately address Public Input No. 49.

The phrase "disconnected from energized parts, locked/tagged in accordance with established standards" would be applicable to the voltage system side of the constant current circuit. Disconnected could mean the opening of the fused switch or circuit breaker on the voltage side of the constant current source. Testing for voltage would be applicable for the voltage side of the constant current regulator.

Opening or disconnecting a component of an energized constant current circuit could be fatal.

Please refer to attached file NFPA_70E_Series_Circuit_R1 contained in PC 11 Supporting Documents.PDF . Once the "circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards", the qualified person now needs to verify the absence of voltage.

The qualified person is working on the threshold of Runway 18R-36L, more than 6,000 feet from the constant current source. In the raceway and manhole systems on the airfield there could be multiple runway or taxiway circuits in the same area. There is no safe way to measure voltage on this constant current circuit at this point. Since the constant current circuit is an ungrounded system, one lead could be directly connected to earth and the system remain operational. No voltage test is available to the qualified person.

The only way the qualified person can positively confirm the constant current circuit is de-energized is by measuring for the absence of current.

I have the privilege of serving on another NFPA Technical Committee and our committee discussions can be candid and frank without being confrontational. Being honest and forthright the statement "widely used, understood, and correlates with the provisions found in this standard as well as OSHA and other regulations" sounds like the "we have always done it this way" excuse. OSHA uses the term "electric energy" and "non-electric energy" in 1910.147 and 1910.333.

The proposal is a logical improvement to include two fundamental components (voltage and current) of electrical energy. The Qualified Person needs to determine which test is necessary based upon the persons training and knowledge of the construction and operation of the system.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 11-NFPA 70E-2025 [Section No. 120.6]	Applicable change for constant current circuits
Public Comment No. 13-NFPA 70E-2025 [Section No. 110.4(A)(1)]	Applicable change for constant current circuits
Public Comment No. 14-NFPA 70E-2025 [Section No. 110.6(E)]	Applicable change for constant current circuits

Public Comment No. 15-NFPA 70E-2025 [Section No. 120.5(B)(6)] Public Comment No. 11-NFPA 70E-2025 [Section No. 120.6] Public Comment No. 13-NFPA 70E-2025 [Section No. 110.4(A)(1)] Public Comment No. 14-NFPA 70E-2025 [Section No. 110.6(E)] Public Comment No. 15-NFPA 70E-2025 [Section No. 120.5(B)(6)]	Applicable change for constant current circuits

Related Item

• Public Input No. 49-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: Carl Johnson
Organization: AVCON, Inc.
Affiliation: none
Street Address:
City:
State:
Zip:
Submittal Date: Tue Mar 25 16:03:37 EDT 2025
Committee: EEW-AAA

Document file Name:

Chap_13_UFC_3-535-01_Visual_Air_navag_Facil_-_25_APRIL_2023.pdf

This material is taken from the DOD's Unified Facilities Requirements. The material describes the characteristics of an airfield lighting series circuit.

Page 1 through Page 17

CHAPTER 13 \1\ CHARACTERISTICS OF AIRFIELD GROUND LIGHTING

13-1 GENERAL.

Airfield ground lighting (AGL) typically includes separate series-circuited lighting systems that provide visual guidance to the pilot for aircraft operations. The systems usually have brightness control for adapting to various visibility conditions. The types of lighting systems installed for a particular runway are an important part in determining the conditions under which aircraft operations are allowed (e.g., Visual Flight Rules (VFR), Category I, Category II, or Category III). The various lighting systems that may be installed for a runway are shown in Figure 13-1. Not included in this figure are the several approach lighting systems (ALS) which may also be installed. Details for lighted approach aids, runway lighting systems, and taxiway lighting are provided in Chapter 3, Chapter 4 and Chapter 5, respectively.

13-1.1 Airfield ground lighting is characterized by constant current series electrical circuits, which provide constant current for intensity control of lighting components. This system allows for selectively changing the brightness of the lighting components by increasing or decreasing the level of the constant current in the series loop. While some older systems use constant voltage for shorter length series circuits, most systems today are constant current type. The series circuit provides energy at constant current to each device (such as a light or sign) on the circuit, supplied from a CCR.

13-1.2 The major parts of a series circuit are: the CCR (power source), the primary circuit cable, isolation transformers, and lighting components (such as lights and signs). The isolation transformers are connected in series on the primary side, with connected loads on the secondary side of each isolation transformer (Figure 13-2). The system is characterized as follows:

- A constant current is delivered along the entire loop on the primary side of the isolation transformers, independent of the number of lighting loads. Power is provided by the CCR.
- The magnitude of the voltage along the series circuit primary depends on the number and size of connected lighting loads. The voltage along the primary cable will measure different at each point. (Calculating voltages for the constant current series circuit is illustrated later in this chapter.)
- The circuit is considered high voltage on the primary side, which typically may be several thousand volts (5kV cable is used), and low voltage on the secondary side or load side of the isolating transformers, which typically is less than 30V.

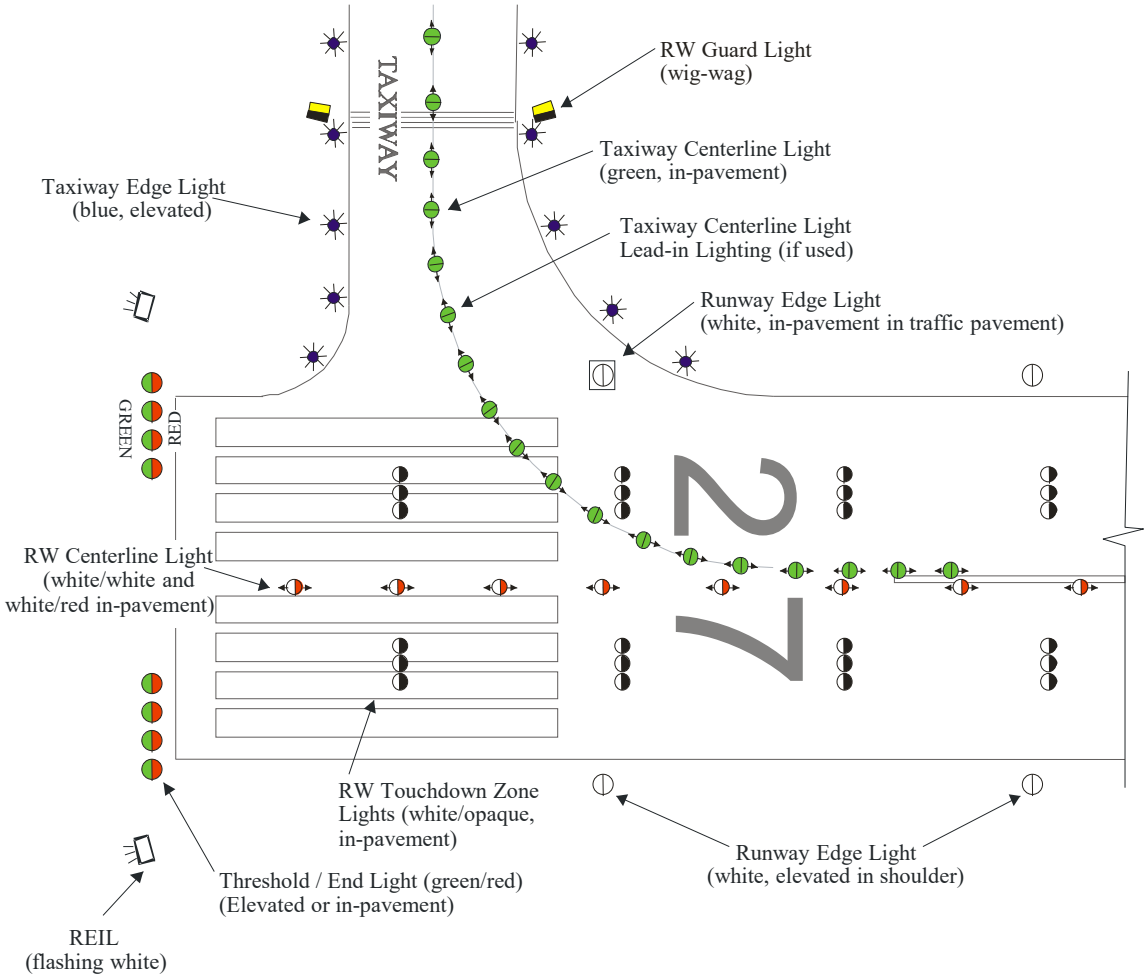
RED TEXT comments by Carl Johnson. Red text is not a part of the original document.

RED LINE in margin indicates information relative to this PI.

- The isolation transformer provides an effective short for the primary circuit in the event of a lamp filament failure, which opens the secondary circuit. This prevents failure of a connected light from causing an open condition on the series primary circuit.

- A constant current series circuit can also be used to power equipment with specific voltage requirements. In this case a power adapter is used. The power adapter also serves to isolate the device from the primary side similar to an isolation transformer. Examples of equipment which may be connected to series lighting circuits include: wind cones, PAPI, REIL, and others which typically may require 120/240V power. NOTE: The lighting circuit must be ON for the equipment to receive power with this type of arrangement.

Figure 13-1 Typical AGL Layout



NOTES:

1. RW EDGE LIGHTING: For high intensity system (HIRL) bidirectional, white/white, with yellow on rollout for last 2,000' (610M) (L-862 elevated, with L-850C for in-pavement). Runway edge lights are spaced about 200' (61M) apart.

2. THRESHOLD/END (T/E) LIGHTS: Group of 4 or 5, spaced 10' (3M) apart symmetrical about centerline. Outer light in each group lines up with RW edge lights. Groups may be wing-out bars, where inner light in each group lines up with RW edge lights.

   T/E lights show green to aircraft approaching for landing, and red to landing aircraft coming to end of the RW.

3. RW CENTERLINE LIGHTS: Bi-directional white/white, with alternating red/white and white/white from 3,000' to 2,000' (915M to 610M) from end of RW, and red/white for last 2,000' (610M) of RW.

4. RW TOUCHDOWN ZONE LIGHTS: Uni-directional, with white towards approaching aircraft.

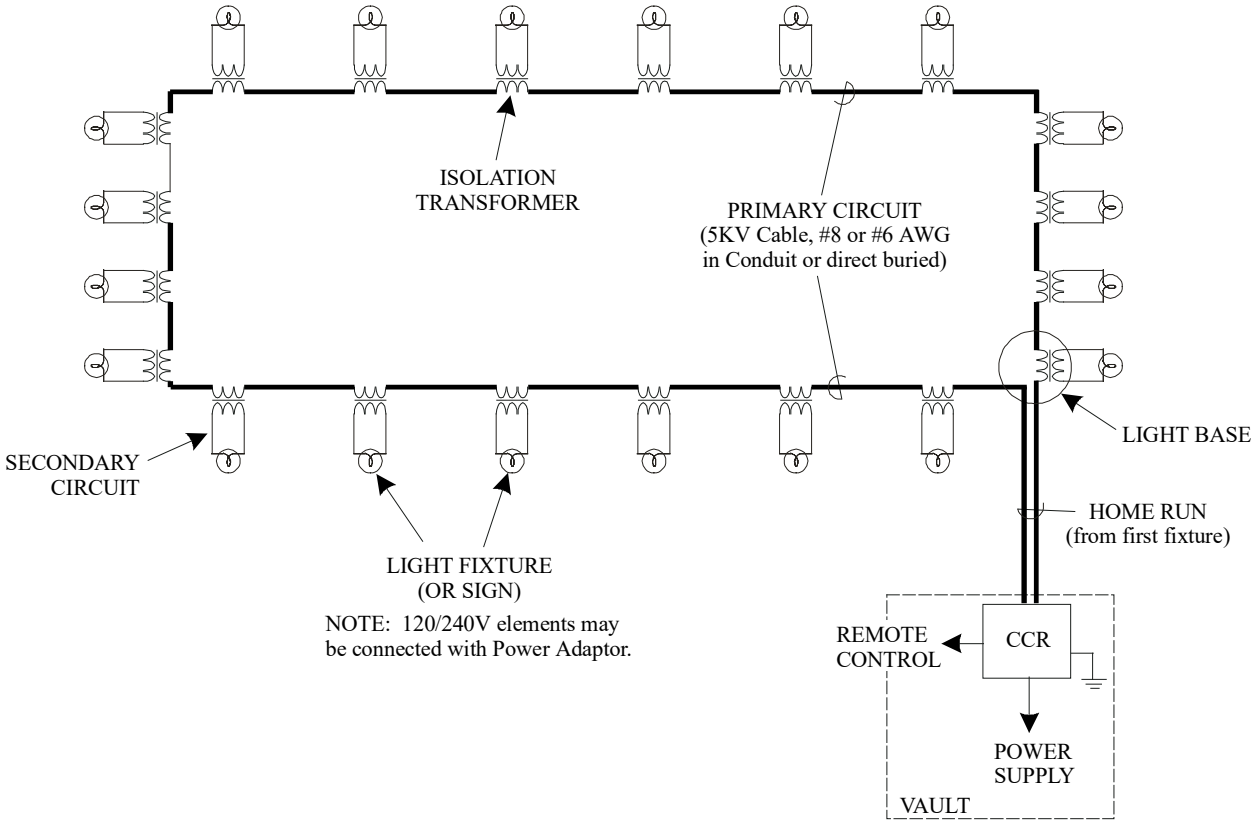
5. TW EDGE LIGHTS: Omni-directional blue (L-861T).

6. TW CENTERLINE LIGHTING: Bi-directional green/green, but may be green/yellow or yellow/yellow for some conditions.

7. REIL: Runway End Identifier Lights, discharge type flashing white lights (about 90 times/min.), Aimed 15 deg outward and 10 deg above horizontal.

8. RW GUARD LIGHT: Uni-directional, flashing yellow. Elevated outside TW, or may be bar of in-pavement across pavement (L-804).

Figure 13-2 Typical AGL Series Lighting Circuit



13-1.3 Parallel circuits are briefly discussed as these may be used to serve facilities such as wind cones, PAPI, REIL, and others. This may be directly from a power source, or via power adapter from a series lighting circuit.

13-2 POWER.

Upstream power for the CCR feeding the AGL may be from a variety of sources. Equipment vaults for AGL may be fed from a variety of sources, and in many cases have emergency standby generator power with automatic transfer in case of outages. Older systems typically feed the CCR at 2400V, while newer installations feed vault CCRs at 480V; 2400V input CCR equipment is for replacement only. The upstream power distribution feeding the CCR is not covered in this section.

13-3 CONTROL AND MONITORING SYSTEMS.

Traditional control/monitoring systems, both military and commercial, are relay systems. L-821 relay panels are very reliable and are suitable for nearly all military airfields. Typically, cables required for these types of systems are multi-pair (50 or more pairs) cables to connect the airfield lighting vault on the airfield with the air traffic control tower. On many air bases, the distance between the two facilities is great, resulting in a costly cable installation with the cable vulnerable to possible damage or failure of one or more pairs in the cable. In addition, these

communications cables require separate duct systems to eliminate interference from the power cables. The traditional relay panel and multi-conductor control cable can also be simplified by using a multiplexer, which requires only one pair cable to communicate between the vault and tower (or other station). A multiplexer can also be built into a PLC system.

13-3.1 Some airfield control/monitoring systems have been installed using Programmable Logic Controllers (PLCs). The PLC industrial systems use high I/O modules that reduce the need for multi-pair cable installation. Cables with 2 to 6 pairs are typically needed, although fiber optic cable can also be used.

13-3.2 PC-based systems are currently being used, with computers (Windows 7 operating system is approved by AF Chief Information Officer) located in the tower, the vault, and/or other work stations. These systems have the capability of displaying the necessary information on a monitor. This is the most flexible system in use today, with off-the-shelf units readily available. Typically, standard operating software is used, and off-the-shelf graphics software is tailored for a specific site. The communications cable requirements are 2 to 6 pairs of cable or fiber optics. Fiber optic cable eliminates the need for separate ducts since there will be no interference between power cable and fiber optic cable. The control panel typically is a touch-screen type. At the time of this writing the essential system PCs are recommended to have the following characteristics: 19" (480 millimeter) rack mount form factor, fully enclosed metal housing, redundant hot-swappable solid state software and data storage devices, redundant hot-swappable cooling system, redundant hot-swappable power supplies. The systems incorporate uninterruptible power supplies (UPS) for primary power to all system components required for normal operation for a duration of fifteen minutes.

13-3.3 Compared to the traditional FAA Type L-821 control/monitoring systems, the PLC or PC-based systems are easily expanded and provide data for the air traffic controller and maintenance personnel. Refer to FAA AC 150/5345-56. Some industrial standards the PLCs meet are NEMA ICS1, NEMA ICS2, NEMA ICS 3, UL 508, ANSI/IEEE C 37.90.1-1989, CAN/CSA C22.2 No. 142, MIL-STD-461B, MIL-STD-810 and ISO 9000.

13-3.4 Often, the computerized system is based on one specific manufacturer’s equipment. This limits the facility to one manufacturer for both service and parts. A good system design will avoid this by establishing competitive parameters in the procurement document.

13-3.5 Considerations for the design of a computerized control/monitoring system are in paragraph 13-18.6.

13-3.6 Factors for consideration when selecting a control system:

- Monitoring AGL equipment: the PLC based system must be customized for each type of CCR.

- For PC based systems, software has been developed and tested, and is easily configured to monitor AGL equipment. Software developed for PC systems is specific for the task and works with all types of CCRs and other related AGL equipment.

- With PLC systems there are established industrial standards and criteria for mean-time-between-failure (MTBF).

13-4 CONSTANT CURRENT SERIES CIRCUITS.

A constant current series circuit is an ungrounded system, where circuit elements are connected in a string with the same current flowing to each element. The circuit is one continuous loop starting and ending at the power source (the constant current regulator for the AGL circuit). The CCR maintains a constant current independent of the load on the circuit.

13-4.1 Circuit Failure.

With constant current, a short-circuit across the output of the CCR is a no-load condition, and an open-circuit is an overload. In a simple series circuit, a lamp failure would cause an open-circuit. For this reason a bypass device such as an isolating transformer is installed between the primary side and secondary side as part of each light fixture connection, or for connecting other loads such as guidance signs. In certain cases, such as for approach lights where 5 steady-burning lights are on a single secondary circuit isolated from the primary series circuit by one or more isolation transformers, a film disc cutout may be used. Film disc cutouts operate in such a way that when a lamp burns out, the film-disc cutout shorts the failed lamp, thereby allowing current to flow to the remaining connected fixtures.

13-4.2 Advantages of Series Lighting Circuits.

- All lamps operate at the same current, hence same intensity.

- Single-conductor cable of one size and insulation voltage rating can be used throughout the circuit.

- Intensity control of lights can be obtained over a wide range.

- A single ground fault along the circuit will not affect light operation.

- Ground faults are easily located.

13-4.3 Major Disadvantages of Series Lighting Circuits.

- Installation costs are high when considering the CCR and isolating transformers.

- Poor efficiency in use of electrical power.

- All components on the primary side must be insulated for full voltage.

- An open-circuit anywhere on the primary side makes the entire circuit inoperative and could damage cable insulation or the CCR.

- Locating faults such as open-circuit conditions can be time-consuming and may be difficult.

13-4.4 Typical Usage.

Series circuits are usually used for runway and taxiway lighting systems and most steady-burning lights of approach lighting systems because they provide more uniform intensity and better intensity control of the lights.

13-5 CONSTANT CURRENT REGULATORS.

The power input to the AGL circuits is controlled by the CCR to which the circuit is connected. While the CCR produces constant current to the circuits depending on the brightness step setting, the voltage input to the circuit varies with the actual load.

13-5.1 Basically, there are three types of constant current regulators used at airports:

- Resonant network circuit (ferro-resonant type using a resonant network control system to produce output current).

- Saturable reactor (ferro-resonant type, where the amount of reactor saturation via closed control loop determines output current).

- Silicon controlled rectifier (SCR) (uses SCR type thyristors to convert constant voltage source to constant current output, with solid state control circuiting). These are not ferro-resonant and are not approved for new installations.

13-5.2 The first two types have been reliable over the years, but fluctuations in input voltage will cause corresponding changes in the output current. Most CCRs now manufactured are SCR type.

13-5.3 Tests have shown that, as circuit load increases toward the rated capacity of a CCR, harmonic distortion is reduced and the wave form approaches a sine wave. This suggests that loading closer to rated capacity results in better circuit performance. However, lamp failures and other factors may increase the output voltage, and this needs to be considered when matching circuit load to CCR size.

13-5.4 CCRs have “taps” for adjustment to accommodate loads. Some manufacturers have introduced taps which automatically adjust to the circuit load, while others use manual taps which are typically set when the CCR is installed, but can be changed later to accommodate changes in the load.

13-5.5 The allowable tolerances in CCR output current are shown in FAA AC 150/5345-10. The allowable tolerances are small, because small changes result in large changes in light output. For a 6.6 amp circuit, reducing the current by 3 percent (to 6.4 amps) will reduce the light output over 15 percent, and reducing the current by 6 percent (to 6.2 amps) will reduce the light output by over 30 percent. The impact is the opposite on lamp life, where a current lower than maximum will significantly increase lamp life, and a higher current will reduce lamp life. The percent of full brightness obtained at each of the nominal current levels for 3 and 5 step systems can be found in paragraph 12-1.11.

13-5.6 15KW through 30KW CCRs may be selected for either 20 or 6.6 amperes output current. Intensity steps are either 5-step or 3-step for all CCRs.

13-5.7 50 kW and 70 kW regulators operating with 20A output current are not approved for new installations and are allowed for replacement only. Regulators with 2400V input are not approved for new installations.

13-6 REGULATOR SIZING.

13-6.1 For steady burning loads such as edge, centerline and touchdown zone lights sizing the regulator is fairly straight forward. Steady burning lights and circuit conductors are resistive loads and therefore will vary as the current varies. Current transformers are impedance loads and have the same electrical characteristics as resistive loads. See Figure 13-3A for calculating the load as the current varies; i.e., at the lowest brightness step. Using Ohms Law (P=IE), the maximum load at the lowest brightness level for a five-step regulator is determined by the ratio of the currents; i.e., (2.8/6.6) or (8.5/20) or 42.4% of the regulator rating. For a three-step regulator it is 4.8/6.6, or 72.7% of the regulator rating. It can be seen that these load percentages are greater than the ones calculated in Figure 13-3A. Therefore, a regulator fully loaded only with lights (and associated transformers) will not overload at the lowest current level.

Figure 13-3A Calculation of Steady Burning Load at the Lowest Brightness Level

DATA:

P = Steady Burning Light Load

I = Regulator Current

R = Steady Burning Light Load Resistance

Subscript $_H$ is the value at the Highest Brightness Step

Subscript $_L$ is the value at the Lowest Brightness Step

Ohms Law: $P = I^2 \times R$

CALCULATIONS:

$$P_H = (I_H)^2 \times R \rightarrow R = P_H / I_H)^2$$

$$P_L = (I_L)^2 \times R \rightarrow R = P_L / (I_L)^2$$

The resistance of the lamp filaments remains constant, therefore

$$P_L / (I_L)^2 = P_H / I_H)^2 \rightarrow P_L = P_H \times (I_L)^2 / I_H)^2 \rightarrow P_L = P_H \times (I_L / I_H)^2$$

The effective load of the steady burning fixtures at the lowest brightness step (P_L) is the load at the highest brightness step (P_H) times the squared ratio of the low (I_L) and high (I_H) currents.

For a 6.6A five step regulator the current ratio squared is $(2.8/6.6)^2$ or 0.18 or 18%.

For a 20A five step regulator the current ratio squared is $(8.5/20)^2$ or 0.18 or 18%.

For a three step regulator the current ratio squared is $(4.8/6.6)^2$ or 0.53 or 53%.

SUMMARY:

For five step regulators the load of steady burning lights at the lowest brightness step is 18% of the load at the highest brightness step.

For three step regulators the load of steady burning lights at the lowest brightness step is 53% of the load at the highest brightness step.

13-6.2 When loads such as REILs, PAPIs, windsocks and airfield signage are connected to a series circuit, consideration must be given to accommodate the effect of these loads on the regulator. Loads such as these have unique power requirements. PAPIs, signs and windsocks must maintain a constant level of light output and require a constant input voltage. When they are connected to a series circuit that has varying current levels the power from the current regulator must be converted to a constant voltage source within the equipment. Airfield signs are required to maintain a constant level of illuminance on the sign face and electronics are needed to operate them from a varying current source. The commonality with all these loads is that they present a constant load to the regulator regardless of current level on the circuit. When the circuit is a combination of steady burning lights and signs or other constant loads, the engineer must insure that the calculated load at the lowest brightness level does not exceed the percentage of the regulator rating as indicated above. Figure 13-3B shows an example where the regulator is over loaded at the lowest brightness step. Although most regulators will continue to operate when over loaded there are risks associated with that. Depending on the degree of overloading, negative effects may include the regulator's inability to stay within the FAA current tolerances. The result would be improper brightness levels. Operating an overloaded regulator can also lead to the premature failure of critical components because the regulator will raise the output voltage to maintain the required current level.

13-6.3 In its Advisory Circulars, the FAA does not address the load imposed on the CCRs by the constant current to constant voltage adapters necessary for REIL operation, or the REIL that are connected into series circuits. With the constant flashing of the lights and the resulting discharging of the capacitor, the REIL place a very short, but heavy, pulsing load on the regulator. Occasionally, this type of pulsing load results in pulsation of the illumination of the steady burning lights on the circuit. This "reflective" pulsation depends on the characteristics of the regulator powering the circuit and on the characteristics of the REIL connected into the circuit. The design engineer needs to ascertain from the regulator manufacturer which type of CCR will handle the overall series circuit load with the addition of the REIL pulse-type load without adverse effect. It has been shown that the problem will be minimized if the REIL are connected into series circuits that have primarily incandescent loads and the circuit load approaches the capacity of the regulator.

13-6.3.1 The actual regulator capacity needed to operate the REIL properly is much greater than the rated load indicated in the typical product literature. Usually the average power requirement is provided; however, the regulator has to accommodate the instantaneous, or pulsing, load to provide the flashing characteristics of the REIL. That REIL may be rated to require only 400 watts to operate, but may actually require up to 4 kilowatts of regulator capacity to meet the pulsing load requirements when also including the impact of the series circuit adapters between the series circuit and the REIL. The series circuit adapters convert 6.6 amps to 120 volts for REIL operation, and often have low efficiency that imposes higher than expected loads on the regulator. The proper sizing of the regulator requires careful consideration of the types of loads on the circuit and the true impact of those loads on the regulator.

Figure 13-3B Sample Calculation of CCR with High Signage Load

DATA:

CCR: 30KW, 480V input, 5-step (2.8A – 6.6A)

Cable: AWG #6, 5kV, L-824 Type C, 20,000 feet primary circuit

Circuit Loads:		
Steady Burn Lights	13,000 W
Transformer Losses (26% of Light Load)	3,380VA
Signage	13,000 VA
Cable losses (19 VA / 1,000')	383 VA

Circuit power factor is assumed to be 0.85.

CALCULATIONS:

1. Total connected load, VA = 13,000 + 3,380 + 13,000 + 383 = 29,763 VA
2. CCR Rated Load @ Lowest Brightness Step: (Reference paragraph 15-6.1)

   30KW x (2.8/6.6) = 12.72 KW or 14.97 KVA

3. Calculated Load @ Lowest Brightness Step: Reference Figure 3-13A(Reference Figure 15-3A)

   (Lights + Losses) x $(2.8/6.6)^2$ + Signage =
   ((13,000 + 3,380 + 383) x 0.18) + 13,000 = 16,017 VA

Because the signage load does not change for the various brightness steps the resulting demand on the regulator at the low step (16.02 KVA) is higher than the rated load for the regulator at the low step (14.97 KVA). While the load at the highest step (29.76 KVA) is less than the rating of the regulator, it will be overloaded at the lowest step; therefore, do not operate in this load configuration.

Loads such as signs, REILs, PAPIs and windsocks are constant regardless of the brightness level and must be carefully considered in circuit design and regulator sizing.

Where:

E = volts (V)	W = Wattage of light fixtures
I = Current, in amperes (A)	VA = Volt-Amps
P = Power Load	kW = kilowatts
	kVA = kilovolt-amps
	P.F. = Power Factor

Ohms Law: $P = IE$, $E=IR$, $P=I^2R$

13-6.3.2 As described in paragraph 13-6.1, the REIL can impose significant loads on the CCR powering the circuits to which they may be connected. It is preferable, if the budget permits, to have separate circuits with 240/120 volt service to power the REILs, thereby eliminating any adverse impacts on series lighting circuits.

13-6.3.3 Sample calculations and comparison with test data, as well as guidance for setting taps, are shown in Figure 13-4. A table format for calculating airfield lighting series

circuit loads is shown in Table 13-1. Carefully consider the notes in Table 13-1 when determining load values.

13-6.3.4 Normally the airfield signage load on a circuit is less than the steady burning light load. When the sign load is significant on a circuit, care must be taken to prevent overloading the regulator at the lowest brightness step. Figure 13-3B shows an example calculation where the sign load is high enough to present a problem.

13-7 CABLE.

The primary series circuit utilizes FAA L-824 Type B or C cable. L-823 connectors are used for connections. For 6.6 ampere primary series AGL circuits, an AWG #8 conductor is normally used. An AWG #6 conductor is used with 20 ampere circuits. For the secondary side lighting loads, a two-conductor AWG #10, 600V insulation is normally used.

13-7.1 The cable is installed in conduit, although it may be direct buried (L-824 cable is rated for direct burial). It is important that insulation is intact and that proper connections are made. Deteriorated or damaged cable can result in current leakage and may present a high voltage hazard to maintenance personnel. While installation in conduit may cost more, this method usually provides longer circuit life, and makes troubleshooting and replacement of cable segments easier. Where cable is installed in the regulator vault it must be in conduit, wireway or conduit or wireway in a floor trench with a solid top. L-824 cable is not rated for installation in cable tray.

13-7.2 The types of faults associated with series circuit cable are open circuit conditions and shorts-to-ground. An open circuit condition will turn off all the lights. A single short-to-ground will not impact the lighting, but multiple shorts-to-ground can cause dimming of lights or outages for portions of the circuit or for the entire circuit.

Figure 13-4 Sample Calculation of CCR Test Data

(1 of 2)

SAMPLE CALCULATIONS, CCR TESTING

DATA: CCR: 30KW, 480V input, 5-step (2.8A - 6.6A), with Power Factor of 0.43

Cable: AWG #8, 5kV, L-824 Type C, 20,000 feet primary circuit

Circuit Load: 70 Edge lights @ 120W (100W transformer)
16 Threshold/end lights @ 200W (200W transformer)

10 signs @ 100VA (at step 5)
5 signs @ 200VA (at step 5) } *(at the input to the isolation transformer*)
3 signs @ 300VA (at step 5)

1 REIL system (2 units) @ 400W, connected by power adapter. [Note that in this example the REIL is only adjusted for PF. Some REIL may require further adjustment, based on manufacturer's information.]

Cable losses (resistance) @25°C: 0.68Ω/1,000'
Fixture losses (obtain from Mfg - This example assumes 18 percent for 120W, and 11 percent for 200W lights)

CALCULATIONS:

1. CCR rated output voltage, V_{RMS} = 30KW/6.6A = 4,545V

2.Total connected load, KVA = $\frac{[W_{lamps} + W_{REIL} + VA_{signs}]/PF + Fixture\ Loss + Cable\ loss}{1{,}000}$

Fixture losses = (70 x 120 x 0.18) + (16 x 200 x 0.11) = 1,864W

Cable losses = I^2R = $[6.6]^2$ x (0.68 x 20) = 592W

TOTAL KVA = $\frac{[(70x120) + (16x200) + (400) + (10x100 + 5x200 + 3x300)]/0.43 + 1{,}864 + 592}{1{,}000}$

= 17.57 KVA

where:

KVA = kilovolt-amperes
V = volts
A = amperes
KW = kilowatts
CCR = Constant Current Regulator
R = Resistance in Ohms, Ω
V_{RMS} = Rated output voltage of CCR
W_{lamps} = Wattage of light fixtures
W_{REIL} = Wattage of REIL
PF = Power Factor
I = Current, in amperes

Figure 13-4 Sample Calculation of CCR Test Data (Cont.)

SAMPLE CALCULATIONS, CCR TESTING (Cont.)

NOTE: Traditional method for determining the load KW assumes that the CCR powers a unity power factor lamp circuit. With REILs, new type signs, and runway guard lights (wig-wags), a unity power factor is not representative, and power factor must be considered.

MEASURED RESULTS (Case 1):

- Output current at Step 5 = 6.52A
- Output voltage at Step 5 = 2,880V

Total KVA Load based on measurements = 6.52A x 2.88kV = 18.8KVA

CONCLUSIONS: The output current is within FAA tolerance. The total KVA measured is slightly higher than the calculated load. This may be due to slightly higher actual fixture losses than assumed values. Overall, the CCR is operating satisfactorily.

MEASURED RESULTS (Case 2):

- Output current at Step 5 = 6.52A
- Output voltage at Step 5 = 1,880V

Total KVA Load based on measurements = 6.52A x 1.88kV = 12.3KVA

CONCLUSIONS: The output current is within FAA tolerance. The total KVA measured is significantly less than the calculated load. The results suggest a partial shorting of the load.

MEASURED RESULTS (Case 3):

- Output current at Step 5 = 6.30A
- Output voltage at Step 5 = 2,550V

From test results, Total KVA Load = 6.30A x 2.55kV = 16.1KVA

CONCLUSIONS: The output current is below that allowed by FAA tolerance. The total KVA measured is below the normal value (2,880V) as found in first test. Results indicate faulty CCR. Perform a short circuit test on the CCR before it is used.

NOTE: Analysis compares KVA with KW. This is because the rated output of the CCR is specified in KW in compliance with FAA AC 150/5345-10. However, load measurements result in KVA. The requirement for total load in KVA to be below the CCR output in KW under operational conditions ensures that the CCR is not overloaded.

Table 13-1 AGL Series Circuit Load Calculation Data Sheet

CKT No.	Regulator (CCR) (Runway or Taxiway, Etc.)	CKT Type (Amps)	Cable Size (AWG)	CCR Rating (KVA) (1)	CCR Input (V)	Steady Burning Light Load (KVA) (2)	Sign Load (KVA) (3)	Other Loads (KVA) (4)	Total Connected Load (KVA)	Transformer Losses (KVA) (5)	Cable Length FT or M)	Cable Losses (KVA) (6)	Calculated CCR Load (KVA)

NOTES:
(1) CCR rating may be in KW. To determine KVA, divide KW by power factor (PF) and CFR efficiency (EF) based on full load. Obtain PF and EF from manufacturer.
(2) To determine KVA for steady burning lights by summing "[no. of fixtures] x [lamp wattage] / 1000" for all lights on circuit. Steady burning lights can be runway edge lights, threshold/end lights, centerline lights, touchdown zone lights, taxiway edge and centerline lights, and approach lights.
(3) Determine KVA for signs based on manufacturer rating or specified limit VA for each size and length (modules or width) of sign on circuit.
(4) Other loads may be pulsing lights such as REIL. Determine KVA based on manufacturer data for each type.
(5) Isolation transformer losses may be estimated at 26% of connected load.
(6) Determine cable losses based on cable length and manufacturer cable data on conductor resistance. Loss per unit length is typically based on the relationship $I^2R = W$ and assumed PF of unity for the cable.
Typical values for cable losses are: 34VA / 1,000ft (34VA / 300M) for 6.6A circuits with uncoated stranded #8 AWG conductor, and
196VA / 1,000ft (196VA / 300M) for 20A circuits with uncoated stranded #6 AWG conductor.

Refer to Paragraph 5-3.2.3, Color Coding.

13-8 TRANSFORMERS.

The isolation transformer provides: electrical isolation between the high voltage series circuit and the low voltage secondary feeding the lighting load (such as a fixture or sign), constant current output for a constant current input at the correct ratio, and an effective short circuit in the event of an open condition in the light fixture, for example with lamp filament failure.

13-8.1 Isolation Transformers.

With the isolation transformer, only low voltage is brought to the light fixture (via the secondary circuit), and failure of the light does not cause an open condition on the primary circuit that would result in other lights and other connected loads to be shut off.

Isolation transformers for AGL are covered by FAA Specification L-830 (for 60 Hz) and FAA Specification L-831 (for 50 Hz), and are typically 6.6 amperes on the secondary side, with either 6.6 amperes or 20 amperes on the primary side for series lighting circuits at the highest intensity step. The wattage of the isolation transformer is approximately matched to the connected load on the secondary side.

13-8.2 Transformer Load.

Ensure the load powered by the transformer is within ±10 percent of the transformer wattage rating to maintain isolation transformer efficiency. Light fixture manufacturers have their fixtures certified using a specified wattage for the isolation transformers. Use the light fixture manufacturer's recommended size for isolation transformers.

\4\ 13-8.3 Series Circuit Selector Switches.

Use switches in accordance with FAA AC 150/5345-5, Type L-847. Series circuit selector switches can be high-maintenance equipment and should be avoided whenever possible.

13-8.4 Control Cables.

Control cables for 120 VAC control systems must be multi-conductor, 600 volts, 12 AWG copper, rated for direct earth burial. Cables for 48 VDC control circuits must be multi-conductor, stranded 19 AWG copper, with 300 volt polyvinyl insulation suitable for installation in wet locations and meeting REA Bulletin 345-14 or 345-67. Color-code all conductors.

13-8.5 Constant Current Regulators (CCR).

Use CCRs per FAA AC 150/5345-10 of a suitable type and style. The size selected should normally provide for approximately 20 percent expansion of the load.

Document file Name:

Part_2.4_150-5340-26C_Maint_of_Airport_Visual_Aid_Facil.pdf

This document is from FAA Advisory Circular 150/5340-26C discussing the electrical hazards associated with an airfield lighting series circuit.

Page 18 through Page 20

c. Perform an electrical hazard analysis consisting of:

1. A **shock hazard analysis** to determine the voltage(s) to which personnel will be exposed, boundary requirements and the personal protective equipment (PPE) necessary to minimize the possibility of electric shock to personnel.

2. A **flash hazard analysis** must be completed to protect personnel from the possibility of being injured by an arc flash. The analysis determines the flash protection boundary and the PPE that personnel within the flash protection boundary must use.

d. Implement the requirements of the shock and flash hazard analysis prior to starting any work.

e. Complete the work safely and return the system to safe operating status.

f. Close out the energized equipment work permit.

2.3 Safety Procedures and Guidelines.

Most airport visual aid equipment is exposed to weather and may develop electrical shock hazards through damage from lightning or electrical cable insulation deterioration from exposure. Begin maintenance procedures only after a visual inspection is made for possible hazards. Due to the hazards associated with lightning, lighted navigational aids should not be serviced during periods of local thunderstorm activity. Each airport should develop and implement procedures to be followed in the event of an accident. Precious seconds are saved rendering medical assistance to injured personnel when action plans are already in place. Rehearse and review action plans regularly.

Part_2.4_150-5340-26C_Maint_of_Airport_Visual_Aid_Facil.pdf

2.4 Electrical Hazards of Series Lighting Circuits.

Airport lighting circuits are very dangerous. This is especially true for maintenance personnel with little or no experience working on constant current series circuits. Airport lighting circuits can operate at potentials of several thousand volts depending on the size of the regulator driving the circuit and the load.

2.4.1 Basic Rules.

There are three basic rules to remember when working on and around airport lighting circuits:

a. **ALWAYS** assume that the circuit is energized until you have proven otherwise. **ALWAYS** check for current before disconnecting the series circuit connector, removing the S1 cutout, or opening the primary series circuit by any other means. Make it a required practice to check the circuit with an ammeter prior to breaking the connection – **NO EXCEPTIONS.** Never attempt to measure voltage in a series lighting circuit using ordinary volt meters. An inductive voltage measuring device (sometimes referred to as a "ticker") such as is described in Chapter 4 may be used to detect the presence of induced voltage on a series lighting cable after checking for the presence of current. Always use a true RMS clamp-on type ammeter to verify if the circuit is energized. **ALWAYS** check

the operation of the test equipment on a known live circuit before and after measurements are taken.

b. **NEVER** under any circumstances open or break a live airfield series circuit. The voltage generated in the circuit can reach levels many times normal before the regulator's open circuit protection can shut it down. As long as a current flow can be maintained, even if it is through you, the regulator will continue to operate. This is one of the reasons that series circuits can be so hazardous to work around - there is no personnel protection provided such as might be found on parallel interior wiring.

c. **NEVER** enter a manhole with energized conductors and never handle cables or transformers in light bases while there is current present. Cables or connectors can have cracked insulation where it is not visible or may be deteriorated and fall apart, exposing you to live circuit conductors.

2.4.2 Induced Voltages.

Series circuits are typically run from the lighting vault in duct banks where the wires are lying parallel to each other in close proximity. Voltages may be induced in an otherwise un-energized conductor and may be a hazard when troubleshooting and testing. Circuits that have a load that varies due to flashing action of runway guard lights or REIL strobes are particularly prone to induce voltages in other conductors due to the pulsing characteristics of the voltage and current in these circuits. Always remember that there may be a possibility of an induced voltage in any conductor. Never work on or in close proximity to live circuits within any duct or manhole.

2.4.3 Re-lamping.

The most common lighting maintenance task on the airfield is re-lamping of incandescent runway and taxiway lighting fixtures.

Note: See paragraph 5.3.2 for information about light emitting diode (LED) light fixtures.

Depending on the type of light fixture, this may be accomplished in the field or, in the case of most in-pavement lights, the entire light fixture is removed, replaced, and brought to the maintenance shop for refurbishing. The greatest unseen danger to you is re-lamping or removing the fixture with the circuit energized. This has always been a common practice by airport electricians for convenience and the dangers are often overlooked. There are two primary hazards associated with this practice:

a. The first hazard occurs when there is a short circuit between the isolation transformer primary and secondary windings. Remember that isolation transformers are not designed for personnel protection. They are designed to isolate the secondary winding from the primary circuit to allow continued operation with a lamp burned out. A transformer with a primary to secondary short may not cause a circuit malfunction and could remain unnoticed during normal operation.

A short from the isolation transformer primary to secondary winding exposes you to the full voltage present on the primary circuit and can be especially dangerous if another

Document file Name:

Part_2.2_AAAE_Airfield_Lgt_Course_Mod_1a.pdf

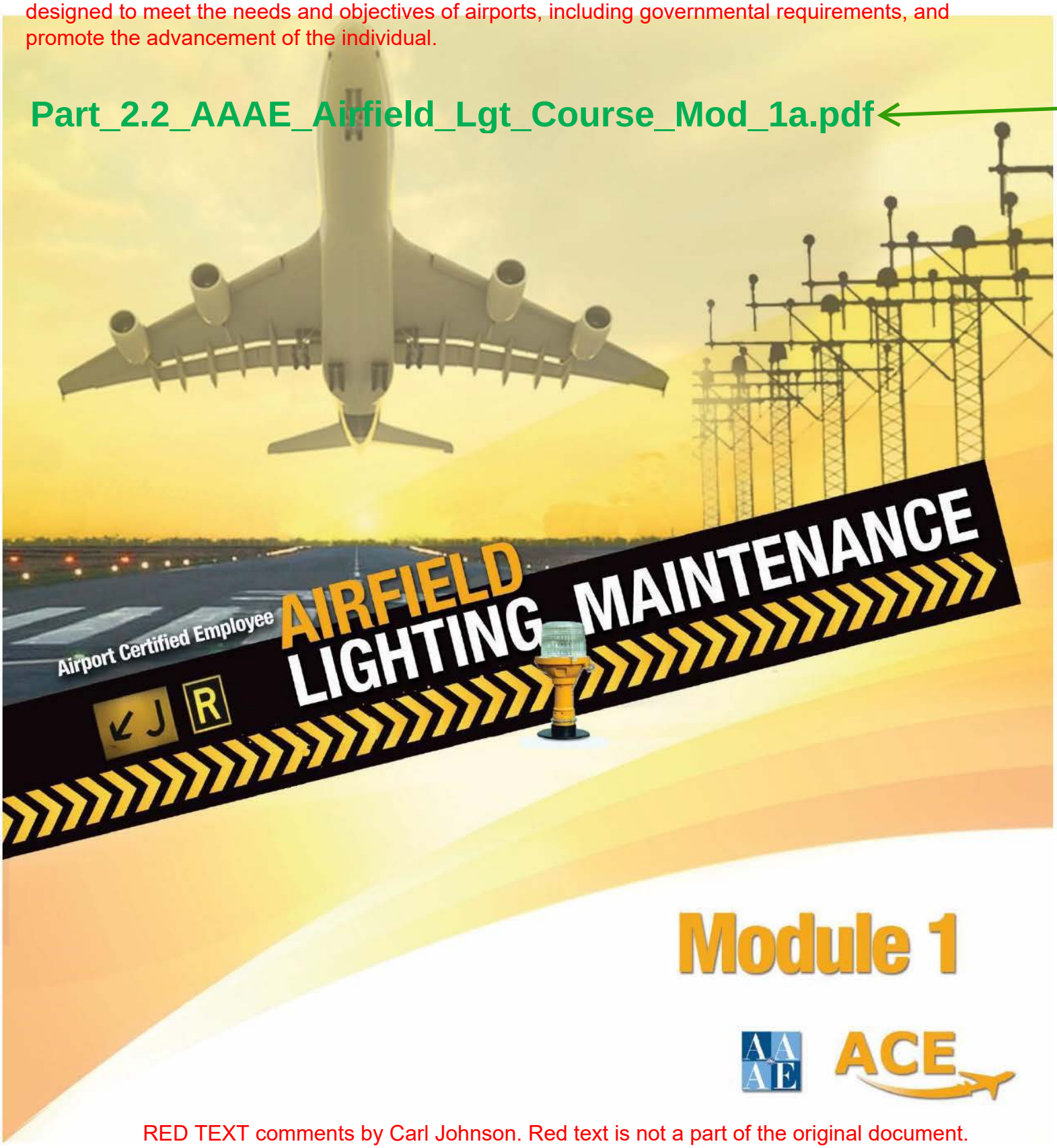
This document is a portion of the Association American Airport Executives (AAAE) airfield lighting maintenance course. The material has been REDLINED to highlight characteristics of an airfield lighting series circuit.

Page 21 through Page 25

American Association of Airport Executives (AAAE) Certification.
Airport Certified Employee (ACE) - Airfield Lighting Maintenance

AAAE certification programs set the standard for industry knowledge and training. Each program is designed to meet the needs and objectives of airports, including governmental requirements, and promote the advancement of the individual.

Part_2.2_AAAE_Airfield_Lgt_Course_Mod_1a.pdf ←



RED TEXT comments by Carl Johnson. Red text is not a part of the original document.

https://www.aaae.org/AAAEMemberResponsive/PD/AC/ACE/Airfield_Lighting_Maintenance/Airfield_Lighting.aspx

2.2 Theory of Operation

As previously stated, the series lighting circuit is a constant current, variable voltage circuit as opposed to a conventional parallel circuit which has a constant voltage output with the current varying at different points in the circuit depending on the circuit layout. Maximum current output on series lighting circuits in the United States is limited to either 6.6 amps or 20 amps depending on the circuit load and the CCR being used. Circuits rated at 6.6A are limited to 30 kW in size due to the fact that at maximum load and maximum current output, the CCR would have an output of 4545 volts which is just below the operating rating of the cable and transformers. If circuits greater in size than 30kW are required, the circuit is changed to 20 amp to reduce the output voltage. For example, the maximum output voltage on a 50kW 20 amp CCR would be 2500 volts. For this reason, and to prolong the life of the cable and transformers, it is at times recommended that the size of the circuits be limited to 20kW or less at 6.6A. Constant current regulators with a 20 amp output are only available as 5 step models and 50 and 70 kW units are limited to replacement units only per FAA AC 150/5345-10F. This change is due to the development of light fixtures which utilize smaller wattage lamps than previous models and therefore present a smaller load to the circuit.

Electrical current flow in the series lighting circuit is from one output terminal on the CCR to the other through the various sized isolation transformers (loads) in the field circuit. The CCR varies the output voltage depending on the amount of load in the circuit and the selected brightness step. The output side of the transformer winding in a CCR is not connected to ground at any point, therefore the voltage to ground is said to be “floating”. Since there is no true current path to ground and back to the source (CCR) as in a normal parallel circuit, there will be no current flow to ground if only one point in the circuit is grounded. However, when two or more locations in the series circuit become grounded, the current will flow through the ground around the load thereby resulting in a section of lights being extinguished. We will cover the theoretical and practical aspects of the behavior of voltage and current in a series circuit in more detail later in this chapter.

2.3 Advantages

The series circuit concept was first used in street lighting systems many years ago and is still in use in some areas today. It has proven to offer several advantages for airport lighting in that it provides:

- An illumination of even intensity to provide the proper visual cues to the pilot.
- The ability to deliver light output at variable intensities under various weather conditions.
- The compact design of the lamp filaments used with the constant current system is much more rugged and provides lamps that are more easily focused in an optical system.
- This system allows standardization of economical cables and cable sizes (#6 and #8 AWG). Relatively small cables can be used to deliver substantial power over very long circuits, typically two to five miles in length.
- A single ground fault in the system will not affect light operation.
- Ground faults may be easily located.
- The ability to easily add, remove or modify the load with the primary concern being the loading of the CCR. We must remember however, that by adding load to a series circuit, we are also increasing the output voltage of the CCR and thereby increasing the voltage stresses on the existing circuit cables and transformers.

2.4 Components of the System

The series lighting circuit uses a variable voltage, constant current AC source to supply electrical energy to the various loads connected to the circuit. The series circuit is comprised of a set of similar building block components in addition to the constant current regulator source. Each of these building blocks consists of the lighting fixture or sign, series isolation transformer and modular connector kit. These building block components are connected to each other and to the CCR by the 5 kV cable which can be either shielded (screened) or non-shielded. Non-shielded cable is typically used at installations in the United States and Canada. Shielded cables are sometimes used in European installations. The perceived benefits and drawbacks of each are the subject of much debate. There are other variables that can be found in various parts of the world such as Canada where isolation transformers are equipped with a grounding terminal that is internally attached to one side of the secondary winding of the transformer. This enables the secondary of the transformer to be grounded in an effort to help provide personnel protection in the event of a primary to secondary short in the transformer windings.

Series isolation transformers are available in several configurations of input current (6.6 or 20 amp), output current (6.6 or 20 amp) and load size (10/15 to 500 watt). Transformers with outputs of 1500 watts are also available for approach lighting systems where multiple lamps are connected to a single transformer. Cable used for series lighting circuits is sized either at #8AWG or #6AWG, the latter being used in 20 amp circuits to provide for less resistance and thereby reducing the I^2R (current squared × resistance = watts) losses in the circuit.

Constant current regulators are available in ratings from 1 kW to 70 kW and with 3 or 5 step outputs per FAA specifications. The 1 and 2 kW sizes were added in the latest edition of FAA AC 150/5345-10 to allow for smaller CCRs for LED circuits. Constant current regulators in other countries may have up to 7 or 8 brightness steps and operate with an output of 6 or 12 amps. Constant current regulators rated for 6.6 amp output are available in 3 or 5 step configurations but 20 amp CCRs are available as 5 step output only per FAA Advisory Circular 150/5345-10.

The last component normally installed as part of a typical airport series lighting system is the counterpoise system. This system provides protection from lightning damage to the circuit. The counterpoise system typically consists of #8 or #6 AWG conductor that is installed a few inches above the circuit conductors or conduit and is attached to ground rods at even spacing around the circuit. The ground rods are normally located at distances not to exceed 500 ft. Depending on the configuration of the system, the counterpoise conductor may be connected to the base cans or mounting stakes or routed around the lights with no connection. The FAA Advisory Circular 150/5340-30, *Design and Installation Details for Airport Visual Aids*, latest addition, should be consulted for the latest requirements for counterpoise installation in the United States.

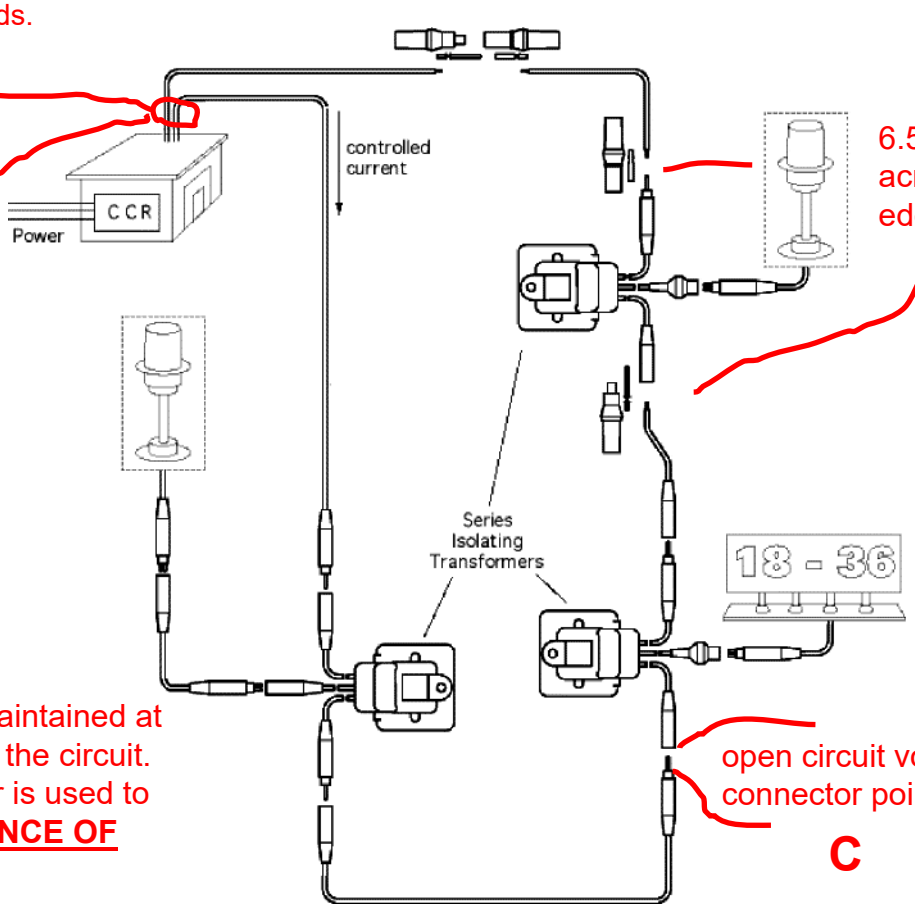
Constant current regulators are manufactured in several designs and styles. Basic types are Resonant Network, Thyristor Controlled (better known as series type), Ferro-Resonant and those employing a Saturable Core Reactor.

Series isolation transformers and CCRs are covered in detail in the following chapters of this training course.

A If there was a way to safely expose the conductors (w/o creating and open circuit) on both sides of the series isolating transformer the voltage drop across a LED runway edge light would be approximately 6.5 volts. Indicating it would be safe to work.

B A fully loaded 30 kW, 6.6 amp constant current regulator (CCR) would have a nominal output voltage of 4,545 volts.

C An open circuited 30 kW CCR would have an output voltage of 9,090 volts for two seconds until the open circuit trip functions. The CCR is designed to raise the output voltage is accordance with the load. The CCR sees an open circuit as an increase in load and raises the output voltage until the overvoltage circuit turns the CCR off after 2 seconds.



The CCR nominal output voltage is determined by the quantity and VA load of the fixtures connected to the individual circuit.

Figure 2-6 – Typical Series Lighting Circuit
Drawing courtesy of Amerace Ltd.

RED TEXT comments by Carl Johnson. Red text is not a part of the original document.

Document file Name:

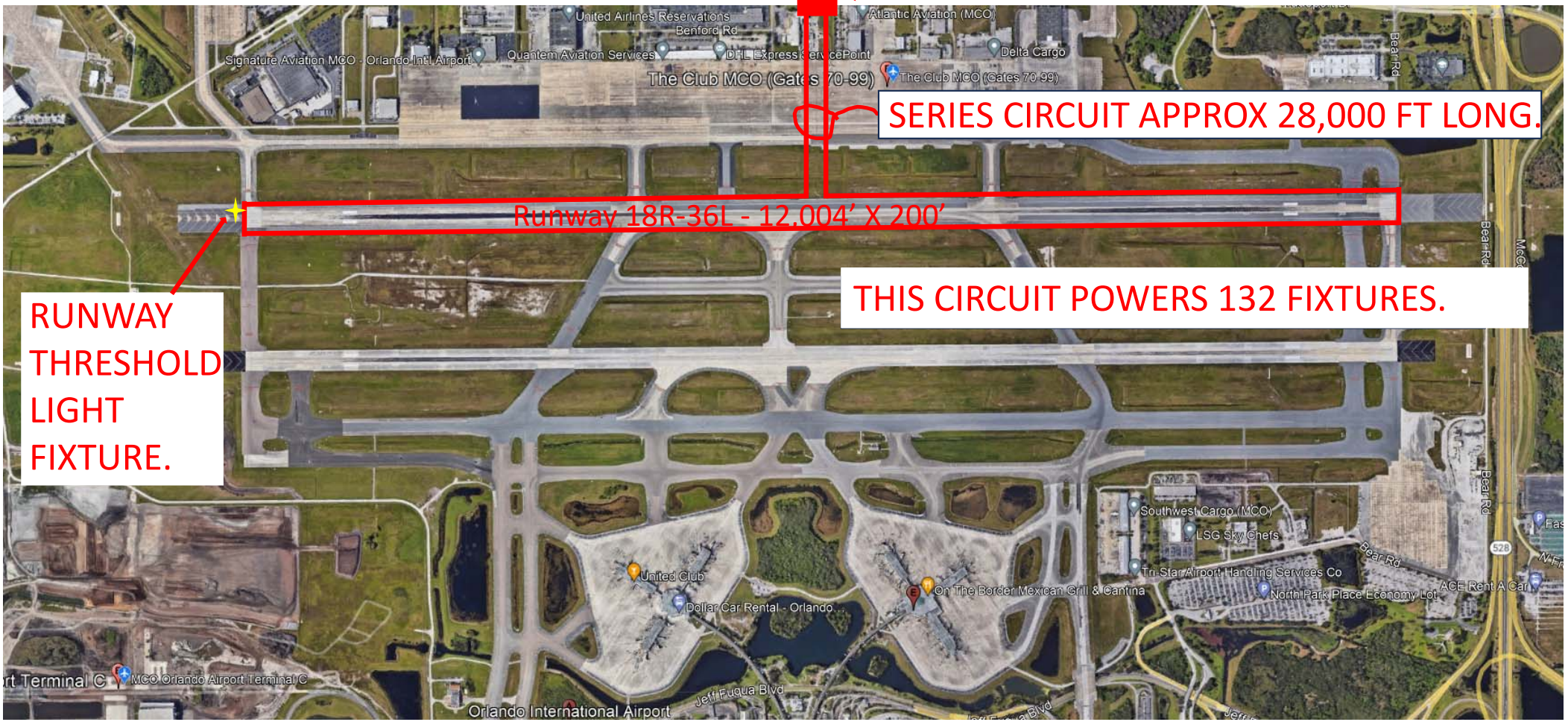
NFPA_70E_Series_Circuit_R1.pdf

PDF version of a PPT describing the scale of an airfield lighting series circuit and some photos demonstrating what an electrician will encounter on an active airfield.

Page 26 through Page 30

NFPA_70E_Series_Circuit_R1

LOCATION OF CONSTANT CURRENT REGULATOR.



FIXTURE TO BE REPAIRED IS MORE THAN 6,OOO FEET FROM THE POWER SOURCE. ABSENCE OF ENERGY MUST BE VERIFIED.

BLOW-UP OF RUNWAY 36L THRESHOLD AREA.

TYPICAL RUNWAY THRESHOLD LIGHT FIXTURE.

RUNWAY THRESHOLD LIGHT FIXTURE.

RUNWAY THRESHOLD
LIGHT FIXTURE BASE OPENED
TO EXPOSE WIRING

Voltage drop across this threshold fixture = 48 volts.
Three – 105-watt halogen lamps at 6.6 amps.

Airfield lighting series circuits are an ungrounded system. Green wire in photo is a bonding jumper used for lightning protection, NFPA 780.

A qualified person would be committing an unsafe act (very possibly fatal act) attempting to open the circuit at a series circuit airfield lighting fixture to test the voltage. Open circuit voltage may reach >9,000 volts. A true RMS clamp-on or open jaw ammeter must be used to determine if the circuit contains energy.

Public Comment No. 27-NFPA 70E-2025 [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 electrical energy (voltage and current) , 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.

Statement of Problem and Substantiation for Public Comment

Testing for voltage is insufficient and potentially unsafe for ungrounded current driven circuits. Ungrounded current driven circuits are used in airfield lighting as well some street lighting. These circuits will operate in a faulted and multiple faulted to ground condition. Testing for live voltage with a circuit that is grounded may present false measurements. Changing the verbiage to indicate "electrical energy" as well as clarifying "(voltage and current)" casts a wider net. Qualified workers should understand which to test depending on power source.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 28-NFPA 70E-2025 [Section No. 110.4(A)(1)]	
Public Comment No. 29-NFPA 70E-2025 [Section No. 110.6(E)]	
Public Comment No. 30-NFPA 70E-2025 [Section No. 120.5(B)(6)]	
Public Comment No. 31-NFPA 70E-2025 [Section No. 120.6]	
Public Comment No. 28-NFPA 70E-2025 [Section No. 110.4(A)(1)]	
Public Comment No. 29-NFPA 70E-2025 [Section No. 110.6(E)]	
Public Comment No. 30-NFPA 70E-2025 [Section No. 120.5(B)(6)]	
Public Comment No. 31-NFPA 70E-2025 [Section No. 120.6]	

Related Item

- 49

Submitter Information Verification

Submitter Full Name: David Williams
Organization: Hanson Professional Services
Street Address:
City:
State:
Zip:

Submittal Date: Thu Mar 27 10:54:58 EDT 2025
Committee: EEW-AAA

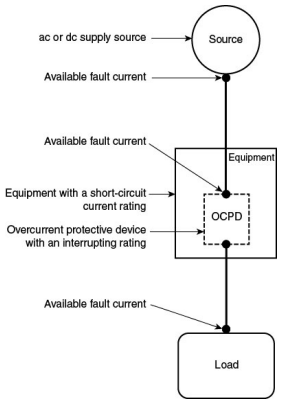
Public Comment No. 121-NFPA 70E-2025 [Definition: Fault Current, Available. (Available Fault Curr...]

Fault Current, Available. (Available Fault Current)

The largest amount of current capable of being delivered at a point on the system during a short-circuit condition.

Informational Note No. 1: See Figure ~~Figure~~ Informational Note 100.0. A short circuit can occur during abnormal conditions such as a fault between circuit conductors or a ground fault.

Figure Informational Note 100.0 ~~Available~~ 0 Fault Current and Available Fault Current.



Informational Note No. 2: If the dc supply is a battery system, the term *available fault current* refers to the prospective short-circuit current.

Informational Note No. 3: The fault current and available fault current varies at different locations within the system due to the location of sources and system impedances.

Statement of Problem and Substantiation for Public Comment

This comment is intended to make a few editorial corrections including removing a redundant term, add a period, and clarify the inclusion and use of the defined terms "fault current" and "available fault current such as whether the figure actually illustrates "available fault current" in all instances where it is mentioned since "available fault current is the largest amount of fault current or is "fault current" also being depicted? Further, should one additional or one fewer occurrence of either "available fault current" or "fault current," or both, be added or removed? Accordingly, a part of this recommendation is to correctly label "available fault current" and "fault current" in the illustration to make the illustration technically correct and whether there are too few or too many references to this terms used in the figure informational note. This action will correlate with the numerous locations where the Technical Committee removed the word "maximum" where used with the defined term "available fault current" as, by definition, it is the "largest" fault current and stating the maximum largest is redundant.

Related Item

• CN-1 • FR-55 • FR-79

Submitter Information Verification

Submitter Full Name: Palmer Hickman

Organization: Electrical Training Alliance

Street Address:

City:

State:

Zip:

Submittal Date: Tue May 27 12:32:44 EDT 2025

Committee:	EEW-AAA

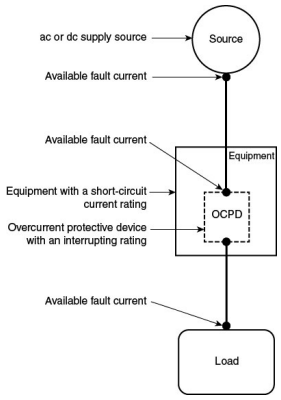
Public Comment No. 40-NFPA 70E-2025 [Definition: Fault Current, Available. (Available Fault Curr...]

Fault Current, Available. (Available Fault Current)

The largest amount of current capable of being delivered at a point on the system during a short-circuit condition.

Informational Note No. 1: See Figure Figure Informational Note 100.0 A short circuit can occur during abnormal conditions such as a fault between circuit conductors or a ground fault.

Figure Informational Note 100.0 Available Fault Current.



Informational Note No. 2: If the dc supply is a battery system, the term *available fault current* refers to the prospective short-circuit current.

Informational Note No. 3: The available fault current varies at different locations within the system due to the location of sources and system impedances.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_8.pdf	70E_CN8	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 8 appeared in the First Draft Report.

The Correlating Committee requests that the Technical Committee review the definition “Fault Current Available” Informational Note to No. 1 Figure regarding “See Figure Figure Informational Note 100.0” and revise for clarity.

Related Item

• Correlating Committee Note No. 8

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 03 14:01:47 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 8-NFPA 70E-2025 [Definition: Fault Current, Available. (Available Fault Curr...]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:40:54 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the definition “Fault Current Available” Informational Note to No. 1 Figure regarding “See Figure Figure Informational Note 100.0” and revise for clarity.

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 227-NFPA 70E-2025 [Definition: Hazard, Electrical. (Electrical Hazard)]

Hazard, Electrical. (Electrical Hazard)

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

Informational Note 1 : See Annex K for further information on the associated hazards.

Informational Note 2: 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.

Statement of Problem and Substantiation for Public Comment

The phrase "or arc blast injury" should be deleted as was proposed in Public Input 232 for the following reasons:
1. It perpetuates the "arc blast" myth that an arc flash is like a bomb explosion. Several peer reviewed papers have categorically demonstrated that vaporization of electrode material does not in itself produce a blast pressure. While there might be a mechanical release of pressure due to enclosure failure during an arc flash, this is not "blast pressure"
2. The definition of "arc blast hazard (as applied to capacitors) adequately deals with the subject as a stand-alone hazard that will be present only in some specific circumstances where the arc flash occurs at a capacitor and the event produces an acoustical shock wave.
3. Annex K has been updated to indicate that there are three primary electrical hazards: shock, arc flash, and contact thermal, and so should be referenced to provide the user of the standard with a better understanding of these hazards.

Related Item

• PI 232

Submitter Information Verification

Submitter Full Name: Daniel Roberts
Organization: Electrical Safety Solutions
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 14:50:04 EDT 2025
Committee: EEW-AAA

Public Comment No. 113-NFPA 70E-2025 [New Definition after Definition: Balaclava.]

Avoid Contact

The implementation of safety measures intended to prevent inadvertent physical contact with energized electrical conductors or circuit parts. This is achieved through actions such as using Personal Protective Equipment (PPE), applying insulating barriers or covers rated for the voltage, minimizing the chance of contact with live electrical parts.

Statement of Problem and Substantiation for Public Comment

It is the author's belief that many injuries and fatalities could be avoided with a better understanding of the potential consequences of 120-volt shocks. In addition to fatalities, low-voltage shocks can also cause serious injuries like: neurological symptoms, cardiac arrhythmias, burns or secondary trauma from falls. According to a paper recently presented at the IEEE Electrical Safety Workshop in Jacksonville, Florida written and presented by George Cole CESCP. In OSHA's Final Rules to 1910.269, Subpart R, OSHA cited 26 fatalities of electric utility workers after inadvertent contact with 120 volts between 1984 to 1996. According to more recent data from the Electrical Foundation International (ESFI) from 2011 to 2022, 30 workers lost their lives from voltages ranging between 110 to 120 volts with another 23 deaths from 208 to 240 volt systems. However, it is very likely that most of the fatal shocks listed as 208 or 240 volt systems were the result of a phase-to-ground contact, which would technically be a 120 volt shock. For more background and details, please review the paper ESW2025-08 titled “Avoid Contact – The Shock Boundary Without a Distance” authored by George T. Cole, presented during the 2025 IEEE Electrical Safety Workshop conference in Jacksonville, FL, USA.

Related Item

• OSHA letter of Interpretation concerning the use of PPE at low voltages.

Submitter Information Verification

Submitter Full Name: Brian Hall
Organization: Rozel LLC
Affiliation: Electrical Instructor
Street Address:
City:
State:
Zip:

Submittal Date: Sun May 25 10:13:10 EDT 2025
Committee: EEW-AAA

Public Comment No. 134-NFPA 70E-2025 [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 standard. Article 105 covers employer and employee responsibilities for the application of safety-related work practices and procedures. Article 110 covers general requirements for electrical safety-related work practices and procedures. Article 120 covers requirements for establishing an electrically safe work condition. Article 130 covers requirements for work involving electrical hazards.~~

Statement of Problem and Substantiation for Public Comment

This section is recommended to be deleted for correlation with actions taken as first revisions. Both the title of Article 105 and the scope of Article 105 have been revised to only include employer and employee responsibilities. Further, the content of 105.5 is unnecessary as it is redundant to 90.4 and Figure 90.4.

Related Item

• FR-31 • FR-105

Submitter Information Verification

Submitter Full Name: Palmer Hickman
Organization: Electrical Training Alliance
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 28 18:21:22 EDT 2025
Committee: EEW-AAA

Public Comment No. 132-NFPA 70E-2025 [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.

Statement of Problem and Substantiation for Public Comment

Equipment installed in accordance with the NEC, which is implied under "properly installed", means meeting section 90.2(B) Adequacy of NEC 2023.

In addition 110.3(B) Installation and Use. and 110.3(C) Listing. imply that the equipment is not modified and the manufacturer's manuals are followed and no modifications outside of the listing requirements were performed. These manuals always carry a maintenance and servicing section.
Since the NEC needs to be followed, sections 110.9 Interrupting Rating. and 110.10 Circuit Impedance, Short-Circuit Current Ratings, and Other Characteristics. need to be followed, requiring a short-circuit current analysis. 110.17 Servicing and Maintenance of Equipment. requires maintenance.

The requirements listed in this section are redundant in itself. It should not be the responsibility of NFPA 70E to educate qualified personnel on the National Electric Code.

Related Item

• Normal Operating Condition

Submitter Information Verification

Submitter Full Name: Mark Pisani
Organization: BASF Corporation
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 28 14:31:02 EDT 2025
Committee: EEW-AAA

Public Comment No. 200-NFPA 70E-2025 [Section No. 110.2(B)]

(B) When Required.

~~Energized~~ All 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.

Statement of Problem and Substantiation for Public Comment

This is a second attempt to add wording that will provide clear direction for when and energized electrical work permit is not required by restoring wording that was in Informational note No 2 to 110.1 in the 2021 edition of NFPA 70E. This note and another one were removed by the correlating committee because it apparently conflicted with

the NEC style Manual. The wording in that informational note was very helpful when explaining what an electrically safe work condition is because it included the word "all". Because this applies only to within the limited approach boundary that would be the extent of the exposed energized parts,
operating at 50 volts or more, that would need to be put in an electrically safe work condition.
The committee statement for rejecting PI 262 is not helpful and incorrect although it supports the interpretation provided by adding the word all. There are varying interpretations as to what is considered "exposed" energized parts therefore the requirement is not clear as presently written. Some are considering equipment to be in an electrically safe working condition even though there are still energized parts operating above 50 volts. The Informational notes that existed in the 2021 edition provided clarity because they contained the word "all" but they were deleted by the correlating committee. The NFPA 70E committee did not suggest deleting them. Adding this one word will provide significant clarity to the requirement without any hardship.

Related Item

• PI 262

Submitter Information Verification

Submitter Full Name: Paul Dobrowsky
Organization: Innovative Technology Services
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 10:18:36 EDT 2025
Committee: EEW-AAA

Public Comment No. 41-NFPA 70E-2025 [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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_9.pdf	70E_CN9	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 9 appeared in the First Draft Report on First Revision No. 34.

The Correlating Committee requests that the Technical Committee review 110.2(B)(2)(7) Exception No.3 Informational Note regarding (e.g., start-up or troubleshooting)that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions and use of “e.g.” shall be avoided and revised to comply with the NEC Style Manual.

Related Item

• First Revision No. 34

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date: Thu Apr 03 15:24:44 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 9-NFPA 70E-2025 [Section No. 110.2(B)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:42:03 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review 110.2(B)(2)(7) Exception No.3 Informational Note regarding (e.g., start-up or troubleshooting) that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions and use of “e.g.” shall be avoided and revised to comply with the NEC Style Manual.

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

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 42-NFPA 70E-2025 [Section No. 110.2(C)]

(C) Requirements Until Established.

(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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_10.pdf	70E_CN10	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 10 appeared in the First Draft Report on First Revision No. 35.

The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content in (C), (1) and (2) to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

Related Item

• First Revision No. 35

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 03 15:26:46 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 10-NFPA 70E-2025 [Section No. 110.2(C)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:51:27 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content in (C), (1) and (2) to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

FR-35-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 244-NFPA 70E-2025 [New Section after 110.3(L)(2)]

TITLE OF NEW CONTENT

Add an informational note to define work practice -

... A work practice may be a program or procedure to perform a specific work to minimize risk from exposure to injury and to achieve a specific objective

Statement of Problem and Substantiation for Public Comment

Work practice is not defined

Related Item

• FR41

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: self
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 16:59:34 EDT 2025
Committee: EEW-AAA

Public Comment No. 238-NFPA 70E-2025 [Section No. 110.3(L)(2)]

(2) Work Practices Audit.

(a) 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.

(d) Audit shall cover at least one work Practice in progress

Statement of Problem and Substantiation for Public Comment

It is infeasible and impractical to audit every work practice every year. The work Practice audit should follow the same protocol as followed by Lock out Tag out Program and procedures which requires at least one one lockout/Tagout in progress.
Similarly, Work Practice audit should also state that at least one Work Pr active in progress.

Related Item

• FR41

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 16:03:45 EDT 2025
Committee: EEW-AAA

Public Comment No. 243-NFPA 70E-2025 [Section No. 110.3(L)(2)]

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

(a) ~~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.~~

Statement of Problem and Substantiation for Public Comment

Delete this requirement.a nd revert to text in the previous edition
Work practice is not defined in NFPA 70E. Every operation and maintenance process and procedure is technically a work practice - work is required to be performed in accordance with the procedure. There can be hundreds of such practices in a large industrial site.

Related Item

• FR41

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 16:32:48 EDT 2025
Committee: EEW-AAA

Public Comment No. 92-NFPA 70E-2025 [Section No. 110.3(L)(2)]

(2) Work Practices Audit.

(a) 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.

Additional Proposed Changes

File Name	Description	Approved
.1747678948952	prosed revision to FR 41	
.1747678979951		
.1747679005207		
First_draft_FR_comments_DRC.docx		
First_draft_FR_comments_DRC.docx	FR 41 revision	
.1747679638355		
FR_41.docx		
FR_41.docx		

Statement of Problem and Substantiation for Public Comment

Field work audit will be addressed
Substantiation: one cannot verify work practices unless the work practice being used are seen during the audit

Related Item

• 70E first draft FR

Submitter Information Verification

Submitter Full Name: Daryld Crow
Organization: DRC Consulting Ltd
Affiliation: my self
Street Address:
City:
State:
Zip:

Submittal Date: Mon May 19 14:21:37 EDT 2025
Committee: EEW-AAA

FR 41 - 110.3(L)(2)

Revise the wording in first revision FR 41as shown below:

1. Field Work Audit - Change the wording in the title of 110.3(L)(2) to **"Field Work Audit"** as stated in the 2024 edition.
2. Change the wording in 110.3(L)(2)(a) to read **"The task(s) observed during the field audit shall verify that the requirements contained in the employee's electrical safety program are being followed".**
3. Keep the proposed wording in (b) and (c) in the FR 41 first revision.

Substantiation: One cannot verify work practices in the employee's electrical safety program are being followed unless the work practices being used are seen during the audit.

One can only audit actions that are taking place when the audit is performed. One cannot see if people are following the work practices that are not used when the audit is taking place.

FR 101 - 130.2(A)(5)

Omit item 5 in FR101 stating an additional person is require when an EEWP is required including the requirement that the additional person cannot cross the limited approach boundary or the arc flash boundary.

Substantiation:

Management is responsible for safety. It is up to management to decide the number of people required and the training and equipment needed to perform a task when an EEWP is required.

The following statements already exist in NFPA 70E:

1. Employees exposed to electrical shock hazards shall be trained in methods of safe release [(110.4(C)(1)].
2. A risk assessment is required before start of work including when a second person could be required and the training and equipment that person should have [110.3(H)(1)].

FR 53 - 130.7(C)(14)

Revise the wording in 130.7(C)(14)(b) to read **"PPE provided by a supplier or manufacturer shall meet the requirements in conformity assessment level 1, 2, or 3"**.

Add note: Refer to informative annex H.4.2 for the requirements listed for conformity assessment levels 1, 2, and 3.

Substantiation: Using the requirements in conformity assessment level 1, 2, or 3 will allow the purchase of quality PPE equipment.

FR 54 - [130.7(C)(14)(b)]

Revise the wording to read **“PPE provided by a supplier or manufacturer shall meet the requirements in conformity assessment level 1, 2, or 3”**.

Add note: Refer to informative annex H.4.2 for the requirements listed for conformity assessment levels 1, 2, and 3.

Substantiation: Using the requirements in conformity assessment level 1, 2, or 3 will allow the purchase of quality PPE equipment.

Public Comment No. 145-NFPA 70E-2025 [Section No. 110.3(L)(4)]

(4) Lockout/Tagout Procedure Audit.

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

~~year.~~
ye

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

~~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 procedures~~

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

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

Statement of Problem and Substantiation for Public Comment

Sections 110.3(L)(4)(a) and 110.3(L)(4)(b) contain repeated text.

Related Item

• FR-42

Submitter Information Verification

Submitter Full Name: Duke Schamel
Organization: Electrical Service Solutions, Inc.
Affiliation: IEC
Street Address:
City:
State:
Zip:

Submittal Date: Sun Jun 01 15:33:51 EDT 2025
Committee: EEW-AAA

Public Comment No. 13-NFPA 70E-2025 [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 with respect to certain equipment and tasks, 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:

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

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

(6) 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

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

(8) Perform the job safety planning

(9) Identify electrical hazards

(10) Assess the associated risk

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

(l) 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.

(m) Employees shall be trained to select an appropriate test instrument and shall demonstrate how to use a device to test for the absence of ~~voltage~~ electrical energy , 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.

(n) 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.

Statement of Problem and Substantiation for Public Comment

NFPA 70E is defining a Qualified Person as one who has been “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.”

Yet later, in the same section, NFPA 70E is instructing the qualified person to “verify the absence of voltage.” So should the Qualified Person conform to the requirements of NFPA 70E and verify the absence of voltage or using the knowledge required to be possessed by the qualified person not comply with NFPA 70E and verify the absence of current. The proposed change from “voltage” to “energy” or “electrical energy” would alleviate this apparent

conflict.

In paragraph (e) the Technical Committee demonstrates the importance of knowing how to select and operate appropriate test equipment but instructs the qualified person to test for the absence of voltage.
Voltage is an incorrect term for this application, measuring current and voltage are two separate tasks with different means and methods.

OSHA uses the term “electric energy” and “non-electric energy” in 1910.147 and 1910.333.

If the term “energy” or “electrical energy” is too broad, then I am requesting the Technical Committee select a term that accurately reflects the two fundamental physical quantities that present an electrical hazard to the qualified person.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 11-NFPA 70E-2025 [Section No. 120.6]	Applicable change for constant current circuits
Public Comment No. 12-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	Applicable change for constant current circuits
Public Comment No. 14-NFPA 70E-2025 [Section No. 110.6(E)]	Applicable change for constant current circuits
Public Comment No. 15-NFPA 70E-2025 [Section No. 120.5(B)(6)]	Applicable change for constant current circuits
Public Comment No. 11-NFPA 70E-2025 [Section No. 120.6]	
Public Comment No. 12-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 14-NFPA 70E-2025 [Section No. 110.6(E)]	
Public Comment No. 15-NFPA 70E-2025 [Section No. 120.5(B)(6)]	

Related Item

- Public Input No. 50-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: Carl Johnson
Organization: AVCON, Inc.
Affiliation: none
Street Address:
City:
State:
Zip:

Submittal Date: Tue Mar 25 16:20:21 EDT 2025
Committee: EEW-AAA

Public Comment No. 28-NFPA 70E-2025 [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 with respect to certain equipment and tasks, 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:

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

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

(6) 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

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

(8) Perform the job safety planning

(9) Identify electrical hazards

(10) Assess the associated risk

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

(l) 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.

(m) Employees shall be trained to select an appropriate test instrument and shall demonstrate how to use a device to test for the absence of electrical energy (voltage and current) , 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.

(n) 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.

Statement of Problem and Substantiation for Public Comment

Testing for voltage is insufficient and potentially unsafe for ungrounded current driven circuits. Ungrounded current driven circuits are used in airfield lighting as well some street lighting. These circuits will operate in a faulted and multiple faulted to ground condition. Testing for voltage with a circuit that is grounded may present false measurements. Changing the verbiage to indicate "electrical energy" as well as clarifying "(voltage and current)" casts a wider net. Qualified workers should understand which to test depending on power source.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 27-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 29-NFPA 70E-2025 [Section No. 110.6(E)]	
Public Comment No. 30-NFPA 70E-2025 [Section No. 120.5(B)(6)]	
Public Comment No. 31-NFPA 70E-2025 [Section No. 120.6]	
Public Comment No. 27-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 29-NFPA 70E-2025 [Section No. 110.6(E)]	
Public Comment No. 30-NFPA 70E-2025 [Section No. 120.5(B)(6)]	
Public Comment No. 31-NFPA 70E-2025 [Section No. 120.6]	

Related Item

• PI 50

Submitter Information Verification

Submitter Full Name: David Williams
Organization: Hanson Professional Services
Street Address:
City:
State:
Zip:

Submittal Date: Thu Mar 27 11:26:41 EDT 2025
Committee: EEW-AAA

Public Comment No. 3-NFPA 70E-2025 [Section No. 110.4(C)(1)]

(1) Contact Release.

Employees exposed to electric shock hazards and those responsible for the safe release of victims from contact with energized electrical conductors or circuit parts shall be trained in methods of safe release. Refresher training shall occur ~~annually.~~ every 2 years or at a frequency that satisfies the requirements of the certifying body

Statement of Problem and Substantiation for Public Comment

To align this with First Aid, Emergency Response, and Resuscitation requierments in section 110.4(5)(C)(2)

Related Item

• 110.4(5)(C)(1)

Submitter Information Verification

Submitter Full Name: Steve Huson
Organization: Mill Plain Electric
Street Address:
City:
State:
Zip:

Submittal Date: Wed Feb 19 17:14:13 EST 2025
Committee: EEW-AAA

Public Comment No. 43-NFPA 70E-2025 [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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_11.pdf	70E_CN11	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 11 appeared in the First Draft Report on First Revision No. 44.

The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

Related Item

• First Revision No. 44

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date: Thu Apr 03 15:35:40 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 11-NFPA 70E-2025 [Section No. 110.5(A)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:52:45 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

FR-44-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 44-NFPA 70E-2025 [Section No. 110.6(D)]

(D) Visual Inspection and Repair.

(1) Inspection.

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 until a person(s) qualified to perform the repairs and tests that are necessary to render the equipment safe has done so.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_12.pdf	70E_CN12	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 12 appeared in the First Draft Report on First Revision No. 46.

The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content restructuring to ensure the title accurately reflects the content of the requirement or remove the second level sub-division.

Related Item

• First Revision No. 46

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 03 15:40:43 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 12-NFPA 70E-2025 [Section No. 110.6(D)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:07:26 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content restructuring to ensure the title accurately reflects the content of the requirement or remove the second level sub-division.

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

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 245-NFPA 70E-2025 [Section No. 110.6(D)(1)]

(1) Inspection.

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

Statement of Problem and Substantiation for Public Comment

To be explicitly clear that inspection (1) is for portable instruments and portable equipment.

Related Item

• Public Input No. 243-NFPA 70E-2024 on Section 110.6(D) - FR-46-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: Alan Bond
Organization: Panduit
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 17:57:54 EDT 2025
Committee: EEW-AAA

Public Comment No. 14-NFPA 70E-2025 [Section No. 110.6(E)]

(E) Operation Verification.

When test instruments are used for testing the absence of ~~voltage~~ electrical energy on conductors or circuit parts operating at voltages equal to or greater than 50 volts, the operation of the test instrument shall be verified on any known ~~voltage~~ electrical energy source before and after an absence of ~~voltage~~ electrical energy test is performed. The known electrical energy source shall match the circuit type under test; constant voltage or constant current.

Informational Note. The test instrument range/function used during the test instrument verification process should be the same range/function used for the absence of electrical energy test.

Statement of Problem and Substantiation for Public Comment

As written section (E) only addresses voltmeters since only voltage is being measured. The three-point aka live-dead-live test should be used on both ammeters and voltmeters. The three-point method should be used every time a meter is used.

If “energy" is considered too broad of a term use “electrical energy”. Voltage and current are two measurable quantities of electrical energy. Absence of voltage is verified to determine if a voltage circuit is de-energized and absence of current is verified to determine if a current circuit is de-energized.

The term “electrical energy” actually adds necessary clarity to the operation verification.

Voltage is an incorrect term for this application, measuring current and voltage are two separate tasks with different means and methods. OSHA uses the term “electric energy” and “non-electric energy” in 1910.147 and 1910.333. OSHA 1910.333(b)(2)(iv)(B) would be compatible with the use of the term “electrical energy”.

The informational note should be added. The informational note would provide additional safety information to the qualified person. This informational note is not applicable to today’s modern DMMs with the auto range functions. However, some of the older DMMs and most analog meters still widely used have range switches. Using the 250-volt range to determine the meter is functioning properly on a convenient receptacle and then selecting the 600-volt range to determine the 480-volt system is de-energized would not be a safe practice. I have seen many individual settings of range switches fail on an otherwise functioning meter.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 11-NFPA 70E-2025 [Section No. 120.6]	Applicable change for constant current circuits
Public Comment No. 12-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	Applicable change for constant current circuits
Public Comment No. 13-NFPA 70E-2025 [Section No. 110.4(A)(1)]	Applicable change for constant current circuits
Public Comment No. 15-NFPA 70E-2025 [Section No. 120.5(B)(6)]	
Public Comment No. 11-NFPA 70E-2025 [Section No. 120.6]	
Public Comment No. 12-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 13-NFPA 70E-2025 [Section No. 110.4(A)(1)]	
Public Comment No. 15-NFPA 70E-2025 [Section No. 120.5(B)(6)]	

Related Item

- Public Input No. 51-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: Carl Johnson
Organization: AVCON, Inc.

Affiliation:	none
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Mar 25 16:30:04 EDT 2025
Committee:	EEW-AAA

Public Comment No. 29-NFPA 70E-2025 [Section No. 110.6(E)]

(E) Operation Verification.

When test instruments are used for testing the absence of ~~voltage on~~ electrical energy (voltage and current) on conductors or circuit parts operating at voltages equal to or greater than 50 volts, the operation of the test instrument shall be verified on any known ~~voltage~~ electrical energy source before and after an absence of ~~voltage~~ electrical energy test is performed.

Statement of Problem and Substantiation for Public Comment

Testing for voltage is insufficient and potentially unsafe for ungrounded current driven circuits. Ungrounded current driven circuits are used in airfield lighting as well some street lighting. These circuits will operate in a faulted and multiple faulted to ground condition. Testing for voltage with a circuit that is grounded may present false measurements. Changing the verbiage to indicate "electrical energy" as well as clarifying "(voltage and current)" casts a wider net. Qualified workers should understand which to test depending on power source.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 27-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 28-NFPA 70E-2025 [Section No. 110.4(A)(1)]	
Public Comment No. 30-NFPA 70E-2025 [Section No. 120.5(B)(6)]	
Public Comment No. 31-NFPA 70E-2025 [Section No. 120.6]	
Public Comment No. 27-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 28-NFPA 70E-2025 [Section No. 110.4(A)(1)]	
Public Comment No. 30-NFPA 70E-2025 [Section No. 120.5(B)(6)]	
Public Comment No. 31-NFPA 70E-2025 [Section No. 120.6]	

Related Item

• PI 51

Submitter Information Verification

Submitter Full Name: David Williams
Organization: Hanson Professional Services
Street Address:
City:
State:
Zip:

Submittal Date: Thu Mar 27 11:32:28 EDT 2025
Committee: EEW-AAA

Public Comment No. 45-NFPA 70E-2025 [Section No. 110.7(D)]

(D) Conductive or Wet Work Locations.

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.

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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_13.pdf	70E_CN13	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 13 appeared in the First Draft Report on First Revision No. 47.

The Correlating Committee requests that the Technical Committee review the text in 110.7(D) regarding (extension cords) that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

Related Item

• First Revision No. 47

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date: Thu Apr 03 15:44:07 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 13-NFPA 70E-2025 [Section No. 110.7(D)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:08:45 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 110.7(D) regarding (extension cords) that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

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

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 46-NFPA 70E-2025 [Sections 110.8(B), 110.8(C)]

Sections 110.8(B), 110.8(C)

(B) Additional Circumstances Requiring GFCI Protection.

(1) 120-Volt Cord Circuits.

Cord sets (extension cords) and cord- and plug-connected tools used for maintenance 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.

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) Testing Ground-Fault Circuit-Interrupter Protection Devices.

GFCI protection devices shall be tested in accordance with the manufacturer's instructions.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_14.pdf	70E_CN14	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 14 appeared in the First Draft Report on First Revision No. 48.

The Correlating Committee requests that the Technical Committee review 110.8(B)(1) and (2) regarding "(extension cords)" that do not comply with the NEC StyleManual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual. Further, consider a parallel grammar in clause (2)as clause (1) to improve structure and readability.

The Correlating Committee requests that the Technical Committee review 110.8(C) regarding the second level subdivision title relative to the content to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

Related Item

• First Revision No. 48

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 03 15:46:06 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 14-NFPA 70E-2025 [Sections 110.8(B), 110.8(C), 110.8(C)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:09:53 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review 110.8(B)(1) and (2) regarding "(extension cords)" that do not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual. Further, consider a parallel grammar in clause (2) as clause (1) to improve structure and readability.

The Correlating Committee requests that the Technical Committee review 110.8(C) regarding the second level subdivision title relative to the content to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

FR-48-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 84-NFPA 70E-2025 [Section No. 110.8(B)(2)]

(2) Greater then 120-Volt Cord Circuits.

Cord sets (extension cords) and cord- and plug-connected tools used for maintenance or construction ~~or maintenance~~ activity, or outdoors, or in conductive or wet work locations and that are supplied by greater than 120-volt, 15-, 20-, or 30-ampere circuits, shall be provided with GFCI protection or operated under 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.

Statement of Problem and Substantiation for Public Comment

The proposed changes improves grammar and makes the structure of 110.8(B)(2) parallel with 110.8(B)(1).

Related Item

• FR-48

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 14 16:26:08 EDT 2025
Committee: EEW-AAA

Public Comment No. 15-NFPA 70E-2025 [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~~ electrical energy source source before and after use

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

(3) Requirement to test before touching every exposed conductor or circuit parts within the defined boundary of the work area

(4) Requirement to retest for absence of ~~voltage~~ electrical energy 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~~ electrical energy measurements such as a constant current circuit.

Statement of Problem and Substantiation for Public Comment

Changing the term from “voltage” to “electrical energy” similar to OSHA 1910.147 and 1910.333 would clarify the intent to ensure the circuit/item is de-energized. The qualified person needs to be reminded to determine which energy source is required to be checked, not simply instructed to check the most common energy source, voltage.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 11-NFPA 70E-2025 [Section No. 120.6]	Applicable change for constant current circuits
Public Comment No. 12-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	Applicable change for constant current circuits
Public Comment No. 13-NFPA 70E-2025 [Section No. 110.4(A)(1)]	Applicable change for constant current circuits
Public Comment No. 14-NFPA 70E-2025 [Section No. 110.6(E)]	Applicable change for constant current circuits
Public Comment No. 11-NFPA 70E-2025 [Section No. 120.6]	
Public Comment No. 12-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 13-NFPA 70E-2025 [Section No. 110.4(A)(1)]	
Public Comment No. 14-NFPA 70E-2025 [Section No. 110.6(E)]	

Related Item

- Public Input No. 52-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: Carl Johnson
Organization: AVCON, Inc.
Affiliation: None
Street Address:
City:
State:
Zip:

Submittal Date: Tue Mar 25 16:44:56 EDT 2025
Committee: EEW-AAA

Public Comment No. 30-NFPA 70E-2025 [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 electrical energy (voltage and current) source before and after use

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

(3) Requirement to test before touching every exposed conductor or circuit parts within the defined boundary of the work area

(4) Requirement to retest for absence of electrical energy (voltage and current) 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

Statement of Problem and Substantiation for Public Comment

Testing for voltage is insufficient and potentially unsafe for ungrounded current driven circuits. Ungrounded current driven circuits are used in airfield lighting as well some street lighting. These circuits will operate in a faulted and multiple faulted to ground condition. Testing for voltage with a circuit that is grounded may present false measurements. Changing the verbiage to indicate "electrical energy" as well as clarifying "(voltage and current)" casts a wider net. Qualified workers should understand which to test depending on power source.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 27-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 28-NFPA 70E-2025 [Section No. 110.4(A)(1)]	
Public Comment No. 29-NFPA 70E-2025 [Section No. 110.6(E)]	
Public Comment No. 31-NFPA 70E-2025 [Section No. 120.6]	
Public Comment No. 27-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 28-NFPA 70E-2025 [Section No. 110.4(A)(1)]	
Public Comment No. 29-NFPA 70E-2025 [Section No. 110.6(E)]	
Public Comment No. 31-NFPA 70E-2025 [Section No. 120.6]	

Related Item

• PI 52

Submitter Information Verification

Submitter Full Name: David Williams
Organization: Hanson Professional Services
Street Address:
City:
State:
Zip:
Submittal Date: Thu Mar 27 11:36:33 EDT 2025
Committee: EEW-AAA

Public Comment No. 47-NFPA 70E-2025 [Section No. 120.5(B)(7)]

(7) Temporary Protective Grounding.

(a) 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) 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_16.pdf	70E_CN16	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 16 appeared in the First Draft Report on First Revision No. 27.

The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content to ensure the title accurately reflects the content of the requirement or remove the second level subdivision restructuring.

Related Item

• First Revision No. 27

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 03 16:43:03 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 16-NFPA 70E-2025 [Section No. 120.5(B)(7)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:12:13 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

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

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 88-NFPA 70E-2025 [New Section after 120.6]

TITLE OF NEW CONTENT

120.6(6) Apply lockout/tagout devices in accordance with a documented and established procedure.

120.6(7) Verify the equipment cannot be started or restarted, by using the control circuitry.

120.6(8) Use and adequately rated portable test instrument to test each conductor or circuit part at each point of work to test for the absence of voltage. For ac systems, test each phase conductor or circuit part both phase-to-phase and phase-to-ground. For dc systems, test each polarity conductor or circuit part both positive (+) to negative(-) and each polarity to ground. Before and after each test, determine that the test instrument is operating correctly through verification on any known voltage source of the applicable current type (ac or dc).

120.6(9) Where the possibility of induced voltages or induced current or stored energy exists, install temporary protective grounds to all circuit conductors and circuit parts before touching them 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/ Equipotential Zone). The location(s), 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 without failure of the grounding equipment.

c. Impedance. Temporary protective grounding equipment and connections shall have an impedance low enough to not delay and cause the immediate operation of protective devices in case of unintentional energizing of the electric conductors or circuit parts.

d. Installation and Removal. Temporary protective grounding equipment shall be applied and removed in the following sequence:

1. Attaching Temporary Protective Grounding - The employee shall first attach the ground end connections, then attaches the other end to the lines or equipment by means of a live-line-tool of adequate length to maintain body parts outside of the restricted approach boundary. For lines or equipment operating at 600 volts or less, the use of insulating equipment of the correct class (such as rubber gloves with protectors) may be used in lieu of a live-line-tool is permitted.

2. Removing Temporary Protective Grounding - The employee shall first remove the connections from the line or equipment by means of a live-line-tool of adequate length to maintain body parts outside of the restricted approach boundary, then the ground end connections shall be removed last. For lines or equipment operating at 600 volts or less, the use of insulating equipment of the correct class (such as rubber gloves with protectors) may be used in lieu of a live-line-tool is permitted.

Statement of Problem and Substantiation for Public Comment

This proposed changes to 120.6 will provide greater safety of electrical workers and align NFPA 70E with applicable OSHA electrical safety regulations based on the following:

First, by adding and inserting a new substep 120.6(7) to attempt to start the equipment to ensure it doesn't start (i.e. "verification of isolation") by inserting it after applying LOTO [existing substep 120.6(6)] and before the absence of voltage testing [existing substep 120.6(7)], will bring the process of establishing an ESWC in alignment with OSHA LOTO regulations.
Mainly with 1910.333(b)(2)(iv) "Verification of deenergized condition. The requirements of this paragraph shall be met before any circuits or equipment can be considered and worked as deenergized." followed by 1910.333(b)(2)(iv)(A) "A qualified person shall operate the equipment operating controls or otherwise verify that the equipment cannot be restarted."
And 1910.147(a)(1)(ii)(D) "Exposure to electrical hazards from work on, near, or with conductors or equipment in electric-utilization installations, which is covered by subpart S of this part." followed by 1910.147(d)(6) "Verification of isolation. Prior to starting work on machines or equipment that have been locked out or tagged out, the authorized employee shall verify that isolation and deenergization of the machine or equipment have been accomplished."
Employers are mandated by federal labor laws to implement a control of hazardous energy program in accordance

with 1910.147 subpart J for non-electrical energy and 1910.333 subpart S for electrical energy but they often also use the ESWC in 70E as a means to accomplish this. So this new substep will help stakeholders perform this very important verification of isolation after attaching the LOTO.

Secondly, Attaching and removing temporary protective grounding (TPG) is a task with many electrical hazards, especially electric shock, from invisible but extremely hazardous conditions, such as electric field and magnetic field induction, capacitive charges that can recharged after initial discharge if left open, back feeds, and accidental reenergization from the source during a human performance error, such as removing the wrong tagout.
The proper sequence of attaching and removing TPGs by using hotsticks and/or rubber gloves is absolutely critical in keeping the employee safe from electric shock, especially from induction. And induction hazards are not only present in transmission and distribution sectors but also exists in power generating plants and large industrial plants. Many years ago, I personally witnessed a co-worker receive a very bad shock when he incorrectly first removed the ground end of a grounding cable that was attached to a "grounding truck" which was still racked up and making contact with the bus inside a GE Magne blast metal clad switchgear. Thankfully he wasn't serious injured, probably because he was wearing standard leather gloves which increased the resistance of his hands thus reducing the subsequent current, but this was pure luck and nothing more. Many electricians, linemen and apprentices have been killed and serious injured because they either installed or removed the TPG in the wrong sequence and by not using hotsticks.
Adding this new step (d) titled "Installation and Removal" following the last step of 120.6 will provide greater safety of electrical workers by aligning with OSHA 1910.269(n)(6) Connecting and Removing Grounds.

Eduardo Ramirez-Bettoni and myself will be presenting a paper during the 2026 IEEE Electrical Safety Workshop conference addressing this very safety issue for the need of TPG inside power generating plants and large industrial plants.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 25-NFPA 70E-2025 [Section No. 130.4(E)]	related to the prevention of electric shock
Public Comment No. 89-NFPA 70E-2025 [Chapter 1]	
Public Comment No. 90-NFPA 70E-2025 [Article 100]	
Public Comment No. 111-NFPA 70E-2025 [Section No. 120.6]	

Related Item

•

Submitter Information Verification

Submitter Full Name: George Cole
Organization: APS/Palo Verde Nuclear Generating Station
Affiliation: E-Hazard
Street Address:
City:
State:
Zip:

Submittal Date: Fri May 16 09:16:46 EDT 2025
Committee: EEW-AAA

Public Comment No. 11-NFPA 70E-2025 [Section No. 120.6]

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. 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~~ electrical energy. Before and after testing, determine that the test instrument is operating satisfactorily . When testing voltage driven circuits test each phase conductor or circuit part at each point of work ~~,~~ both phase~~-~~ to~~-~~phase and phase~~-~~ to~~-~~ ground to confirm the absence of voltage . When testing current driven (constant current) circuits test each conductor or circuit part at each point of work to confirm the absence of current flow/amperage. Before and after ~~testing~~ each test , determine that the test instrument is operating satisfactorily through verification ~~on any known voltage source.~~ in accordance with 110.6(E).

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:

(8) 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.

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

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

(11) 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. Noncontact capacitive test instruments shall not be used to test for the absence of electrical energy on a current driven circuit.

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.

Informational Note No. 5: An airfield lighting series circuit is an ungrounded current loop, operating at up to 4,545 volts (open circuit >9,000 volts). Absence of electrical energy testing of an airfield lighting series circuit is performed with an ammeter. To determine that the airfield lighting series circuit is de-energized a true RMS ammeter should be used. See Federal Aviation Administration (FAA) Advisory Circular 150/5340-26C, Maintenance of Airport Visual Aid Facilities, June 20, 2014.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Additional Proposed Changes

File Name	Description	Approved
PC_11_Supporting_Documents.pdf	Supporting Documentation for Public Comment No.11 & associated PCs.	

Statement of Problem and Substantiation for Public Comment

This change was previously submitted as PI No. 48.

Airfield lighting series circuits and street lighting series circuits are in used extensively throughout the United States and the world. The power source for this type series circuit is a constant current regulator. A constant current regulator is designed to raise or lower its output voltage to maintain a specific current through the load. Voltage measurements cannot not be safely performed in the field. Current is measured to determine the proper operation of the circuit and to determine if the circuit is energized.

I strongly disagree with the Committee Statement. The change of the word "voltage" to "electrical energy" clarifies the issue by requiring the qualified person to recognize there may be more than one hazard that must be addressed. The proposed changes to 120.6(6) very specifically clarify the testing needs of both a voltage circuit and a current circuit.

Alternatively the Technical Committee could change the wording to:"….absence of electrical energy (voltage or current as applicable)……"

The creation of an electrically safe work condition is arranged in a step-by-step sequence for the Qualified Person. Section 120.6 requires the Qualified Person to perform the steps "in the order presented, if feasible:" Thus implying that checking voltage is a required step. Checking for voltage on a constant current circuit could be a fatal misstep.

A non-contact capacitive test instrument cannot be used to determine if a constant current circuit is de-energized. There is a null point within an energized constant current circuit at which a non-contact capacitive device will read zero.

Proposed Informational note 4 should be added to the standard even if the words "electrical energy" are rejected.

Informational Note 4 provides insight into the operation of a constant current circuit and provides a reference where to find additional information. There is precedence for this note, NFPA 70, 2023 contains three informational notes relating to the unique application of constant current circuits.

I have been involved in the training of airfield lighting electricians for more than two decades. Qualified persons are trained from birth to verify the absence of voltage!
Constant current series circuits require a qualified person to verify the absence of current. Verifying the absence of current is a “sea change”; a substantial change in perspective, which affects every person working on a constant current series circuit. The qualified persons must retrain that memory muscle to check for the absence of current.

Changing “voltage” to “electrical energy” alerts the qualified person that voltage may not be the only energy source.

I have the privilege of serving on another NFPA Technical Committee and our committee discussions can be outspoken and blunt. May I ask how many of the Technical Committee would have known prior to Public Input No. 48 that to determine if an airfield lighting constant current series circuit is de-energized, the absence of current must be verified? With all the years of experience the Technical Committee has would checking for current even been a passing thought? Checking for voltage on an energized constant current circuit could be fatal.

Constant current series circuits are not isolated occurrences but are widespread across the United States. The FAA states there are approximately 520 Part 139 (air carrier airports) in the United States. Many of the air carrier airports may have a hundred or more constant current series circuits. There are almost another 19,000 other airports and landing facilities that may have 5 to 30 constant current circuits. Some may only have one circuit or not be lighted. These numbers do not include the US military installations across the US and around the world that use constant current circuits.

References for quantity of FAA airports:
https://www.faa.gov/airports/airport_safety/part139_cert
https://www.ncesc.com/how-many-faa-airports-are-there-in-the-us/

Many smaller general aviation airports do not have a budget sufficient to support maintaining a full-time electrician/qualified person. The airport will hire a local electrical contractor. Many times, these local contractors do not have the skills necessary to safely work on a constant current circuit. The FAA in concert with National Academies of Sciences, Engineering, and Medicine developed a training program to address this problem.
https://crp.trb.org/acrpwebresource20/

Many cities are still equipped with constant current series circuits for their street lighting systems, albeit they are being changed out to LEDs on voltage systems as budgets allow. Worldwide there are many more uses of a constant current series circuit, especially in airfield lighting.

Please refer to the attached file titled "PC 11 Supporting Documents.PDF" in support of this public comment. The files were provided with the original PI No.48 and are incorporated into a single PDF.

Depending upon where the NFPA 70E Second Draft Technical Committee meets a site visit to an airport for the Technical Committee could possibly be arranged. The site visit would allow the Technical Committee to observe firsthand a constant current series circuit in operation.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 12-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	Applicable change for constant current circuits
Public Comment No. 13-NFPA 70E-2025 [Section No. 110.4(A)(1)]	Applicable change for constant current circuits
Public Comment No. 14-NFPA 70E-2025 [Section No. 110.6(E)]	Applicable change for constant current circuits
Public Comment No. 15-NFPA 70E-2025 [Section No. 120.5(B)(6)]	Applicable change for constant current circuits
Public Comment No. 12-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 13-NFPA 70E-2025 [Section No. 110.4(A)(1)]	
Public Comment No. 14-NFPA 70E-2025 [Section No. 110.6(E)]	
Public Comment No. 15-NFPA 70E-2025 [Section No. 120.5(B)(6)]	

Related Item

- PI No.48 through PI No. 52

Submitter Information Verification

Submitter Full Name: Carl Johnson
Organization: AVCON, Inc.
Affiliation: none
Street Address:
City:
State:
Zip:
Submittal Date: Mon Mar 24 10:19:38 EDT 2025
Committee: EEW-AAA

Document file Name:

Chap_13_UFC_3-535-01_Visual_Air_navag_Facil_-_25_APRIL_2023.pdf

This material is taken from the DOD's Unified Facilities Requirements. The material describes the characteristics of an airfield lighting series circuit.

Page 1 through Page 17

CHAPTER 13 \1\ CHARACTERISTICS OF AIRFIELD GROUND LIGHTING

13-1 GENERAL.

Airfield ground lighting (AGL) typically includes separate series-circuited lighting systems that provide visual guidance to the pilot for aircraft operations. The systems usually have brightness control for adapting to various visibility conditions. The types of lighting systems installed for a particular runway are an important part in determining the conditions under which aircraft operations are allowed (e.g., Visual Flight Rules (VFR), Category I, Category II, or Category III). The various lighting systems that may be installed for a runway are shown in Figure 13-1. Not included in this figure are the several approach lighting systems (ALS) which may also be installed. Details for lighted approach aids, runway lighting systems, and taxiway lighting are provided in Chapter 3, Chapter 4 and Chapter 5, respectively.

13-1.1 Airfield ground lighting is characterized by constant current series electrical circuits, which provide constant current for intensity control of lighting components. This system allows for selectively changing the brightness of the lighting components by increasing or decreasing the level of the constant current in the series loop. While some older systems use constant voltage for shorter length series circuits, most systems today are constant current type. The series circuit provides energy at constant current to each device (such as a light or sign) on the circuit, supplied from a CCR.

13-1.2 The major parts of a series circuit are: the CCR (power source), the primary circuit cable, isolation transformers, and lighting components (such as lights and signs). The isolation transformers are connected in series on the primary side, with connected loads on the secondary side of each isolation transformer (Figure 13-2). The system is characterized as follows:

- A constant current is delivered along the entire loop on the primary side of the isolation transformers, independent of the number of lighting loads. Power is provided by the CCR.
- The magnitude of the voltage along the series circuit primary depends on the number and size of connected lighting loads. The voltage along the primary cable will measure different at each point. (Calculating voltages for the constant current series circuit is illustrated later in this chapter.)
- The circuit is considered high voltage on the primary side, which typically may be several thousand volts (5kV cable is used), and low voltage on the secondary side or load side of the isolating transformers, which typically is less than 30V.

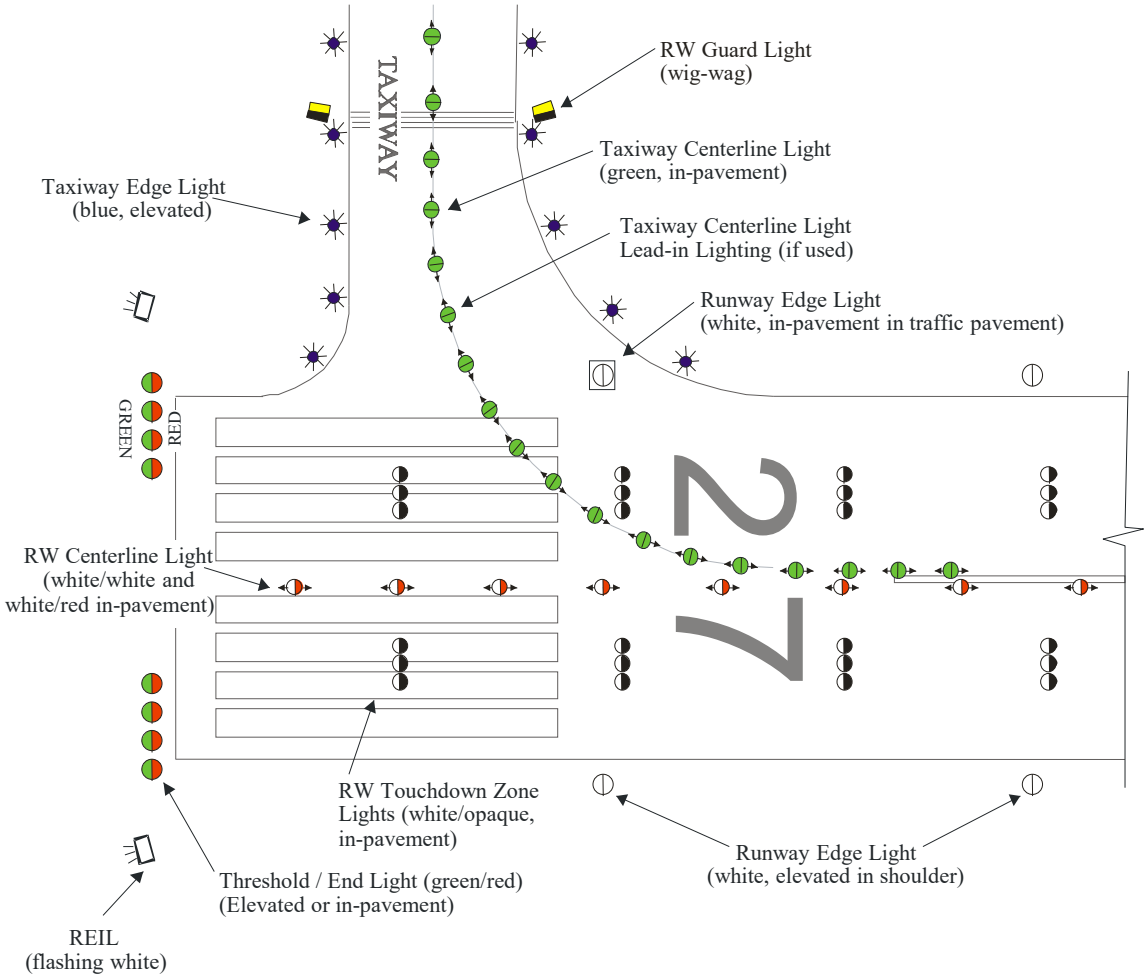
RED TEXT comments by Carl Johnson. Red text is not a part of the original document.

RED LINE in margin indicates information relative to this PI.

- The isolation transformer provides an effective short for the primary circuit in the event of a lamp filament failure, which opens the secondary circuit. This prevents failure of a connected light from causing an open condition on the series primary circuit.

- A constant current series circuit can also be used to power equipment with specific voltage requirements. In this case a power adapter is used. The power adapter also serves to isolate the device from the primary side similar to an isolation transformer. Examples of equipment which may be connected to series lighting circuits include: wind cones, PAPI, REIL, and others which typically may require 120/240V power. NOTE: The lighting circuit must be ON for the equipment to receive power with this type of arrangement.

Figure 13-1 Typical AGL Layout



NOTES:

1. RW EDGE LIGHTING: For high intensity system (HIRL) bidirectional, white/white, with yellow on rollout for last 2,000' (610M) (L-862 elevated, with L-850C for in-pavement). Runway edge lights are spaced about 200' (61M) apart.

2. THRESHOLD/END (T/E) LIGHTS: Group of 4 or 5, spaced 10' (3M) apart symmetrical about centerline. Outer light in each group lines up with RW edge lights. Groups may be wing-out bars, where inner light in each group lines up with RW edge lights.

   T/E lights show green to aircraft approaching for landing, and red to landing aircraft coming to end of the RW.

3. RW CENTERLINE LIGHTS: Bi-directional white/white, with alternating red/white and white/white from 3,000' to 2,000' (915M to 610M) from end of RW, and red/white for last 2,000' (610M) of RW.

4. RW TOUCHDOWN ZONE LIGHTS: Uni-directional, with white towards approaching aircraft.

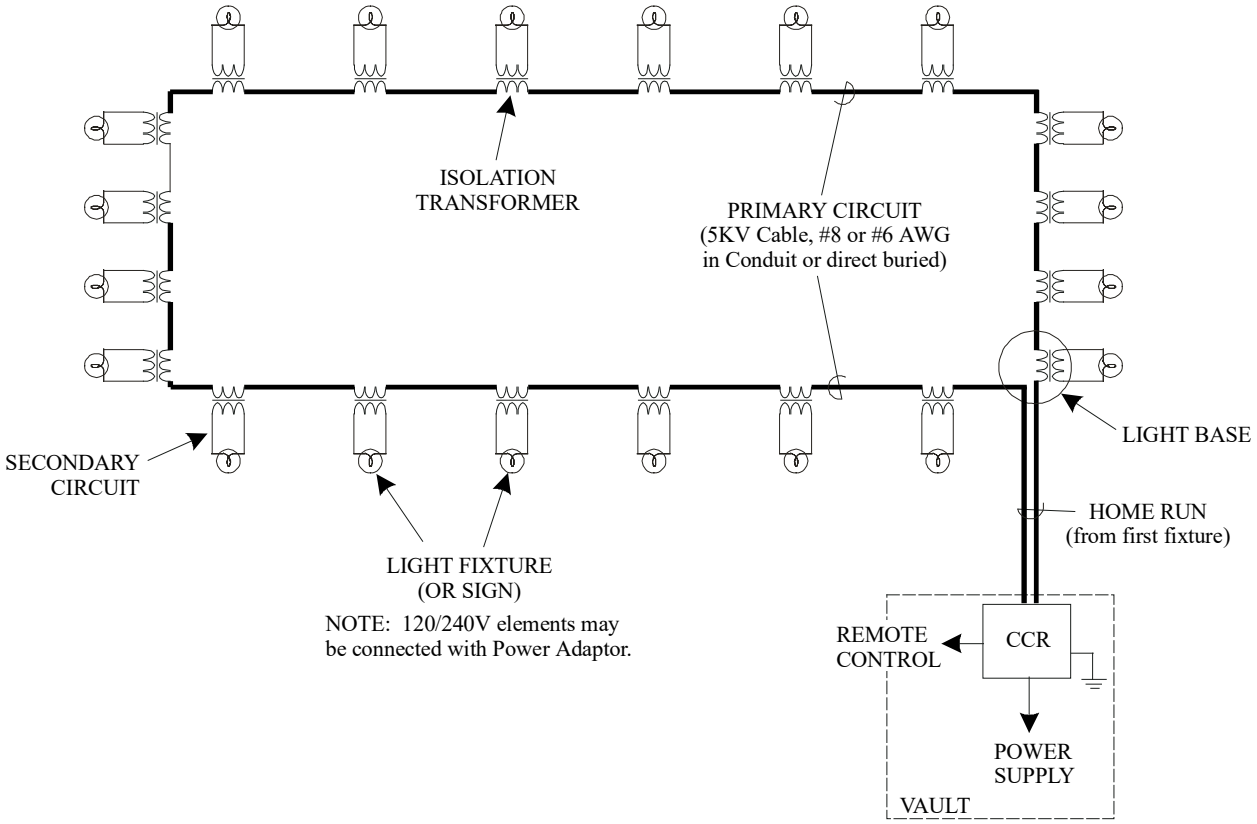
5. TW EDGE LIGHTS: Omni-directional blue (L-861T).

6. TW CENTERLINE LIGHTING: Bi-directional green/green, but may be green/yellow or yellow/yellow for some conditions.

7. REIL: Runway End Identifier Lights, discharge type flashing white lights (about 90 times/min.), Aimed 15 deg outward and 10 deg above horizontal.

8. RW GUARD LIGHT: Uni-directional, flashing yellow. Elevated outside TW, or may be bar of in-pavement across pavement (L-804).

Figure 13-2 Typical AGL Series Lighting Circuit



13-1.3 Parallel circuits are briefly discussed as these may be used to serve facilities such as wind cones, PAPI, REIL, and others. This may be directly from a power source, or via power adapter from a series lighting circuit.

13-2 POWER.

Upstream power for the CCR feeding the AGL may be from a variety of sources. Equipment vaults for AGL may be fed from a variety of sources, and in many cases have emergency standby generator power with automatic transfer in case of outages. Older systems typically feed the CCR at 2400V, while newer installations feed vault CCRs at 480V; 2400V input CCR equipment is for replacement only. The upstream power distribution feeding the CCR is not covered in this section.

13-3 CONTROL AND MONITORING SYSTEMS.

Traditional control/monitoring systems, both military and commercial, are relay systems. L-821 relay panels are very reliable and are suitable for nearly all military airfields. Typically, cables required for these types of systems are multi-pair (50 or more pairs) cables to connect the airfield lighting vault on the airfield with the air traffic control tower. On many air bases, the distance between the two facilities is great, resulting in a costly cable installation with the cable vulnerable to possible damage or failure of one or more pairs in the cable. In addition, these

communications cables require separate duct systems to eliminate interference from the power cables. The traditional relay panel and multi-conductor control cable can also be simplified by using a multiplexer, which requires only one pair cable to communicate between the vault and tower (or other station). A multiplexer can also be built into a PLC system.

13-3.1 Some airfield control/monitoring systems have been installed using Programmable Logic Controllers (PLCs). The PLC industrial systems use high I/O modules that reduce the need for multi-pair cable installation. Cables with 2 to 6 pairs are typically needed, although fiber optic cable can also be used.

13-3.2 PC-based systems are currently being used, with computers (Windows 7 operating system is approved by AF Chief Information Officer) located in the tower, the vault, and/or other work stations. These systems have the capability of displaying the necessary information on a monitor. This is the most flexible system in use today, with off-the-shelf units readily available. Typically, standard operating software is used, and off-the-shelf graphics software is tailored for a specific site. The communications cable requirements are 2 to 6 pairs of cable or fiber optics. Fiber optic cable eliminates the need for separate ducts since there will be no interference between power cable and fiber optic cable. The control panel typically is a touch-screen type. At the time of this writing the essential system PCs are recommended to have the following characteristics: 19" (480 millimeter) rack mount form factor, fully enclosed metal housing, redundant hot-swappable solid state software and data storage devices, redundant hot-swappable cooling system, redundant hot-swappable power supplies. The systems incorporate uninterruptible power supplies (UPS) for primary power to all system components required for normal operation for a duration of fifteen minutes.

13-3.3 Compared to the traditional FAA Type L-821 control/monitoring systems, the PLC or PC-based systems are easily expanded and provide data for the air traffic controller and maintenance personnel. Refer to FAA AC 150/5345-56. Some industrial standards the PLCs meet are NEMA ICS1, NEMA ICS2, NEMA ICS 3, UL 508, ANSI/IEEE C 37.90.1-1989, CAN/CSA C22.2 No. 142, MIL-STD-461B, MIL-STD-810 and ISO 9000.

13-3.4 Often, the computerized system is based on one specific manufacturer’s equipment. This limits the facility to one manufacturer for both service and parts. A good system design will avoid this by establishing competitive parameters in the procurement document.

13-3.5 Considerations for the design of a computerized control/monitoring system are in paragraph 13-18.6.

13-3.6 Factors for consideration when selecting a control system:

- Monitoring AGL equipment: the PLC based system must be customized for each type of CCR.

- For PC based systems, software has been developed and tested, and is easily configured to monitor AGL equipment. Software developed for PC systems is specific for the task and works with all types of CCRs and other related AGL equipment.

- With PLC systems there are established industrial standards and criteria for mean-time-between-failure (MTBF).

13-4 CONSTANT CURRENT SERIES CIRCUITS.

A constant current series circuit is an ungrounded system, where circuit elements are connected in a string with the same current flowing to each element. The circuit is one continuous loop starting and ending at the power source (the constant current regulator for the AGL circuit). The CCR maintains a constant current independent of the load on the circuit.

13-4.1 Circuit Failure.

With constant current, a short-circuit across the output of the CCR is a no-load condition, and an open-circuit is an overload. In a simple series circuit, a lamp failure would cause an open-circuit. For this reason a bypass device such as an isolating transformer is installed between the primary side and secondary side as part of each light fixture connection, or for connecting other loads such as guidance signs. In certain cases, such as for approach lights where 5 steady-burning lights are on a single secondary circuit isolated from the primary series circuit by one or more isolation transformers, a film disc cutout may be used. Film disc cutouts operate in such a way that when a lamp burns out, the film-disc cutout shorts the failed lamp, thereby allowing current to flow to the remaining connected fixtures.

13-4.2 Advantages of Series Lighting Circuits.

- All lamps operate at the same current, hence same intensity.

- Single-conductor cable of one size and insulation voltage rating can be used throughout the circuit.

- Intensity control of lights can be obtained over a wide range.

- A single ground fault along the circuit will not affect light operation.

- Ground faults are easily located.

13-4.3 Major Disadvantages of Series Lighting Circuits.

- Installation costs are high when considering the CCR and isolating transformers.

- Poor efficiency in use of electrical power.

- All components on the primary side must be insulated for full voltage.

- An open-circuit anywhere on the primary side makes the entire circuit inoperative and could damage cable insulation or the CCR.

- Locating faults such as open-circuit conditions can be time-consuming and may be difficult.

13-4.4 Typical Usage.

Series circuits are usually used for runway and taxiway lighting systems and most steady-burning lights of approach lighting systems because they provide more uniform intensity and better intensity control of the lights.

13-5 CONSTANT CURRENT REGULATORS.

The power input to the AGL circuits is controlled by the CCR to which the circuit is connected. While the CCR produces constant current to the circuits depending on the brightness step setting, the voltage input to the circuit varies with the actual load.

13-5.1 Basically, there are three types of constant current regulators used at airports:

- Resonant network circuit (ferro-resonant type using a resonant network control system to produce output current).

- Saturable reactor (ferro-resonant type, where the amount of reactor saturation via closed control loop determines output current).

- Silicon controlled rectifier (SCR) (uses SCR type thyristors to convert constant voltage source to constant current output, with solid state control circuiting). These are not ferro-resonant and are not approved for new installations.

13-5.2 The first two types have been reliable over the years, but fluctuations in input voltage will cause corresponding changes in the output current. Most CCRs now manufactured are SCR type.

13-5.3 Tests have shown that, as circuit load increases toward the rated capacity of a CCR, harmonic distortion is reduced and the wave form approaches a sine wave. This suggests that loading closer to rated capacity results in better circuit performance. However, lamp failures and other factors may increase the output voltage, and this needs to be considered when matching circuit load to CCR size.

13-5.4 CCRs have “taps” for adjustment to accommodate loads. Some manufacturers have introduced taps which automatically adjust to the circuit load, while others use manual taps which are typically set when the CCR is installed, but can be changed later to accommodate changes in the load.

13-5.5 The allowable tolerances in CCR output current are shown in FAA AC 150/5345-10. The allowable tolerances are small, because small changes result in large changes in light output. For a 6.6 amp circuit, reducing the current by 3 percent (to 6.4 amps) will reduce the light output over 15 percent, and reducing the current by 6 percent (to 6.2 amps) will reduce the light output by over 30 percent. The impact is the opposite on lamp life, where a current lower than maximum will significantly increase lamp life, and a higher current will reduce lamp life. The percent of full brightness obtained at each of the nominal current levels for 3 and 5 step systems can be found in paragraph 12-1.11.

13-5.6 15KW through 30KW CCRs may be selected for either 20 or 6.6 amperes output current. Intensity steps are either 5-step or 3-step for all CCRs.

13-5.7 50 kW and 70 kW regulators operating with 20A output current are not approved for new installations and are allowed for replacement only. Regulators with 2400V input are not approved for new installations.

13-6 REGULATOR SIZING.

13-6.1 For steady burning loads such as edge, centerline and touchdown zone lights sizing the regulator is fairly straight forward. Steady burning lights and circuit conductors are resistive loads and therefore will vary as the current varies. Current transformers are impedance loads and have the same electrical characteristics as resistive loads. See Figure 13-3A for calculating the load as the current varies; i.e., at the lowest brightness step. Using Ohms Law (P=IE), the maximum load at the lowest brightness level for a five-step regulator is determined by the ratio of the currents; i.e., (2.8/6.6) or (8.5/20) or 42.4% of the regulator rating. For a three-step regulator it is 4.8/6.6, or 72.7% of the regulator rating. It can be seen that these load percentages are greater than the ones calculated in Figure 13-3A. Therefore, a regulator fully loaded only with lights (and associated transformers) will not overload at the lowest current level.

Figure 13-3A Calculation of Steady Burning Load at the Lowest Brightness Level

DATA:

P = Steady Burning Light Load

I = Regulator Current

R = Steady Burning Light Load Resistance

Subscript $_H$ is the value at the Highest Brightness Step

Subscript $_L$ is the value at the Lowest Brightness Step

Ohms Law: $P = I^2 \times R$

CALCULATIONS:

$$P_H = (I_H)^2 \times R \rightarrow R = P_H / I_H)^2$$

$$P_L = (I_L)^2 \times R \rightarrow R = P_L / (I_L)^2$$

The resistance of the lamp filaments remains constant, therefore

$$P_L / (I_L)^2 = P_H / I_H)^2 \rightarrow P_L = P_H \times (I_L)^2 / I_H)^2 \rightarrow P_L = P_H \times (I_L / I_H)^2$$

The effective load of the steady burning fixtures at the lowest brightness step (P_L) is the load at the highest brightness step (P_H) times the squared ratio of the low (I_L) and high (I_H) currents.

For a 6.6A five step regulator the current ratio squared is $(2.8/6.6)^2$ or 0.18 or 18%.

For a 20A five step regulator the current ratio squared is $(8.5/20)^2$ or 0.18 or 18%.

For a three step regulator the current ratio squared is $(4.8/6.6)^2$ or 0.53 or 53%.

SUMMARY:

For five step regulators the load of steady burning lights at the lowest brightness step is 18% of the load at the highest brightness step.

For three step regulators the load of steady burning lights at the lowest brightness step is 53% of the load at the highest brightness step.

13-6.2 When loads such as REILs, PAPIs, windsocks and airfield signage are connected to a series circuit, consideration must be given to accommodate the effect of these loads on the regulator. Loads such as these have unique power requirements. PAPIs, signs and windsocks must maintain a constant level of light output and require a constant input voltage. When they are connected to a series circuit that has varying current levels the power from the current regulator must be converted to a constant voltage source within the equipment. Airfield signs are required to maintain a constant level of illuminance on the sign face and electronics are needed to operate them from a varying current source. The commonality with all these loads is that they present a constant load to the regulator regardless of current level on the circuit. When the circuit is a combination of steady burning lights and signs or other constant loads, the engineer must insure that the calculated load at the lowest brightness level does not exceed the percentage of the regulator rating as indicated above. Figure 13-3B shows an example where the regulator is over loaded at the lowest brightness step. Although most regulators will continue to operate when over loaded there are risks associated with that. Depending on the degree of overloading, negative effects may include the regulator's inability to stay within the FAA current tolerances. The result would be improper brightness levels. Operating an overloaded regulator can also lead to the premature failure of critical components because the regulator will raise the output voltage to maintain the required current level.

13-6.3 In its Advisory Circulars, the FAA does not address the load imposed on the CCRs by the constant current to constant voltage adapters necessary for REIL operation, or the REIL that are connected into series circuits. With the constant flashing of the lights and the resulting discharging of the capacitor, the REIL place a very short, but heavy, pulsing load on the regulator. Occasionally, this type of pulsing load results in pulsation of the illumination of the steady burning lights on the circuit. This "reflective" pulsation depends on the characteristics of the regulator powering the circuit and on the characteristics of the REIL connected into the circuit. The design engineer needs to ascertain from the regulator manufacturer which type of CCR will handle the overall series circuit load with the addition of the REIL pulse-type load without adverse effect. It has been shown that the problem will be minimized if the REIL are connected into series circuits that have primarily incandescent loads and the circuit load approaches the capacity of the regulator.

13-6.3.1 The actual regulator capacity needed to operate the REIL properly is much greater than the rated load indicated in the typical product literature. Usually the average power requirement is provided; however, the regulator has to accommodate the instantaneous, or pulsing, load to provide the flashing characteristics of the REIL. That REIL may be rated to require only 400 watts to operate, but may actually require up to 4 kilowatts of regulator capacity to meet the pulsing load requirements when also including the impact of the series circuit adapters between the series circuit and the REIL. The series circuit adapters convert 6.6 amps to 120 volts for REIL operation, and often have low efficiency that imposes higher than expected loads on the regulator. The proper sizing of the regulator requires careful consideration of the types of loads on the circuit and the true impact of those loads on the regulator.

Figure 13-3B Sample Calculation of CCR with High Signage Load

DATA:

CCR: 30KW, 480V input, 5-step (2.8A – 6.6A)

Cable: AWG #6, 5kV, L-824 Type C, 20,000 feet primary circuit

Circuit Loads:		
Steady Burn Lights	13,000 W
Transformer Losses (26% of Light Load)	3,380VA
Signage	13,000 VA
Cable losses (19 VA / 1,000')	383 VA

Circuit power factor is assumed to be 0.85.

CALCULATIONS:

1. Total connected load, VA = 13,000 + 3,380 + 13,000 + 383 = 29,763 VA
2. CCR Rated Load @ Lowest Brightness Step: (Reference paragraph 15-6.1)

   30KW x (2.8/6.6) = 12.72 KW or 14.97 KVA

3. Calculated Load @ Lowest Brightness Step: Reference Figure 3-13A(Reference Figure 15-3A)

   (Lights + Losses) x $(2.8/6.6)^2$ + Signage =
   ((13,000 + 3,380 + 383) x 0.18) + 13,000 = 16,017 VA

Because the signage load does not change for the various brightness steps the resulting demand on the regulator at the low step (16.02 KVA) is higher than the rated load for the regulator at the low step (14.97 KVA). While the load at the highest step (29.76 KVA) is less than the rating of the regulator, it will be overloaded at the lowest step; therefore, do not operate in this load configuration.

Loads such as signs, REILs, PAPIs and windsocks are constant regardless of the brightness level and must be carefully considered in circuit design and regulator sizing.

Where:

E = volts (V)	W = Wattage of light fixtures
I = Current, in amperes (A)	VA = Volt-Amps
P = Power Load	kW = kilowatts
	kVA = kilovolt-amps
	P.F. = Power Factor

Ohms Law: $P = IE$, $E=IR$, $P=I^2R$

13-6.3.2 As described in paragraph 13-6.1, the REIL can impose significant loads on the CCR powering the circuits to which they may be connected. It is preferable, if the budget permits, to have separate circuits with 240/120 volt service to power the REILs, thereby eliminating any adverse impacts on series lighting circuits.

13-6.3.3 Sample calculations and comparison with test data, as well as guidance for setting taps, are shown in Figure 13-4. A table format for calculating airfield lighting series

circuit loads is shown in Table 13-1. Carefully consider the notes in Table 13-1 when determining load values.

13-6.3.4 Normally the airfield signage load on a circuit is less than the steady burning light load. When the sign load is significant on a circuit, care must be taken to prevent overloading the regulator at the lowest brightness step. Figure 13-3B shows an example calculation where the sign load is high enough to present a problem.

13-7 CABLE.

The primary series circuit utilizes FAA L-824 Type B or C cable. L-823 connectors are used for connections. For 6.6 ampere primary series AGL circuits, an AWG #8 conductor is normally used. An AWG #6 conductor is used with 20 ampere circuits. For the secondary side lighting loads, a two-conductor AWG #10, 600V insulation is normally used.

13-7.1 The cable is installed in conduit, although it may be direct buried (L-824 cable is rated for direct burial). It is important that insulation is intact and that proper connections are made. Deteriorated or damaged cable can result in current leakage and may present a high voltage hazard to maintenance personnel. While installation in conduit may cost more, this method usually provides longer circuit life, and makes troubleshooting and replacement of cable segments easier. Where cable is installed in the regulator vault it must be in conduit, wireway or conduit or wireway in a floor trench with a solid top. L-824 cable is not rated for installation in cable tray.

13-7.2 The types of faults associated with series circuit cable are open circuit conditions and shorts-to-ground. An open circuit condition will turn off all the lights. A single short-to-ground will not impact the lighting, but multiple shorts-to-ground can cause dimming of lights or outages for portions of the circuit or for the entire circuit.

Figure 13-4 Sample Calculation of CCR Test Data

(1 of 2)

SAMPLE CALCULATIONS, CCR TESTING

DATA: CCR: 30KW, 480V input, 5-step (2.8A - 6.6A), with Power Factor of 0.43

Cable: AWG #8, 5kV, L-824 Type C, 20,000 feet primary circuit

Circuit Load: 70 Edge lights @ 120W (100W transformer)
16 Threshold/end lights @ 200W (200W transformer)

10 signs @ 100VA (at step 5)
5 signs @ 200VA (at step 5) } *(at the input to the isolation transformer*)
3 signs @ 300VA (at step 5)

1 REIL system (2 units) @ 400W, connected by power adapter. [Note that in this example the REIL is only adjusted for PF. Some REIL may require further adjustment, based on manufacturer's information.]

Cable losses (resistance) @25°C: 0.68Ω/1,000'
Fixture losses (obtain from Mfg - This example assumes 18 percent for 120W, and 11 percent for 200W lights)

CALCULATIONS:

1. CCR rated output voltage, V_{RMS} = 30KW/6.6A = 4,545V

2.Total connected load, KVA = $\frac{[W_{lamps} + W_{REIL} + VA_{signs}]/PF + Fixture\ Loss + Cable\ loss}{1{,}000}$

Fixture losses = (70 x 120 x 0.18) + (16 x 200 x 0.11) = 1,864W

Cable losses = I^2R = $[6.6]^2$ x (0.68 x 20) = 592W

TOTAL KVA = $\frac{[(70x120) + (16x200) + (400) + (10x100 + 5x200 + 3x300)]/0.43 + 1{,}864 + 592}{1{,}000}$

= 17.57 KVA

where:

KVA = kilovolt-amperes
V = volts
A = amperes
KW = kilowatts
CCR = Constant Current Regulator
R = Resistance in Ohms, Ω
V_{RMS} = Rated output voltage of CCR
W_{lamps} = Wattage of light fixtures
W_{REIL} = Wattage of REIL
PF = Power Factor
I = Current, in amperes

Figure 13-4 Sample Calculation of CCR Test Data (Cont.)

SAMPLE CALCULATIONS, CCR TESTING (Cont.)

NOTE: Traditional method for determining the load KW assumes that the CCR powers a unity power factor lamp circuit. With REILs, new type signs, and runway guard lights (wig-wags), a unity power factor is not representative, and power factor must be considered.

MEASURED RESULTS (Case 1):

- Output current at Step 5 = 6.52A
- Output voltage at Step 5 = 2,880V

Total KVA Load based on measurements = 6.52A x 2.88kV = 18.8KVA

CONCLUSIONS: The output current is within FAA tolerance. The total KVA measured is slightly higher than the calculated load. This may be due to slightly higher actual fixture losses than assumed values. Overall, the CCR is operating satisfactorily.

MEASURED RESULTS (Case 2):

- Output current at Step 5 = 6.52A
- Output voltage at Step 5 = 1,880V

Total KVA Load based on measurements = 6.52A x 1.88kV = 12.3KVA

CONCLUSIONS: The output current is within FAA tolerance. The total KVA measured is significantly less than the calculated load. The results suggest a partial shorting of the load.

MEASURED RESULTS (Case 3):

- Output current at Step 5 = 6.30A
- Output voltage at Step 5 = 2,550V

From test results, Total KVA Load = 6.30A x 2.55kV = 16.1KVA

CONCLUSIONS: The output current is below that allowed by FAA tolerance. The total KVA measured is below the normal value (2,880V) as found in first test. Results indicate faulty CCR. Perform a short circuit test on the CCR before it is used.

NOTE: Analysis compares KVA with KW. This is because the rated output of the CCR is specified in KW in compliance with FAA AC 150/5345-10. However, load measurements result in KVA. The requirement for total load in KVA to be below the CCR output in KW under operational conditions ensures that the CCR is not overloaded.

Table 13-1 AGL Series Circuit Load Calculation Data Sheet

CKT No.	Regulator (CCR) (Runway or Taxiway, Etc.)	CKT Type (Amps)	Cable Size (AWG)	CCR Rating (KVA) (1)	CCR Input (V)	Steady Burning Light Load (KVA) (2)	Sign Load (KVA) (3)	Other Loads (KVA) (4)	Total Connected Load (KVA)	Transformer Losses (KVA) (5)	Cable Length FT or M)	Cable Losses (KVA) (6)	Calculated CCR Load (KVA)

NOTES:
(1) CCR rating may be in KW. To determine KVA, divide KW by power factor (PF) and CFR efficiency (EF) based on full load. Obtain PF and EF from manufacturer.
(2) To determine KVA for steady burning lights by summing "[no. of fixtures] x [lamp wattage] / 1000" for all lights on circuit. Steady burning lights can be runway edge lights, threshold/end lights, centerline lights, touchdown zone lights, taxiway edge and centerline lights, and approach lights.
(3) Determine KVA for signs based on manufacturer rating or specified limit VA for each size and length (modules or width) of sign on circuit.
(4) Other loads may be pulsing lights such as REIL. Determine KVA based on manufacturer data for each type.
(5) Isolation transformer losses may be estimated at 26% of connected load.
(6) Determine cable losses based on cable length and manufacturer cable data on conductor resistance. Loss per unit length is typically based on the relationship $I^2R = W$ and assumed PF of unity for the cable.
Typical values for cable losses are: 34VA / 1,000ft (34VA / 300M) for 6.6A circuits with uncoated stranded #8 AWG conductor, and
196VA / 1,000ft (196VA / 300M) for 20A circuits with uncoated stranded #6 AWG conductor.

Refer to Paragraph 5-3.2.3, Color Coding.

13-8 TRANSFORMERS.

The isolation transformer provides: electrical isolation between the high voltage series circuit and the low voltage secondary feeding the lighting load (such as a fixture or sign), constant current output for a constant current input at the correct ratio, and an effective short circuit in the event of an open condition in the light fixture, for example with lamp filament failure.

13-8.1 Isolation Transformers.

With the isolation transformer, only low voltage is brought to the light fixture (via the secondary circuit), and failure of the light does not cause an open condition on the primary circuit that would result in other lights and other connected loads to be shut off.

Isolation transformers for AGL are covered by FAA Specification L-830 (for 60 Hz) and FAA Specification L-831 (for 50 Hz), and are typically 6.6 amperes on the secondary side, with either 6.6 amperes or 20 amperes on the primary side for series lighting circuits at the highest intensity step. The wattage of the isolation transformer is approximately matched to the connected load on the secondary side.

13-8.2 Transformer Load.

Ensure the load powered by the transformer is within ±10 percent of the transformer wattage rating to maintain isolation transformer efficiency. Light fixture manufacturers have their fixtures certified using a specified wattage for the isolation transformers. Use the light fixture manufacturer's recommended size for isolation transformers.

\4\ 13-8.3 Series Circuit Selector Switches.

Use switches in accordance with FAA AC 150/5345-5, Type L-847. Series circuit selector switches can be high-maintenance equipment and should be avoided whenever possible.

13-8.4 Control Cables.

Control cables for 120 VAC control systems must be multi-conductor, 600 volts, 12 AWG copper, rated for direct earth burial. Cables for 48 VDC control circuits must be multi-conductor, stranded 19 AWG copper, with 300 volt polyvinyl insulation suitable for installation in wet locations and meeting REA Bulletin 345-14 or 345-67. Color-code all conductors.

13-8.5 Constant Current Regulators (CCR).

Use CCRs per FAA AC 150/5345-10 of a suitable type and style. The size selected should normally provide for approximately 20 percent expansion of the load.

Document file Name:

Part_2.4_150-5340-26C_Maint_of_Airport_Visual_Aid_Facil.pdf

This document is from FAA Advisory Circular 150/5340-26C discussing the electrical hazards associated with an airfield lighting series circuit.

Page 18 through Page 20

c. Perform an electrical hazard analysis consisting of:

1. A **shock hazard analysis** to determine the voltage(s) to which personnel will be exposed, boundary requirements and the personal protective equipment (PPE) necessary to minimize the possibility of electric shock to personnel.

2. A **flash hazard analysis** must be completed to protect personnel from the possibility of being injured by an arc flash. The analysis determines the flash protection boundary and the PPE that personnel within the flash protection boundary must use.

d. Implement the requirements of the shock and flash hazard analysis prior to starting any work.

e. Complete the work safely and return the system to safe operating status.

f. Close out the energized equipment work permit.

2.3 Safety Procedures and Guidelines.

Most airport visual aid equipment is exposed to weather and may develop electrical shock hazards through damage from lightning or electrical cable insulation deterioration from exposure. Begin maintenance procedures only after a visual inspection is made for possible hazards. Due to the hazards associated with lightning, lighted navigational aids should not be serviced during periods of local thunderstorm activity. Each airport should develop and implement procedures to be followed in the event of an accident. Precious seconds are saved rendering medical assistance to injured personnel when action plans are already in place. Rehearse and review action plans regularly.

Part_2.4_150-5340-26C_Maint_of_Airport_Visual_Aid_Facil.pdf

2.4 Electrical Hazards of Series Lighting Circuits.

Airport lighting circuits are very dangerous. This is especially true for maintenance personnel with little or no experience working on constant current series circuits. Airport lighting circuits can operate at potentials of several thousand volts depending on the size of the regulator driving the circuit and the load.

2.4.1 Basic Rules.

There are three basic rules to remember when working on and around airport lighting circuits:

a. **ALWAYS** assume that the circuit is energized until you have proven otherwise. **ALWAYS** check for current before disconnecting the series circuit connector, removing the S1 cutout, or opening the primary series circuit by any other means. Make it a required practice to check the circuit with an ammeter prior to breaking the connection – **NO EXCEPTIONS.** Never attempt to measure voltage in a series lighting circuit using ordinary volt meters. An inductive voltage measuring device (sometimes referred to as a "ticker") such as is described in Chapter 4 may be used to detect the presence of induced voltage on a series lighting cable after checking for the presence of current. Always use a true RMS clamp-on type ammeter to verify if the circuit is energized. **ALWAYS** check

the operation of the test equipment on a known live circuit before and after measurements are taken.

b. **NEVER** under any circumstances open or break a live airfield series circuit. The voltage generated in the circuit can reach levels many times normal before the regulator's open circuit protection can shut it down. As long as a current flow can be maintained, even if it is through you, the regulator will continue to operate. This is one of the reasons that series circuits can be so hazardous to work around - there is no personnel protection provided such as might be found on parallel interior wiring.

c. **NEVER** enter a manhole with energized conductors and never handle cables or transformers in light bases while there is current present. Cables or connectors can have cracked insulation where it is not visible or may be deteriorated and fall apart, exposing you to live circuit conductors.

2.4.2 Induced Voltages.

Series circuits are typically run from the lighting vault in duct banks where the wires are lying parallel to each other in close proximity. Voltages may be induced in an otherwise un-energized conductor and may be a hazard when troubleshooting and testing. Circuits that have a load that varies due to flashing action of runway guard lights or REIL strobes are particularly prone to induce voltages in other conductors due to the pulsing characteristics of the voltage and current in these circuits. Always remember that there may be a possibility of an induced voltage in any conductor. Never work on or in close proximity to live circuits within any duct or manhole.

2.4.3 Re-lamping.

The most common lighting maintenance task on the airfield is re-lamping of incandescent runway and taxiway lighting fixtures.

Note: See paragraph 5.3.2 for information about light emitting diode (LED) light fixtures.

Depending on the type of light fixture, this may be accomplished in the field or, in the case of most in-pavement lights, the entire light fixture is removed, replaced, and brought to the maintenance shop for refurbishing. The greatest unseen danger to you is re-lamping or removing the fixture with the circuit energized. This has always been a common practice by airport electricians for convenience and the dangers are often overlooked. There are two primary hazards associated with this practice:

a. The first hazard occurs when there is a short circuit between the isolation transformer primary and secondary windings. Remember that isolation transformers are not designed for personnel protection. They are designed to isolate the secondary winding from the primary circuit to allow continued operation with a lamp burned out. A transformer with a primary to secondary short may not cause a circuit malfunction and could remain unnoticed during normal operation.

A short from the isolation transformer primary to secondary winding exposes you to the full voltage present on the primary circuit and can be especially dangerous if another

Document file Name:

Part_2.2_AAAE_Airfield_Lgt_Course_Mod_1a.pdf

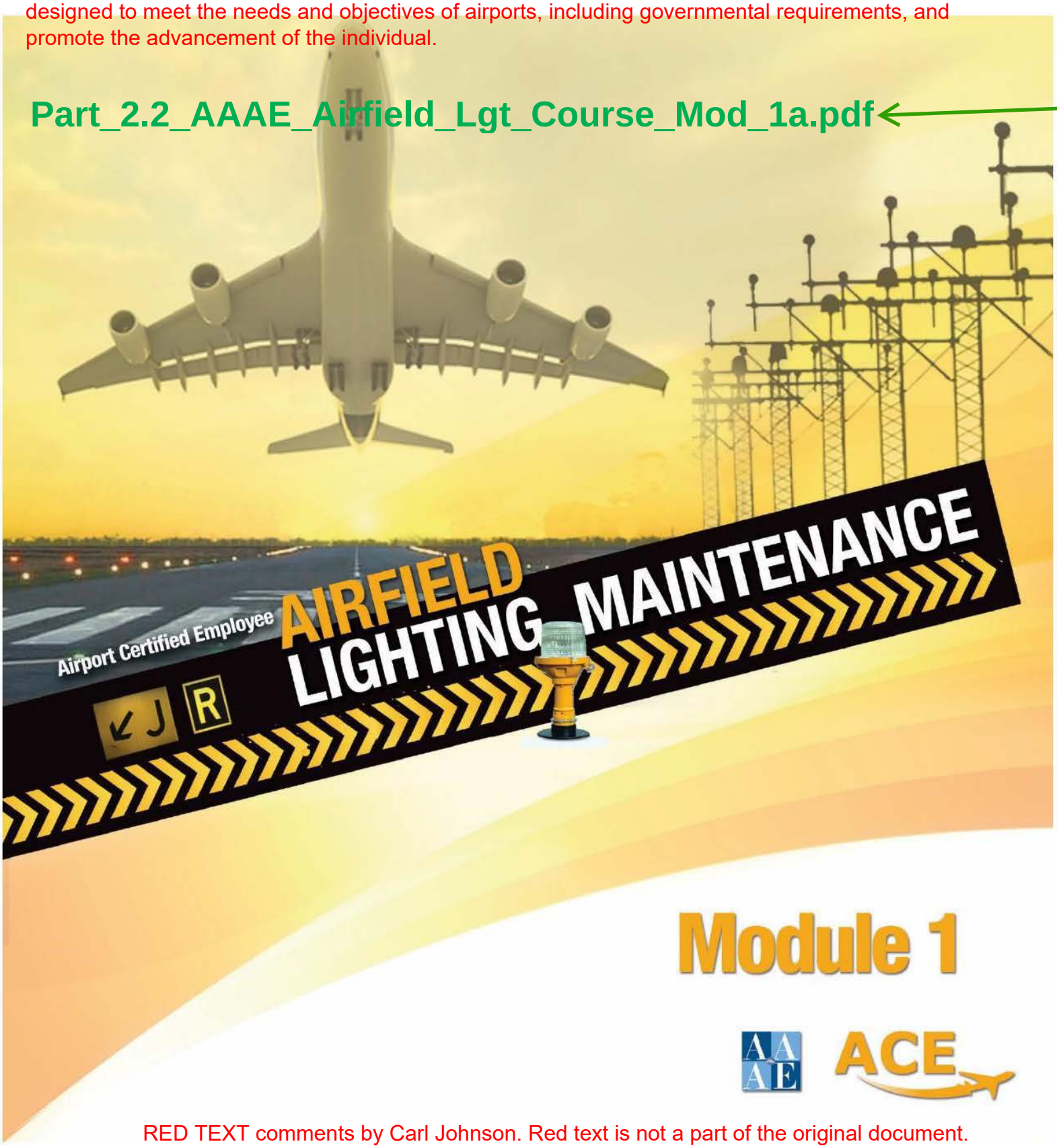
This document is a portion of the Association American Airport Executives (AAAE) airfield lighting maintenance course. The material has been REDLINED to highlight characteristics of an airfield lighting series circuit.

Page 21 through Page 25

American Association of Airport Executives (AAAE) Certification.
Airport Certified Employee (ACE) - Airfield Lighting Maintenance

AAAE certification programs set the standard for industry knowledge and training. Each program is designed to meet the needs and objectives of airports, including governmental requirements, and promote the advancement of the individual.

Part_2.2_AAAE_Airfield_Lgt_Course_Mod_1a.pdf ←



RED TEXT comments by Carl Johnson. Red text is not a part of the original document.

https://www.aaae.org/AAAEMemberResponsive/PD/AC/ACE/Airfield_Lighting_Maintenance/Airfield_Lighting.aspx

2.2 Theory of Operation

As previously stated, the series lighting circuit is a constant current, variable voltage circuit as opposed to a conventional parallel circuit which has a constant voltage output with the current varying at different points in the circuit depending on the circuit layout. Maximum current output on series lighting circuits in the United States is limited to either 6.6 amps or 20 amps depending on the circuit load and the CCR being used. Circuits rated at 6.6A are limited to 30 kW in size due to the fact that at maximum load and maximum current output, the CCR would have an output of 4545 volts which is just below the operating rating of the cable and transformers. If circuits greater in size than 30kW are required, the circuit is changed to 20 amp to reduce the output voltage. For example, the maximum output voltage on a 50kW 20 amp CCR would be 2500 volts. For this reason, and to prolong the life of the cable and transformers, it is at times recommended that the size of the circuits be limited to 20kW or less at 6.6A. Constant current regulators with a 20 amp output are only available as 5 step models and 50 and 70 kW units are limited to replacement units only per FAA AC 150/5345-10F. This change is due to the development of light fixtures which utilize smaller wattage lamps than previous models and therefore present a smaller load to the circuit.

Electrical current flow in the series lighting circuit is from one output terminal on the CCR to the other through the various sized isolation transformers (loads) in the field circuit. The CCR varies the output voltage depending on the amount of load in the circuit and the selected brightness step. The output side of the transformer winding in a CCR is not connected to ground at any point, therefore the voltage to ground is said to be “floating”. Since there is no true current path to ground and back to the source (CCR) as in a normal parallel circuit, there will be no current flow to ground if only one point in the circuit is grounded. However, when two or more locations in the series circuit become grounded, the current will flow through the ground around the load thereby resulting in a section of lights being extinguished. We will cover the theoretical and practical aspects of the behavior of voltage and current in a series circuit in more detail later in this chapter.

2.3 Advantages

The series circuit concept was first used in street lighting systems many years ago and is still in use in some areas today. It has proven to offer several advantages for airport lighting in that it provides:

- An illumination of even intensity to provide the proper visual cues to the pilot.
- The ability to deliver light output at variable intensities under various weather conditions.
- The compact design of the lamp filaments used with the constant current system is much more rugged and provides lamps that are more easily focused in an optical system.
- This system allows standardization of economical cables and cable sizes (#6 and #8 AWG). Relatively small cables can be used to deliver substantial power over very long circuits, typically two to five miles in length.
- A single ground fault in the system will not affect light operation.
- Ground faults may be easily located.
- The ability to easily add, remove or modify the load with the primary concern being the loading of the CCR. We must remember however, that by adding load to a series circuit, we are also increasing the output voltage of the CCR and thereby increasing the voltage stresses on the existing circuit cables and transformers.

2.4 Components of the System

The series lighting circuit uses a variable voltage, constant current AC source to supply electrical energy to the various loads connected to the circuit. The series circuit is comprised of a set of similar building block components in addition to the constant current regulator source. Each of these building blocks consists of the lighting fixture or sign, series isolation transformer and modular connector kit. These building block components are connected to each other and to the CCR by the 5 kV cable which can be either shielded (screened) or non-shielded. Non-shielded cable is typically used at installations in the United States and Canada. Shielded cables are sometimes used in European installations. The perceived benefits and drawbacks of each are the subject of much debate. There are other variables that can be found in various parts of the world such as Canada where isolation transformers are equipped with a grounding terminal that is internally attached to one side of the secondary winding of the transformer. This enables the secondary of the transformer to be grounded in an effort to help provide personnel protection in the event of a primary to secondary short in the transformer windings.

Series isolation transformers are available in several configurations of input current (6.6 or 20 amp), output current (6.6 or 20 amp) and load size (10/15 to 500 watt). Transformers with outputs of 1500 watts are also available for approach lighting systems where multiple lamps are connected to a single transformer. Cable used for series lighting circuits is sized either at #8AWG or #6AWG, the latter being used in 20 amp circuits to provide for less resistance and thereby reducing the I^2R (current squared × resistance = watts) losses in the circuit.

Constant current regulators are available in ratings from 1 kW to 70 kW and with 3 or 5 step outputs per FAA specifications. The 1 and 2 kW sizes were added in the latest edition of FAA AC 150/5345-10 to allow for smaller CCRs for LED circuits. Constant current regulators in other countries may have up to 7 or 8 brightness steps and operate with an output of 6 or 12 amps. Constant current regulators rated for 6.6 amp output are available in 3 or 5 step configurations but 20 amp CCRs are available as 5 step output only per FAA Advisory Circular 150/5345-10.

The last component normally installed as part of a typical airport series lighting system is the counterpoise system. This system provides protection from lightning damage to the circuit. The counterpoise system typically consists of #8 or #6 AWG conductor that is installed a few inches above the circuit conductors or conduit and is attached to ground rods at even spacing around the circuit. The ground rods are normally located at distances not to exceed 500 ft. Depending on the configuration of the system, the counterpoise conductor may be connected to the base cans or mounting stakes or routed around the lights with no connection. The FAA Advisory Circular 150/5340-30, *Design and Installation Details for Airport Visual Aids*, latest addition, should be consulted for the latest requirements for counterpoise installation in the United States.

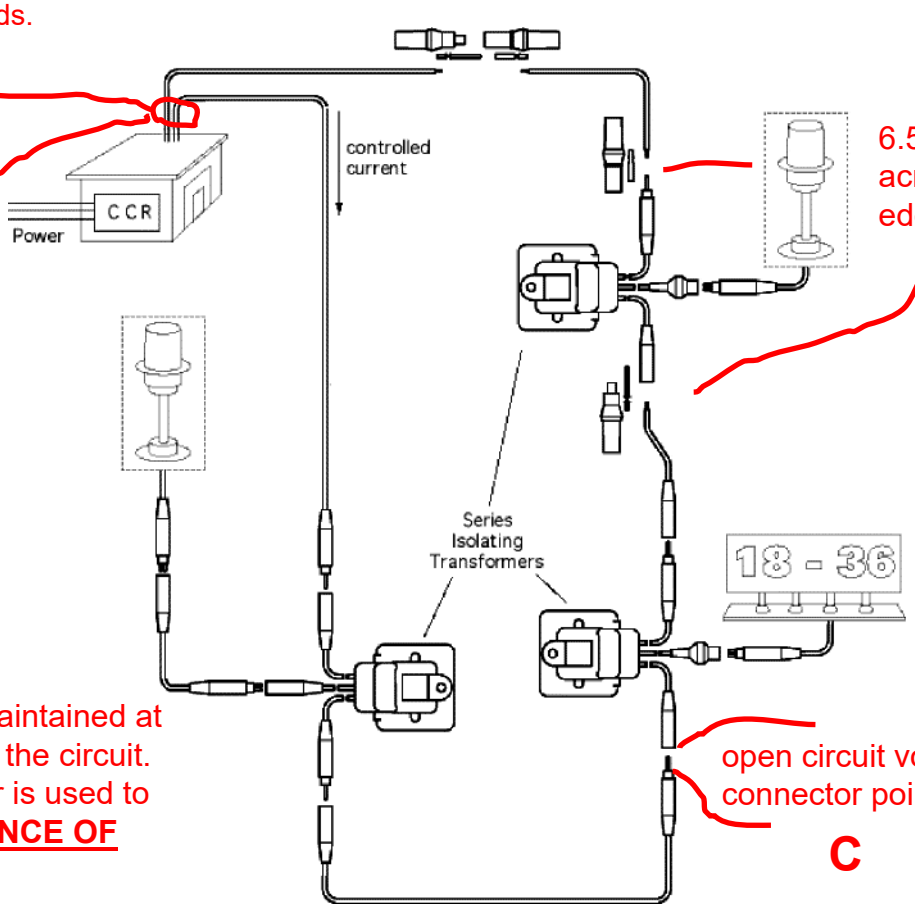
Constant current regulators are manufactured in several designs and styles. Basic types are Resonant Network, Thyristor Controlled (better known as series type), Ferro-Resonant and those employing a Saturable Core Reactor.

Series isolation transformers and CCRs are covered in detail in the following chapters of this training course.

A If there was a way to safely expose the conductors (w/o creating and open circuit) on both sides of the series isolating transformer the voltage drop across a LED runway edge light would be approximately 6.5 volts. Indicating it would be safe to work.

B A fully loaded 30 kW, 6.6 amp constant current regulator (CCR) would have a nominal output voltage of 4,545 volts.

C An open circuited 30 kW CCR would have an output voltage of 9,090 volts for two seconds until the open circuit trip functions. The CCR is designed to raise the output voltage is accordance with the load. The CCR sees an open circuit as an increase in load and raises the output voltage until the overvoltage circuit turns the CCR off after 2 seconds.



The CCR nominal output voltage is determined by the quantity and VA load of the fixtures connected to the individual circuit.

Figure 2-6 – Typical Series Lighting Circuit
Drawing courtesy of Amerace Ltd.

RED TEXT comments by Carl Johnson. Red text is not a part of the original document.

Document file Name:

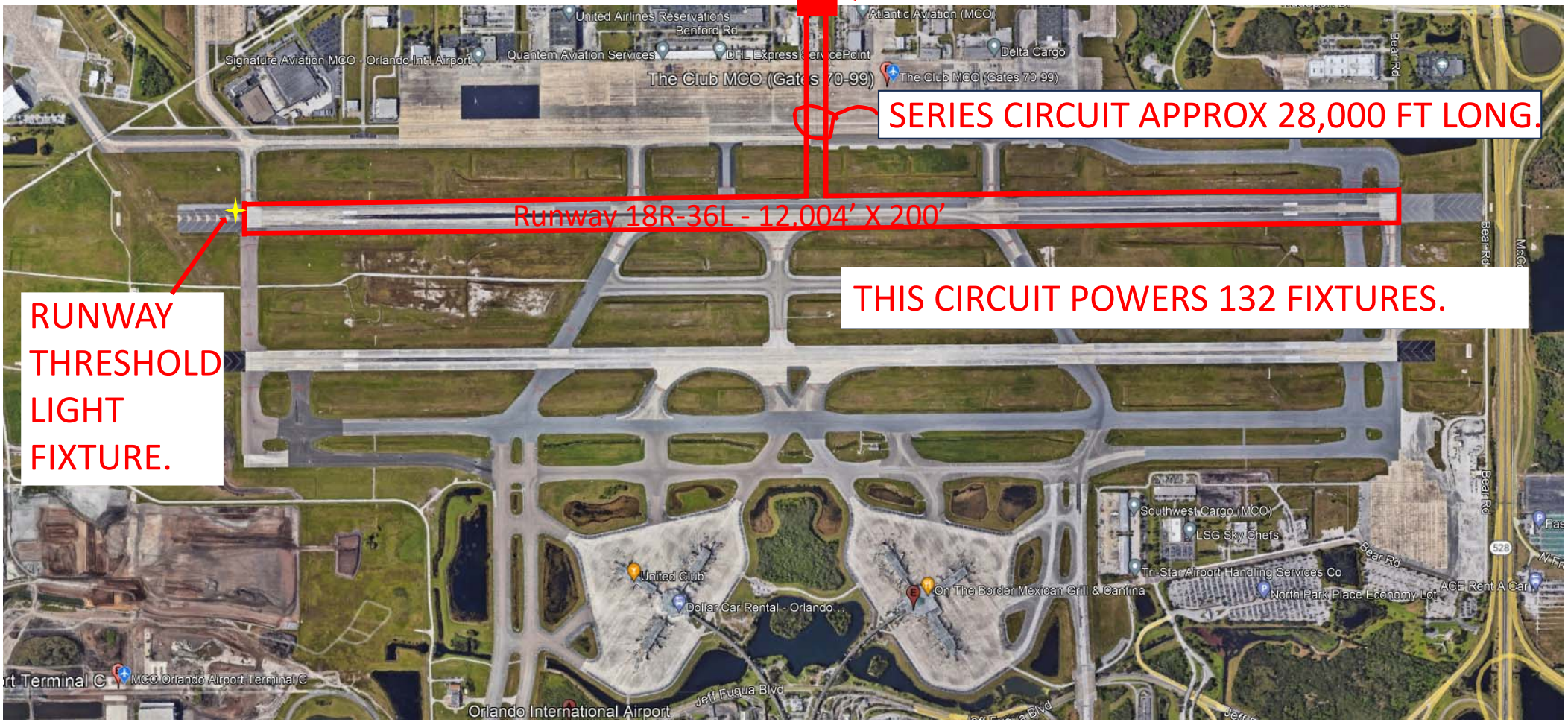
NFPA_70E_Series_Circuit_R1.pdf

PDF version of a PPT describing the scale of an airfield lighting series circuit and some photos demonstrating what an electrician will encounter on an active airfield.

Page 26 through Page 30

NFPA_70E_Series_Circuit_R1

LOCATION OF CONSTANT CURRENT REGULATOR.



FIXTURE TO BE REPAIRED IS MORE THAN 6,OOO FEET FROM THE POWER SOURCE. ABSENCE OF ENERGY MUST BE VERIFIED.

BLOW-UP OF RUNWAY 36L THRESHOLD AREA.

TYPICAL RUNWAY THRESHOLD LIGHT FIXTURE.

RUNWAY THRESHOLD LIGHT FIXTURE.

RUNWAY THRESHOLD
LIGHT FIXTURE BASE OPENED
TO EXPOSE WIRING

Voltage drop across this threshold fixture = 48 volts.
Three – 105-watt halogen lamps at 6.6 amps.

Airfield lighting series circuits are an ungrounded system. Green wire in photo is a bonding jumper used for lightning protection, NFPA 780.

A qualified person would be committing an unsafe act (very possibly fatal act) attempting to open the circuit at a series circuit airfield lighting fixture to test the voltage. Open circuit voltage may reach >9,000 volts. A true RMS clamp-on or open jaw ammeter must be used to determine if the circuit contains energy.

Public Comment No. 111-NFPA 70E-2025 [Section No. 120.6]

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. 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~~,~~ . For ac systems test phase to phase and phase to ground, for dc systems test positive (+) to negative (-) and each polarity to ground . Before and after testing, determine that the test instrument ~~is~~ and leads are operating satisfactorily through verification on any known voltage source of the applicable current (ac or dc) type .

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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Statement of Problem and Substantiation for Public Comment

step 120.6(7) directing the testing for the absence of voltage is an extremely important element when establishing and verifying an ESWC exits. However, the existing directive "Test each phase conductor or circuit part both phase-to-phase and phase-to-ground." is only applicable to alternating current (ac), because the word "Phase" is related to the word Phasor and is technically limited to only ac circuits. Direct current (dc) on the other hand never uses the term phase to describe any part of its circuit. Rather dc uses "polarity" and/or "poles" to denote this.
With the significant amount of dc equipment, systems and sources now saturating countless industries, it is imperative that electricians and technicians understand if they are working on ac or dc equipment, so they can place their meters into the correct setting to test for the absence of dc voltage. To do this, they need to test across opposite polarities then test each polarity to ground to ensure with a 100% certainty no hazardous dc voltage is present.
I presented a paper on this exact topic which was presented during the 2023 IEEE ESW conference in Reno, NV explaining the urgent need for this revision in great detail. Please see paper ESW2023-32 titled "Is Absence of Voltage 'Live-Dead-Live' Testing According to NFPA 70E Adequate?"

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 88-NFPA 70E-2025 [New Section after 120.6]	connected to electrically safe work condition (ESWC)

Related Item

- electrically safe work condition

Submitter Information Verification

Submitter Full Name: George Cole
Organization: Pvngs Aps
Affiliation: E-Hazard
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 21 20:23:20 EDT 2025
Committee: EEW-AAA

Public Comment No. 144-NFPA 70E-2025 [Section No. 120.6]

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. 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.
~~Use an adequately rated~~

(7) 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. If visual verification of isolation cannot be confirmed, use an application-specific portable test instrument to verify the absence of generated electrical power at each point of work.

(8) Release stored electrical energy.

(9) Use an application-specific 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. Test for all possible energy sources. Before and after testing, determine that the test instrument is operating satisfactorily through verification on
~~any~~

(10) a 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~~

Exception No . 1 to 7:

~~An adequately rated permanently~~

A 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.

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~~

Exception No . 2 to 7: On electrical systems over 1000 volts,

~~adequately~~

appropriately 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. 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:

(1) 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.

(2) 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) If required by 120.6(8) , temporary protective grounding equipment shall be installed in accordance with the following:

(1) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(2) 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).

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

(4) *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.

(5) *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.

Statement of Problem and Substantiation for Public Comment

Removal of the phrase "to the extent if feasible" in the first sentence of the section to eliminate the unenforceable and vague term "feasible" based on the NEC Style Manual Section 3.2.1.

In section 120.6(7) and Exceptions No. 2 to 7, replace the phrase "adequately rated" with "application-specific" to eliminate the unenforceable and vague term "adequately," as stated in NEC Style Manual Section 3.2.1.

In Exceptions No. 1 to 7, the phrase "adequately rated" has been removed to eliminate the unenforceable and vague term "adequately," as specified in Section 3.2.1 of the NEC Style Manual. The phrase "an adequately rated" is clarified in Exceptions No. 1 to 7 (1) & (2).

Moving step (5) Block or relieve stored nonelectrical energy and (6) Apply lockout/tagout devices to steps (3) and (4) establishes control of hazardous generated electrical power earlier in the process. This revised process order establishes control of the disconnecting devices prior to releasing stored electrical energy.

Establishing and verifying an electrically safe work condition can be hazardous if the step for "releasing stored electrical energy" is carried out without visually confirming the disconnection. This is particularly crucial when the disconnecting device is an insulated or molded case circuit breaker, as one or more phases may remain energized due to a malfunction of the internal disconnecting device. Language has been added at the end of this section to ensure the disconnection of generated electrical power before releasing stored electrical energy. Additionally, the phrase "whenever possible" has been removed from the beginning of the section to align with the new language introduced at the end.

The phrase "Test for all possible energy sources" has been added to section 120.6(7) to address potential energy sources requiring absence verification, including generated electrical power and stored energy.

Related Item

• FR-28

Submitter Information Verification

Submitter Full Name: Duke Schamel
Organization: Electrical Service Solutions, Inc.
Affiliation: IEC
Street Address:
City:
State:
Zip:
Submittal Date: Sun Jun 01 15:02:16 EDT 2025
Committee: EEW-AAA

Public Comment No. 189-NFPA 70E-2025 [Section No. 120.6]

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. 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~~ electrical energy on each phase conductor or circuit part at each point of work, phase to phase and phase to ground. Before and after 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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Additional Proposed Changes

File Name	Description	Approved
Safety_Presentation.pdf	Safety Presentation PDF	

Statement of Problem and Substantiation for Public Comment

Series circuits always have a point in the circuit where the voltage measured will be 0 volts though there is significant and highly dangerous electrical energy present. Changing the word voltage to energy will at least bring awareness to this issue when dealing with series circuits.

Related Item

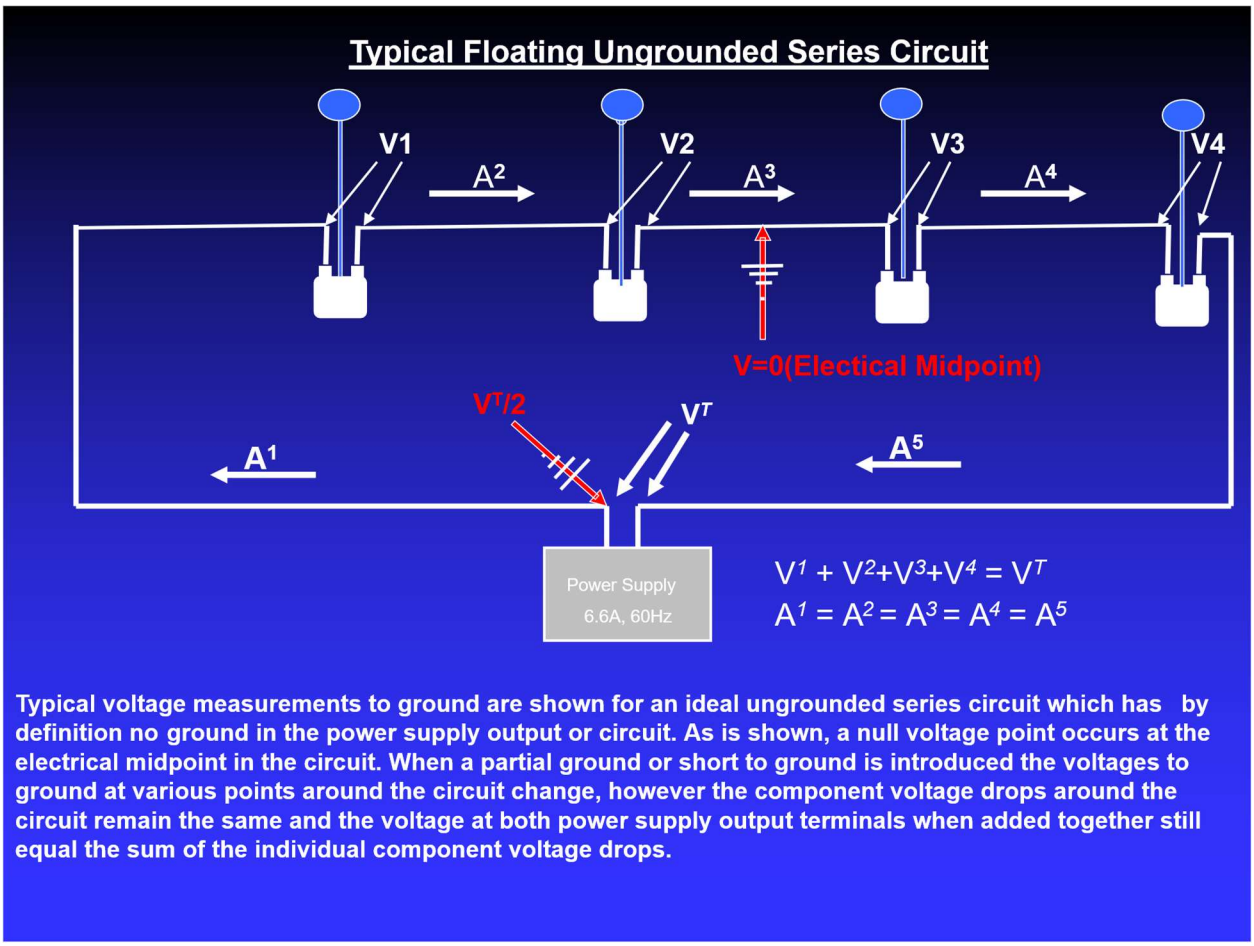
- • NFPA 70 E Upcoming

Submitter Information Verification

Submitter Full Name: Seward Ford
Organization: Visual Aids Services Inc
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 02 20:58:34 EDT 2025
Committee: EEW-AAA

The electrical energy characteristics of an ungrounded series circuit.

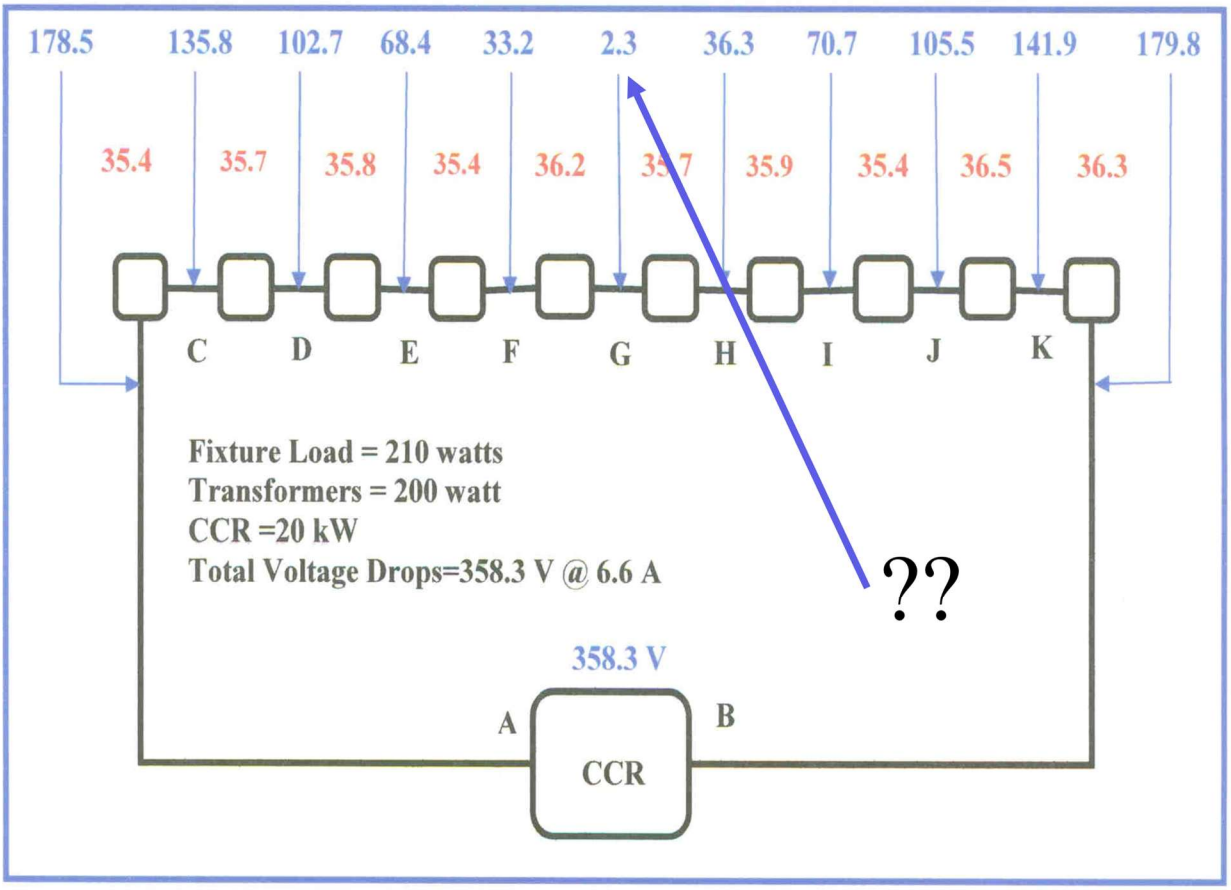
Only when it has been verified that the circuit has no indication of the presence of electrical energy is a circuit safe to work on. Measurement of a voltage to ground that indicates approximately ZERO voltage **does not** indicate a deenergized circuit. Note the typical energized airport lighting series circuit shown below indicates the absence of voltage to ground at the approximate midpoint. However, this circuit is energized even though there is a point where voltage to ground approximates ZERO. Current flow is verified by observing a true RMS clamp-on ammeter.



Typical voltage measurements to ground are shown for an ideal ungrounded series circuit which has by definition no ground in the power supply output or circuit. As is shown, a null voltage point occurs at the electrical midpoint in the circuit. When a partial ground or short to ground is introduced the voltages to ground at various points around the circuit change, however the component voltage drops around the circuit remain the same and the voltage at both power supply output terminals when added together still equal the sum of the individual component voltage drops.

Actual test circuit results

Below is an actual test series circuit showing by blue font the voltage to ground at various circuit locations of an energized 6.6-amp series circuit. Also shown are recorded voltage drops (red font) across the primary of each series circuit transformer when operating at 6.6 amps. Current flow or the lack of it can be verified by using a true RMS clamp-on ammeter.



!!CAUTION!!

SERIES CIRCUIT CONSTANT CURRENT REGULATORS ARE CAPABLE OF DEVELOPING EXTEMELY HIGH AND LETHAL VOLTAGES. THE FOLLOWING INFORMATION IS PRESENTED FOR EDUCATIONAL PURPOSES ONLY. MEASUREMENTS OF VOLTAGES IN SERIES CIRCUITS SHOULD NOT BE ATTEMPTED. NEVER UNDER ANY CIRCUMSTANCES ATTEMPT TO MAKE DIRECT VOLTAGE MEASUREMNTS OF AIRPORT LIGHTING SERIES CIRCUITS.

Public Comment No. 246-NFPA 70E-2025 [Section No. 120.6]

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. 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. Before and after testing, determine that the test ~~instrument is operating~~ instrument and equipment used to test for the absence of voltage are 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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Statement of Problem and Substantiation for Public Comment

There are currently two methods to accomplish step 7.

1 - Utilizing a portable test instrument to accomplish the Live-Dead-Live testing process, which works for validating and trusting your measurement as one is physically taking measurements within the cabinet at the circuitry/point of work and is able to validate the function of the portable test instrument.

2 - Exception No 1 to 7 allows an Absence of Voltage Tester (AVT) to perform the process and obtain measurements for you, while also taking measurements at the point of work. Through this process, the device enabling the process, the AVT, goes through a series of internal and connection verification steps to ensure it's function and outcome can be trusted that are required by a UL standard, UL 1436, to be considered an AVT.

The issue comes with utilizing a portable test instrument while obtaining absence of voltage measurements through additional devices that are unable to validate their internal function or validate their connection to the point of work. For clarity, this is in relation to the inclusion of Annex O.2.4(13) in the 2024 edition.

With the removal of 110.6(E) – Operation Verification, the verification on equipment is not called out in 120.6. It is only called out to be accomplished on test instruments, and not any device or equipment that is used to obtain an electrically safe work condition. Public input 246-NFPA 70E-2024 was added to help clarify that instruments, devices, equipment, etc. should be validated for function, prior to trusting the testing results that they provide. The committee's statement that 120.6(7) already addresses "and equipment" is unclear. The word Equipment is not mentioned within 120.6(7), just test instruments, which are commonly understood as hand held meters.

The inclusion of "all test instruments and equipment used in the testing process are" operating satisfactorily through verification on any known voltage source. This would ensure that any instrument or equipment that is used to obtain the measurements used for the Live-Dead-Live process has been validated before an electrically safe work condition is confirmed.

Related Item

• PI No. 246-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: Alan Bond
Organization: Panduit
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jun 03 18:07:41 EDT 2025

Committee:	EEW-AAA

Public Comment No. 247-NFPA 70E-2025 [Section No. 120.6]

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. 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. Identify abandoned-in-place electrical equipment and record this equipment on current drawings. Mark for later removal. Verify this abandoned equipment is not energized.

(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. Before and after 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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Additional Proposed Changes

File Name	Description	Approved
NFPA_70E_-_Section_120.6_1_-_Support_for_my_Public_Inputs_-_2.pdf	Campbell_120.6(1)	

Statement of Problem and Substantiation for Public Comment

Justification: This will add attention to abandoned-in-place electrical equipment and circuits where were intended to be and designated as "de-energized".

Impact if not provided: As more electrical equipment and metallic conduits are abandoned-in-place to save money in a project, we must consider the danger to personnel who must work on electrical systems and circuits, and the contribution that surges from lightning (10k Hz) and from power outages (60 Hz) picked up by these abandoned-in-place metallic conduits and equipment can play toward security and safety.

Related Item

• First Revision No. 28

Submitter Information Verification

Submitter Full Name: Joanie Campbell
Organization: US Department of the Air Force
Street Address:
City:
State:
Zip:

Submittal Date: Wed Jun 04 11:45:45 EDT 2025
Committee: EEW-AAA

NFPA 70E – Article 120.6 – Support for Public Inputs

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

NOTE: We have effectively ignored one of the more deadly conditions for personnel. This is, safety measures for establishing and verifying an electrically safe work condition for current-regulated (series) circuits for airfield lighting (up to 5kV rated because the voltage changes to maintain a constant current throughout the series lighting circuit). As with voltage-regulated circuits of multiple phases, we should provide safety measures for single phase series circuits.

Problem: Abandoned-in-place electrical equipment plays a part in availability of unexpected surges due to lightning and power outages. This can affect operation and temporary energization of electronic controls.

Recommendation: Reword Section 120.6, part (1) to read:

> *(1) Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags. Identify abandoned-in-place electrical equipment and record this equipment on current drawings. Mark for later removal. Verify this abandoned equipment is not energized.*

Justification: This will add attention to abandoned-in-place electrical equipment and circuits where were intended to be and designated as "de-energized".

Impact if not provided: As more electrical equipment and metallic conduits are abandoned-in-place to save money in a project, we must consider the danger to personnel who must work on electrical systems

and circuits, and the contribution that surges from lightning (10k Hz) and from power outages (60 Hz) picked up by these abandoned-in-place metallic conduits and equipment can play toward security and safety.

Public Comment No. 248-NFPA 70E-2025 [Section No. 120.6]

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. 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" position or to the fully disconnected position identified by the manufacturer .

(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. Before and after 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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Additional Proposed Changes

File Name	Description	Approved
NFPA_70E_-_Section_120.6_3_-_Support_for_my_Public_Inputs_-_3.pdf	Campbell_120.6(3)	

Statement of Problem and Substantiation for Public Comment

Justification: Distractions can cause irreversible injury.

Impact if not provided: Injuries and possible deaths.

Related Item

• First Revision No. 28

Submitter Information Verification

Submitter Full Name: Joanie Campbell
Organization: US Department of the Air Force
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 04 11:55:14 EDT 2025
Committee: EEW-AAA

NFPA 70E – Article 120.6 – Support for Public Inputs

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

Problem: Dangerous complacency in the workplace through routine daily work operation repairs and maintenance

Recommendation: Reword Section 120.6, part (3) to clarify specific actions which should be reviewed prior to each new project or job.

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

Justification: Distractions can cause irreversible injury.

Impact if not provided: Injuries and possible deaths

Public Comment No. 249-NFPA 70E-2025 [Section No. 120.6]

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. 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 by creating short circuits for voltage regulated/controlled circuits and by creating open circuits for current regulated (series) circuits .

(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. Before and after 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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Additional Proposed Changes

File Name	Description	Approved
NFPA_70E_-_Section_120.6_4_-_Support_for_my_Public_Inputs_-_4.pdf	Campbell_120.6(4)	

Statement of Problem and Substantiation for Public Comment

Justification: Inclusion of conditions caused by series circuit characteristics will minimize dangers not often encountered.

Impact if not provided: False sense of security and complacency.

Related Item

• First Revision No. 28

Submitter Information Verification

Submitter Full Name: Joanie Campbell
Organization: US Department of the Air Force
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 04 13:10:07 EDT 2025
Committee: EEW-AAA

NFPA 70E – Article 120.6 – Support for Public Inputs

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

Problem: Lack of inclusion of series circuits in an electrically Safe Work Condition can be responsible for an unanticipated source of stored electrical energy.

Recommendation: Reword Section 120.6, part (4) as follows.

(4) Release stored electrical energy by creating short circuits for voltage regulated/controlled circuits and by creating open circuits for current regulated (series) circuits.

Justification: Inclusion of conditions caused by series circuit characteristics will minimize dangers not often encountered.

Impact if not provided: False sense of security and complacency

Public Comment No. 250-NFPA 70E-2025 [Section No. 120.6]

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. 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~~ the devices having capability to store nonelectrical energy .

(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. Before and after 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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Additional Proposed Changes

File Name	Description	Approved
NFPA_70E_-_Section_120.6_5_-_Support_for_my_Public_Inputs_-_5.pdf	Campbell_120.6(5)	

Statement of Problem and Substantiation for Public Comment

Justification: Provides clarification and self confidence for personnel.

Impact if not provided: Possible misinterpretation.

Related Item

• First Revision No. 28

Submitter Information Verification

Submitter Full Name: Joanie Campbell
Organization: US Department of the Air Force
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 04 13:12:19 EDT 2025
Committee: EEW-AAA

NFPA 70E – Article 120.6 – Support for Public Inputs

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

Problem: Clarification Required

Recommendation: Add to last sentence "the devices having capability to store nonelectrical energy."

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

Justification: Provides clarification and self confidence for personnel

Impact if not provided: Possible misinterpretation

Public Comment No. 251-NFPA 70E-2025 [Section No. 120.6]

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. 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~~ For voltage-regulated circuits, use an adequately~~-~~ rated, portable test ~~instrument to test for the absence of voltage of~~ instrument to test each phase conductor or circuit part at each point (node) of work ~~, phase to~~ to verify the absence-of-voltage. Test each phase conductor or circuit part both phase-to- phase and phase~~-~~ to~~-~~ ground. Before and after ~~testing, determine~~ each test procedure on each part of the circuit, determine that the test instrument is operating satisfactorily through verification by performing a test on any source with a known voltage~~- source.~~ . Verify the test instrument function has not been changed. At each point of interruption or restart of testing, re-verify the instrument, its function, and re-test for absence-of-voltage. Verify the neutral of a wye-configured, voltage-regulated circuit verifies absence-of-current (is not carrying any current), a condition which requires further attention.

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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Additional Proposed Changes

File Name	Description	Approved
NFPA_70E_-_Section_120.6_7_-_Support_for_my_Public_Inputs_-_6.pdf	Campbell_120.6(7)	

Statement of Problem and Substantiation for Public Comment

Justification: This will introduce additional safety instructions for testing prior to beginning electrical work.

Impact if not provided: These extra considerations will provide added safety for personnel working in dangerous conditions.

See attachment for clear revision.

Related Item

• First Revision No. 28

Submitter Information Verification

Submitter Full Name: Joanie Campbell
Organization: US Department of the Air Force
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 04 13:14:03 EDT 2025
Committee: EEW-AAA

NFPA 70E – Article 120.6 – Support for Public Inputs

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

Problem: No description of test and safety procedures have been provided for test instrument change-of-function and for verification of accidental absence of current on a neutral, that might be part of a wye-configured circuit.

Recommendation: Reword item (7) as below, to provide additional electrically safe working considerations and conditions for personnel.

> (7) For voltage-regulated circuits, use an adequately-rated, portable test instrument to test each phase conductor or circuit part at each point (node) of work to verify the absence-of-voltage. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test procedure on each part of the circuit, determine that the test instrument is operating satisfactorily through verification by performing a test on any source with a known voltage. Verify the test instrument function has not been changed. At each point of interruption or restart of testing, re-verify the instrument, its function, and re-test for absence-of-voltage. Verify the neutral of a wye-configured, voltage-regulated circuit verifies absence-of-current (is not carrying any current), a condition which requires further attention.

Justification: This will introduce additional safety instructions for testing prior to beginning electrical work.

Impact if not provided: These extra considerations will provide added safety for personnel working in dangerous conditions.

Public Comment No. 252-NFPA 70E-2025 [Section No. 120.6]

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. 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. Before and after 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:

(8) 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.

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

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

(11) 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. 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.

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

(12) ~~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.~~
~~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~~

(13) For current-regulated circuits such as airfield lighting circuits (rated 5kV), it is necessary to test for absence-of-current. Prior to testing each series circuit, test each series circuit conductor with a true RMS, clamp-on, properly-rated ammeter, on a circuit known to be energized. Test the series circuit conductor under repair with that same ammeter. Protect the series circuits against induced voltages which are an inherent issue in airfield lighting circuits. If the circuit conductors are shielded, disconnect the shield at each end of the segment under repair. Airfield lighting circuit conductors may be L-824-C,

either shielded or non-shielded, depending on the application and environment. Check to ensure if testing is being performed on shielded or unshielded cable, as other safety procedures may apply. Airfield lighting is typically backed up by a generator with automatic transfer capabilities. Ensure the transfer switch is locked out so the generator cannot be automatically energized during work .

(14) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(15) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(16) 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).

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

(18) *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.

(19) *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.

Additional Proposed Changes

File Name	Description	Approved
NFPA_70E_-_Section_120.6_8_-_Support_for_my_Public_Inputs_-_7.pdf	Campbell_120.6(8)	

Statement of Problem and Substantiation for Public Comment

Justification: This will introduce formerly unconsidered dangers encountered with airfield Lighting Systems and other series circuit characteristics and will identify the training the employer should be providing.

Impact if not provided: We will continue to ignore life-threatening dangers that appear benign to the electrician because series circuits are typically a single conductor, and that single conductor can be shielded or unshielded….with "shielded" representing a totally different hazard threat.

See attached file for clear revision.

Related Item

• First Revision No. 28

Submitter Information Verification

Submitter Full Name: Joanie Campbell
Organization: US Department of the Air Force
Street Address:
City:
State:
Zip:

Submittal Date: Wed Jun 04 13:24:24 EDT 2025
Committee: EEW-AAA

NFPA 70E – Article 120.6 – Support for Public Inputs

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

Problem: We have effectively ignored one of the more deadly conditions for electricians. That is, safety measures for establishing and verifying an electrically safe work condition for current-regulated (series) circuits for airfield lighting (p to 5kV rated, because the voltage changes to maintain a constant current throughout the series lighting circuit. As with voltage-regulated circuits of multiple phases, we should provide safety measures for single phase series circuits.

Recommendation: Reword Section 120.6 part (8) as follows.

(8) For current-regulated circuits such as airfield lighting circuits (rated 5kV), it is necessary to test for absence-of-current. Prior to testing each series circuit, test each series circuit conductor with a true RMS, clamp-on, properly-rated ammeter, on a circuit known to be energized. Test the series circuit conductor under repair with that same ammeter. Protect the series circuits against induced voltages which are an inherent issue in airfield lighting circuits. If the circuit conductors are shielded, disconnect the shield at each end of the segment under repair. Airfield lighting circuit conductors may be L-824-C, either shielded or non-shielded, depending on the application and environment. Check to ensure if testing is being performed on shielded or unshielded cable, as other safety procedures may apply. Airfield lighting is typically backed up by a generator with automatic transfer capabilities. Ensure the transfer switch is locked out so the generator cannot be automatically energized during work.

Justification: This will introduce formerly unconsidered dangers encountered with airfield Lighting Systems and other series circuit characteristics and will identify the training the employer should be providing.

Impact if not provided: We will continue to ignore life-threatening dangers that appear benign to the electrician because series circuits are typically a single conductor, and that single conductor can be shielded or unshielded….with "shielded" representing a totally different hazard threat.

Public Comment No. 253-NFPA 70E-2025 [Section No. 120.6]

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. 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. Before and after 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 (multimeter) 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:

~~It~~

(1) The multimeter is permanently mounted and installed in accordance with the manufacturer's instructions and tests the conductors and circuit parts at the

~~point~~

(1) points of work.

~~It~~

(1) The multimeter is listed and labeled for the purpose of testing for

~~the~~

(1) absence - of - voltage.

~~It tests~~

(1) The multimeter tests each phase conductor or circuit part both phase-to-phase and phase-to-ground.

(2) The

~~test device~~

(1) multimeter is verified as operating satisfactorily on any known voltage source before and after testing for the absence - of - voltage. Note: For large future construction projects, consider the addition of a permanent electrical safety device that may provide indicator lamps when voltage is present, adding an additional layer of personnel safety.

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. 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:

(9) 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.

(10) 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.

(11) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(12) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(13) 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).

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

(15) *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.

(16) *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.

Additional Proposed Changes

File Name	Description	Approved
NFPA_70E_-_120.6_Exception_No._1_to_7.pdf	Campbell_120.6 Exception No. 1 to 7	

Statement of Problem and Substantiation for Public Comment

Justification: Provides some clarification to the statement of Exceptions.

See attached file for clear revision.

Related Item

• First Revision No. 28

Submitter Information Verification

Submitter Full Name: Joanie Campbell
Organization: US Department of the Air Force
Street Address:
City:
State:
Zip:

Submittal Date:	Wed Jun 04 13:26:06 EDT 2025
Committee:	EEW-AAA

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

Problem: "Exception No. 1 to 7" can be better clarified with the addition of explanatory terms below.

Recommendation: Reword Section "Exception No. 1 to 7, as stated below.

Exception No. 1 to 7: An adequately rated, permanently mounted absence-of-voltage tester (multimeter) 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) The multimeter is permanently mounted and installed in accordance with the manufacturer's instructions and tests the conductor and circuit parts at the points of work (2) The multimeter is listed and labeled for the purpose of testing for absence-of-voltage; (3) The multimeter tests each phase conductor or circuit part, both phase-to-phase and phase-to-ground; (4) The multimeter is verified as operating satisfactorily on any known voltage source before and after testing for absence-of-voltage. Note: For large future construction projects, consider the addition of a permanent electrical safety device that may provide indicator lamps when voltage is present, adding an additional layer of personnel safety.

Justification: Provides some clarification to the statement of Exceptions.

Public Comment No. 31-NFPA 70E-2025 [Section No. 120.6]

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. 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 electrical energy (voltage and current) of each ~~phase~~ conductor or circuit part at each point of work~~, phase to phase and phase to ground~~ . Before and after testing, determine that the test instrument is operating satisfactorily through verification on any known ~~voltage~~ electrical energy source.

(8) When testing voltage driven circuits, test each conductor or circuit part to confirm the absence of voltage for both phase to phase and phase to ground.

(9) When testing current driven (constant current) circuits, test each conductor or circuit part to confirm the absence of current.

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: Noncontact capacitive test instruments are not suitable to test for the absence of electrical energy for current driven series circuits such as airfield lighting circuits. Absence of electrical energy testing of an airfield lighting series circuit must be performed with a true RMS ammeter.

Exception No. 1 to

~~7~~

8 : 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:

(10) 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.

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

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

(13) 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~~

3 : 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~~

8 : 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. Noncontact capacitive test instruments shall not be used to test for the absence of energy on a current driven

circuits.

Informational Note No.

~~3~~

4 : 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~~

5 : 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.

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

(15) 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.

(16) 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.

(17) If required by 120.6(~~8~~ 10), temporary protective grounding equipment shall be installed in accordance with the following:

(18) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(19) 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).

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

(21) *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.

(22) *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.

Statement of Problem and Substantiation for Public Comment

Testing for voltage is insufficient and potentially unsafe for ungrounded current driven circuits. Ungrounded current driven circuits are used in airfield lighting as well some street lighting. These circuits will operate in a faulted and multiple faulted to ground condition. Testing for voltage with a circuit that is grounded may present false measurements. Changing the verbiage to indicate "electrical energy" as well as clarifying "(voltage and current)" casts a wider net. Qualified workers should understand which to test depending on power source.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 27-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]	
Public Comment No. 28-NFPA 70E-2025 [Section No. 110.4(A)(1)]	
Public Comment No. 29-NFPA 70E-2025 [Section No. 110.6(E)]	
Public Comment No. 30-NFPA 70E-2025 [Section No. 120.5(B)(6)]	

Public Comment No. 27-NFPA 70E-2025 [Definition: Electrically Safe Work Condition.]

Public Comment No. 28-NFPA 70E-2025 [Section No. 110.4(A)(1)]

Public Comment No. 29-NFPA 70E-2025 [Section No. 110.6(E)]

Public Comment No. 30-NFPA 70E-2025 [Section No. 120.5(B)(6)]

Related Item

• PI 48

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Hanson Professional Services

Street Address:

City:

State:

Zip:

Submittal Date: Thu Mar 27 11:41:03 EDT 2025

Committee: EEW-AAA

Public Comment No. 35-NFPA 70E-2025 [Section No. 120.6]

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. 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. Before and after 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.

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. 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) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

a. *Placement.* 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_3.pdf	70E_CN3	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 3 appeared in the First Draft Report on First Revision No. 29.

The Correlating Committee requests that the Technical Committee review 120.6(7) Exceptions No. 1 and 2 to (7) for use of the term "adequately" in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 on unenforceable terms.

Related Item

• First Revision No. 29

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 03 13:25:26 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 3-NFPA 70E-2025 [Section No. 120.6]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:29:08 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review 120.6(7) Exceptions No. 1 and 2 to (7) for use of the term “adequately” in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 on unenforceable terms.

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

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 48-NFPA 70E-2025 [Section No. 120.6]

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. 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. Before and after 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.

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. 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) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

a. *Placement.* 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_17.pdf	70E_CN17	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 17 appeared in the First Draft Report on First Revision No. 28.

The Correlating Committee requests that the Technical Committee review the word "feasible" in 120.6 in the phrase "to the extent feasible" in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1.

Related Item

• First Revision No. 28

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 03 16:46:54 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 17-NFPA 70E-2025 [Section No. 120.6]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:13:42 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the word “feasible” in 120.6 in the phrase “to the extent feasible” in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1.

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

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 9-NFPA 70E-2025 [Section No. 120.6]

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. 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. Before and after 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.

Informational Note No. 2: After all the above steps have been taken, there could still be an unknown source that is connected to the system through a neutral conductor. Extra care should be taken to ensure hazardous voltage does not appear when disconnecting neutral conductors.

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:

(8) 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.

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

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

(11) 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. 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.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Statement of Problem and Substantiation for Public Comment

Electrically Safe Work Conditions are established by locking out all known sources. There can, however, be unknown sources that can never be known until a neutral is lifted. Sometimes, these sources can even be in other buildings or structures. There is currently a note to this effect in 120.5. This is in the section of identifying sources. This is a good note and should stay. I propose that an additional note be placed in 120.6. 120.5 is before the lock-out procedure. The proposed note in 120.6 is after the lock-out procedure. It is very important to make it known, that even after all due diligence has been performed, there could still be unknown hazardous sources. NFPA70 solved the issue of multi-wire branch circuits in 2008 by requiring handle-ties for the breakers. But there still exists hazards from wiring errors where neutrals are crossed. All neutrals in a system are, in fact, tied together through the grounding systems. Even with wiring errors, everything will work just fine as long as the neutrals are connected together. The hazards won't be known until neutrals are lifted.

Related Item

• PI-76 NFPA70E-2024

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Sun Mar 23 14:31:36 EDT 2025
Committee: EEW-AAA

Public Comment No. 91-NFPA 70E-2025 [Section No. 120.6]

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. 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. Before and after 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:

(8) 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.

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

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

(11) 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. 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.

Informational Note No. 5: Never break any connection on an airfield lighting primary series circuit without first checking for current with a true RMS ammeter.

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

(13) 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.

(14) 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.

(15) If required by 120.6(8), temporary protective grounding equipment shall be installed in accordance with the following:

(16) *Placement.* Placement of temporary grounding equipment shall meet the following requirements:

(17) 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).

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

(19) *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.

(20) *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.

Statement of Problem and Substantiation for Public Comment

Measuring voltage on an energized airfield lighting series circuit is a hazardous task. All connections should be made while the system is de-energized. The only way to verify id an airfield lighting series circuit is de-energized is to confirm zero current flow with a true RMS ammeter.

Also please reference CSA Z463:24 Part 10.34 a).

FAA Advisory Circular 150/5340-26C, Part 2.4.1:
a. ALWAYS assume that the circuit is energized until you have proven otherwise. ALWAYS check for current before disconnecting the series circuit connector, removing the S1 cutout, or opening the primary series circuit by any other means. Make it a required practice to check the circuit with an ammeter prior to breaking the connection – NO EXCEPTIONS. Never attempt to measure voltage in a series lighting circuit using ordinary volt meters. An inductive voltage measuring device (sometimes referred to as a "ticker") such as is described in Chapter 4 may be used to detect the presence of induced voltage on a series lighting cable after checking for the presence of current. Always use a true RMS clamp-on type ammeter to verify if the circuit is energized……

Related Item

• PI No. 48 and PC No. 11

Submitter Information Verification

Submitter Full Name: Carl Johnson
Organization: AVCON, Inc.
Affiliation: none
Street Address:
City:
State:
Zip:

Submittal Date: Mon May 19 07:37:21 EDT 2025
Committee: EEW-AAA

Public Comment No. 115-NFPA 70E-2025 [Section No. 130.2(A)(2)]

~~**(2)** Additional Person.~~

~~If an energized electrical work permit is required in accordance with 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.~~

Delete this requirement of mandatred second person

Statement of Problem and Substantiation for Public Comment

Section 110.3(H)(1) of the 2024 NFPA 70E standard outlines a risk assessment procedure that includes identifying hazards, assessing risks, and implementing controls.
Informational Note No. 1 provides guidance that the risk assessment procedure could identify when a second person is necessary, along with the required training and equipment.
The risk assessment-based identification for an additional person during energized electrical work has been a component of NFPA 70E since the 2009 edition, effective September 5, 2008. Over the past 16 years, since hazard/risk-based identification of a second person was introduced, there has been no documented evidence indicating that the absence of an additional person, as determined by a risk assessment, has led to worker injuries or fatalities. This suggests that the existing risk-based approach has been effective in preventing such incidents.
In the 2027 revision of NFPA 70E, a more prescriptive requirement has been introduced. Section 130.2(A)(2) mandates that if an energized electrical work permit is required, at least one additional person trained in emergency response must be present.
The current risk assessment process, as outlined in Section 110.3(H)(1), remains a valid and effective method for determining the necessity of a second person and the appropriate training required. If the risk assessment identifies the need for an individual trained in emergency response to perform the work, it is highly unlikely that an employer would consider the risk acceptable and permit energized work to be performed.

Related Item

• FR101

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Mon May 26 15:40:57 EDT 2025
Committee: EEW-AAA

Public Comment No. 122-NFPA 70E-2025 [Section No. 130.2(A)(2)]

~~**(2)** Additional Person.~~

~~If an energized electrical work permit is required in accordance with 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.~~

Statement of Problem and Substantiation for Public Comment

This first draft new requirement is excessively restrictive for all work cases. There are many cases where an energized electrical work permit is needed but the risk of injury is extremely small. For example, a person may need to change a deenergized fuse in a piece of equipment but there is a 480 Volt terminal within 1 foot of the work location. With proper precautions already in the energized work permit process, that task may be able to be performed safely without requiring a standby person. The need for the standby person (the second person) needs to be based on the risk assessment and not a firm rule.

Related Item

• FR No. 101; PI No. 54

Submitter Information Verification

Submitter Full Name: Paul Sullivan
Organization: DuPont
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 27 12:40:55 EDT 2025
Committee: EEW-AAA

Public Comment No. 137-NFPA 70E-2025 [Section No. 130.2(A)(2)]

(2) Additional Person.

If an energized electrical work permit is required in accordance with 130.3(A), the shock and arc flash risk assessments shall determine and document if 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~~ within sight of the worker and outside of both the limited approach boundary ~~or~~ and arc flash boundary~~, whichever is greater~~ .

Statement of Problem and Substantiation for Public Comment

The proposed requirement for a standby person every time an energized work permit is required may be overly restrictive for some activities. The decision for whether a second person is required could be determined using information contained in the shock and arc flash risk assessments. The proposed language also replaces the potentially vague term “in the vicinity” with the phrase “within sight” ensuring the second person is able to visually observe the qualified worker located inside the boundaries.

Related Item

• FR 101

Submitter Information Verification

Submitter Full Name: Rodney West
Organization: Schneider Electric
Street Address:
City:
State:
Zip:

Submittal Date: Thu May 29 07:42:42 EDT 2025
Committee: EEW-AAA

Public Comment No. 179-NFPA 70E-2025 [Section No. 130.2(A)(2)]

(2) Additional Person.

If an energized electrical work permit is required in accordance with 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.

Determining whether an additional person is required based on the proposed language should continue to be the responsibility of the employer based on the existing required risk assessments currently defined in 110.3(H):

Currently 110.3 (H) Informational Note No 1 states

Informational Note No. 1: The risk assessment procedure could include identifying when a second person could be required and the training and equipment that person should have.

Statement of Problem and Substantiation for Public Comment

The proposed new requirement of a second person should continue to be the responsibility of the employer based on the existing required risk assessments currently defined in 110.3(H):
Currently 110.3 (H) Informational Note No 1 states
Informational Note No. 1: The risk assessment procedure could include identifying when a second person could be required and the training and equipment that person should have.

Related Item

• FR 101

Submitter Information Verification

Submitter Full Name: Jim Phillips
Organization: Brainfiller, Inc.
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 16:27:08 EDT 2025
Committee: EEW-AAA

Public Comment No. 2-NFPA 70E-2025 [Section No. 130.2(A)(2)]

(2) Additional Person.

If an energized electrical work permit is required in accordance with 130.3(A), at least one additional person meeting the emergency response training requirements of 110.4(C)(1) and 110.4(C)(2) shall be present in the vicinity of, but outside of, either the limited approach boundary or arc flash boundary, whichever is greater.

Statement of Problem and Substantiation for Public Comment

This would allow immediate First Aid / CPR in case of an event, instead of requiring another person to be near by that is First Aid / CPR trained.

Related Item

• PI • FR-101

Submitter Information Verification

Submitter Full Name: Jeff Klemp
Organization: EC Electric
Street Address:
City:
State:
Zip:

Submittal Date: Wed Feb 19 13:00:11 EST 2025
Committee: EEW-AAA

Public Comment No. 85-NFPA 70E-2025 [Section No. 130.2(A)(2)]

(2) Additional Person.

If an energized electrical work permit is required in accordance with 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.

Statement of Problem and Substantiation for Public Comment

The reference to 130.3(A) should be changed to 130.3. As currently written, the requirement could be interpreted as requiring additional persons even under the exceptions given in 130.3(C) when an Energized Electrical Work Permit is not required. By referencing 130.3 more generally, both the requirement for Energized Electrical Work Permit and the exceptions are covered in the requirement for additional persons.

Related Item

• FR-101

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 14 16:47:39 EDT 2025
Committee: EEW-AAA

Public Comment No. 86-NFPA 70E-2025 [Section No. 130.2(A)(2)]

(2) Additional Person.

If an energized electrical work permit is required in accordance with 130.3(A), and either the shock risk assessment in accordance with 130.4 or the arc flash risk assessment in accordance with 130.5 determine that an additional person is required, 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.

Statement of Problem and Substantiation for Public Comment

The action taken by FR-101 for an additional or standby person any time an energized electrical work permit is required can be overly restrictive for some activities and voltage levels. The shock and arc flash risk assessments should determine the need for additional or standby persons and not depend entirely on the need for an energized electrical work permit. The purpose of these risk assessments is to identify the shock and arc flash hazards, to estimate the likelihood and severity of injury and to determine if additional protection measures are required. The need for additional or standby persons is an additional protection measure that should be based on these risk assessments, and not solely on the energized electrical work permit.

Related Item

• FR-101

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 14 17:15:38 EDT 2025
Committee: EEW-AAA

Public Comment No. 87-NFPA 70E-2025 [Section No. 130.2(A)(2)]

(2) Additional Person.

If an energized electrical work permit is required in accordance with 130.3(A) for elecrical conductors or circuit parts operating at more than 600 volts , 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.

Statement of Problem and Substantiation for Public Comment

The requirement for standby persons for all work requiring an Energized Electrical Work permit is overly restrictive for some activities and especially at lower voltage levels. This Public Comment seeks to provide voltage level criteria equivalent to the requirement for at least two employees in OSHA 1910.269, 1910.269(l)(2)(i)(A).

Related Item

• FR-101

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 14 18:29:55 EDT 2025
Committee: EEW-AAA

Public Comment No. 93-NFPA 70E-2025 [Section No. 130.2(A)(2)]

(2) Additional Person.

If an energized electrical work permit is required in accordance with 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.

Additional Proposed Changes

File Name	Description	Approved
FR_101.docx	Omit item 5 in FR 101	

Statement of Problem and Substantiation for Public Comment

Management is responsible for safety. It is up to management to decide the number of people required and the training and equipment needed to perform a task when an EEWP is required

Related Item

• first revision FR 101 130.2(A)(5)

Submitter Information Verification

Submitter Full Name: Daryld Crow
Organization: DRC Consulting Ltd
Affiliation: my self
Street Address:
City:
State:
Zip:

Submittal Date: Mon May 19 14:51:23 EDT 2025
Committee: EEW-AAA

FR 101 - 130.2(A)(5)

Omit item 5 in FR101 stating an additional person is require when an EEWP is required including the requirement that the additional person cannot cross the limited approach boundary or the arc flash boundary.

Substantiation:

Management is responsible for safety. It is up to management to decide the number of people required and the training and equipment needed to perform a task when an EEWP is required.

The following statements already exist in NFPA 70E:

1. Employees exposed to electrical shock hazards shall be trained in methods of safe release [(110.4(C)(1)].
2. A risk assessment is required before start of work including when a second person could be required and the training and equipment that person should have [110.3(H)(1)].

Public Comment No. 49-NFPA 70E-2025 [Section No. 130.3(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. 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 Figure J.1 for an example of an acceptable energized work permit.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_18.pdf	70E_CN18	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 18 appeared in the First Draft Report on First Revision No. 60.

The Correlating Committee requests that the Technical Committee review the text in 130.3(B)(9) regarding " (authorizing or responsible management, safety officer, or owner, etc,)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual. Additionally, the Technical Committee should review the bracketed references for conversion to part of the requirement or for inclusion as an informational note. In list item (9) the term "signature(s)" with the parenthetical " (s)" should be revised for compliance with the NEC Style Manual on the use of plural terminology.

Related Item

• First Revision No. 60

Submitter Information Verification

Submitter Full Name: CC Notes

Organization:	NEC Correlating Committee
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Apr 03 16:49:41 EDT 2025
Committee:	EEW-AAA

Correlating Committee Note No. 18-NFPA 70E-2025 [Section No. 130.3(B)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:24:47 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 130.3(B)(9) regarding "(authorizing or responsible management, safety officer, or owner, etc,)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual. Additionally, the Technical Committee should review the bracketed references for conversion to part of the requirement or for inclusion as an informational note. In list item (9) the term "signature(s)" with the parenthetical "(s)" should be revised for compliance with the NEC Style Manual on the use of plural terminology.

FR-60-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 201-NFPA 70E-2025 [New Section after 130.3(C)]

130.3(D) Energized Electrical Work Permit Not Required. Tasks done in compliance with 110.2(B) Exception No 1, Exception No 2, or Exception No 5 shall be permitted without an energized electrical work permit.

Statement of Problem and Substantiation for Public Comment

This is a second attempt to add wording that will provide clear direction for when an energized electrical work permit is not required. It is being suggested as subdivision (D) because the initial wording in subdivision (C) uses the term "work" and requires the use of PPE. They could possible be combined in one subdivision in the future - with some wording changes but suggest not doing that at the second draft. I the committee desires to do that now, this is an option: 130.3(C)(5) Tasks done in compliance with 110.2(B) Exception No 1, Exception No 2, or Exception No 5 shall be permitted without an energized electrical work permit. PPE shall not be required unless a risk assessment determines it is necessary.

The committee statement for rejecting PI 255 is not very helpful. Section 110.2(B) is a requirement for establishing an electrically safe working condition, not the need for an energized electrical work permit. The present requirement for an energized electrical work permit is being interpreted differently. It somewhat depends on the subjective decision of whether an arc flash hazard is likely during interaction. Although using 110.2(B) Exception No 1 would not have any exposed energized parts, Exceptions 2 and 5 might. Section 130.2(A) also does not have the 50 volt threshold wording. Adding this wording will provide significant clarity for when an energized electrical work permit is not required and also for when one is!

Related Item

• Public Input No. 255

Submitter Information Verification

Submitter Full Name: Paul Dobrowsky
Organization: Innovative Technology Services
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 10:25:33 EDT 2025
Committee: EEW-AAA

Public Comment No. 5-NFPA 70E-2025 [Section No. 130.3(C)]

(C) Exemptions to Work Permit.

Electrical work shall be permitted without an energized electrical work permit if a qualified person is provided with and uses appropriate safe work practices and PPE in accordance with Chapter 1 under any of the following conditions:

(1) Testing, troubleshooting, or voltage measuring

(2) Thermography, ultrasound, or visual inspections if the restricted approach boundary is not crossed

(3) Access to and egress from an area with energized electrical equipment if no electrical work is performed and the restricted approach boundary is not crossed

(4) General housekeeping and miscellaneous non-electrical tasks if the restricted approach boundary is not crossed

(5) For sources that by their nature (such as batteries) cannot be physically de-energized, a separate energized electrical work permit shall not be required if the hazard analysis covered here in Article 130.3 is part of a general job hazard/safety analysis (JHA/JSA) that already requires signatures.

Statement of Problem and Substantiation for Public Comment

Because almost everyone knows that installation or removal of batteries cannot be done de-energized, the application of the requirements for an energized electrical work permit are routinely ignored. Since the purpose of an EEWP is to encourage electrically "dead" work vs "live" work on sources that can be de-energized, requiring it for equipment that by the laws of physics cannot be de-energized drives complacency and ignoring the rules, especially if the hazard analysis is already part of an established JHA/JSA / tailgate meeting analysis/review and signature process.

Related Item

• PI-255

Submitter Information Verification

Submitter Full Name: Curtis Ashton
Organization: American Power Systems LLC
Affiliation: East Penn Manufacturing
Street Address:
City:
State:
Zip:

Submittal Date: Fri Mar 07 09:33:27 EST 2025
Committee: EEW-AAA

Public Comment No. 50-NFPA 70E-2025 [Section No. 130.4(C)]

(C) Additional Protective Measures.

(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

Additional Proposed Changes

File Name	Description	Approved
70E_CN_19.pdf	70E_CN19	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 19 appeared in the First Draft Report on First Revision No. 61.

The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

Related Item

• First Revision No. 61

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date: Thu Apr 03 16:51:20 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 19-NFPA 70E-2025 [Section No. 130.4(C)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:25:21 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

FR-61-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 25-NFPA 70E-2025 [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:

* Avoid Contact does not contain an Inadvertent Movement Adder. See definition of Avoid Contact in Article 100 for additional information.

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

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

* Avoid Contact does not contain an Inadvertent Movement Adder. See definition of Avoid Contact in Article 100 for additional information.

* [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).

Statement of Problem and Substantiation for Public Comment

Columns #4 in Table 130.4(E)(a) and Table 130.4(E)(b) states the Restricted Approach Boundary includes an Inadvertent Movement Adder. But this is only true for those RABs with a physical distance, such as 0.31 (1 ft 0 in) for the voltage range of 151 to 750 V. However, the RAB of 'Avoid Contact' is a directive and not a physical distance which has no inadvertent movement factor, also known as the ergonomic component. Therefore, this comment in the title of column #4 is not technically accurate.
According to OSHA regulations pursuant to 29CFR1910.269, Subpart R, Appendix B – Working On Exposed Energized Parts states in part states ‘Avoid Contact’ contains neither an electrical component nor an ergonomic component.” Please note, OSHA uses the term “Minimum Approach Distance” (MAD) rather than RAB to designate the shock boundary, furthermore the OSHA voltage range for ‘Avoid Contact’ is 50 to 300 volts. But the purpose for OSHA’s MAD is identical to NFPA 70E's RAB.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 88-NFPA 70E-2025 [New Section after 120.6]	

Related Item

• This PI is related to my PI to add a new definition of Avoid Contact in Article 100

Submitter Information Verification

Submitter Full Name: George Cole
Organization: Pvngs Aps
Affiliation: PVNGS APS
Street Address:
City:
State:
Zip:

Submittal Date: Wed Mar 26 15:11:16 EDT 2025
Committee: EEW-AAA

Public Comment No. 139-NFPA 70E-2025 [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

(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 No. 1 : 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).

Informational Note No. 2: Some equipment is marked with third-party verified incident energy information to aid in the selection of arc flash PPE for specified tasks.

Statement of Problem and Substantiation for Public Comment

Note this public comment is one of two related public comments.

While the exception added to 130.5(F)(3) in the First Draft is a viable option, this comment offers an alternative approach to relocate and simplify the language. The exception included in the First Draft language for 130.5(F)(3) is far broader than the concept introduced by PI 100. Additionally, the resulting First Draft language was inadvertently mis located as an exception to 130.5(F)(3) not 130.5(F)(1) as originally proposed.

During debate on this topic the committee had significant discussion about the location within the document with some suggesting that 130.5(B) was a more suitable location. This comment is intended to address those suggestions.

As mentioned above, there are two related public comments and the end action seeks two related steps:

Step 1: Add an informational note number 2 to 130.5(B) which deals with likelihood and severity estimations of arc flash risk assessments. This informational note includes the task specific concepts introduced by PI 100 and FR 38.

Step 2: Delete the exception in 130.5(F)(3) that was added by FR 38 in the First Draft. It is no longer needed based on the informational note added in Step 1.

Taken together the result will be the relocation and simplification of the exception from 130.5(F)(3) to an informational note in 130.5(B). 130.5(B) is the section that deals with likelihood and severity estimation during the arc flash risk assessment and the informational note will add clarifying information to users who encounter task specific verified markings in the field.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 138-NFPA 70E-2025 [Section No. 130.5(F)(3)]	
Public Comment No. 138-NFPA 70E-2025 [Section No. 130.5(F)(3)]	

Related Item

• FR 38

Submitter Information Verification

Submitter Full Name: Rodney West
Organization: Schneider Electric
Street Address:

City:	
State:	
Zip:	
Submittal Date:	Thu May 29 07:56:15 EDT 2025
Committee:	EEW-AAA

Public Comment No. 51-NFPA 70E-2025 [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

(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).

Additional Proposed Changes

File Name	Description	Approved
70E_CN_20.pdf	70E_CN20	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 20 appeared in the First Draft Report on First Revision No. 36.

The Correlating Committee requests that the Technical Committee review 130.5(B)(2) regarding “operation condition” and consider changing to “operating condition” as it appears in (3) for correlation.

Related Item

• First Revision No. 36

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 08:50:29 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 20-NFPA 70E-2025 [Section No. 130.5(B)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:26:08 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review 130.5(B)(2) regarding “operation condition” and consider changing to “operating condition” as it appears in (3) for correlation.

FR-36-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 96-NFPA 70E-2025 [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

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

Statement of Problem and Substantiation for Public Comment

Changing "operation condition" to "operating condition" aligns with how the phrase "operating condition" is used elsewhere in the Standard, including 130.4(B)(2), 130.5(B)(3) and Table 130.5(C)(3).

Related Item

• FR-36

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 20 10:37:50 EDT 2025
Committee: EEW-AAA

Public Comment No. 36-NFPA 70E-2025 [Section No. 130.5(C)]

(C) Additional Protective Measures.

(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).		
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		

Task	Operating Condition[a]	Likelihood of Occurrence[b]
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 fault currents could result in higher incident energy. If the fault current increases without a decrease in the fault clearing time of the overcurrent protective device, the incident energy will increase. If the 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_4.pdf	70E_CN4	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 4 appeared in the First Draft Report on First Revision No. 58.

The Correlating Committee requests that the Technical Committee review expression of maximum and minimum limits as described in the NEC Style Manual Section 3.2.2. regarding “below 600 V” and physical clearance “where the exposed electrical conductors are separated by more than 1 millimeter (0.039 in.) per volt”.

Related Item

• First Revision No. 58

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date: Thu Apr 03 13:31:11 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 4-NFPA 70E-2025 [Section No. 130.5(C)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:31:52 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review expression of maximum and minimum limits as described in the NEC Style Manual Section 3.2.2. regarding “below 600 V” and physical clearance “where the exposed electrical conductors are separated by more than 1 millimeter (0.039 in.) per volt”.

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

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 52-NFPA 70E-2025 [Section No. 130.5(C)]

(C) Additional Protective Measures.

(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).		
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		

Task	Operating Condition[a]	Likelihood of Occurrence[b]
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 fault currents could result in higher incident energy. If the fault current increases without a decrease in the fault clearing time of the overcurrent protective device, the incident energy will increase. If the 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_21.pdf	70E_CN21	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 21 appeared in the First Draft Report on First Revision No. 58.

The Correlating Committee requests that the Technical Committee review expression of maximum and minimum limits as described in the NEC Style Manual Section3.2.2. regarding “below 600 V” and physical clearance “where the exposed electrical conductors are separated by more than 1 millimeter (0.039 in.) per volt”.

Related Item

• First Revision No. 58

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 08:54:17 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 21-NFPA 70E-2025 [Detail]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:27:20 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review expression of maximum and minimum limits as described in the NEC Style Manual Section 3.2.2. regarding “below 600 V” and physical clearance “where the exposed electrical conductors are separated by more than 1 millimeter (0.039 in.) per volt”.

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

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 160-NFPA 70E-2025 [Section No. 130.5(C)(3)]

(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 per volt (~~0.039~~ 1 in. per 25 volts) ~~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).	-	-
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

Task	Operating Condition[a]	Likelihood of Occurrence[b]
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 fault currents could result in higher incident energy. If the fault current increases without a decrease in the fault clearing time of the overcurrent protective device, the incident energy will increase. If the 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.

Statement of Problem and Substantiation for Public Comment

'millimeters-per-volt' are the units of this threshold and should be kept together when stating what the ratio is in 'inches-per-volt.' However, it is not easy to intuitively understand what 0.039 inches per volt would mean for a 247 V battery, for example, so a better ratio to use is 1 inch for every 25 volts. Note that the exact ratio is 1 inch per 25.4 volts but dropping the 0.4 volts makes this slightly conservative while retaining the same number of significant digits as the current conversion to 0.039 inches. This ratio is much simpler to apply to real world batteries. This change would make it intuitively easy to apply to the example 247 V battery as needing a >10'' gap to clear the threshold.

Related Item

• First Revision No. 58-NFPA 70E-2024 • Public Input No. 155-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name:	David Rosewater
Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	

Submittal Date:	Mon Jun 02 14:16:36 EDT 2025
Committee:	EEW-AAA

Public Comment No. 53-NFPA 70E-2025 [Section No. 130.5(F)]

(F) Arc Flash PPE Selection Methods.

(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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_22.pdf	70E_CN22	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 22 appeared in the First Draft Report on First Revision No. 38.

The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

The Correlating Committee requests that the Technical Committee review the new exception to130.5(F)(3) regarding if the location is appropriate as it is "task based" and if the exception to the rule is needed. See the affirmative and negative ballot comments.

Related Item

• First Revision No. 38

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:

Zip:	
Submittal Date:	Fri Apr 04 08:56:11 EDT 2025
Committee:	EEW-AAA

Correlating Committee Note No. 22-NFPA 70E-2025 [Section No. 130.5(F)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:28:31 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the second level subdivision title relative to the content to ensure the title accurately reflects the content of the requirement or remove the second level sub-division restructuring.

The Correlating Committee requests that the Technical Committee review the new exception to130.5(F)(3) regarding if the location is appropriate as it is “task based” and if the exception to the rule is needed. See the affirmative and negative ballot comments.

FR-38-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned
Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All
Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 97-NFPA 70E-2025 [Section No. 130.5(F)]

(F) Arc Flash PPE Selection Methods.

(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 to 130.5(F)(1) : 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.

Statement of Problem and Substantiation for Public Comment

This Public Comment adds reference to 130.5(F)(1) to the Exception. The current location of the exception is confusing, making it appear that the exception is to 130.5(F)(3) instead of 130.5(F)(1), which was not the intent of the Technical Committee. As an alternative, the Exception should be relocated under 130.5(F)(1) for clarity.

Related Item

• FR-38

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 20 10:47:27 EDT 2025
Committee: EEW-AAA

Public Comment No. 161-NFPA 70E-2025 [New Section after 130.5(F)(3)]

TITLE OF NEW CONTENT

Type your content here ...Table 130.7(C)(15)(a) highlihts the fault current and clearing times (incident energy) of surface equipment and advises the corresponding PPE category and Arc Flash Boundary. For the Oil & Gas industry, Electrical Submersible Pumps utilizing Permanent Magnet Motors (PMMs) could potentially generate lethal level of voltages if their shafts are unintentionally rotated by fluid movements downhole. A similar table to 130.7(c)(15)(a) needs to be developed for these motors based on their HP ratings. There have been some simulated power studies to quantify the potential incident energy generated. We need to have similar visibility of the incident energy and the corresponding PPE and Arc Flash Boundaries for downhole PMMs.

Additional Proposed Changes

File Name	Description	Approved
NFPA_70E-2027_Update_PMM_Incident_Energy.pdf	NFPA 70E-2027 Update_PMM Incident Energy	

Statement of Problem and Substantiation for Public Comment

Quantifying the incident energy and corresponding PPE and Arc Flash Boundary when testing and/or working with cable that is connected to a downhole Permanent Magnet Motor in a well.

Related Item

• Table 130.7(c)(15)(a)

Submitter Information Verification

Submitter Full Name: Hany Zakhary
Organization: Levare U.S., Inc.
Street Address:
City:
State:
Zip:

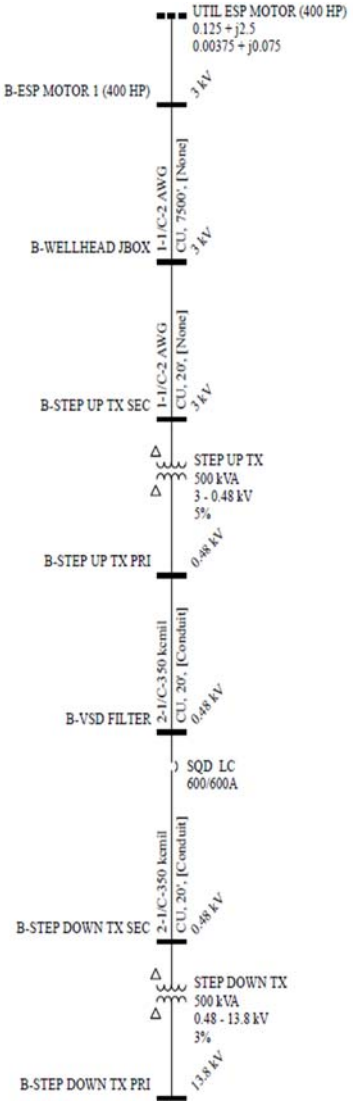
Submittal Date: Mon Jun 02 14:44:17 EDT 2025
Committee: EEW-AAA

Incident Energy generated by Downhole Permanent Magnet Motors:

Type your content here ...Table 130.7(C)(15)(a) highlights the fault current and clearing times (incident energy) of surface equipment and advises the corresponding PPE category and Arc Flash Boundary. For the Oil & Gas industry, Electrical Submersible Pumps utilizing Permanent Magnet Motors (PMMs) could potentially generate lethal level of voltages if their shafts are unintentionally rotated by fluid movements downhole. A similar table to 130.7(c)(15)(a) needs to be developed for these motors based on their HP ratings. There have been some simulated power studies to quantify the potential incident energy generated (as shown below). We need to have similar visibility of the incident energy and the corresponding PPE and Arc Flash Boundaries for downhole PMMs.

Arc-Flash Study Methodology:

- 5 Motor Sizes Selected (80, 144, 250, 264 & 400 HP)
- 2 Seconds Rule Applied



Results:

MOTOR SIZE (HP)	ARC FLASH BOUNDARY (INCHES)	INCIDENT ENERGY (CAL./ SQ. CM)	BOLTED FAULT CURRENT (kA)	ARCING CURRENT (kA)
400	11.6	0.6	0.09	0.08
264	9.1	0.4	0.061	0.053
250	8.7	0.4	0.057	0.05
144	5.9	0.2	0.031	0.027
80	4.4	0.1	0.019	0.017

Public Comment No. 1-NFPA 70E-2025 [Section No. 130.5(F)(3)]

(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.

Statement of Problem and Substantiation for Public Comment

This exception must be deleted. It is inappropriate for reasons including, but limited to, the fact that PPE selection is not "task based" as indicated by this inappropriate exception. For example, the "task" is factored in requirements such as Table 130.5(C). PPE has not been determined by the task for several editions of NFPA 70E.

Related Item

• FR-38

Submitter Information Verification

Submitter Full Name: Palmer Hickman
Organization: Electrical Training Alliance
Street Address:
City:
State:
Zip:

Submittal Date: Tue Feb 18 13:12:55 EST 2025
Committee: EEW-AAA

Public Comment No. 138-NFPA 70E-2025 [Section No. 130.5(F)(3)]

(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.~~

Statement of Problem and Substantiation for Public Comment

Note this public comment is one of two related public comments.

While the exception added to 130.5(F)(3) in the First Draft is a viable option, this comment offers an alternative approach to relocate and simplify the language. The exception included in the First Draft language for 130.5(F)(3) is far broader than the concept introduced by PI 100. Additionally, the resulting First Draft language was inadvertently mis located as an exception to 130.5(F)(3) not 130.5(F)(1) as originally proposed.

During debate on this topic the committee had significant discussion about the location within the document with some suggesting that 130.5(B) was a more suitable location. This comment is intended to address those suggestions.

As mentioned above, there are two related public comments and the end action seeks two related steps:

Step 1: Add an informational note number 2 to 130.5(B) which deals with likelihood and severity estimations of arc flash risk assessments. This informational note includes the task specific concepts introduced by PI 100 and FR 38.

Step 2: Delete the exception in 130.5(F)(3) that was added by FR 38 in the First Draft. It is no longer needed based on the informational note added in Step 1.

Taken together the result will be the relocation and simplification of the exception from 130.5(F)(3) to an informational note in 130.5(B). 130.5(B) is the section that deals with likelihood and severity estimation during the arc flash risk assessment and the informational note will add clarifying information to users who encounter task specific verified markings in the field.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 139-NFPA 70E-2025 [Section No. 130.5(B)]	
Public Comment No. 139-NFPA 70E-2025 [Section No. 130.5(B)]	

Related Item

• FR 38

Submitter Information Verification

Submitter Full Name: Rodney West

Organization:	Schneider Electric
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu May 29 07:52:07 EDT 2025
Committee:	EEW-AAA

Public Comment No. 98-NFPA 70E-2025 [Section No. 130.5(F)(3)]

(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.

(6) The specific tasks and operating conditions covered by the task specific incident energy is marked on the equipment.

Informational Note: See UL RP 2986, *Recommended Practice for Measuring Incident Energy Exposure*, for further information.

Statement of Problem and Substantiation for Public Comment

The new exception to 130.5(F)(1) is intended to permit manufacturers to employ safety-by-design techniques to reduce incident energy exposure and to permit the use of the reduced incident energy in the selection of PPE provided the stated conditions are met. As currently written, it is also unclear how the manufacturer will communicate to the worker under what specific tasks and conditions the equipment was tested and listed to. For example, supply changes to the equipment (such as system configuration) can modify the conditions of use in which the equipment was designed and tested and therefore result in an increase of the incident energy exposure without the worker knowing that such an operating condition was not included in the testing. This Public Comment seeks to clarify the specific tasks and operating conditions covered by the "task specific incident energy" by requiring manufacturers to mark the equipment with these conditions so that persons working on or near the equipment understand the limitations of the listing and marked incident energy levels.

Related Item

• FR-38

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 20 10:52:45 EDT 2025
Committee: EEW-AAA

Public Comment No. 54-NFPA 70E-2025 [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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_23.pdf	70E_CN23	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 23 appeared in the First Draft Report on First Revision No. 49.

The Correlating Committee requests that the Technical Committee review 130.7(A) regarding “adequately” in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 on use of unenforceable terms.

Related Item

• First Revision No. 49

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date: Fri Apr 04 09:04:12 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 23-NFPA 70E-2025 [Section No. 130.7(A)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:30:35 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review 130.7(A) regarding “adequately” in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 on use of unenforceable terms.

FR-49-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 136-NFPA 70E-2025 [Section No. 130.7(C)(6)]

(6) Body Protection.

Employees shall wear arc-rated clothing wherever there is possible exposure to incident energy ~~of~~ equal to or greater than 1.2 cal/cm^2 (5 J/cm^2).

Statement of Problem and Substantiation for Public Comment

The section should be clarified to indicate that arc-rated clothing is required when the incident energy is "equal to or greater than" 1.2 cal/cm2. This modification will align the requirement with the definition of arc flash boundary.

Related Item

• FR51

Submitter Information Verification

Submitter Full Name: Rodney West
Organization: Schneider Electric
Street Address:
City:
State:
Zip:

Submittal Date: Thu May 29 07:39:31 EDT 2025
Committee: EEW-AAA

Public Comment No. 204-NFPA 70E-2025 [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 ~~of~~ level for a second degree burn [1.2 cal/ ~~cm~~ ~~2~~ - cm2 (~~5 J~~ 5 J / ~~cm~~ ~~2~~ cm2)] .

Statement of Problem and Substantiation for Public Comment

Restore the wording to what it was in the 2024 edition.
I'm submitting this comment so the committee can have a discussion about the benefit of making the change. Although the submitter is correct there is a slight difference in wording between this section and Table 130.5(G), how important is that. An alternative is to change that table to "above 1.2calcm2". The requirement to wear arc rated PPE "above" the 1.2 calcm2" level has existed in NFPA 70E for a long time, to some extent since arc rated PPE was required. It was very clear that arc rated PPE was not required until the arc flash boundary was crossed. Now touching the boundary will require arc rated PPE. Other requirements in NFPA 70E are based on being "within" the arc lash boundary.

Related Item

• FR 51

Submitter Information Verification

Submitter Full Name: Paul Dobrowsky
Organization: Innovative Technology Services
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 10:43:53 EDT 2025
Committee: EEW-AAA

Public Comment No. 230-NFPA 70E-2025 [Section No. 130.7(C)(6)]

(6) Body Protection.

Employees shall wear arc-rated clothing wherever there is possible exposure to incident energy of 1.2 cal/cm^2 (5 J/cm^2) or more .

Statement of Problem and Substantiation for Public Comment

The phrase “or more” needs to be added after “1.2 cal/cm2” per PI No. 98 and the phrasing provided in the task group report.
As it currently reads the requirement is inaccurate. The only time someone would require arc-rated clothing is when the incident energy is 1.2 ca./cm2.

Related Item

• FR 51

Submitter Information Verification

Submitter Full Name: Daniel Roberts
Organization: Electrical Safety Solutions
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 15:20:01 EDT 2025
Committee: EEW-AAA

Public Comment No. 55-NFPA 70E-2025 [Section No. 130.7(C)(6)]

(6) Body Protection.

Employees shall wear arc-rated clothing wherever there is possible exposure to incident energy of 1.2 cal/cm^2 (5 J/cm^2).

Additional Proposed Changes

File Name	Description	Approved
70E_CN_24.pdf	70E_CN24	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 24 appeared in the First Draft Report on First Revision No. 51.

The Correlating Committee requests that the Technical Committee review 130.7(C)(6) regarding the ballot comments and verify the intended revised language. The recommendation is to ensure clarity of the intended committee action.

Related Item

• First Revision No. 51

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date: Fri Apr 04 09:06:07 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 24-NFPA 70E-2025 [Section No. 130.7(C)(6)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:31:13 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review 130.7(C)(6) regarding the ballot comments and verify the intended revised language. The recommendation is to ensure clarity of the intended committee action.

FR-51-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 99-NFPA 70E-2025 [Section No. 130.7(C)(6)]

(6) Body Protection.

Employees shall wear arc-rated clothing wherever there is possible exposure to incident energy ~~of~~ greater than or equal to 1.2 cal/cm^2 (5 J/cm^2).

Statement of Problem and Substantiation for Public Comment

As currently written, PPE protection would only be required when the incident energy is equal to 1.2cal/cm2, and at no value greater than this. This Public Comment corrects the unintended error. The proposed wording aligns with how the phrase is already used in Table H.3.

Related Item

• FR-51

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 20 11:09:32 EDT 2025
Committee: EEW-AAA

Public Comment No. 56-NFPA 70E-2025 [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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_25.pdf	70E_CN25	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 25 appeared in the First Draft Report on First Revision No. 103.

The Correlating Committee requests that the Technical Committee review the title to (e) relative to the content as the title does not accurately reflect the term covered by the requirement.

Related Item

• First Revision No. 103

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 09:08:10 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 25-NFPA 70E-2025 [Section No. 130.7(C)(7)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:32:09 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the title to (e) relative to the content as the title does not accurately reflect the term covered by the requirement.

FR-103-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 57-NFPA 70E-2025 [Section No. 130.7(C)(10)]

(10) Arc Flash Protective Equipment.

(a) *Arc Flash Suits.* 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 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.* 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_26.pdf	70E_CN26	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 26 appeared in the First Draft Report on First Revision No. 52.

The Correlating Committee requests that the Technical Committee review the text in 130.7(C)(10)(c)(4) regarding " (safety glasses or goggles)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

Related Item

• First Revision No. 52

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 09:10:49 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 26-NFPA 70E-2025 [Section No. 130.7(C)(10)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:34:10 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 130.7(C)(10)(c)(4) regarding "(safety glasses or goggles)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

FR-52-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 107-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed~~ All suppliers or manufacturers of PPE shall demonstrate conformity with an appropriate product standard by one of the following methods:

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

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

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

Informational Note No. 1: See 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.

(f) *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:

(7) Name of manufacturer

(8) Conformity assessment method used

(9) Product performance standards to which the product conforms

(10) Arc rating where appropriate for the equipment

(11) One or more identifiers such as model, serial number, lot number, or traceability code

(12) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	

Subject	Document Title	Document Number
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

Statement of Problem and Substantiation for Public Comment

This public comment only seeks to restore 130.7(C)(14)(b) related to conformity assessment back to the 2024 edition of the Standard and only addresses changes associated with FR-54. TerraView incorrectly shows many more changes and incorrectly reflects the format and numbering.

The oversimplification of requiring all arc-rated PPE to be listed and deleting all three forms of conformity assessment is problematic for a number of reasons:

1) The change focusses on arc-rated PPE and does not address shock protection. Previously, 130.7(C)(14)(b) addressed all PPE and did not restrict the conformity requirements to only arc rated PPE. There is no substantiation given in FR-54 as to why electric shock PPE was deleted from the conformity requirements. The changes made by FR-54 have the unintended consequences of relaxing the conformity assessment requirements for PPE types other than arc-rated. I'm not sure that was the intent of the NFPA 70E technical committee.
2) In the submitter's opinion, insufficient technical substantiation was provided to warrant such a sweeping industry change. Yes, arc-rated PPE is important to worker safety as noted in the committee statement. However, where is the supportive data and examples demonstrating that the current requirements of the three tiered conformity assessment process is resulting in injuries, or resulting in workers being under protected?
3) The committee statement indicates that "most arc-rated PPE manufacturers are reliable". Manufacturers considered "reliable" are likely conducting extensive testing similar to conformity assessment option (2) as part of an overall quality program. This suggests, the possibility for a two-tiered conformity assessment process that includes items (2) and (3) and deletes item (1) related to self-declaration without a corresponding demonstrable quality program or testing by an accredited laboratory.
4) The oversimplification of the requirement also makes it unclear whether the "listing" is required for arc-rated fabrics or completed arc-rated garments and apparel.
5) In the past, when a significant industry-wide change was implemented, a future deadline was given for the industry to properly transition. No transition time was given in this oversimplified requirement.

Related Item

• FR-54

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 20 20:25:12 EDT 2025
Committee: EEW-AAA

Public Comment No. 109-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed.

Informational Note No. 1: See 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:

(4) Name of manufacturer

(5) ~~Conformity assessment method used~~

(1)

(2) Product performance standards to which the product conforms

(3) Arc rating where appropriate for the equipment

(4) One or more identifiers such as model, serial number, lot number, or traceability code

(5) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	ASTM F2178	

Subject	Document Title	Document Number
	Personal Eye or Face Protective Products	
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

Statement of Problem and Substantiation for Public Comment

This public comment only seeks to delete the addition of 130.7(C)(14)(c), list item (2) "Conformity assessment method used".

This public comment is conditional depending on what happens during the 2nd Draft Meeting to 130.7(C)(14)(b). If 130.7(C)(14)(b) is reduced to a single conformity assessment method as indicated by the action in FR-54, which seeks to require all arc-rated PPE to be listed, and to delete all other conformity assessment methods, then the "conformity assessment method used" is not needed to be marked on the PPE.

Related Item

• FR-53

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:
Submittal Date: Tue May 20 21:38:44 EDT 2025
Committee: EEW-AAA

Public Comment No. 114-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed.~~

Informational Note No. 1: See 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:

(4) Name of manufacturer

(5) Conformity assessment method used

(6) Product performance standards to which the product conforms

(7) Arc rating where appropriate for the equipment

(8) One or more identifiers such as model, serial number, lot number, or traceability code

(9) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	

Subject	Document Title	Document Number
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

Statement of Problem and Substantiation for Public Comment

Since the issuance of NFPA 70E-2018 on August 1, 2017, with an effective date of August 21, 2017, almost eight years ago,70E has recognized ANSI/ISEA 125 as an accepted framework for personal protective equipment (PPE) conformity assessment. This allowed PPE evaluated under any of the three levels defined in ANSI/ISEA 125—ranging from self-declaration (Level 1) to full third-party certification (Level 3)—to be considered compliant.
In contrast, the First Draft of NFPA 70E-2027 proposes to eliminate this flexibility by mandating third-party certification (Level 3) as the sole acceptable method for PPE conformity assessment.
In the nearly eight years since ANSI/ISEA 125 introduced its tiered conformity assessment model, there has been no documented technical data or evidence indicating that PPE assessed under Levels 1 or 2 has resulted in failure to meet performance requirements or contributed to occupational injuries. Imposing a Level 3-only requirement would effectively invalidate previously compliant PPE, necessitating widespread replacement. This shift would introduce significant logistical, financial, and operational challenges for end users and manufacturers without a clear technical justification.
In the absence of evidence demonstrating deficiencies in Level 1 or Level 2 assessments, and given the practical implications of requiring universal third-party certification, it is technically and operationally advisable to maintain the approach adopted in NFPA 70E-2018. That edition aligned with ANSI/ISEA 125 by recognizing all three conformity assessment levels, allowing risk-based selection of PPE in accordance with the hazard environment and

organizational capabilities.
Reinstating this tiered approach would reflect the intent of ANSI/ISEA 125, supporting a scalable and risk-appropriate strategy for PPE conformity. It would ensure that safety requirements remain technically sound and proportional to actual hazard exposure, while minimizing undue burdens on industry stakeholders.

Related Item

• FR54

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Mon May 26 12:52:43 EDT 2025
Committee: EEW-AAA

Public Comment No. 120-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be ~~listed. demonstrate conformity with an appropriate product standard by one of the following methods:~~

~~(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 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:

(4) Name of manufacturer

(5) Conformity assessment method used

(6) Product performance standards to which the product conforms

(7) Arc rating where appropriate for the equipment

(8) One or more identifiers such as model, serial number, lot number, or traceability code

(9) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	

Subject	Document Title	Document Number
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

Statement of Problem and Substantiation for Public Comment

The first draft language removes the options to have arc-flash PPE be delf-declared with a Supplier's Declaration of Conformity and self-declaration under a registered quality management system. There was no technical justification provided for making this change. The first draft wording is silent about what listings are required (is the listing for the fabric, garment, or part of the garment like the face shield). The lack of specifics concerning the listing will cause confusion. There is no future effective date for the first draft listing requirement. That causes an immediate problem for companies and people that adopt the new revision of NFPA 70E as listed PPE may not be readily available,

thereby creating an issue where people and companies are not able to follow NFPA 70E. The proposed first draft wording doesn't address what to do with arc-flash PPE that was previously purchased and is not listed. That PPE would no longer be able to be used if someone follows the revised NFPA 70E. It would take time and money for arc-flash PPE companies to test their variety of garments in order to get a listing. That cost will be passed on to PPE users. PPE users may need to purchase all new arc-flash PPE, which may be beneficial to PPE manufacturers but would be very burdensome to PPE users. ANSI/ISEA 125 allows three levels of conformance that follow the language in the existing NFPA 70E. European Union has similar conformance options. Removing these optiosn from NFPA 70E will go against ANSI/ISEA and EU norms. With no substantial technical reason for the proposed change, the original NFPA 70E allowances for arc-flash PPE certification should be left in place.

Related Item

• FR No. 54;PI No. 100

Submitter Information Verification

Submitter Full Name: Paul Sullivan
Organization: DuPont
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 27 12:24:55 EDT 2025
Committee: EEW-AAA

Public Comment No. 133-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed. This requirement will go into effect January 1, 2030.

Informational Note No. 1: See 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:

(4) Name of manufacturer

(5) Conformity assessment method used

(6) Product performance standards to which the product conforms

(7) Arc rating where appropriate for the equipment

(8) One or more identifiers such as model, serial number, lot number, or traceability code

(9) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	ASTM F2178	

Subject	Document Title	Document Number
	Personal Eye or Face Protective Products	
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

Statement of Problem and Substantiation for Public Comment

Eliminating the other conformity assessments and requiring PPE to be listed is significant and industry changing. This public comment seeks to provide a 3 year period following the effective date of the 2027 edition for users, suppliers and laboratories to transition into the requirement.

Related Item

• FR-54

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)

Street Address:
City:
State:
Zip:
Submittal Date: Wed May 28 17:58:18 EDT 2025
Committee: EEW-AAA

Public Comment No. 140-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed.

Informational Note No. 1: See 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	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

Subject	Document Title	Document Number
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

Additional Proposed Changes

File Name	Description	Approved
ASTM_F18_Comments_for_NFPA70E_FDR_May_2025.pdf	Comments from ASTM Committee F18 on Electrical Protective Equipment for Workers	

Statement of Problem and Substantiation for Public Comment

The ASTM F18 Committee tried to mandate retesting every 5 years, but this effort was delayed after members documented variability as high as ±20% vs. published arc ratings when repeatedly testing widely used FR fabrics. The Committee has undertaken an effort to understand and address the sources of this variability. The Committee doesn't believe it's reasonable to mandate listing of Arc Rated PPE before this variability is addressed. Otherwise, a large portion of fabrics currently on the market could have new ratings that are no more accurate than current ratings.

Related Item

• Third party listing

Submitter Information Verification

Submitter Full Name:	Craig Updyke
Organization:	ASTM International
Affiliation:	ASTM Committee F18 on Electrical Protective Equipment for Workers
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu May 29 20:02:40 EDT 2025
Committee:	EEW-AAA

ADVANCING STANDARDS
TRANSFORMING MARKETS

Andrew G. Kireta Jr.
President

100 Barr Harbor Drive
PO Box C700
West Conshohocken, PA
19428-2959 USA

akireta@astm.org
tel +1.610.832.9721
www.astm.org

May 29, 2025

National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471

Submitted electronically via submittals.nfpa.org

Re: Public Comments on NFPA 70E First Draft Report

To Whom It May Concern,

Attached is a letter that has been approved by the Executive Subcommittee of ASTM International Committee F18 on Electrical Protective Equipment for Workers commenting on a proposal in the First Draft Report of the next edition of NFPA 70E.

Committee F18 is one of 147 ASTM technical committees composed of technical experts who represent producer, user, consumer, government, and academic stakeholder interests in the development of voluntary consensus standards for materials, products, systems, and services. Committee F18 adheres to well-regarded, industry- recognized, and time-tested principles for the development of voluntary consensus standards that reflect current technology and best practices.

ASTM International, a Pennsylvania-headquartered non-profit organization, is one of the world's largest standards development organizations. Over 13,000 ASTM standards, which address health, safety, and the environment, operate globally. ASTM standards, and related technical information, are widely used in the U.S. and throughout the world as a basis of purchasing and other contracts, codes, and regulations.

If you have any questions regarding the attached comments, please contact Krista Robbins, Staff Manager of Committee F18, at krobbins@astm.org.

Sincerely,

Andrew G. Kireta Jr.

Andrew G. Kireta Jr.

cc: Krista Robbins

ADVANCING STANDARDS
TRANSFORMING MARKETS

100 Barr Harbor Drive, P.O. Box C700
West Conshohocken, PA,
19428-2959, USA
Tel +1.610.832.9500
Web go.astm.org

Public Comments for NFPA 70E in Reference to Third Party Certification

ASTM F1506, *Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs*, is the most widely used performance specification for Arc Flash Personal Protective Equipment (PPE). The ASTM F18 Committee on Electrical Protective Equipment for Workers developed this standard, and other applicable arc-flash standards and test methods, and continues to update them to address arc flash protection needs of industries worldwide. The ASTM F18 Committee offers the following comments as guidance regarding **FR53** and its proposed changes to section **130.7(C)(14)(b)** in the First Draft Report.

1) Variability in Arc Test Results – The ASTM F18 Committee tried to mandate retesting every 5 years, but this effort was delayed after members documented variability as high as ±20%[1] vs published arc ratings when repeatedly testing widely used FR fabrics. The Committee has undertaken an effort to understand and address the sources of this variability. The Committee doesn't believe it's reasonable to mandate listing of Arc Rated PPE before this variability is addressed. Otherwise, a large portion of fabrics currently on the market could have new ratings that are no more accurate than current ratings. For example, a shirt fabric that is currently rated as 8.5 cal/cm^2 based on previous testing, could get a new rating of 7.5 cal/cm^2 when retested. This could lead to disruption in the marketplace, unnecessary product recalls, and unfounded loss of confidence in arc rated PPE.

   [1]A. Atiq, E. Ramirez-Bettoni, B. Shiels, C. Maurice and H. Hoagland, "Arc Rating Variability and Repeatability: Why Does Fabric Arc Rating Vary and Which Value is Correct?," in IEEE Transactions on Industry Applications, vol. 60, no. 2, pp. 2749-2755, March-April 2024 https://ieeexplore.ieee.org/document/10380719#citations

2) The statement "All arc rated PPE shall be listed" should be clarified. "Arc Rated PPE" is not defined. As written, it potentially covers a very wide range of products such as Daily Wear, Outerwear, Faceshields, Arc Flash Kits, Rainwear, Gloves, Keepers, and Arc Flash Blankets. All of these have their own separate standards. Some of these products would be covered by standards that are currently in development in F18. It could take years to develop and finalize appropriate testing protocols to comply with listing requirements and for manufacturers to obtain listing for these products. PPE items for which listing is being mandated should be clearly identified before adopting such a change.

The F18 Committee has considered Listing (Third-Party Certification) over the years, but each time we concluded that Third-Party Certification would not address the problem. Instead, the F18 Committee worked to identify the underlying problems and address them directly. The F18 Committee suggests a delay in this proposed change and would work with the NFPA 70E Committee to identify and address underlying concerns.

Public Comment No. 16-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed.

Informational Note No. 1: See 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:

(4) Name of manufacturer

(5) Conformity assessment method used

(6) Product performance standards to which the product conforms

(7) Arc rating where appropriate for the equipment

(8) One or more identifiers such as model, serial number, lot number, or traceability code

(9) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	

Subject	Document Title	Document Number
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

Statement of Problem and Substantiation for Public Comment

Life Ending Risks neither any other risks allow flexibilities, and a Safety Standard should not allow any flexibility window for risks neither as people safety should doubtlessly be the unique objective.

ANSI/ISEA 125 mixes multiple references attempting to allow a gap for different multiple ways of Conformity Assessment processes by losing the objective on Safety and protection. PPE for any risk should always be a reliable protection without any doubt for the user, and safety standards should always keep the objective for the highest protection of people.

NFPA 70E should not address "flexible-unclear" references as Safety Standards should provide clear guidance to unexperienced and experienced people about the best possible accurate practice-protection responsibilities.

Related Item

• First Revision No. 53-NFPA 70E-2024 [Section No. 130.7(C)(14)]

Submitter Information Verification

Submitter Full Name: Alan Campos
Organization: FIRE WORK WEAR SAS
Street Address:
City:
State:
Zip:
Submittal Date: Wed Mar 26 12:32:45 EDT 2025
Committee: EEW-AAA

Public Comment No. 17-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed.

Informational Note No. 1: See 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:

(4) Name of manufacturer

~~Conformity assessment method used~~

(1) PPE Listing or PPE Certification code reference or PPE Certification QR Code

(2) Product performance standards to which the product conforms

(3) Arc rating where appropriate for the equipment

(4) One or more identifiers such as model, serial number, lot number, or traceability code

(5) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	ASTM F2178	

Subject	Document Title	Document Number
	Personal Eye or Face Protective Products	
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

Statement of Problem and Substantiation for Public Comment

To be consisten with First Revision No. 53-NFPA 70E-2024 [Section No. 130.7(C)(14)] to ensure that the PPE provides the appropriate level of protection.

Related Item

• First Revision No. 53-NFPA 70E-2024 [Section No. 130.7(C)(14)]

Submitter Information Verification

Submitter Full Name: Alan Campos
Organization: FIRE WORK WEAR SAS
Street Address:

City:	
State:	
Zip:	
Submittal Date:	Wed Mar 26 13:40:59 EDT 2025
Committee:	EEW-AAA

Public Comment No. 184-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed.

Informational Note No. 1: See 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~~ Requirements for bodies certifying products, processes, and services*, for an example of a process to accredit independent third-party certification organizations.

The language as written deletes items (1) and (2) regarding Self declaration. Self declaration under a registered quality management system and product testing by an accredited laboratory and a Supplier's Declaration of Conformity should NOT be deleted as this method for conformity assessment has been used successfully in North America and Globally. Requiring ALL arc-rated PPE to be listed will create an unnecessary burden for the industry by increasing cost and potentially making PPE that is currently used out of compliance with NFPA 70E requiring replacement.

(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:

(4) Name of manufacturer

(5) Conformity assessment method used

(6) Product performance standards to which the product conforms

(7) Arc rating where appropriate for the equipment

(8) One or more identifiers such as model, serial number, lot number, or traceability code

(9) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	ANSI/ISEA Z87.1	

Subject	Document Title	Document Number
	Professional Eye and Face Protection	
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

Statement of Problem and Substantiation for Public Comment

Items 1 and 2 from the existing 2024 Edition of NFPA 70E should NOT be deleted as this method for conformity assessment has been used successfully in North America and Globally. Requiring ALL arc-rated PPE to be listed will create an unnecessary burden for the industry.

Related Item

• FR 54

Submitter Information Verification

Submitter Full Name: Jim Phillips
Organization: Brainfiller, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 02 16:42:01 EDT 2025
Committee: EEW-AAA

Public Comment No. 206-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed. All suppliers or manufacturers of PPE shall demonstrate conformity with an appropriate product standard by one of the following methods:~~

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

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

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

Informational Note No. 1: See 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.

(f) *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:

(7) Name of manufacturer

(8) Conformity assessment method used

(9) Product performance standards to which the product conforms

(10) Arc rating where appropriate for the equipment

(11) One or more identifiers such as model, serial number, lot number, or traceability code

(12) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	

Subject	Document Title	Document Number
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

Statement of Problem and Substantiation for Public Comment

In North America, the most common means for manufacturers of FR apparel to demonstrate compliance with NFPA 70E is to self-certify their products to ASTM F1506, Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs. To achieve 3rd party certification to NFPA 70E as currently required in the draft language, a manufacturer would also need to seek 3rd party certification to F1506.

While the performance standards for FR apparel are well-defined in ASTM F1506, neither the existing version of F1506 nor NFPA 70E draft provide any guidance to 3rd party certifiers in preparing a certification program. This leaves certifying bodies with the burden of creating their own internal protocol for granting product certifications. Critical issues such as:

- What qualifications should a 3rd party certification organization meet? Accreditation to ISO 17065 is typical but not currently stated in F1506.
- How often should a product certification be renewed?
- On what timeline do certifying bodies respond to new editions of the standard?
- What are the requirements for follow-up inspections?
- Are manufacturers required to have a quality assurance program?

NFPA 2112 devotes as entire chapter to stating the guidelines within which a certification body provides their services. Without standardizing these foundational issues, competing certifying bodies can (and would be allowed to) set very different parameters for their clients to mark their products as 3rd party certified to the same industry standard. In the worst case, some programs of certification might not be as robust as others with minimal follow-up or continuous monitoring that other certifiers require of manufacturers.
While 3rd party certification of products does have merit in the world of protective clothing, until F1506 or NFPA 70E is revised to include this vital language, mandating 3rd party certification to NFPA 70E won't provide the assurances being sought by endusers of FR clothing.

My recommendation is to retain the language as it is in the 2024 Edition and use the next revision cycle create the language necessary to successfully transition the industry to 3rd party certified arc-rated apparel.

Related Item

- FR53

Submitter Information Verification

Submitter Full Name: Denise Statham
Organization: Workwear Outfitters/Bulward Protection
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 11:42:40 EDT 2025
Committee: EEW-AAA

Public Comment No. 222-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed. All suppliers or manufacturers of PPE shall demonstrate conformity with an appropriate product standard by one of the following methods:~~

(c) (1) Self-declaration and product testing under a registed quality management system, arc rating by an accredited laboratory, and a Supplier's Declaration of Conformity

(d) (2) Certification by an accredited independent third-party certification organization

Informational Note No. 1: See 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.

(e) *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:

(6) Name of manufacturer

(7) Conformity assessment method used

(8) Product performance standards to which the product conforms

(9) Arc rating where appropriate for the equipment

(10) One or more identifiers such as model, serial number, lot number, or traceability code

(11) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	ANSI/ISEA Z87.1	

Subject	Document Title	Document Number
	Professional Eye and Face Protection	
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

Additional Proposed Changes

File Name	Description	Approved
Public_Comment_on_proposed_NFPA_70E_edition.docx	Explanation of proposed changes.	

Statement of Problem and Substantiation for Public Comment

In Article 130.7 Personal and Other Protective Equipment from the draft for the next edition of NFPA 70E, part (14) (b) Conformity Assessment, the language simply says that “All arc-rated PPE shall be listed.”

In the Article 100 Definitions of draft for the next edition of NFPA 70E is the definition for “Listed” as follows: “Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.”

For the listing organization, there appears to be a large amount of interpretation regarding what can be listed. Per the definition, they can either state that the product meets appropriate designated standards or has been tested and found suitable for a specified purpose. In the first case, to state that a product meets a standard, the organization would have to test and verify that all parameters of that standard were met. In the second case (after the “or”), it is acceptable to state that it has been tested and found suitable, so an organization could accept a test report and list the product.

Table 130.7(C)(14) lists examples of standards that a listing organization can use for arc-rated clothing. In North America, the standard manufacturers of FR and arc-rated apparel typically use to demonstrate product compliance with NFPA 70E is ASTM F1506, Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs. Today, this is largely done with a third-party arc rating from an accredited laboratory and a self-certification of all other parameters per the standard. To have products listed per the new language in NFPA 70E would indicate a full third-party certification to ASTM F1506. Since this standard does not currently give guidance to certifying organizations, much would be left to their interpretation about what is required for listing.
Similarly, a listed product to IEC 61482-2 standard would indicate a full third-party certification, but the parameters are different between these two standards. And if a listing organization were to interpret 70E as reviewing an IEC 61482-1-1 test report (as listed in Table 130(C)(14)) to find a product “suitable,” then you would have three differently tested products that were all listed. The current draft language creates a false sense that all products have been vetted equally.
Without clear guidance from ASTM F1506 or additional clarifying language, the draft changes for conformity assessment fail to improve the standard and may, in fact, create more uncertainty for both manufacturers and end users of arc-rating PPE.

Related Item

• FR-54-NFPA 70E-2024 • FR-53-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: James Cliver
Organization: Milliken & Company/Westex, Inc
Affiliation: Milliken and Company
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 12:51:31 EDT 2025
Committee: EEW-AAA

In Article 130.7 Personal and Other Protective Equipment from the draft for the next edition of NFPA 70E, part (14)(b) Conformity Assessment, the language simply says that "*All arc-rated PPE shall be listed*."
In the Article 100 Definitions of draft for the next edition of NFPA 70E is the definition for "Listed" as follows: "*Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material or service meets appropriate designated standards or has been tested and found suitable for a specified purpose."*

For the listing organization, there appears to be a large amount of interpretation regarding what can be listed. Per the definition, they can either state that the product meets appropriate designated standards or has been tested and found suitable for a specified purpose. In the first case, to state that a product meets a standard, the organization would have to test and verify that all parameters of that standard were met. In the second case (after the "or"), it is acceptable to state that it has been tested and found suitable, so an organization could accept a test report and list the product.

Table 130.7(C)(14) lists examples of standards that a listing organization can use for arc-rated clothing. In North America, the standard manufacturers of FR and arc-rated apparel typically use to demonstrate product compliance with NFPA 70E is ASTM F1506, *Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs.* Today, this is largely done with a third-party arc rating from an accredited laboratory and a self-certification of all other parameters per the standard. To have products listed per the new language in NFPA 70E would indicate a full third-party certification to ASTM F1506. Since this standard does not currently give guidance to certifying organizations, much would be left to their interpretation about what is required for listing.

Similarly, a listed product to IEC 61482-2 standard would indicate a full third-party certification, but the parameters are different between these two standards. And if a listing organization were to interpret 70E as reviewing an IEC 61482-1-1 test report (as listed in Table 130(C)(14)) to find a product "suitable," then you would have three differently tested products that were all listed. The current draft language creates a false sense that all products have been vetted equally.

Without clear guidance from ASTM F1506 or additional clarifying language, the draft changes for conformity assessment fail to improve the standard and may, in fact, create more uncertainty for both manufacturers and end users of arc-rating PPE.

Public Comment No. 32-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed.

Informational Note No. 1: See 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~~ Garments that are not certified as indicated on 130.7(b)(14) above shall not use any label or reference to a certification organization nor to any safety standard.

Manufacturers shall not label clothing nor claim compliance with a portion(s) or segment(s) of the applicable requirements of the corresponding standard and shall not use the same or identification of NFPA standards in any statement about their respective products unless the garment product is certified as indicated on 130.7(b)(14) above.

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:

(4) Name of manufacturer

(5) Conformity assessment method used

(6) Product performance standards to which the product conforms

(7) Arc rating where appropriate for the equipment

(8) One or more identifiers such as model, serial number, lot number, or traceability code

(9) 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	-	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	

Subject	Document Title	Document Number
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

Statement of Problem and Substantiation for Public Comment

Deceitful marketing activities uses NFPA references to mislead users within multiple Industries and countries keeping risky and unreliable PPE that does not meet appropriate protection requirements within industries and countries. The wrong use of NFPA standards references on non-safety products should be refrained. Permanent efforts to defeat these untruthful practices should kept.

Related Item

• FR No. 53-NFPA 70E-2024 [Section No. 130.7(C)(14)]

Submitter Information Verification

Submitter Full Name: Alan Campos
Organization: FIRE WORK WEAR SAS
Street Address:
City:
State:
Zip:

Submittal Date: Mon Mar 31 16:25:27 EDT 2025
Committee: EEW-AAA

Public Comment No. 94-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed.

Informational Note No. 1: See 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	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

Subject	Document Title	Document Number
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

Additional Proposed Changes

File Name	Description	Approved
FR_53.docx	FR 53 [130.7(C)(14)	
FR_53.docx	proposed revision to FR 53 -130.7(C)(14)	

Statement of Problem and Substantiation for Public Comment

adding the conformity assessment levels 1, 2, and 3 will allow selection of quality PPE

Related Item

• FR 53 - 130.7(C)(14) • 130.7(C)(14) • 130.7(C)(14)

Submitter Information Verification

Submitter Full Name: Daryld Crow
Organization: DRC Consulting Ltd
Affiliation: my self
Street Address:
City:
State:
Zip:

Submittal Date: Mon May 19 15:01:12 EDT 2025
Committee: EEW-AAA

FR 53 - 130.7(C)(14)

Revise the wording in 130.7(C)(14)(b) to read **“PPE provided by a supplier or manufacturer shall meet the requirements in conformity assessment level 1, 2, or 3”**.

Add note: Refer to informative annex H.4.2 for the requirements listed for conformity assessment levels 1, 2, and 3.

Substantiation: Using the requirements in conformity assessment level 1, 2, or 3 will allow the purchase of quality PPE equipment.

Public Comment No. 95-NFPA 70E-2025 [Section No. 130.7(C)(14)]

(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 arc-rated PPE shall be listed.

Informational Note No. 1: See 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, and/or EBT) of clothing materials and of protective clothing using an open arc	IEC 61482–1–1
	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

Subject	Document Title	Document Number
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

Additional Proposed Changes

File Name	Description	Approved
.1747684012616	FR 54 [130.7(C)(140(b)	
FR_54.docx	FR 54 130.7(C)(140(b)	

Statement of Problem and Substantiation for Public Comment

using the requirements in conformity assessment level 1, 2, or 3 will allow the purchase of quality PPE

Related Item

• 130.7(C)(14)(b)

Submitter Information Verification

Submitter Full Name: Daryld Crow
Organization: DRC Consulting Ltd
Affiliation: my self
Street Address:
City:
State:
Zip:

Submittal Date: Mon May 19 15:46:34 EDT 2025
Committee: EEW-AAA

FR 54 - [130.7(C)(14)(b)]

Revise the wording to read **“PPE provided by a supplier or manufacturer shall meet the requirements in conformity assessment level 1, 2, or 3”**.

Add note: Refer to informative annex H.4.2 for the requirements listed for conformity assessment levels 1, 2, and 3.

Substantiation: Using the requirements in conformity assessment level 1, 2, or 3 will allow the purchase of quality PPE equipment.

Public Comment No. 233-NFPA 70E-2025 [Section No. 130.7(C)(15)]

(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.* Alternating-current (ac) equipment shall meet the following requirements:

(2) 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~~

(1)

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:

(3) Power systems with greater than the estimated

~~maximum~~

(1)

a. available fault current

b. Power systems with longer than the maximum fault clearing times

c. Less than the minimum working distance

(d) *Direct-Current (dc) Equipment.* Direct-current (dc) equipment shall meet the following requirements:

(5) 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~~

(1)

available fault current, maximum arc duration, and working distances for dc equipment are listed in 130.7(C)(15)(b) .The estimated

~~maximum~~

(1)

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:

(6) Power systems with greater than the estimated

~~maximum~~

(1)

a. available fault current

b. Power systems with longer than the maximum arc duration

c. Less than the minimum working distance

(g) *Protective Clothing and Personal Protective Equipment (PPE).* Protective clothing and PPE shall meet the following requirements:

(8) 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.

(9) This clothing and equipment shall be used when working within the arc flash boundary.

(10) 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 ac Systems

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 volts and below	1	485 mm (19 in.)
Parameters: Available fault current not exceeding 25 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	-	-
Panelboards or other equipment rated greater than 240 volts and up to 600 volts	2	900 mm (3 ft)
Parameters: Available fault current not exceeding 25 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	-	-
600-volt class motor control centers (MCCs)	2	1.5 m (5 ft)
Parameters: Available fault current not exceeding 65 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	-	-
600-volt class motor control centers (MCCs)	4	4.3 m (14 ft)
Parameters: Available fault current not exceeding of 42 kA fault clearing time not exceeding 0.33 sec (20 cycles); 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)

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Parameters: 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: 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: 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: 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: 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: 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 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. 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, 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.

(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)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[e]
	-	Leather footwear[f] (AN)

Arc Flash PPE Category	PPE	
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)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[e]
	-	Leather footwear[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)[e]
	-	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Leather footwear[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 Flash PPE Category	PPE	
	Arc-rated arc flash suit pants (AR)	
	-	Arc-rated arc flash suit hood
	-	Arc-rated gloves or rubber insulating gloves with protectors (SR)[e]
	-	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	-	**Protective Equipment**
	-	Hard hat
	-	Safety glasses or safety goggles (SR)
	-	Hearing protection (ear canal inserts)[d]
	-	Leather footwear[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.

[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.

[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.

[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.

[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.

Statement of Problem and Substantiation for Public Comment

The qualifier “maximum” should be deleted in front of each occurrence of “available fault current” in 130.7(C)(15) per the Committee Statement on First Revision No. 55-NFPA 70E-2024, and per Public Input Number 11 and 12.

Related Item

• FR 55

Submitter Information Verification

Submitter Full Name: Daniel Roberts
Organization: Electrical Safety Solutions
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jun 03 15:29:24 EDT 2025
Committee: EEW-AAA

Public Comment No. 37-NFPA 70E-2025 [Section No. 130.7(C)(15)]

(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.* 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.* 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).* 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 ac Systems

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 volts and below Parameters: Available fault current not exceeding 25 kA; fault clearing time not exceeding 0.03 sec (2 cycles); 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: Available fault current not exceeding 25 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	2	900 mm (3 ft)
600-volt class motor control centers (MCCs) Parameters: Available fault current not exceeding 65 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
600-volt class motor control centers (MCCs) Parameters: Available fault current not exceeding of 42 kA fault clearing time not exceeding 0.33 sec (20 cycles); minimum working distance 455 mm (18 in.)	4	4.3 m (14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Available fault current not exceeding 35 kA; fault clearing time not exceeding 0.5 sec (30 cycles); minimum working distance 455 mm (18 in.)	4	6 m (20 ft)
Other 600-volt class (277 volts through 600 volts, nominal) equipment Parameters: Available fault current not exceeding 65 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: 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)
Metal-clad switchgear, 1 kV through 15 kV Parameters: 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)
Metal enclosed interrupter switchgear, fused or unfused type construction, 1 kV through 15 kV Parameters: 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: 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 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

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 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. 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, 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.

(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)[c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[d]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[e]
	Leather footwear[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)[c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[d]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[e]
	Leather footwear[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 Flash PPE Category	PPE
	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)[e]
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[d]
	Leather footwear[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-rated gloves or rubber insulating gloves with protectors (SR)[e]
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[d]
	Leather footwear[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.

[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.

[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.

[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.

[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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_5.pdf	70E_CN5	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 5 appeared in the First Draft Report on First Revision No. 79.

The Correlating Committee requests that the Technical Committee review the text in Table 130.7(C)(15)(b) regarding "(excluding capacitors covered in Article 360)" and Table 130.7(C)(15)(c) arc-flash category 1,2,3 and 4 regarding "(ear canal inserts)" that do not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

Related Item

• First Revision No. 79

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 03 13:48:18 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 5-NFPA 70E-2025 [Section No. 130.7(C)(15)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:34:10 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in Table 130.7(C)(15)(b) regarding "(excluding capacitors covered in Article 360)" and Table 130.7(C)(15)(c) arc-flash category 1,2,3 and 4 regarding "(ear canal inserts)" that do not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

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

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 58-NFPA 70E-2025 [Section No. 130.7(C)(15)]

(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.* 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.* 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).* 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 ac Systems

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 volts and below Parameters: Available fault current not exceeding 25 kA; fault clearing time not exceeding 0.03 sec (2 cycles); 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: Available fault current not exceeding 25 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	2	900 mm (3 ft)
600-volt class motor control centers (MCCs) Parameters: Available fault current not exceeding 65 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
600-volt class motor control centers (MCCs) Parameters: Available fault current not exceeding of 42 kA fault clearing time not exceeding 0.33 sec (20 cycles); minimum working distance 455 mm (18 in.)	4	4.3 m (14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Available fault current not exceeding 35 kA; fault clearing time not exceeding 0.5 sec (30 cycles); minimum working distance 455 mm (18 in.)	4	6 m (20 ft)
Other 600-volt class (277 volts through 600 volts, nominal) equipment Parameters: Available fault current not exceeding 65 kA; fault clearing time not exceeding 0.03 sec (2 cycles); minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: 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)
Metal-clad switchgear, 1 kV through 15 kV Parameters: 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)
Metal enclosed interrupter switchgear, fused or unfused type construction, 1 kV through 15 kV Parameters: 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: 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 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

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 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. 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, 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.

(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)[c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[d]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[e]
	Leather footwear[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)[c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[d]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with protectors (SR)[e]
	Leather footwear[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 Flash PPE Category	PPE
	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)[e]
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[d]
	Leather footwear[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-rated gloves or rubber insulating gloves with protectors (SR)[e]
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[d]
	Leather footwear[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.

[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.

[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.

[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.

[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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_27.pdf	70E_CN27	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 27 appeared in the First Draft Report on First Revision No. 55.

The Correlating Committee requests that the Technical Committee review the text in Table 130.7(C)(15)(b) regarding "(excluding capacitors covered in Article 360)" thatdoes not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

Further, clarify whether “maximum” should be deleted from preceding the defined term “available fault current” in multiple locations. See 130.7(C)(15)(a)(1) IN, 130.7(C)(15)(a)(2)(a), 130.7(C)(15)(b)(1) IN, and 130.7(C)(15)(b)(2)(a) per the committee statement, and per Public Inputs 11 and 12. See the ballot comment stating that the defined term "available fault current" is the "largest amount of current capable of being delivered and based on this definition the term "maximum" is superfluous.

Related Item

• First Revision No. 55

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 09:13:00 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 27-NFPA 70E-2025 [Section No. 130.7(C)(15)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:35:06 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in Table 130.7(C)(15)(b) regarding "(excluding capacitors covered in Article 360)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

Further, clarify whether “maximum” should be deleted from preceding the defined term “available fault current” in multiple locations. See 130.7(C)(15)(a)(1) IN, 130.7(C)(15)(a)(2)(a), 130.7(C)(15)(b)(1) IN, and 130.7(C)(15)(b)(2)(a) per the committee statement, and per Public Inputs 11 and 12. See the ballot comment stating that the defined term "available fault current" is the "largest amount of current capable of being delivered and based on this definition the term "maximum" is superfluous.

First Revision No. 55-NFPA 70E-2024 [Section No. 130.7(C)(15)]

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 59-NFPA 70E-2025 [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.

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.

(5) 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_28.pdf	70E_CN28	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 28 appeared in the First Draft Report on First Revision No. 56.

The Correlating Committee requests that the Technical Committee review 130.7(D)(1)(5) regarding "(e.g., damaged tip on a screwdriver)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual. Also, clarify “inspection shall look for damage” and consider rewording for clarity.

Related Item

• First Revision No. 56

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 09:15:09 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 28-NFPA 70E-2025 [Section No. 130.7(D)(1)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:37:14 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review 130.7(D)(1)(5) regarding "(e.g., damaged tip on a screwdriver)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual. Also, clarify “inspection shall look for damage” and consider rewording for clarity.

FR-56-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 60-NFPA 70E-2025 [Section No. 130.7(D)(2)]

(2) Barriers.

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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_29.pdf	70E_CN29	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 29 appeared in the First Draft Report on First Revision No. 57.

The Correlating Committee requests that the Technical Committee review the text in 130.7(D)(2)(2)(c) regarding " (field fabricated)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

Related Item

• First Revision No. 57

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date:	Fri Apr 04 10:02:02 EDT 2025
Committee:	EEW-AAA

Correlating Committee Note No. 29-NFPA 70E-2025 [Section No. 130.7(D)(2)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:37:50 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 130.7(D)(2)(2)(c) regarding "(field fabricated)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

FR-57-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 61-NFPA 70E-2025 [Section No. 130.8(I)]

(I) Housekeeping Duties.

(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 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_30.pdf	70E_CN30	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 30 appeared in the First Draft Report on First Revision No. 64.

The Correlating Committee requests that the Technical Committee review the text in 130.8(I)(1) regarding "(such as insulating equipment or barriers)" and 130.8(I)(2)regarding "(including conductive solids such as steel wool, metalized cloth, and silicon carbide, as well as conductive liquid solutions)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

Related Item

• First Revision No. 64

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date: Fri Apr 04 10:03:43 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 30-NFPA 70E-2025 [Section No. 130.8(I)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:38:32 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 130.8(I)(1) regarding "(such as insulating equipment or barriers)" and 130.8(I)(2) regarding "(including conductive solids such as steel wool, metalized cloth, and silicon carbide, as well as conductive liquid solutions)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

FR-64-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 76-NFPA 70E-2025 [Section No. 225.4]

225.4 Circuit Breaker Testing After Electrical Faults.

Circuit breakers that ~~interrupt faults~~ have interrupted an electrical fault approaching their interrupting ratings, capable of saving and making the magnitude of the cleared fault current available, shall be inspected and tested in accordance with the manufacturer's instructions.

Statement of Problem and Substantiation for Public Comment

Not all circuit breakers are equipped to record the fault current they interrupt. Only those with an Electronic Trip Unit (ETU) or other digital monitoring capabilities possess this functionality. For instance, a fault event that causes an EATON HFD Molded Case Circuit Breaker to trip cannot be captured, making it inconclusive whether the breaker requires testing or maintenance.

Additionally, it would be beneficial to define a specific percentage of the breaker's Ampere Interrupting Capacity (AIC) as a threshold to trigger maintenance protocols. This section also overlooks the impact of the X/R ratio—both of the overcurrent protection device and the fault current itself. Devices that do store fault current data typically do not include the X/R ratio in their recordings, which may result in an underestimation of the actual fault current magnitude.

Related Item

• Circuit Breaker Testing After Electrical Faults.

Submitter Information Verification

Submitter Full Name: Mark Pisani
Organization: BASF Corporation
Street Address:
City:
State:
Zip:

Submittal Date: Mon Apr 21 20:59:13 EDT 2025
Committee: EEW-AAA

Public Comment No. 104-NFPA 70E-2025 [Chapter 3]

Chapter 3 Safety Requirements for Special Equipment

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.

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.

Article 310 Safety-Related Work Practices: dc Electrical Hazards (Reserved)

Article 320 Safety-Related Work Requirements for Capacitors

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.

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)

320.4 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 capacitors that exceed the energy thresholds in 320.3 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 capacitors shall be trained in, and familiar with, any electrical safety-related work practices necessary for their safety.

(B) Performing a Risk Assessment for Capacitors.

(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 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 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 as follows:

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

b. Hearing protection where the stored energy exceeds 100 joules.

c. The lung protection boundary 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) to warn employees of the hazards.

(5) Required test and grounding method meeting the following requirements:

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 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.

320.5 Establishing an Electrically Safe Work Condition for a Capacitor(s).

(A) Written Procedure.

Where a conductor or circuit part is connected to a capacitor(s) operating at or above the thresholds in 320.3, a written procedure shall be used to document the necessary steps and sequence to discharge the capacitor(s) and place the equipment into an electrically safe work condition. The written procedure shall incorporate the results of the risk assessment performed in 320.5(B) and specify the following at a minimum:

(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:

   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. Perform soft grounding above 1000 joules and remote soft grounding 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:

   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 on a known dc voltage source before and after each absence of voltage procedure is performed.

(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's terminals.

(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.

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.

320.6 Ground or Shorting Sticks.

(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.

(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, it shall be replaced or repaired and tested before returning to service.

(3) If the defect or contamination exists on the cable, 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 1 ohm 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 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 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.

Article 330 Electrical Hazards 1 Hz to 110 MHz (Not Including 50/60 Hz)

330.1 Scope.

This article covers the hazards and safety-related work or equipment 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 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*

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:

(1) Alternating current (ac) (1 Hz to 3 kHz): 50 volts and 3 milliamperes (not including 50/60 Hz)

(2) Alternating current (ac) (3 kHz to 100 kHz): 1 x f mA, f in kHz

(3) Alternating current (ac) (100 kHz to 3 MHz): 100 mA

(4) Alternating current (ac) (3 MHz to 30 MHz):100 $(f/3)^{*0.3}$, f in MHz

(5) 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.

Article 340 Safety-Related Work Practices: Electrical Hazards for Mixed Frequencies (Reserved)

Article 350 Safety-Related Work Practices for Electrolytic Cells

350.1 Scope.

The requirements of this article shall apply to the electrical safety-related work practices used in the types of electrolytic cell areas.

Informational Note No. 1: See Informative Annex L for a typical application of safeguards in the cell line working zone.

Informational Note No. 2: See *NFPA 70*, *National Electrical Code*, Article 668 for further information about electrolytic cells.

Informational Note No. 3: See IEEE 463, *Electrical Safety Practices in Electrolytic Cell Line Working Zones*, for further information about electrical safety-related work practices in electrolytic cell lines.

350.3 Safety Training.

(A) General.

The training requirements of this chapter shall apply to employees exposed to electrical hazards in the cell line working zone and shall supplement or modify the requirements of 110.2, 110.4, 130.1, and 130.9.

(B) Training Requirements.

Employees shall be trained to understand the specific electrical hazards associated with electrical energy on the cell line. Employees shall be trained in safety-related work practices and procedural requirements to provide protection from the electrical hazards associated with their respective job or task assignment.

350.4 Employee Training.

(A) Qualified Persons.

(1) Training.

Qualified persons shall be trained and knowledgeable in the operation of cell line working zone equipment and specific work methods and shall be trained to avoid the electrical hazards that are present. Such persons shall be familiar with the proper use of precautionary techniques and PPE. Training for a qualified person shall include the following:

(1) Skills and techniques to avoid an electric shock hazard:

a. Between exposed energized surfaces, which might include temporarily insulating or guarding parts to permit the employee to work on exposed energized parts

b. Between exposed energized surfaces and grounded equipment, other grounded objects, or the earth itself, that might include temporarily insulating or guarding parts to permit the employee to work on exposed energized parts

(2) Method of determining the cell line working zone area boundaries

(2) Qualified Persons.

Qualified persons shall be permitted to work within the cell line working zone.

(B) Unqualified Persons.

(1) Training.

Unqualified persons shall be trained to identify electrical hazards to which they could be exposed and the proper methods of avoiding the hazards.

(2) In Cell Line Working Zone.

When there is a need for an unqualified person to enter the cell line working zone to perform a specific task, that person shall be advised of the electrical hazards by the designated qualified person in charge to ensure that the unqualified person is safeguarded.

350.5 Safeguarding of Employees in the Cell Line Working Zone.

(A) General.

Operation and maintenance of electrolytic cell lines might require contact by employees with exposed energized surfaces such as buses, electrolytic cells, and their attachments. The approach distances referred to in Table 130.4(E)(a) and Table 130.4(E)(b) shall not apply to work performed by qualified persons in the cell line working zone. Safeguards such as safety-related work practices and other safeguards shall be used to protect employees from injury while working in the cell line working zone. These safeguards shall be consistent with the nature and extent of the related electrical hazards. Safeguards might be different for energized cell lines and de-energized cell lines. Hazardous battery effect voltages shall be dissipated to consider a cell line de-energized.

Informational Note No. 1: Exposed energized surfaces might not present an electrical hazard. Electric shock hazards are related to current through the body, producing possible injury or damage to health. Electric shock severity is a function of many factors, including skin and body resistance, current path through the body, paths in parallel with the body, and system voltage. Arc flash burns and arc blasts are a function of the arcing current and the duration of arc exposure.

Informational Note No. 2: A cell line or group of cell lines operated as a unit for the production of a particular metal, gas, or chemical compound might differ from other cell lines producing the same product because of variations in the particular raw materials used, output capacity, use of proprietary methods or process practices, or other modifying factors. Detailed standard electrical safety-related work practice requirements could become overly restrictive without accomplishing the stated purpose of Chapter 1.

(B) Signs.

Permanent signs shall clearly designate electrolytic cell areas.

(C) Arc Flash Risk Assessment.

The requirements of 130.5, Arc Flash Risk Assessment, shall not be required for electrolytic cell line working zones.

(1) General.

Each task performed in the electrolytic cell line working zone shall be analyzed for the likelihood of arc flash injury. If there is a likelihood of personal injury, appropriate measures shall be taken to protect persons exposed to the arc flash hazards, including one or more of the following:

(1) Providing appropriate PPE *[see 350.5(D)(2)]* to prevent injury from the arc flash hazard

(2) Altering work procedures to reduce the likelihood of occurrence of an arc flash incident

(3) Scheduling the task so that work can be performed when the cell line is de-energized

(2) Routine Tasks.

Arc flash risk assessment shall be done for all routine tasks performed in the cell line work zone. The results of the arc flash risk assessment shall be used in training employees in job procedures that minimize the possibility of arc flash hazards. The training shall be included in the requirements of 350.3.

(3) Nonroutine Tasks.

Before a nonroutine task is performed in the cell line working zone, an arc flash risk assessment shall be done. If an arc flash hazard is a possibility during nonroutine work, appropriate instructions shall be given to employees involved on how to minimize the risk associated with arc flash.

(4) Arc Flash Hazards.

If the likelihood of occurrence of an arc flash hazard exists for either routine or nonroutine tasks, employees shall use appropriate safeguards.

(D) Safeguards.

Safeguards shall include one or a combination of the following means.

(1) Insulation.

Insulation shall be suitable for the specific conditions, and its components shall be permitted to include glass, porcelain, epoxy coating, rubber, fiberglass, and plastic and, when dry, such materials as concrete, tile, brick, and wood. Insulation shall be permitted to be applied to energized or grounded surfaces.

(2) Personal Protective Equipment (PPE).

PPE shall provide protection from electrical hazards. PPE shall include one or more of the following, as determined by authorized management:

(1) Footwear for wet service

(2) Gloves for wet service

(3) Sleeves for wet service

(4) Footwear for dry service

(5) Gloves for dry service

(6) Sleeves for dry service

(7) Electrically insulated head protection

(8) Protective clothing

(9) Eye protection with nonconductive frames

(10) Face shield (polycarbonate or similar nonmelting type)

(a) *PPE.* Personal and other protective equipment shall be appropriate for conditions, as determined by authorized management.

(b) *Testing of PPE.* PPE shall be verified with regularity and by methods that are consistent with the exposure of employees to electrical hazards.

(3) Barriers.

Barriers shall be devices that prevent contact with energized or grounded surfaces that could present an electrical hazard.

(4) Voltage Equalization.

Voltage equalization shall be permitted by bonding a conductive surface to an exposed energized surface, either directly or through a resistance, so that there is insufficient voltage to create an electrical hazard.

(5) Isolation.

Isolation shall be established by placing equipment or other items in locations such that employees are unable to simultaneously contact exposed conductive surfaces that could present an electrical hazard.

(6) Safe Work Practices.

Employees shall be trained in safe work practices. The training shall include why the work practices in a cell line working zone are different from similar work situations in other areas of the plant. Employees shall comply with established safe work practices and the safe use of protective equipment.

(a) *Attitude Awareness.* Safe work practice training shall include attitude awareness instruction. Simultaneous contact with energized parts and ground can cause serious electric shock. Of special importance is the need to be aware of body position where contact may be made with energized parts of the electrolytic cell line and grounded surfaces.

(b) *Bypassing of Safety Equipment.* Safe work practice training shall include techniques to prevent bypassing the protection of safety equipment. Clothing may bypass protective equipment if the clothing is wet. Trouser legs should be kept at appropriate length, and shirt sleeves should be a good fit so as not to drape while reaching. Jewelry and other metal accessories that may bypass protective equipment shall not be worn while working in the cell line working zone.

(7) Tools.

Tools and other devices used in the energized cell line work zone shall be selected to prevent bridging between surfaces at hazardous potential difference.

Informational Note: Tools and other devices of magnetic material could be difficult to handle in the area of energized cells due to their strong dc magnetic fields.

(8) Portable Cutout-Type Switches.

Portable cell cutout switches that are connected shall be considered as energized and as an extension of the cell line working zone. Appropriate procedures shall be used to ensure proper cutout switch connection and operation.

(9) Cranes and Hoists.

Cranes and hoists shall meet the requirements of applicable codes and standards to safeguard employees. Insulation required for safeguarding employees, such as insulated crane hooks, shall be periodically tested.

(10) Attachments.

Attachments that extend the cell line electrical hazards beyond the cell line working zone shall use one or more of the following:

(1) Temporary or permanent extension of the cell line working zone

(2) Barriers

(3) Insulating breaks

(4) Isolation

(11) Pacemakers and Metallic Implants.

Employees with implanted pacemakers, ferromagnetic medical devices, or other electronic devices vital to life shall not be permitted in cell areas unless written permission is obtained from the employee's physician.

Informational Note: The American Conference of Governmental Industrial Hygienists (ACGIH) and IEEE 463, *Electrical Safety Practices in Electrolytic Cell Line Working Zones*, recommend that persons with implanted pacemakers should not be exposed to magnetic flux densities above 5 gauss.

(12) Testing.

Equipment safeguards for employee protection shall be tested to ensure they are in a safe working condition.

350.6 Portable Tools and Equipment.

Informational Note: The order of preference for the energy source for portable hand-held equipment is considered to be as follows:

(1) Battery power

(2) Pneumatic power

(3) Portable generator

(4) Nongrounded-type receptacle connected to an ungrounded source

(A) Portable Electrical Equipment.

The grounding requirements of 110.7(B) shall not be permitted within an energized cell line working zone. Portable electrical equipment and associated power supplies shall meet the requirements of applicable codes and standards.

(B) Auxiliary Nonelectric Connections.

Auxiliary nonelectric connections such as air, water, and gas hoses shall meet the requirements of applicable codes and standards. Pneumatic-powered tools and equipment shall be supplied with nonconductive air hoses in the cell line working zone.

(C) Welding Machines.

Welding machine frames shall be considered at cell potential when within the cell line working zone. Safety-related work practices shall require that the cell line not be grounded through the welding machine or its power supply. Welding machines located outside the cell line working zone shall be barricaded to prevent employees from touching the welding machine and ground simultaneously where the welding cables are in the cell line working zone.

(D) Portable Test Equipment.

Test equipment in the cell line working zone shall be suitable for use in areas of large magnetic fields and orientation.

> Informational Note: Test equipment that is not suitable for use in such magnetic fields could result in an incorrect response. When such test equipment is removed from the cell line working zone, its performance might return to normal, giving the false impression that the results were correct.

Article 360 Safety Requirements Related to Batteries and Battery Rooms

360.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while working with exposed stationary storage batteries that exceed 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

360.3 Safety Procedures.

(A) Electrical Hazard Thresholds.

Exposure levels shall not exceed the following unless appropriate controls are implemented:

(1) Alternating current (ac): 50 volts and 5 milliamperes

(2) 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 four.

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

(B) Battery Risk Assessment.

Prior to any work on a battery system, a risk assessment shall be performed and documented for chemical, contact thermal, electric shock, and arc flash hazards 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 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.

(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.

(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.

(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

(C) Battery Room or Enclosure Requirements.

(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.

(D) Apparel.

Personnel shall not wear electrically conductive objects such as jewelry while working on a battery system.

(E) Abnormal Battery Conditions.

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.

(F) Warning Signs.

The following warning signs or labels shall be posted in appropriate locations:

(1) Electrical hazard warnings indicating the electric shock hazard, arc flash 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) 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

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.

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

370.1 Scope.

The requirements of this article shall apply to the electrical installations in those areas, with custom or special electrical equipment, designated by the facility management for research and development (R&D) or as laboratories.

370.3 Applications of Other Articles.

The electrical system for R&D and laboratory applications shall meet the requirements of the remainder of this document, except as amended by Article 370.

Informational Note: Examples of these applications include low-voltage–high-current power systems; high-voltage–low-current power systems; dc power supplies; capacitors; cable trays for signal cables and other systems, such as steam, water, air, gas, or drainage; and custom-made electronic equipment.

370.4 Electrical Safety Authority (ESA).

Each laboratory or R&D system application shall be permitted to assign an ESA to ensure the use of appropriate electrical safety-related work practices and controls. The ESA shall be permitted to be an electrical safety committee, engineer, or equivalent qualified individual. The ESA shall be permitted to delegate authority to an individual or organization within their control.

(A) Responsibility.

The ESA shall act in a manner similar to an authority having jurisdiction for R&D electrical systems and electrical safe work practices.

(B) Qualifications.

The ESA shall be competent in the following:

(1) The requirements of this standard

(2) Electrical system requirements applicable to the R&D laboratories

370.5 Specific Measures and Controls for Personnel Safety.

Each laboratory or R&D system application shall designate a qualified person as defined in this article to ensure the use of appropriate electrical safety-related work practices and controls.

(A) Job Briefings.

Job briefings shall be performed in accordance with 110.3(I).

Exception: Prior to starting work, a brief discussion shall be permitted if the task and hazards are documented and the employee has reviewed applicable documentation and is qualified for the task.

(B) Personnel Protection.

Safety-related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from exposed electrical conductors or circuit parts that are or can become energized. The specific safety-related work practices shall be consistent with the electrical hazard(s) and the associated risk. For calibration and adjustment of equipment as it pertains to sensors, motor controllers, control hardware, and other devices that need to be installed inside equipment or control cabinet, surrounded by electrical hazards, the ESA shall define the required PPE based on the risk and exposure.

Use of electrical insulating blankets, covers, or barriers shall be permitted to prevent inadvertent contact to exposed terminals and conductors. Insulated/nonconductive adjustment and alignment tools shall be used where feasible.

370.6 Approval Requirements.

The equipment or systems used in the R&D area or in the laboratory shall be listed or field evaluated prior to use.

> Informational Note: Laboratory and R&D equipment or systems can pose unique electrical hazards that might require mitigation. Such hazards include ac and dc, low voltage and high amperage, high voltage and low current, large electromagnetic fields, induced voltages, pulsed power, multiple frequencies, and similar exposures.

370.7 Custom Built, Non-Listed Research Equipment, 1000 Volts or less ac or dc.

(A) Equipment Marking and Documentation.

(1) Marking.

Marking of equipment shall be required for, but not limited to, equipment fabricated, designed, or developed for research testing and evaluation of electrical systems. Marking shall sufficiently list all voltages entering and leaving control cabinets, enclosures, and equipment.

Caution, Warning, or Danger labels shall be affixed to the exterior describing specific hazards and safety concerns.

> Informational Note: See ANSI Z535, *Series of Standards for Safety Signs and Tags*, for more information on precautionary marking of electrical systems or equipment.

(2) Documentation.

Sufficient documentation shall be provided and readily available to personnel that install, operate, and maintain equipment that describes operation, shutdown, safety concerns, and nonstandard installations.

Schematics, drawings, and bill of materials describing power feeds, voltages, currents, and parts used for construction, maintenance, and operation of the equipment shall be provided.

(3) Shutdown Procedures.

Safety requirements and emergency shutdown procedures of equipment shall include lockout/tagout (LOTO) requirements. If equipment-specific LOTO is required, then documentation outlining this procedure and PPE requirements shall be made readily available.

(4) Specific Hazards.

Specific hazards, other than electrical, associated with research equipment shall be documented and readily available.

(5) Approvals.

Drawings, standard operational procedures, and equipment shall be approved by the ESA on site before initial startup. Assembly of equipment shall comply with national standards where applicable unless research application requires exceptions. Equipment that does not meet the applicable standards shall be required to be approved by the ESA. Proper safety shutdown procedures and PPE requirements shall be considered in the absence of grounding and/or bonding.

(B) Tools, Training, and Maintenance.

Documentation shall be provided if special tools, unusual PPE, or other equipment is necessary for proper maintenance and operation of equipment. The ESA shall make the determination of appropriate training and qualifications required to perform specific tasks.

370.8 Custom Built, Unlisted Research Equipment, >1000 Volts ac or dc.

Installations shall comply with all requirements of 370.7.

In the event that research equipment requires PPE beyond what is commercially available, the ESA shall determine safe work practices and PPE to be used.

370.9 Electrical Hazard Thresholds.

Exposure levels shall not exceed those identified in the following list unless appropriate controls are implemented as approved by the ESA:

(1) Alternating current (ac): 50 volts and 5 milliamperes

(2) Direct current (dc): 100 volts and 40 milliamperes

Informational Note No. 1: See Department of Energy, *DOE Electrical Safety Handbook*, DOE-HDBK-1092, for information on electrical hazard thresholds.

Informational Note No. 2: See 320.3 and Informative Annex R for information on capacitor hazards and controls.

370.10 Establishing an Electrically Safe Work Condition.

Energized electrical conductors and circuit parts shall be put into an electrically safe work condition before an employee performs work.

Exception: At the discretion of the ESA, alternative methods of ensuring worker safety shall be permitted to be employed for the following conditions:

(1) Minor tool changes and adjustments, and other normal production operations that are routine, repetitive, or sequential and integral to the use of the equipment for production

(2) Minor changes to the unit under test and other minor servicing activities, to include the activities listed under 370.10 Exception condition (1), that take place during research and development

(3) Work on cord-and-plug-connected equipment for which exposure to the hazards of unexpected energization or start up is controlled by the following:

a. Unplugging the equipment from the energy source

b. The employee performing the work maintaining exclusive control of the plug

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.

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.

Statement of Problem and Substantiation for Public Comment

Note: It was very difficult to show the suggested changes in TerraView; therefore the suggested structure changes to Chapter 3 are given below. The purpose of this change is to improve useability by grouping where possible dc hazards together and ac hazards together in the redistribution of Chapter 3 articles. No technical changes, or changes to article titles are proposed for this public comment, only changes in article numbers. If the suggested changes are accepted, 300.3 will need to be updated to reflect the organization.

Article 300 Introduction
Article 310 Safety-Related Work Practices: dc Electrical Hazards (Reserved)
Article 320 Safety Requirements Related to Batteries and Battery Rooms
Article 330 Safety-Related Work Practices: Electrical Double Layer Capacitors (EDLCs)
Article 340 Safety-Related Requirements: Photovoltaic Systems
Article 350 Safety-Related Work Practices for Electrolytic Cell Lines
Article 360 Electrical Hazards 1 Hz to 110 MHz (Not Including 50/60 Hz)
Article 370 Safety-Related Work Practices: Electrical Hazards for Mixed Frequencies (Reserved)
Article 380 Safety-Related Work Requirements for Capacitors
Article 390 Safety-Related Work Requirements: Research and Development Laboratories

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 105-NFPA 70E-2025 [Section No. 300.3]	
Public Comment No. 105-NFPA 70E-2025 [Section No. 300.3]	

Related Item

- FR-80

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:
Submittal Date: Tue May 20 15:40:10 EDT 2025
Committee: EEW-AAA

Public Comment No. 177-NFPA 70E-2025 [Chapter 3]

Chapter 3 Safety Requirements for Special Equipment

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.

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.

Article 310 Safety-Related Work Practices: dc Electrical Hazards (Reserved)

Article 320 Safety-Related Work Requirements for Capacitors

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.

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)

320.4 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 capacitors that exceed the energy thresholds in 320.3 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 capacitors shall be trained in, and familiar with, any electrical safety-related work practices necessary for their safety.

(B) Performing a Risk Assessment for Capacitors.

(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 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 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 as follows:

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

b. Hearing protection where the stored energy exceeds 100 joules.

c. The lung protection boundary 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) to warn employees of the hazards.

(5) Required test and grounding method meeting the following requirements:

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 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.

320.5 Establishing an Electrically Safe Work Condition for a Capacitor(s).

(A) Written Procedure.

Where a conductor or circuit part is connected to a capacitor(s) operating at or above the thresholds in 320.3, a written procedure shall be used to document the necessary steps and sequence to discharge the capacitor(s) and place the equipment into an electrically safe work condition. The written procedure shall incorporate the results of the risk assessment performed in 320.5(B) and specify the following at a minimum:

(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:

   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. Perform soft grounding above 1000 joules and remote soft grounding 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:

   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 on a known dc voltage source before and after each absence of voltage procedure is performed.

(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's terminals.

(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.

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.

320.6 Ground or Shorting Sticks.

(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.

(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, it shall be replaced or repaired and tested before returning to service.

(3) If the defect or contamination exists on the cable, 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 1 ohm 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 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 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.

Article 330 Electrical Hazards 1 Hz to 110 MHz (Not Including 50/60 Hz)

330.1 Scope.

This article covers the hazards and safety-related work or equipment 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 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*

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:

(1) Alternating current (ac) (1 Hz to 3 kHz): 50 volts and 3 milliamperes (not including 50/60 Hz)

(2) Alternating current (ac) (3 kHz to 100 kHz): 1 x f mA, f in kHz

(3) Alternating current (ac) (100 kHz to 3 MHz): 100 mA

(4) Alternating current (ac) (3 MHz to 30 MHz):100 $(f/3)^{*0.3}$, f in MHz

(5) 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.

Article 340 Safety-Related Work Practices: Electrical Hazards for Mixed Frequencies (Reserved)

Article 350 Safety-Related Work Practices for Electrolytic Cells

350.1 Scope.

The requirements of this article shall apply to the electrical safety-related work practices used in the types of electrolytic cell areas.

Informational Note No. 1: See Informative Annex L for a typical application of safeguards in the cell line working zone.

Informational Note No. 2: See *NFPA 70*, *National Electrical Code*, Article 668 for further information about electrolytic cells.

Informational Note No. 3: See IEEE 463, *Electrical Safety Practices in Electrolytic Cell Line Working Zones*, for further information about electrical safety-related work practices in electrolytic cell lines.

350.3 Safety Training.

(A) General.

The training requirements of this chapter shall apply to employees exposed to electrical hazards in the cell line working zone and shall supplement or modify the requirements of 110.2, 110.4, 130.1, and 130.9.

(B) Training Requirements.

Employees shall be trained to understand the specific electrical hazards associated with electrical energy on the cell line. Employees shall be trained in safety-related work practices and procedural requirements to provide protection from the electrical hazards associated with their respective job or task assignment.

350.4 Employee Training.

(A) Qualified Persons.

(1) Training.

Qualified persons shall be trained and knowledgeable in the operation of cell line working zone equipment and specific work methods and shall be trained to avoid the electrical hazards that are present. Such persons shall be familiar with the proper use of precautionary techniques and PPE. Training for a qualified person shall include the following:

(1) Skills and techniques to avoid an electric shock hazard:

a. Between exposed energized surfaces, which might include temporarily insulating or guarding parts to permit the employee to work on exposed energized parts

b. Between exposed energized surfaces and grounded equipment, other grounded objects, or the earth itself, that might include temporarily insulating or guarding parts to permit the employee to work on exposed energized parts

(2) Method of determining the cell line working zone area boundaries

(2) Qualified Persons.

Qualified persons shall be permitted to work within the cell line working zone.

(B) Unqualified Persons.

(1) Training.

Unqualified persons shall be trained to identify electrical hazards to which they could be exposed and the proper methods of avoiding the hazards.

(2) In Cell Line Working Zone.

When there is a need for an unqualified person to enter the cell line working zone to perform a specific task, that person shall be advised of the electrical hazards by the designated qualified person in charge to ensure that the unqualified person is safeguarded.

350.5 Safeguarding of Employees in the Cell Line Working Zone.

(A) General.

Operation and maintenance of electrolytic cell lines might require contact by employees with exposed energized surfaces such as buses, electrolytic cells, and their attachments. The approach distances referred to in Table 130.4(E)(a) and Table 130.4(E)(b) shall not apply to work performed by qualified persons in the cell line working zone. Safeguards such as safety-related work practices and other safeguards shall be used to protect employees from injury while working in the cell line working zone. These safeguards shall be consistent with the nature and extent of the related electrical hazards. Safeguards might be different for energized cell lines and de-energized cell lines. Hazardous battery effect voltages shall be dissipated to consider a cell line de-energized.

Informational Note No. 1: Exposed energized surfaces might not present an electrical hazard. Electric shock hazards are related to current through the body, producing possible injury or damage to health. Electric shock severity is a function of many factors, including skin and body resistance, current path through the body, paths in parallel with the body, and system voltage. Arc flash burns and arc blasts are a function of the arcing current and the duration of arc exposure.

Informational Note No. 2: A cell line or group of cell lines operated as a unit for the production of a particular metal, gas, or chemical compound might differ from other cell lines producing the same product because of variations in the particular raw materials used, output capacity, use of proprietary methods or process practices, or other modifying factors. Detailed standard electrical safety-related work practice requirements could become overly restrictive without accomplishing the stated purpose of Chapter 1.

(B) Signs.

Permanent signs shall clearly designate electrolytic cell areas.

(C) Arc Flash Risk Assessment.

The requirements of 130.5, Arc Flash Risk Assessment, shall not be required for electrolytic cell line working zones.

(1) General.

Each task performed in the electrolytic cell line working zone shall be analyzed for the likelihood of arc flash injury. If there is a likelihood of personal injury, appropriate measures shall be taken to protect persons exposed to the arc flash hazards, including one or more of the following:

(1) Providing appropriate PPE *[see 350.5(D)(2)]* to prevent injury from the arc flash hazard

(2) Altering work procedures to reduce the likelihood of occurrence of an arc flash incident

(3) Scheduling the task so that work can be performed when the cell line is de-energized

(2) Routine Tasks.

Arc flash risk assessment shall be done for all routine tasks performed in the cell line work zone. The results of the arc flash risk assessment shall be used in training employees in job procedures that minimize the possibility of arc flash hazards. The training shall be included in the requirements of 350.3.

(3) Nonroutine Tasks.

Before a nonroutine task is performed in the cell line working zone, an arc flash risk assessment shall be done. If an arc flash hazard is a possibility during nonroutine work, appropriate instructions shall be given to employees involved on how to minimize the risk associated with arc flash.

(4) Arc Flash Hazards.

If the likelihood of occurrence of an arc flash hazard exists for either routine or nonroutine tasks, employees shall use appropriate safeguards.

(D) Safeguards.

Safeguards shall include one or a combination of the following means.

(1) Insulation.

Insulation shall be suitable for the specific conditions, and its components shall be permitted to include glass, porcelain, epoxy coating, rubber, fiberglass, and plastic and, when dry, such materials as concrete, tile, brick, and wood. Insulation shall be permitted to be applied to energized or grounded surfaces.

(2) Personal Protective Equipment (PPE).

PPE shall provide protection from electrical hazards. PPE shall include one or more of the following, as determined by authorized management:

(1) Footwear for wet service

(2) Gloves for wet service

(3) Sleeves for wet service

(4) Footwear for dry service

(5) Gloves for dry service

(6) Sleeves for dry service

(7) Electrically insulated head protection

(8) Protective clothing

(9) Eye protection with nonconductive frames

(10) Face shield (polycarbonate or similar nonmelting type)

(a) *PPE.* Personal and other protective equipment shall be appropriate for conditions, as determined by authorized management.

(b) *Testing of PPE.* PPE shall be verified with regularity and by methods that are consistent with the exposure of employees to electrical hazards.

(3) Barriers.

Barriers shall be devices that prevent contact with energized or grounded surfaces that could present an electrical hazard.

(4) Voltage Equalization.

Voltage equalization shall be permitted by bonding a conductive surface to an exposed energized surface, either directly or through a resistance, so that there is insufficient voltage to create an electrical hazard.

(5) Isolation.

Isolation shall be established by placing equipment or other items in locations such that employees are unable to simultaneously contact exposed conductive surfaces that could present an electrical hazard.

(6) Safe Work Practices.

Employees shall be trained in safe work practices. The training shall include why the work practices in a cell line working zone are different from similar work situations in other areas of the plant. Employees shall comply with established safe work practices and the safe use of protective equipment.

(a) *Attitude Awareness.* Safe work practice training shall include attitude awareness instruction. Simultaneous contact with energized parts and ground can cause serious electric shock. Of special importance is the need to be aware of body position where contact may be made with energized parts of the electrolytic cell line and grounded surfaces.

(b) *Bypassing of Safety Equipment.* Safe work practice training shall include techniques to prevent bypassing the protection of safety equipment. Clothing may bypass protective equipment if the clothing is wet. Trouser legs should be kept at appropriate length, and shirt sleeves should be a good fit so as not to drape while reaching. Jewelry and other metal accessories that may bypass protective equipment shall not be worn while working in the cell line working zone.

(7) Tools.

Tools and other devices used in the energized cell line work zone shall be selected to prevent bridging between surfaces at hazardous potential difference.

Informational Note: Tools and other devices of magnetic material could be difficult to handle in the area of energized cells due to their strong dc magnetic fields.

(8) Portable Cutout-Type Switches.

Portable cell cutout switches that are connected shall be considered as energized and as an extension of the cell line working zone. Appropriate procedures shall be used to ensure proper cutout switch connection and operation.

(9) Cranes and Hoists.

Cranes and hoists shall meet the requirements of applicable codes and standards to safeguard employees. Insulation required for safeguarding employees, such as insulated crane hooks, shall be periodically tested.

(10) Attachments.

Attachments that extend the cell line electrical hazards beyond the cell line working zone shall use one or more of the following:

(1) Temporary or permanent extension of the cell line working zone

(2) Barriers

(3) Insulating breaks

(4) Isolation

(11) Pacemakers and Metallic Implants.

Employees with implanted pacemakers, ferromagnetic medical devices, or other electronic devices vital to life shall not be permitted in cell areas unless written permission is obtained from the employee's physician.

Informational Note: The American Conference of Governmental Industrial Hygienists (ACGIH) and IEEE 463, *Electrical Safety Practices in Electrolytic Cell Line Working Zones*, recommend that persons with implanted pacemakers should not be exposed to magnetic flux densities above 5 gauss.

(12) Testing.

Equipment safeguards for employee protection shall be tested to ensure they are in a safe working condition.

350.6 Portable Tools and Equipment.

Informational Note: The order of preference for the energy source for portable hand-held equipment is considered to be as follows:

(1) Battery power

(2) Pneumatic power

(3) Portable generator

(4) Nongrounded-type receptacle connected to an ungrounded source

(A) Portable Electrical Equipment.

The grounding requirements of 110.7(B) shall not be permitted within an energized cell line working zone. Portable electrical equipment and associated power supplies shall meet the requirements of applicable codes and standards.

(B) Auxiliary Nonelectric Connections.

Auxiliary nonelectric connections such as air, water, and gas hoses shall meet the requirements of applicable codes and standards. Pneumatic-powered tools and equipment shall be supplied with nonconductive air hoses in the cell line working zone.

(C) Welding Machines.

Welding machine frames shall be considered at cell potential when within the cell line working zone. Safety-related work practices shall require that the cell line not be grounded through the welding machine or its power supply. Welding machines located outside the cell line working zone shall be barricaded to prevent employees from touching the welding machine and ground simultaneously where the welding cables are in the cell line working zone.

(D) Portable Test Equipment.

Test equipment in the cell line working zone shall be suitable for use in areas of large magnetic fields and orientation.

> Informational Note: Test equipment that is not suitable for use in such magnetic fields could result in an incorrect response. When such test equipment is removed from the cell line working zone, its performance might return to normal, giving the false impression that the results were correct.

Article 360 Safety Requirements Related to Batteries and Battery Rooms

360.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while working with exposed stationary storage batteries that exceed 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

360.3 Safety Procedures.

(A) Electrical Hazard Thresholds.

Exposure levels shall not exceed the following unless appropriate controls are implemented:

(1) Alternating current (ac): 50 volts and 5 milliamperes

(2) 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 four.

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

(B) Battery Risk Assessment.

Prior to any work on a battery system, a risk assessment shall be performed and documented for chemical, contact thermal, electric shock, and arc flash hazards 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 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.

(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.

(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.

(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

(C) Battery Room or Enclosure Requirements.

(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.

(D) Apparel.

Personnel shall not wear electrically conductive objects such as jewelry while working on a battery system.

(E) Abnormal Battery Conditions.

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.

(F) Warning Signs.

The following warning signs or labels shall be posted in appropriate locations:

(1) Electrical hazard warnings indicating the electric shock hazard, arc flash 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) 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

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.

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

370.1 Scope.

The requirements of this article shall apply to the electrical installations in those areas, with custom or special electrical equipment, designated by the facility management for research and development (R&D) or as laboratories.

370.3 Applications of Other Articles.

The electrical system for R&D and laboratory applications shall meet the requirements of the remainder of this document, except as amended by Article 370.

Informational Note: Examples of these applications include low-voltage–high-current power systems; high-voltage–low-current power systems; dc power supplies; capacitors; cable trays for signal cables and other systems, such as steam, water, air, gas, or drainage; and custom-made electronic equipment.

370.4 Electrical Safety Authority (ESA).

Each laboratory or R&D system application shall be permitted to assign an ESA to ensure the use of appropriate electrical safety-related work practices and controls. The ESA shall be permitted to be an electrical safety committee, engineer, or equivalent qualified individual. The ESA shall be permitted to delegate authority to an individual or organization within their control.

(A) Responsibility.

The ESA shall act in a manner similar to an authority having jurisdiction for R&D electrical systems and electrical safe work practices.

(B) Qualifications.

The ESA shall be competent in the following:

(1) The requirements of this standard

(2) Electrical system requirements applicable to the R&D laboratories

370.5 Specific Measures and Controls for Personnel Safety.

Each laboratory or R&D system application shall designate a qualified person as defined in this article to ensure the use of appropriate electrical safety-related work practices and controls.

(A) Job Briefings.

Job briefings shall be performed in accordance with 110.3(I).

Exception: Prior to starting work, a brief discussion shall be permitted if the task and hazards are documented and the employee has reviewed applicable documentation and is qualified for the task.

(B) Personnel Protection.

Safety-related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from exposed electrical conductors or circuit parts that are or can become energized. The specific safety-related work practices shall be consistent with the electrical hazard(s) and the associated risk. For calibration and adjustment of equipment as it pertains to sensors, motor controllers, control hardware, and other devices that need to be installed inside equipment or control cabinet, surrounded by electrical hazards, the ESA shall define the required PPE based on the risk and exposure.

Use of electrical insulating blankets, covers, or barriers shall be permitted to prevent inadvertent contact to exposed terminals and conductors. Insulated/nonconductive adjustment and alignment tools shall be used where feasible.

370.6 Approval Requirements.

The equipment or systems used in the R&D area or in the laboratory shall be listed or field evaluated prior to use.

> Informational Note: Laboratory and R&D equipment or systems can pose unique electrical hazards that might require mitigation. Such hazards include ac and dc, low voltage and high amperage, high voltage and low current, large electromagnetic fields, induced voltages, pulsed power, multiple frequencies, and similar exposures.

370.7 Custom Built, Non-Listed Research Equipment, 1000 Volts or less ac or dc.

(A) Equipment Marking and Documentation.

(1) Marking.

Marking of equipment shall be required for, but not limited to, equipment fabricated, designed, or developed for research testing and evaluation of electrical systems. Marking shall sufficiently list all voltages entering and leaving control cabinets, enclosures, and equipment.

Caution, Warning, or Danger labels shall be affixed to the exterior describing specific hazards and safety concerns.

> Informational Note: See ANSI Z535, *Series of Standards for Safety Signs and Tags*, for more information on precautionary marking of electrical systems or equipment.

(2) Documentation.

Sufficient documentation shall be provided and readily available to personnel that install, operate, and maintain equipment that describes operation, shutdown, safety concerns, and nonstandard installations.

Schematics, drawings, and bill of materials describing power feeds, voltages, currents, and parts used for construction, maintenance, and operation of the equipment shall be provided.

(3) Shutdown Procedures.

Safety requirements and emergency shutdown procedures of equipment shall include lockout/tagout (LOTO) requirements. If equipment-specific LOTO is required, then documentation outlining this procedure and PPE requirements shall be made readily available.

(4) Specific Hazards.

Specific hazards, other than electrical, associated with research equipment shall be documented and readily available.

(5) Approvals.

Drawings, standard operational procedures, and equipment shall be approved by the ESA on site before initial startup. Assembly of equipment shall comply with national standards where applicable unless research application requires exceptions. Equipment that does not meet the applicable standards shall be required to be approved by the ESA. Proper safety shutdown procedures and PPE requirements shall be considered in the absence of grounding and/or bonding.

(B) Tools, Training, and Maintenance.

Documentation shall be provided if special tools, unusual PPE, or other equipment is necessary for proper maintenance and operation of equipment. The ESA shall make the determination of appropriate training and qualifications required to perform specific tasks.

370.8 Custom Built, Unlisted Research Equipment, >1000 Volts ac or dc.

Installations shall comply with all requirements of 370.7.

In the event that research equipment requires PPE beyond what is commercially available, the ESA shall determine safe work practices and PPE to be used.

370.9 Electrical Hazard Thresholds.

Exposure levels shall not exceed those identified in the following list unless appropriate controls are implemented as approved by the ESA:

(1) Alternating current (ac): 50 volts and 5 milliamperes

(2) Direct current (dc): 100 volts and 40 milliamperes

Informational Note No. 1: See Department of Energy, *DOE Electrical Safety Handbook*, DOE-HDBK-1092, for information on electrical hazard thresholds.

Informational Note No. 2: See 320.3 and Informative Annex R for information on capacitor hazards and controls.

370.10 Establishing an Electrically Safe Work Condition.

Energized electrical conductors and circuit parts shall be put into an electrically safe work condition before an employee performs work.

Exception: At the discretion of the ESA, alternative methods of ensuring worker safety shall be permitted to be employed for the following conditions:

(1) Minor tool changes and adjustments, and other normal production operations that are routine, repetitive, or sequential and integral to the use of the equipment for production

(2) Minor changes to the unit under test and other minor servicing activities, to include the activities listed under 370.10 Exception condition (1), that take place during research and development

(3) Work on cord-and-plug-connected equipment for which exposure to the hazards of unexpected energization or start up is controlled by the following:

a. Unplugging the equipment from the energy source

b. The employee performing the work maintaining exclusive control of the plug

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.

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.

Statement of Problem and Substantiation for Public Comment

The reordering of Chapter 3 suggested in Public Input No. 236 is a good change. It allow for defining hazards more broadly initially and breaking them down into details as appropriate and reference back to prior sections for common hazard definitions. I feel this organization makes chapter 3 more user friendly than the previous organization.

Related Item

• Public Input No. 236

Submitter Information Verification

Submitter Full Name: Matt Hendrickson
Organization:
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 02 16:10:49 EDT 2025
Committee: EEW-AAA

Public Comment No. 105-NFPA 70E-2025 [Section No. 300.3]

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~~ batteries and battery rooms . Article 330 ~~covers electrical~~ applies to electrical double-layer capacitors. Article 340 applies to photovoltaic systems. Article 350 applies to electrolytic cell lines. Article 360 applies to electrical hazards from 1 Hz to 110 MHz, other than dc and 50/60 Hz. Article ~~350~~ 370 applies to ~~electrolytic cells. Article 360 applies to batteries and battery rooms. Article 370~~ electrical hazards for mixed frequencies. Article 380 applies to capacitors. Article 390 applies to research and development laboratories. ~~Article 380 applies to electrical double-layer capacitors. Article 390 applies to photovoltaic systems.~~

Statement of Problem and Substantiation for Public Comment

This public comments, along with PC 104, seeks to change the organization of Chapter 3 for useability so that it groups the articles that address dc hazards together and those that address ac hazards together where possible.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 104-NFPA 70E-2025 [Chapter 3]	
Public Comment No. 104-NFPA 70E-2025 [Chapter 3]	

Related Item

- FR-106

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:
Submittal Date: Tue May 20 16:09:22 EDT 2025
Committee: EEW-AAA

Public Comment No. 143-NFPA 70E-2025 [New Article after 310]

Article 310 DC Electrical Hazards

This article covers the electrical safety-related requirements for the practical safeguarding of employees while working with direct current (dc) that present an electrical hazard.

310.2 DC Electrical Hazard Thresholds

(A) Electrical Thermal Hazard Thresholds

For dc systems, hazardous power is considered greater than or equal to 1000 W.

(B) Electrical Shock Thresholds.

For dc systems, hazardous voltage is considered greater than or equal to 100 volts dc and 40 mA.

(C) Electrical Arc Flash Hazard Thresholds.

For dc systems, hazardous arc flash is considered for systems greater than or equal to 150 volts dc and greater than or equal to 1.2 cal/cm2 incident energy.

Statement of Problem and Substantiation for Public Comment

This material was in the original PI 236.

This material was in the Agenda of the NFPA 70E First Draft Meeting (A2026) on page 651.

This material was in the Minutes of the NFPA 70E First Draft Meeting (A2026) on page 80. It was listed as a New Article, carried over from PI 236, as an FR. This item stated, To create a revision, revise text above or paste the final version here. The "text above" was not revised, so it stood, as is.

In the file PIResponses, the following was stated on page 10, "Article 310 Safety-Related Work Practices. DC Electrical Hazards RESERVED (New Article existing 310 moved to 360)

This was never the intent. The thresholds for dc electrical hazards is NOT only an R&D issue, nor was it proposed to be. DC electrical hazards applies to the whole of chapter 3, including capacitors, R&D, electrolytic cells, batteries, EDLC, and PV, unless otherwise modified (e.g., capacitors add energy). The intent was to NOT have to repeat the thresholds for dc thermal and shock many times. Historically, they get out of sync. Now, the dc thermal and shock hazards are repeated in 360.3, 370.9, 380(B)(4)(2), and 390.2.
In addition, 360 and 380(B)(4)(2) make the following confusing statements: "in accordance with 130.7 if the voltage is greater than or equal to 100 V dc"
This is confusing, since it is an unnecessary modification of 130.7, which uses 50 V dc, to 100 V dc. As was submitted, this article under discussion, Article 310, deals with the shock thresholds for dc, up front, in Chapter 3, and applies to all of Chapter 3, subject to modification (e.g., capacitors add energy).

This new article was not new material, it was pulled from several locations in the 2024. It is a new article in that it puts a uniform requirement that was distributed throughout the 2024 NFPA 70E, into a single location at the front of Chapter 3. That was the intent of the Chapter 3 reorganization.

Keep in mind that the intent of the reorganization of Chapter 3 was to start with the electrical hazards of Special Equipment: dc, capacitor, RF, which are set for the rest of the chapter, and then follow with applications: electrolytic cells, batteries, R&D, EDLCs, PV.

SUMMARY - DC was NOT meant to only apply to DC, all of Chapter 3 incorporates DC. DC thresholds need to be covered at the very beginning and applies to the rest of the chapter.

Related Item

• PI 236 • FR 80

Submitter Information Verification

Submitter Full Name: Lloyd Gordon
Organization: Gordon

Street Address:
City:
State:
Zip:
Submittal Date: Sun Jun 01 15:00:11 EDT 2025
Committee: EEW-AAA

Public Comment No. 6-NFPA 70E-2025 [Section No. 320.1]

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. It does not cover capacitors that are a part of NRTL listed products that include instructions that deal with the discharge of capacitors before working on the equipment.

Informational Note 1: An example of instructions are the instructions on a variable frequency drive that instructs the user to turn the VFD off, lead the display blank out, and then wait a number of seconds before the door is opened.

Informational Note 2: See Informative Annex R for more information on working safely with capacitors.

Statement of Problem and Substantiation for Public Comment

The added text here was in PI 210-NFPA. It appears as though the PI was rejected because the committee thought that the purpose of the PI was to point out that manufacturer's instructions must be followed. This was not the intention of the PI. The intention of the PI is to recognize that there are two distinct categories of capacitors. One - those used in listed products, and Two - stand-alone capacitors used in power factor correction or research laboratories. The key statement in the current text of 320.1 is "...that present an electrical hazard." By adding the proposed text, it is made clear that capacitors that are part of listed products do not present an electrical hazard.
Here is my original substantiation for the PI that was submitted:
This article was written for capacitors that are used in Research & Development and in pulsed power applications. These capacitors are significant and are installed individually in racks to perform a very unique function. These capacitor are extremely hazardous and are the scope of Article 360. Capacitors in listed products, however, have circuits to ensure that the capacitors are discharged before the equipment is worked on. Still, however, a worker should always be cautious. This PI is an attempt to be parallel to the scope of Article 460 in NFPA70. Article 460 is for power factor correction installations. The language in 460 states "Surge capacitors or capacitors included as a component part of other apparatus and conforming with the requirements of such apparatus are excluded from these requirements."

Related Item

• 210-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Wed Mar 19 11:30:38 EDT 2025
Committee: EEW-AAA

Public Comment No. 102-NFPA 70E-2025 [Section No. 320.3]

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~~ di /dt is greater than 109 amperes per second (lung collapse acoustic hazard)

Statement of Problem and Substantiation for Public Comment

The units "dl/dt" are corrected to "di/dt" (with an "i") to properly indicate change in current over time, not change is length ,or distance, over time.

Related Item

• FR-96

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 20 12:03:36 EDT 2025
Committee: EEW-AAA

Public Comment No. 146-NFPA 70E-2025 [Section No. 320.3]

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~~ 10^9 amperes per second (lung collapse acoustic hazard)

Statement of Problem and Substantiation for Public Comment

Typo in creating first revision. It is NOT 109 A/sec, the 9 is a super script, e.g., it is 10 to the power 9.
This is an important correction.

Related Item

• PI 188 • FR 96

Submitter Information Verification

Submitter Full Name: Lloyd Gordon
Organization: Gordon
Street Address:
City:
State:
Zip:

Submittal Date: Sun Jun 01 15:52:15 EDT 2025
Committee: EEW-AAA

Public Comment No. 178-NFPA 70E-2025 [Section No. 320.3]

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~~ 1*10^9 amperes per second (lung collapse acoustic hazard)

Statement of Problem and Substantiation for Public Comment

The first draft version shows stored energy hazard threshold (6) as " Greater than 122kJ of stored energy when di/dt is greater than 109 amperes per second (lung collapse acoustic hazard" However Public Input No. 188 states "Greater than 122 kJ of stored energy when dI/dt is greater than 10^9 A/sec (severe acoustic hazard)" It appears that in the formatting the 9 lost its superscript format. This change is needed to have an accurate di/dt value in the document. The value of 10^9 A/sec was also part of Mr. Gordon's paper presented at the 2024 electrical safety workshop.

Related Item

• Public Input No. 188

Submitter Information Verification

Submitter Full Name: Matt Hendrickson

Organization:

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jun 02 16:20:12 EDT 2025

Committee: EEW-AAA

Public Comment No. 68-NFPA 70E-2025 [Section No. 320.3]

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)

Additional Proposed Changes

File Name	Description	Approved
70E_CN_37.pdf	70E_CN37	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 37 appeared in the First Draft Report on First Revision No. 96.

The Correlating Committee requests that the Technical Committee review the text in 320.3(1) regarding "(contact thermal hazard)", 320.3(2) regarding "(electric shock hazard)", 320.3(3) "(electric shock hazard)", 320.3(4) regarding "(arc flash hazard)", 320.3(5) regarding "(hearing acoustic hazard)", 320.3(6) regarding "(lung collapse acoustic hazard)", that do not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual. Further, review the term “appropriate” in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 on the use of unenforceable terms. Also, consider the concerns expressed in the ballot comment regarding list item (6), "dl/dt" that should be "di/dt".

Related Item

• First Revision No. 96

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:31:21 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 37-NFPA 70E-2025 [Section No. 320.3]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:51:13 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 320.3(1) regarding "(contact thermal hazard)", 320.3(2) regarding "(electric shock hazard)", 320.3(3) "(electric shock hazard)", 320.3(4) regarding "(arc flash hazard)", 320.3(5) regarding "(hearing acoustic hazard)", 320.3(6) regarding "(lung collapse acoustic hazard)", that do not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual. Further, review the term “appropriate” in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 on the use of unenforceable terms. Also, consider the concerns expressed in the ballot comment regarding list item (6), "dl/dt" that should be "di/dt".

FR-96-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned
Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All
Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 147-NFPA 70E-2025 [Section No. 320.4(B)(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 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 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 as follows:

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

b. Hearing protection where the stored energy exceeds 100 joules.

c. The lung protection boundary if stored energy is above 122 kJ and dI/dt is greater than ~~109~~ 10 ^{9} A/sec. Employees shall not enter the lung protection boundary.

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

(5) Required test and grounding method meeting the following requirements:

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 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.

Statement of Problem and Substantiation for Public Comment

Typo in creating first revision. It is NOT 109 A/sec, the 9 is a super script, e.g., it is 10 to the power 9.
This is an important correction.

Related Item

• PI 189 • FR 97

Submitter Information Verification

Submitter Full Name: Lloyd Gordon
Organization: Gordon
Street Address:
City:
State:

Zip:	
Submittal Date:	Sun Jun 01 15:59:25 EDT 2025
Committee:	EEW-AAA

Public Comment No. 185-NFPA 70E-2025 [Section No. 320.4(B)(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 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 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 as follows:

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

b. Hearing protection where the stored energy exceeds 100 joules.

c. The lung protection boundary if stored energy is above 122 kJ and dI/dt is greater than ~~109~~ 1*10^9 A/sec. Employees shall not enter the lung protection boundary.

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

(5) Required test and grounding method meeting the following requirements:

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 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.

Statement of Problem and Substantiation for Public Comment

In the reformatting of the Public Input No. 189 10^9 A/sec was changed to 109A/sec. This error results in a significant change to the end user and needs to be corrected so that user can get the key change that it take a very large rate of change of current to result in the lung collapse hazard. That message is a key improvement from the public input and helps clarify that even if you have a large capacitor bank it may not be a hazard if you have inductance in the circuit that limits the di/dt. This is very important to the end user performing the risk assessment.

Related Item

• Public Input No. 189

Submitter Information Verification

Submitter Full Name: Matt Hendrickson

Organization:

Street Address:

City:
State:
Zip:
Submittal Date: Mon Jun 02 16:42:29 EDT 2025
Committee: EEW-AAA

Public Comment No. 186-NFPA 70E-2025 [New Section after 320.5(B)]

TITLE OF NEW CONTENT

Type your content here ...

Statement of Problem and Substantiation for Public Comment

Public Input No. 197 addition of "For single, series, or parallel capacitors an approved engineered discharge path that remains in place after zero energy is verified, may 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 capacitor elements are shorted and grounded." is a very good addition. It is good because for large power electronic cabinets with a common DC bus, the best way to service them is using the engineered system designed for the power electronics cabinet. It often isn't practical to short each individual capacitor. This change allows the industry to use best practices as designed.

Related Item

• Public Input No. 197

Submitter Information Verification

Submitter Full Name: Matt Hendrickson
Organization:
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 16:56:39 EDT 2025
Committee: EEW-AAA

Public Comment No. 148-NFPA 70E-2025 [Section No. 320.5(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:

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. Perform soft grounding above 1000 joules and remote soft grounding 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~~ shall be used up to 100 kJ, and remote soft shorting ~~is permitted~~ shall be used above 100 kJ.

(6) Verify that the capacitors are discharged and grounded in accordance with the following:

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 on a known dc voltage source before and after each absence of voltage procedure is performed.

(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's terminals.

(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.

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.

Statement of Problem and Substantiation for Public Comment

in reformatting the material to fit the NFPA style, errors were made. The two shalls are required, to be consistent with 360.5(B)(5) c prior, and 360.5(B)(6) b and c, following this line. In summary, above 1000 J and below 100 kJ, soft ground/shorting sticks are required, and above 100 kJ, remote soft energy removal, engineered systems shall be used.

Related Item

• PI 190 • FR 98

Submitter Information Verification

Submitter Full Name: Lloyd Gordon
Organization: Gordon
Street Address:
City:
State:
Zip:

Submittal Date: Sun Jun 01 16:14:40 EDT 2025
Committee: EEW-AAA

Public Comment No. 69-NFPA 70E-2025 [Section No. 320.5(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:

   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. Perform soft grounding above 1000 joules and remote soft grounding 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:

   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 on a known dc voltage source before and after each absence of voltage procedure is performed.

(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’s terminals.

(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.

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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_38.pdf	70E_CN38	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 38 appeared in the First Draft Report on First Revision No. 98.

The Correlating Committee requests that the Technical Committee review the text in 320.5(B)(5)e regarding " (containing a discharge resistor)" and 320.5(B)(10)regarding "(e.g., a ground stick)" that do not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

Related Item

• First Revision No. 98

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:36:01 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 38-NFPA 70E-2025 [Section No. 360.5(B)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:53:01 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 320.5(B)(5)e regarding "(containing a discharge resistor)" and 320.5(B)(10) regarding "(e.g., a ground stick)" that do not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

First Revision No. 98-NFPA 70E-2024 [Section No. 360.5(B)]

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 70-NFPA 70E-2025 [Section No. 320.6]

320.6 Ground or Shorting Sticks.

(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.

(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, it shall be replaced or repaired and tested before returning to service.

(3) If the defect or contamination exists on the cable, 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 1 ohm 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 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 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_39.pdf	70E_CN39	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 39 appeared in the First Draft Report on First Revision No. 99.

The Correlating Committee requests that the Technical Committee review 320.6(B)(3) and 320.5(B)(3) regarding "proper" in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 regarding the use of unenforceable terms.

Related Item

• First Revision No. 99

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:37:41 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 39-NFPA 70E-2025 [Section No. 320.6]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:55:33 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review 320.6(B)(3) and 320.5(B)(3) regarding “proper” in context, and if the resulting requirement is unenforceable or vague, the term shall not be used. See the NEC Style Manual Section 3.2.1 regarding the use of unenforceable terms.

FR-99-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 66-NFPA 70E-2025 [Article 330]

Article 330 Electrical Hazards 1 Hz to 110 MHz (Not Including 50/60 Hz)

330.1 Scope.

This article covers the hazards and safety-related work or equipment 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 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*

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:

(1) Alternating current (ac) (1 Hz to 3 kHz): 50 volts and 3 milliamperes (not including 50/60 Hz)

(2) Alternating current (ac) (3 kHz to 100 kHz): 1 x f mA, f in kHz

(3) Alternating current (ac) (100 kHz to 3 MHz): 100 mA

(4) Alternating current (ac) (3 MHz to 30 MHz):100 $(f/3)^{*0.3}$, f in MHz

(5) 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_35.pdf	70E_CN35	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 35 appeared in the First Draft Report on First Revision No. 93.

The Correlating Committee requests that the Technical Committee review the text in 330.4(1) regarding "(not including 50/60 Hz)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual. Further, the article title “electrical hazards” does not correlate with the scope in Section 330.1 and needs to be clarified.

Related Item

• First Revision No. 93

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:23:07 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 35-NFPA 70E-2025 [Article 330]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:49:35 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 330.4(1) regarding "(not including 50/60 Hz)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual. Further, the article title “electrical hazards” does not correlate with the scope in Section 330.1 and needs to be clarified.

FR-93-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 106-NFPA 70E-2025 [Section No. 330.1]

330.1 Scope.

This article covers the hazards and safety-related work ~~or~~ practices for equipment 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:

(6) Motor drives

(7) Uninterruptible power supply systems

(8) Lighting controllers

(9) Generators producing sub RF (1 kHz to 3 kHz) and RF (3 kHz to 100 MHz) fields

(10) Ionizing radiation field generators including X-rays, magnetrons, klystrons, thyratrons, vacuum tubes, and similar high-voltage vacuum devices

(11) Nonionizing radiation field generating equipment, including the following:

(12) Antennas and RF transmission lines

(13) Radar equipment

(14) Industrial scientific and medical equipment

(15) RF induction and dielectric heaters

(16) Industrial microwave heaters and diathermy radiators

(17) Magnetic resonance imagers (MRIs)

(18) Large electromagnets

Informational Note: See the following standards for specific guidance on safety-related work practices around 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*

Statement of Problem and Substantiation for Public Comment

This public comment only adds "practices" to "safety-related work" and grammatically changes "or" to "for" in the first sentence. Adding "practices" better aligns with the use of the term "safety-related work practices" throughout the Standard. "Practices" might have been inadvertently deleted as part of FR-93.

Related Item

• FR-93

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired

Affiliation:	American Petroleum Institute (API)
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue May 20 16:29:15 EDT 2025
Committee:	EEW-AAA

Public Comment No. 149-NFPA 70E-2025 [Section No. 330.5]

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), and 330 . 5(C) .

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.

(C) Training for Workers Exposed to EM hazards.

If risk assessment determines that there are hazards to the thresholds set by IEEE C95.1, *IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagetic Fields, 0 Hz to 300 GHz, 2019* , created by electrical equipment, the workers must be trained to EM hazards and controls must be put in place to prevent exposure, such as access prevention.

Statement of Problem and Substantiation for Public Comment

RF training was proposed to be added to 110.4(D) to require training for workers exposed to EM fields emitted by some electrical equipment. This PI 253 was resolved. Some electrical equipment creates substantial EM fields and workers that might be exposed to such EM field hazards must be trained.

Related Item

• PI 253

Submitter Information Verification

Submitter Full Name: Lloyd Gordon
Organization: Gordon
Street Address:
City:
State:
Zip:
Submittal Date: Sun Jun 01 16:46:57 EDT 2025
Committee: EEW-AAA

Public Comment No. 67-NFPA 70E-2025 [Section No. 350.5]

350.5 Safeguarding of Employees in the Cell Line Working Zone.

(A) General.

Operation and maintenance of electrolytic cell lines might require contact by employees with exposed energized surfaces such as buses, electrolytic cells, and their attachments. The approach distances referred to in Table 130.4(E)(a) and Table 130.4(E)(b) shall not apply to work performed by qualified persons in the cell line working zone. Safeguards such as safety-related work practices and other safeguards shall be used to protect employees from injury while working in the cell line working zone. These safeguards shall be consistent with the nature and extent of the related electrical hazards. Safeguards might be different for energized cell lines and de-energized cell lines. Hazardous battery effect voltages shall be dissipated to consider a cell line de-energized.

Informational Note No. 1: Exposed energized surfaces might not present an electrical hazard. Electric shock hazards are related to current through the body, producing possible injury or damage to health. Electric shock severity is a function of many factors, including skin and body resistance, current path through the body, paths in parallel with the body, and system voltage. Arc flash burns and arc blasts are a function of the arcing current and the duration of arc exposure.

Informational Note No. 2: A cell line or group of cell lines operated as a unit for the production of a particular metal, gas, or chemical compound might differ from other cell lines producing the same product because of variations in the particular raw materials used, output capacity, use of proprietary methods or process practices, or other modifying factors. Detailed standard electrical safety-related work practice requirements could become overly restrictive without accomplishing the stated purpose of Chapter 1.

(B) Signs.

Permanent signs shall clearly designate electrolytic cell areas.

(C) Arc Flash Risk Assessment.

The requirements of 130.5, Arc Flash Risk Assessment, shall not be required for electrolytic cell line working zones.

(1) General.

Each task performed in the electrolytic cell line working zone shall be analyzed for the likelihood of arc flash injury. If there is a likelihood of personal injury, appropriate measures shall be taken to protect persons exposed to the arc flash hazards, including one or more of the following:

(1) Providing appropriate PPE *[see 350.5(D)(2)]* to prevent injury from the arc flash hazard

(2) Altering work procedures to reduce the likelihood of occurrence of an arc flash incident

(3) Scheduling the task so that work can be performed when the cell line is de-energized

(2) Routine Tasks.

Arc flash risk assessment shall be done for all routine tasks performed in the cell line work zone. The results of the arc flash risk assessment shall be used in training employees in job procedures that minimize the possibility of arc flash hazards. The training shall be included in the requirements of 350.3.

(3) Nonroutine Tasks.

Before a nonroutine task is performed in the cell line working zone, an arc flash risk assessment shall be done. If an arc flash hazard is a possibility during nonroutine work, appropriate instructions shall be given to employees involved on how to minimize the risk associated with arc flash.

(4) Arc Flash Hazards.

If the likelihood of occurrence of an arc flash hazard exists for either routine or nonroutine tasks, employees shall use appropriate safeguards.

(D) Safeguards.

Safeguards shall include one or a combination of the following means.

(1) Insulation.

Insulation shall be suitable for the specific conditions, and its components shall be permitted to include glass, porcelain, epoxy coating, rubber, fiberglass, and plastic and, when dry, such materials as concrete, tile, brick, and wood. Insulation shall be permitted to be applied to energized or grounded surfaces.

(2) Personal Protective Equipment (PPE).

PPE shall provide protection from electrical hazards. PPE shall include one or more of the following, as determined by authorized management:

(1) Footwear for wet service

(2) Gloves for wet service

(3) Sleeves for wet service

(4) Footwear for dry service

(5) Gloves for dry service

(6) Sleeves for dry service

(7) Electrically insulated head protection

(8) Protective clothing

(9) Eye protection with nonconductive frames

(10) Face shield (polycarbonate or similar nonmelting type)

(a) *PPE.* Personal and other protective equipment shall be appropriate for conditions, as determined by authorized management.

(b) *Testing of PPE.* PPE shall be verified with regularity and by methods that are consistent with the exposure of employees to electrical hazards.

(3) Barriers.

Barriers shall be devices that prevent contact with energized or grounded surfaces that could present an electrical hazard.

(4) Voltage Equalization.

Voltage equalization shall be permitted by bonding a conductive surface to an exposed energized surface, either directly or through a resistance, so that there is insufficient voltage to create an electrical hazard.

(5) Isolation.

Isolation shall be established by placing equipment or other items in locations such that employees are unable to simultaneously contact exposed conductive surfaces that could present an electrical hazard.

(6) Safe Work Practices.

Employees shall be trained in safe work practices. The training shall include why the work practices in a cell line working zone are different from similar work situations in other areas of the plant. Employees shall comply with established safe work practices and the safe use of protective equipment.

(a) *Attitude Awareness.* Safe work practice training shall include attitude awareness instruction. Simultaneous contact with energized parts and ground can cause serious electric shock. Of special importance is the need to be aware of body position where contact may be made with energized parts of the electrolytic cell line and grounded surfaces.

(b) *Bypassing of Safety Equipment.* Safe work practice training shall include techniques to prevent bypassing the protection of safety equipment. Clothing may bypass protective equipment if the clothing is wet. Trouser legs should be kept at appropriate length, and shirt sleeves should be a good fit so as not to drape while reaching. Jewelry and other metal accessories that may bypass protective equipment shall not be worn while working in the cell line working zone.

(7) Tools.

Tools and other devices used in the energized cell line work zone shall be selected to prevent bridging between surfaces at hazardous potential difference.

Informational Note: Tools and other devices of magnetic material could be difficult to handle in the area of energized cells due to their strong dc magnetic fields.

(8) Portable Cutout-Type Switches.

Portable cell cutout switches that are connected shall be considered as energized and as an extension of the cell line working zone. Appropriate procedures shall be used to ensure proper cutout switch connection and operation.

(9) Cranes and Hoists.

Cranes and hoists shall meet the requirements of applicable codes and standards to safeguard employees. Insulation required for safeguarding employees, such as insulated crane hooks, shall be periodically tested.

(10) Attachments.

Attachments that extend the cell line electrical hazards beyond the cell line working zone shall use one or more of the following:

(1) Temporary or permanent extension of the cell line working zone

(2) Barriers

(3) Insulating breaks

(4) Isolation

(11) Pacemakers and Metallic Implants.

Employees with implanted pacemakers, ferromagnetic medical devices, or other electronic devices vital to life shall not be permitted in cell areas unless written permission is obtained from the employee's physician.

> Informational Note: The American Conference of Governmental Industrial Hygienists (ACGIH) and IEEE 463, *Electrical Safety Practices in Electrolytic Cell Line Working Zones*, recommend that persons with implanted pacemakers should not be exposed to magnetic flux densities above 5 gauss.

(12) Testing.

Equipment safeguards for employee protection shall be tested to ensure they are in a safe working condition.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_36.pdf	70E_CN36	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 36 appeared in the First Draft Report on First Revision No. 94.

The Correlating Committee requests that the Technical Committee consider removing "as defined in this article" to correlate with the Article 100 definition of "qualified person".

Related Item

• First Revision No. 94

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:26:08 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 36-NFPA 70E-2025 [Section No. 350.5 [Excluding any Sub-Sections]]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:50:27 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee consider removing “as defined in this article” to correlate with the Article 100 definition of “qualified person”.

First Revision No. 94-NFPA 70E-2024 [Section No. 350.5 [Excluding any Sub-Sections]]

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 124-NFPA 70E-2025 [Section No. 360.1]

360.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while manufacturing, handling, or working with ~~exposed stationary storage~~ batteries that exceed 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

Statement of Problem and Substantiation for Public Comment

PI 139 in the first draft of 2027 NFPA 70E requested the scope of the article on batteries and battery rooms be revised to include working on portable batteries used for electric vehicles. The technical committee rejected the request citing 90.3(B)(1) as making the internal wiring of automotive vehicles out of the scope of NFPA 70E. However, the manufacturing of batteries for electric vehicles or batteries for any other purpose besides stationary storage, where those batteries pose the same hazard, should be able to use the methods of risk management addressed in NFPA 70E. This public comment does not change the scope, it merely makes it clear that NFPA 70E risk management principles can be used to address electrical hazards presented by all batteries unless they are part of the internal wiring of an automobile.

Related Item

• PI 139 was rejected. This PC meets the intent of PI 139 and addresses the TC substantiation for rejection.

Submitter Information Verification

Submitter Full Name: Bobby Gray
Organization: Hoydar/Buck, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue May 27 14:08:21 EDT 2025
Committee: EEW-AAA

Public Comment No. 150-NFPA 70E-2025 [Section No. 360.1]

360.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while working with ~~exposed stationary storage~~ exposed storage batteries that exceed 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~~ storage 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

Statement of Problem and Substantiation for Public Comment

This would address the hazards of working with batteries that are not considered stationary. The same hazards are encountered with batteries that are portable, like those in electric vehicle battery assembly plants. This would add them to the scope of this article and therefor NFPA 70E.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 210-NFPA 70E-2025 [Section No. 360.3(B)(4)]	

Related Item

• PI 139

Submitter Information Verification

Submitter Full Name: Scott Lubaczewski
Organization: UAW
Affiliation: UAW-GM Joint Programs
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 02 10:48:54 EDT 2025
Committee: EEW-AAA

Public Comment No. 163-NFPA 70E-2025 [Section No. 360.1]

360.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while working with exposed stationary storage or other batteries that exceed 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

Statement of Problem and Substantiation for Public Comment

This proposed change removes a critical loophole that the previous change (FR-81 based on PI-103) could lead to. Batteries designed for electric vehicles are being installed as stationary storage batteries, in the vehicle, after it has been removed from the vehicle, or without ever having been installed in a vehicle (a dual-purpose battery pack). These batteries exceed one or more of the thresholds in 360.3(A) but it is ambiguous as to if the requirements of this section could be applied to protect the workers that assemble, install, maintain, or remove them.

Related Item

• First Revision No. 81-NFPA 70E-2024 • Public Input No. 103-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: David Rosewater

Organization: Sandia National Laboratories

Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Jun 02 15:12:06 EDT 2025
Committee:	EEW-AAA

Public Comment No. 62-NFPA 70E-2025 [Section No. 360.1]

360.1 Scope.

This article covers electrical safety requirements for the practical safeguarding of employees while working with exposed stationary storage batteries that exceed 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

Additional Proposed Changes

File Name	Description	Approved
70E_CN_31.pdf	70E_CN31	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 31 appeared in the First Draft Report on First Revision No. 81.

The technical committee needs to review the scope statement that includes the reference to 360.3(A) and consider not using a reference to a specific requirement in the scope of an article.

Related Item

• First Revision No. 81

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:07:51 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 31-NFPA 70E-2025 [Section No. 360.1]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:45:40 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The technical committee needs to review the scope statement that includes the reference to 360.3(A) and consider not using a reference to a specific requirement in the scope of an article.

FR-81-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 64-NFPA 70E-2025 [Section No. 360.3(A)]

(A) Electrical Hazard Thresholds.

Exposure levels shall not exceed the following unless appropriate controls are implemented:

(1) Alternating current (ac): 50 volts and 5 milliamperes

(2) 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 four.

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

Additional Proposed Changes

File Name	Description	Approved
70E_CN_33.pdf	70E_CN33	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 33 appeared in the First Draft Report on First Revision No. 82.

The Correlating Committee requests that the Technical Committee verify that the title in (A) "electrical hazard" is correct for this section.

Related Item

• First Revision No. 82

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:20:09 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 33-NFPA 70E-2025 [Section No. 360.3(A)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:47:40 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee verify that the title in (A) “electrical hazard” is correct for this section.

FR-82-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned
Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All
Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 164-NFPA 70E-2025 [Section No. 360.3(B)(2)]

(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 one of 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.

Statement of Problem and Substantiation for Public Comment

This requirement could be erroneously interpreted as the need to use tools that are both insulated and too short to cause a short-circuit. The requirement should be that tools are either too short to cause a short-circuit (hence insulation would be redundant) or insulated to the working voltage. Both bullet points are independently sufficient to guard against short-circuit. Please change the text “Tools meeting one of the following criteria” or “Tools meeting at least one of the following criteria.”

Related Item

• First Revision No. 85-NFPA 70E-2024 • Public Input No. 109-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name:	David Rosewater
Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	

Submittal Date:	Mon Jun 02 15:14:28 EDT 2025
Committee:	EEW-AAA

Public Comment No. 38-NFPA 70E-2025 [Section No. 360.3(B)(2)]

(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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_6.pdf	70E_CN6	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 6 appeared in the First Draft Report on First Revision No. 85.

The Correlating Committee requests that the Technical Committee review the text in 360.3(B)(2)b(2)c to comply with the NEC Style Manual Section 2.1.6.3.4 regarding subdivision numbering.

Related Item

• First Revision No. 85

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Thu Apr 03 13:51:10 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 6-NFPA 70E-2025 [Detail]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:36:28 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 360.3(B)(2)b(2)c to comply with the NEC Style Manual Section 2.1.6.3.4 regarding subdivision numbering.

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

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 166-NFPA 70E-2025 [Section No. 360.3(B)(3)]

(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 distance 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~~

(4) conductor .

(5) 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.

Statement of Problem and Substantiation for Public Comment

Editorial correction. Change “spacing separation” to “separation distance” to 1: remove the redundancy of synonyms ‘spacing’ and ‘separation’ and 2: to be consistent with the language in 360.3 (B) (4) (b) (4).
Editorial correction. Change “grounded surface” to “grounded conductor” to 1: remove the ambiguity of if a non-conductive surface qualifies (it should not), and 2: maintain consistent language with the rest of the standard.
Editorial correction. Switch 360.3 (B) (3) (b) (2) and 360.3 (B) (3) (b) (3) to follow the hierarchy of controls as (3) is an administrative control and (2) is PPE.

Related Item

• First Revision No. 86-NFPA 70E-2024 • Public Input No. 108-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name:	David Rosewater
Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	

Submittal Date:	Mon Jun 02 15:17:39 EDT 2025

Committee: EEW-AAA

Public Comment No. 210-NFPA 70E-2025 [Section No. 360.3(B)(4)]

(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~~ on 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:

(4) The location of the gap where an arc could occur

(5) The arc flash boundary

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

Statement of Problem and Substantiation for Public Comment

Arc Flash Risk Assessments need to be performed on battery systems not considered stationary also, such as EV batteries that are included in the scope of Article 360.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 150-NFPA 70E-2025 [Section No. 360.1]	

Related Item

• PI 139

Submitter Information Verification

Submitter Full Name: Scott Lubaczewski
Organization: UAW
Street Address:
City:

State:	
Zip:	
Submittal Date:	Tue Jun 03 12:22:55 EDT 2025
Committee:	EEW-AAA

Public Comment No. 39-NFPA 70E-2025 [Section No. 360.3(B)(4)]

(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

Additional Proposed Changes

File Name	Description	Approved
70E_CN_7.pdf	70E_CN7	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 7 appeared in the First Draft Report on First Revision No. 87.

The Correlating Committee requests that the Technical Committee review the text in 360.3(B)(4)(a)(1) regarding the word “matter” and consider changing to “manner”.

Related Item

• First Revision No. 87

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:

City:
State:
Zip:
Submittal Date: Thu Apr 03 13:53:31 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 7-NFPA 70E-2025 [Detail]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:39:59 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 360.3(B)(4)(a)(1) regarding the word “matter” and consider changing to “manner”.

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

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 83-NFPA 70E-2025 [Section No. 360.3(B)(4)]

(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~~ manner 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:

(4) The location of the gap where an arc could occur

(5) The arc flash boundary

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

Statement of Problem and Substantiation for Public Comment

This public comment only changes "matter" to "manner", which is the more correct term to use.

Related Item

• FR-87

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 14 16:10:54 EDT 2025

Committee:	EEW-AAA

Public Comment No. 65-NFPA 70E-2025 [Section No. 360.3(F)]

(F) Warning Signs.

The following warning signs or labels shall be posted in appropriate locations:

(1) Electrical hazard warnings indicating the electric shock hazard, arc flash 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) 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

Additional Proposed Changes

File Name	Description	Approved
70E_CN_34.pdf	70E_CN34	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 34 appeared in the First Draft Report on First Revision No. 88.

The Correlating Committee requests that the Technical Committee review the text in 360.3(F)(2)a regarding "(when applicable to the battery type)" and 360.3(F)(2)c "(when applicable to the battery type)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

Related Item

• First Revision No. 88

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee

Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:21:27 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 34-NFPA 70E-2025 [Section No. 360.3(F)]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:48:39 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in 360.3(F)(2)a regarding "(when applicable to the battery type)" and 360.3(F)(2)c "(when applicable to the battery type)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

FR-88-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 63-NFPA 70E-2025 [Section No. 360.4]

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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_32.pdf	70E_CN32	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 32 appeared in the First Draft Report on First Revision No. 91.

The Correlating Committee requests that the Technical Committee provide titles in 360.4(A)(1), (2) and (3) in accordance with NEC Style Manual Section 2.1.6.3.2 regarding subdivision titles.

Related Item

• First Revision No. 32

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:18:37 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 32-NFPA 70E-2025 [Section No. 360.4]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:47:02 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee provide titles in 360.4(A)(1), (2) and (3) in accordance with NEC Style Manual Section 2.1.6.3.2 regarding subdivision titles.

FR-91-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 100-NFPA 70E-2025 [Section No. 360.4(A)]

(A) General.

Each employer whose employees perform work on batteries shall establish, document, and implement a battery hazardous energy control program.

(1) ~~Head Needed.~~ Procedures

The battery hazardous energy control program shall specify procedures to safeguard workers from exposure to battery electrical hazards.

(2) ~~Head Needed.~~ Work Planning

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.~~ Battery Sectionalizing

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.

Statement of Problem and Substantiation for Public Comment

This Public Comment adds suggested 2nd level subdivision titles as required by 2.1.6.3.2 of the 2023 NEC Style Manual

Related Item

• FR-91

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 20 11:38:42 EDT 2025
Committee: EEW-AAA

Public Comment No. 167-NFPA 70E-2025 [Section No. 360.4(A)(1)]

(1) ~~Head Needed~~ Battery hazardous energy control program .

The battery hazardous energy control program shall specify procedures to safeguard workers from exposure to battery electrical hazards.

Statement of Problem and Substantiation for Public Comment

Head needed change to “Battery hazardous energy control program”

Related Item

• First Revision No. 91-NFPA 70E-2024 • Public Input No. 114-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name:	David Rosewater
Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	

Submittal Date:	Mon Jun 02 15:26:14 EDT 2025
Committee:	EEW-AAA

Public Comment No. 168-NFPA 70E-2025 [Section No. 360.4(A)(2)]

(2) ~~Head Needed~~ Work planning .

Employees performing work within the restricted approach boundary of a battery shall plan work to minimize exposure to electric shock and arc flash hazards.

Statement of Problem and Substantiation for Public Comment

Head needed change to “Work planning”

Related Item

• First Revision No. 91-NFPA 70E-2024 • Public Input No. 114-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name:	David Rosewater
Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	

Submittal Date:	Mon Jun 02 15:29:50 EDT 2025
Committee:	EEW-AAA

Public Comment No. 169-NFPA 70E-2025 [Section No. 360.4(A)(3)]

(3) ~~Head Needed~~ Risk reduction method .

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.

Statement of Problem and Substantiation for Public Comment

Head needed change to “Risk reduction method”

Related Item

• First Revision No. 91-NFPA 70E-2024 • Public Input No. 114-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name:	David Rosewater
Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	

Submittal Date:	Mon Jun 02 15:31:02 EDT 2025
Committee:	EEW-AAA

Public Comment No. 172-NFPA 70E-2025 [New Section after 360.4(B)(2)]

Lockout/Tagout Charger

Apply lockout/tagout devices to the battery charger(s) in accordance with a documented and established procedure.

Statement of Problem and Substantiation for Public Comment

See proposed change to 360.4(B)(2) Charger Mode. This is a good requirement, but it should be clear that the requitement to lock applies to both bypass mode and to turned off mode. The requirement to lock it is independent of the requirement to switch it into bypass or off.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 170-NFPA 70E-2025 [Section No. 360.4(B)(2)]	
Public Comment No. 170-NFPA 70E-2025 [Section No. 360.4(B)(2)]	

Related Item

• First Revision No. 91-NFPA 70E-2024 • Public Input No. 114-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name:	David Rosewater
Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	

Submittal Date:	Mon Jun 02 15:36:56 EDT 2025
Committee:	EEW-AAA

Public Comment No. 170-NFPA 70E-2025 [Section No. 360.4(B)(2)]

(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.

Statement of Problem and Substantiation for Public Comment

This is a good requirement, but it should be clear if the requitement to lock applies to both bypass mode and to turned off mode or if it applies only to turned off mode. Proposed alternative text “The battery charger shall either be placed into bypass mode or turned off prior to sectionalizing the battery.” Then add a new section after this one “Apply lockout/tagout devices to the battery charger in accordance with a documented and established procedure.”

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 172-NFPA 70E-2025 [New Section after 360.4(B)(2)]	
Public Comment No. 172-NFPA 70E-2025 [New Section after 360.4(B)(2)]	

Related Item

• First Revision No. 91-NFPA 70E-2024 • Public Input No. 114-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name:	David Rosewater
Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	

Submittal Date:	Mon Jun 02 15:32:44 EDT 2025
Committee:	EEW-AAA

Public Comment No. 173-NFPA 70E-2025 [Section No. 360.4(C)(2)]

(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~~ energy isolation 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.

Statement of Problem and Substantiation for Public Comment

This section uses the term lockout device when it means energy isolation device that a tag is applied to in tagout.

Related Item

• First Revision No. 91-NFPA 70E-2024 • Public Input No. 114-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name:	David Rosewater
Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Jun 02 15:45:05 EDT 2025
Committee:	EEW-AAA

Public Comment No. 174-NFPA 70E-2025 [Section No. 360.4(D)(3)]

(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(s) , group lockbox(es) , or comparable ~~mechanism~~ mechanisms when the employee begins work.

(2) Review the battery risk assessment associated with the current configuration of the battery to identify required protective measures including PPE.

(3) 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.

Statement of Problem and Substantiation for Public Comment

Group Sectionalizing procedures should account for how the group moves between risk assessments and PPE in stages. Unlike other equipment batteries stay energized even when disconnected so employees need to understand the current condition of the battery to know what controls are needed to keep them safe.

Related Item

• First Revision No. 91-NFPA 70E-2024 • Public Input No. 114-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: David Rosewater

Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group
Street Address:	
City:	
State:	
Zip:	

Submittal Date:	Mon Jun 02 15:47:54 EDT 2025
Committee:	EEW-AAA

Public Comment No. 175-NFPA 70E-2025 [Section No. 360.4(E)(4)]

(4) Initial Assembly, Installation, or 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 the means and order that battery circuit connections are to be made and any resulting changes in the following:

a. Direct current (dc) voltage,

b. Available short circuit power,

c. Contact thermal PPE,

d. Limited approach boundary,

e. Restricted approach boundary,

f. Electric shock PPE,

g. Arc flash incident energy,

h. Arc flash boundary, and

i. Arc flash PPE."

(a) The procedure shall identify any wires or flexible circuit elements that could be reinstalled improperly resulting in a battery short circuit.

(b) Reinstallation of these circuit elements shall be identified in the procedure as having an elevated risk of short circuit.

(c) When ~~returning a battery to service~~ - ~~PPE~~

(c) (a) performing battery circuit manipulation , employees shall wear the PPE identified

(d)

(a) for the resulting circuit configuration prior to making any circuit connection that increases the risk of shock, thermal, or arc flash hazard.

Statement of Problem and Substantiation for Public Comment

This is the section that identifies the requirements for initial installation or assembly of battery equipment. In this roll it insufficiently detailed. At minimum, it should include requirements that the procedure identify when the electrical hazards change and by how much. Editorial correction to the last sentence to be more clear about exactly when employees shall ware what PPE.

Related Item

• First Revision No. 91-NFPA 70E-2024 • Public Input No. 114-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name:	David Rosewater
Organization:	Sandia National Laboratories
Affiliation:	The IEEE Energy Storage and Stationary Battery Committee (ESSB) Codes Working Group and the Energy Facilities Contractors Group (EFCOG), DC Working Group

Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 02 15:56:06 EDT 2025
Committee: EEW-AAA

Public Comment No. 101-NFPA 70E-2025 [Section No. 370.5 [Excluding any Sub-Sections]]

Each laboratory or R&D system application shall designate a qualified person ~~as defined in this article~~ to ensure the use of appropriate electrical safety-related work practices and controls.

Statement of Problem and Substantiation for Public Comment

FR-94 modified this requirement to change "competent person" to "qualified person". Since all definitions are now relocated to Article 100, the phrase "as defined in this article" is no longer correct.

Related Item

• FR-94

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 20 11:58:32 EDT 2025
Committee: EEW-AAA

Public Comment No. 205-NFPA 70E-2025 [New Section after 380.2(A)]

Electrical Hazard Thresholds

Exposure levels shall not exceed the following unless controls are implemented:

(1) The highest voltage of the EDLCs exceeds 100 volts dc.

(2) The theoretical maximum power exceeds 1000 watts.

Informational Note: The theoretical maximum power for EDLCs is calaculated as $V^2/(4*R)$, where V is the initial voltage across the string of capacitors and R is the equivalent series resistance of the string of capacitors, including all connection resistances.

Statement of Problem and Substantiation for Public Comment

This change is intended to make this article mirror other articles such as 360 where there is a specific section for thresholds. Additionally, an informational note was added to explain how to determine the theoretical maximum power.

This proposal has been submitted on behalf of an EDLC task group consisting of Steve Edley, Dave Wright, Curtis Ashton, Lloyd Gordon

Related Item

• FR-100

Submitter Information Verification

Submitter Full Name: Steve Edley
Organization: Atlas Power Technologies
Affiliation: Atlas Power Technologies
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 11:34:09 EDT 2025
Committee: EEW-AAA

Public Comment No. 127-NFPA 70E-2025 [Section No. 380.2(B)(4)]

(4) PPE.

~~The appropriate~~ PPE ~~for the hazards~~ shall be determined meeting the ~~following conditions~~ conditions in 380.2(B)(4) list items (1), (2) and (3) :

(1) Contact thermal hazard — ~~the appropriate~~ contact thermal PPE in accordance with 130.7(C)(7)(e) 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(C) 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: Arc flash~~ hazard — arc flash PPE in accordance with 130.7 (C) if the voltage exceeds 150 volts dc and the incident energy exceeds 1.2 cal/ ~~cm~~ ^{2} - cm2 (~~5 J~~ 5J / ~~cm~~ ^{2} cm2) at the working distance

(4) ~~Alerting techniques in accordance with~~ ~~130.8(O)~~ ~~to warn employees of the hazards~~

(5)

(6)

Statement of Problem and Substantiation for Public Comment

The public comment offers alternate language to delete the vague and unenforceable term "appropriate" per the 2023 NEC Style Manual, section 3.2.1 and to make the list items parallel structure per the 2023 NEC Style Manual, section 3.5.5.2. List item (3)(b) is deleted, because alerting techniques are not associated with PPE and do not belong in this subsection. Since alerting techniques are already addressed in 130.8(O), they should not need to be repeated in Chapter 3.

Related Item

• FR-100

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 28 11:30:07 EDT 2025
Committee: EEW-AAA

Public Comment No. 207-NFPA 70E-2025 [Section No. 380.2(B)(4)]

(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~~ required 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

Statement of Problem and Substantiation for Public Comment

This change is intended to address the committee ballot comment regarding the use of the term "appropriate". We believe these changes address the ambiguity in this section.

This proposal has been submitted on behalf of an EDLC task group consisting of Steve Edley, Dave Wright, Curtis Ashton, Lloyd Gordon

Related Item

• FR-100 • PC-209 • PC-211

Submitter Information Verification

Submitter Full Name: Steve Edley
Organization: Atlas Power Technologies
Affiliation: Atlas Power Technologies
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 12:14:06 EDT 2025
Committee: EEW-AAA

Public Comment No. 128-NFPA 70E-2025 [Section No. 380.3(B)(1)]

(1) EDLC Discharge.

Unless a discharge method is provided by the manufacturer,

~~an appropriately sized and safeguarded resistor shall~~
a safeguarded resistor sized to safety discharge the system shall be selected, and a method shall be described to fully discharge the EDLC system.

Statement of Problem and Substantiation for Public Comment

This public comment offers alternate language to delete the vague and unenforceable term "appropriate" per the 2023 NEC Style Manual, section 3.2.1. Also note, this sentence contains two requirements and should be split into two separate clauses (a) and (b) per NEC Style Manual, section 3.5.1.2

Related Item

• FR-100

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 28 12:02:25 EDT 2025
Committee: EEW-AAA

Public Comment No. 209-NFPA 70E-2025 [Section No. 380.3(B)(1)]

(1) EDLC Discharge.

Unless a discharge method is provided by the manufacturer, ~~an appropriately sized and~~ a safeguarded resistor shall be selected capable of sustaining the worst-case current and thermal loads , and a method shall be described to fully discharge the EDLC system.

Statement of Problem and Substantiation for Public Comment

This change is intended to address the committee ballot comment regarding the use of the term "appropriate". We believe these changes address the ambiguity in this section.

This proposal has been submitted on behalf of an EDLC task group consisting of Steve Edley, Dave Wright, Curtis Ashton, Lloyd Gordon

Related Item

• FR-100 • PC-207 • PC-211

Submitter Information Verification

Submitter Full Name: Steve Edley
Organization: Atlas Power Technologies
Affiliation: Atlas Power Technologies
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 12:21:29 EDT 2025
Committee: EEW-AAA

Public Comment No. 129-NFPA 70E-2025 [Section No. 380.3(C)(1)]

(1) Uninstalled Capacitors.

~~All~~ After being discharged, all uninstalled capacitors shall be short-circuited with a conductor ~~of appropriate size after being discharged.~~ sized to safely maintain the capacitors in a discharged state for storage and transport.

Statement of Problem and Substantiation for Public Comment

The public comment offers alternate language to delete the vague and unenforceable term "appropriate" per the 2023 NEC Style Manual, section 3.2.1

Related Item

• FR-100

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 28 12:16:38 EDT 2025
Committee: EEW-AAA

Public Comment No. 211-NFPA 70E-2025 [Section No. 380.3(C)(1)]

(1) Uninstalled Capacitors.

All uninstalled capacitors shall be short-circuited with a ~~conductor of appropriate size after~~ 22 AWG or larger conductor after being discharged.

Statement of Problem and Substantiation for Public Comment

This change is intended to address the committee ballot comment regarding the use of the term "appropriate". We believe these changes address the ambiguity in this section.

This proposal has been submitted on behalf of an EDLC task group consisting of Steve Edley, Dave Wright, Curtis Ashton, Lloyd Gordon

Related Item

• FR-100 • PC-207 • PC-209

Submitter Information Verification

Submitter Full Name: Steve Edley
Organization: Atlas Power Technologies
Affiliation: Atlas Power Technologies
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 12:25:46 EDT 2025
Committee: EEW-AAA

Public Comment No. 226-NFPA 70E-2025 [Article 390]

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.

Replace the above with the following:

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 Employee Training

(A) General Requirements

The training requirements shall apply to employees exposed to electrical hazards associated with work on or near solar energy sources, including the interconnected photovoltaic equipment, collection systems and associated power conversion system. An emphasis shall include the issue of continuously energized systems, including the issue that an Electrically Safe Work Condition cannot be achieved on PV panels.

(B) Employee Training

Employees who install, operate, maintain, or repair solar installations and equipment shall be trained in the operating characteristics of the PV modules and equipment with which they will work. Only qualified electrical workers shall work on PV installations and equipment. They shall be trained to:

(1) recognize the continuously energized nature of PV panels,

(2) perform a risk assessment for energized electrical work,

(3) develop and follow procedures that minimize exposure, and

(4) use control measures, including PPE to prevent injury.

390.4 PV Risk Assessments.

Prior to any work on an energized PV array, risk assessments 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. Article 130 shall be used to perform risk assessments on the 60 Hz sources.

(A) Thermal Risk Assessment

A thermal risk assessment shall be performed for systems that can provide a thermal hazard, 390.2(1), to the worker. Procedures shall be developed and PPE worn, to prevent contact thermal burn injury.

(B) Electric Shock Risk Assessment

An electric shock risk assessment shall be performed in accordance with 130.4, for those systems that exceed the dc shock threshold, 390.2(2). Work procedures shall focus on risk reduction by avoiding exposure to energized components. Shock PPE shall be worn, if required.

(C) Arc Flash Risk Assessment

An arc-flash risk assessment shall be performed on PV systems above 150 V dc, per 390(3). If incident energy may exceed 1.2 cal/cm2, efforts shall be implemented to avoid creating an arc and to choose appropriate arc-rated PPE if required.

390.5 Specific Work Procedures.

(A) Hazard Thresholds.

When work must be performed on exposed PV terminal greater than the shock or arc flash thresholds, 390.2, additional protective methods shall be determined in accordance with Articles 130.4(C) and 130.5(C).

(B) Conductor Manipulation.

Before manipulating any connectors on an energized system, a risk assessment shall be performed to determine the maximum open circuit voltage that would be generated and the maximum current to be interrupted if a fault were to occur.

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.

Specific 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. Procedures for unplugging PV module cable connectors shall include testing for absence of load current prior to disconnecting.

Informational Note: An adequately rated non-contact test instrument capable of measuring amperage ("amp clamp") can be used to perform this test.

Statement of Problem and Substantiation for Public Comment

The original PIs, 142 and 245, were the first inputs for a new article. PI 245 was chosen for the First Revision 102, as it was more ready for the NFPA syle, but, it was rather brief.
This newly revised Article 390 was a joint effort between the authors of the two PIs 142 and 245, and industry that installs and maintains large solar arrays. Elements of the long 142 were added to the short 245 to be more complete.

Related Item

• PI 142 • PI 245 • FR 102

Submitter Information Verification

Submitter Full Name: Lloyd Gordon
Organization: Gordon
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 13:03:32 EDT 2025
Committee: EEW-AAA

Public Comment No. 34-NFPA 70E-2025 [Section No. 390.1]

390.1 Scope.

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

Additional Proposed Changes

File Name	Description	Approved
70E_CN_2.pdf	70E_CN2	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 2 appeared in the First Draft Report on First Revision No. 102.

The Correlating Committee requests that the Technical Committee review the scope section. A PV system (as defined by the NEC) includes the ac output. This new article appears to only address the dc conductors of the PV system. Consider the appropriateness of the use of the word “robust” as mentioned in the ballot comment.

Related Item

• First Revision No. 102

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date: Thu Apr 03 13:06:21 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 2-NFPA 70E-2025 [Article 390]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Wed Jan 15 16:21:22 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the scope section. A PV system (as defined by the NEC) includes the ac output. This new article appears to only address the dc conductors of the PV system. Consider the appropriateness of the use of the word “robust” as mentioned in the ballot comment.

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

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned
Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All
Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 130-NFPA 70E-2025 [Section No. 390.2]

390.2 Energy Hazard Thresholds.

~~Appropriate~~ Applicable 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

Statement of Problem and Substantiation for Public Comment

The public comment offers alternate language to delete the vague and unenforceable term "appropriate" per the 2023 NEC Style Manual, section 3.2.1.

Related Item

• FR-102

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Wed May 28 12:27:07 EDT 2025
Committee: EEW-AAA

Public Comment No. 142-NFPA 70E-2025 [Section No. D.5]

D.5 Direct-Current Incident Energy Calculations.

<<<I am not trying to edit the text, but I would like to comment on the changes to D.5. I agree that we need better and more precise ways to assess the DC arc flash hazard, but I do not think the new sections in 70E Annex D.5 will lead the industry in the desired direction. The new equations are a piecemeal approach and have not been well validated. Specific applications for their use and their limitations are not well defined. I will try to attach my comments as a file on a later screen of this editor. >>

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	Gap Distance, above which arc will quickly extinguish	
(volts)	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 *(see reference 4)* 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. 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.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.3a]}$$

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.

$$K_{ab} = \left[0.55 \times In\left(d_{ab}\right)\right] - 0.6 \quad \textbf{[D.5.3b]}$$

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 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.

$$T_{arc} = 0.0043 \times V_{sys} \quad \textbf{[D.5.4]}$$

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.

Additional Proposed Changes

File Name	Description	Approved
2025March19_TGammon_70E_Annex_D.5.docx	Specific and Global Comments - Annex D.5	

Statement of Problem and Substantiation for Public Comment

I am concerned about the changes to NFPA 70E Annex D.5 Direct-Current Incident Energy Calculations scheduled to appear in the next edition of 70E. A comprehensive procedure for addressing the DC arc-flash hazard needs to be developed. The new equations are a piecemeal approach and have not been well validated. Specific applications for their use and their limitations are not well defined. In addition, some of the supplemental material suggested is not completely accurate and is not completely applicable to DC arcing. Please read my attached text carefully.

Related Item

• Changes to Annex D.5

Submitter Information Verification

Submitter Full Name: Tammy Gammon
Organization: John Matthews and Associates, Inc.
Street Address:
City:
State:

Zip:	
Submittal Date:	Sat May 31 13:47:01 EDT 2025
Committee:	EEW-AAA

Tammy Gammon, PhD, PE, IEEE Fellow

July 23, 2025

Subject: Annex D.5 Direct-Current Incident Energy Calculations

Dear NFPA 70E Committee:

I am concerned about the changes to NFPA 70E Annex D.5 Direct-Current Incident Energy Calculations scheduled to appear in the next edition of 70E. My work with arcing faults and arc flash incidents began in graduate school in the 1990s. I have published about fifty IEEE papers on arcing faults, arc flash phenomena, arc modeling, and electrical injuries. I wrote a key 2015 article on DC arc models. I was a secondary author on another well-known article that presented the Ammerman/Sen DC arc model. I have been involved with IEEE 1584 and was the research manager of the IEEE Arc Flash Project from 2006 to 2014.

While I agree that a comprehensive set of guidelines addressing potential DC arc-flash hazards is needed, I do not think the new sections in 70E Annex D.5 will lead the industry in the desired direction. The new equations are a piecemeal approach and have not been well validated. Specific applications for their use and their limitations are not well defined. If 70E published these equations, they would be used worldwide because they will be deemed as being endorsed by NFPA 70E. If a worker is severely injured by a DC arc flash, the establishment where the injury occurs would use the 70E Standard as a buffer for liability, whether the equation was improperly used, its application was improperly explained in 70E, or the equation just failed to predict the hazard.

In the following paragraphs, I will share some initial thoughts and impressions about 70E D.5 with the Committee. I am relying on my years of experience and a preliminary review of articles on DC arcing published in recent years.

D.5.1 It would be helpful if these statements were more focused on DC arcing as applicable to DC equipment. Discussion might include the impact of voltage and current levels and gap width and how these factors affect the likelihood of a self-sustaining DC arc.

D.5.2 I agree that eroding electrodes and elongating DC arcs (increasing the arc voltage), which are time-dependent, contribute to arc extinction. The correlation between various electrode materials and erosion rate is not mentioned, but has been addressed in DUGV 203-077. The equations presented aim to determine the widest gap for which an arc can be sustained as a function of system voltage.

This set of equations raises several concerns:

1) Using Eqn. D5.2b does not reproduce the values in Table D.5.2?
2) How will they be used in a DC arc flash assessment?
3) Specific guidance for using this set of equations is not provided.
4) No validation or substantiation of this set of equations is provided.
5) Three references (Gordon, Ammerman et al., and Ashton) are provided. I find not find these equations in the three references. Gordon does provide a table of minimum voltages for vertical gaps and includes some discussion.

D.5.3 The maximum power method was published by Doan in 2010 and is included in the current and prior editions of NFPA 70E.

Recommendations on DC arc flash should be validated by testing. I do agree that enclosures will reflect energy from both AC and DC arcs.

I am concerned about using a multiplier with the maximum power method, which as recent papers (including Gray et al. 2020) have noted, overpredicts the incident energy. The disparity is inversely but nonlinearly related to the system voltage.

D.5.4 The duration of the arc depends on system voltage, but it also depends on gap width, short-circuit current, and other factors. I certainly understand the need to define and limit the arc duration to realistic values, but DC arc models presented by industry standards should rely on more than the plot in Reference 3, Figure 1 for substantiation. It also needs to be part of a procedure for assessing the potential DC arc-flash hazard.

Additional Notes:

D.5.5 Stokes/Oppenlander tests were based on **decaying DC arcs up to 1 kA and single-phase sinusoidally decaying 50 Hz arc up to 20 kA.** The electrodes were placed in series for both horizontal and vertical positioning. Stokes/Oppenlander observed that the arc power tended to be more constant than either the instantaneous arc current or the arc voltage. Stokes/Oppenlander presented an equation for arc power as a nonlinear relationship with arc current, but linear with gap width. **Stokes/Oppenlander did not use this relationship to determine the incident energy or as part of an iterative technique.**

D5.6 Paukert presented equations for arc voltage as a nonlinear function of arc current for seven different gap widths (1 to 200 mm). The equations were based on seven sets of test data: two DC (vertical electrodes, one set Cu, and one set Mo), four AC (both vertical and

horizontal), and one impulse. Supply voltages were not given. Based on the arc characteristics in Figure 1, **one set of DC test data involved arc currents below 100 A.** I could not identify the other DC data in the hand-drawn graph.

The equations are not representative of a range of DC arcs. They were not used to determine arc power or incident energy.

D5.8 An arc resistance equation is developed from the Stokes/Oppenlander equation for instantaneous power. The arc current is determined through iteration using the arc resistance equation and circuit parameters. The incident energy is determined using a spherical surface for open air arcs or Wilkins' formula (~2004) derived based on three-phase AC arc testing for arcs in enclosures.

I recommend omitting D5.5 and D5.6.

In Summary:

A comprehensive procedure for addressing the DC arc-flash hazard needs to be developed. The recommendations must be based on DC arc testing over a wide range of parameters which cover realistic DC installations.

Sincerely,

Tammy Gammon
tgammonphd@gmail.com

Public Comment No. 141-NFPA 70E-2025 [Section No. D.5.1]

~~**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)* .~~

Additional Proposed Changes

File Name	Description	Approved
.1748913731581 70E_2027_Annex_D5_CHANGES_ACCEPTED_consolidated.docx	AnnexD5 as Proposed	

Statement of Problem and Substantiation for Public Comment

The following comments are the consensus recommendations of NFPA 70E 2027 Informative Annex D.5 Task Group formed by NFPA 70E Chair. Members of this group are Ray Crow, Lloyd Gordon (ad hoc), Mike Lang, Wei-Jen Lee, Albert Marroquin, Tony Parsons, Jim Phillips, David Rosewater and Daleep Mohla (Chair).

The arc is a dynamic phenomenon no matter if it is AC or DC. The accepted text from FR-71 states “Direct-current arcs are similar to three-phase ac arcs in that continuously flowing current maintains the hot plasma”. This is a false analogy, and no technical testing data has been provided to support this assertion. While in a DC arc, continuously following current maintains the hot plasma, three-phase AC arcs generate plasma alternately between different phases (they push different portions of the hot plasma and are not uniform). Annex D5 is titled “Direct- Current Incident Energy Calculation Methods”. The proposed text does not provide any method to calculate incident energy. The Maximum Power Method forms the basis of PPE selection in Table 130.7 (C)(15)(b). Including this reference as the first item in this section would create confusion to the reader because it does not provide a method to calculate incident energy.

Recommendation:
Delete the text for D.5.1 from Annex D5.1 in the First Draft and retain the existing text in NFPA 70E 2024 Informative Annex D.5.1.

Related Item

• FR71

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Sat May 31 13:43:08 EDT 2025
Committee: EEW-AAA

D.5 Direct-Current Incident Energy Calculations.

D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.1]}$$

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} = 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).

D.5.2 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.

).5.3 Short Circuit Current and Clearing time

The determination of the short-circuit current is necessary in order to use Table 130.7 (C)(15) and to determine the arcing current.

.
The manufacturer or the equipment supplier is the best source to obtain the data necessary to calculate the dc short-circuit current from sources such as batteries, capacitors, motors, and photovoltaics. The total short-circuit current in the system depends on the total network impedance between the source and the point of the arc fault. The arc duration of the dc arc is determined based on the clearing time of the protective devices typically obtained using the arc current and needs to consider the discharge time of energy storing components as well. The arcing current and protective device clearing time is determined by a qualified person(s) based on system parameters, design and analysis.

The short-circuit current a battery can deliver depends on the total impedance of the short-circuit path.
For lead-calcium batteries, a conservative estimate of the short-circuit current at 25°C is 10 times the battery's 1-minute discharge rating (to 1.75 volts per cell at 25°C with a specific gravity of 1.215).

A more accurate value for a specific application can be obtained from the battery manufacturer or the equipment supplier.

References:

1. IEEE 946-2020, *Recommended Practice for the Design of DC Auxiliary Powers Systems for Generating Stations*

Public Comment No. 159-NFPA 70E-2025 [Section No. D.5.1]

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)*.

Statement of Problem and Substantiation for Public Comment

The paragraphs in the public input do a good job of summarizing papers that have been presented in electrical safety to highlight the challenges with current DC arc flash calculation methods. The full set of paragraphs in Public Input No. 208-NFPA 70E-2024 [Section No. D.5] does a very good of the summary. The single paragraph currently in the first draft is not as good a summary as what is in the accepted Public Input No. 208. Including all of the paragraphs in the public input summary is important to the industry to help practitioners understand the challenges and allow them to have the best information for making arc flash PPE decisions

Related Item

• Public Input No. 208

Submitter Information Verification

Submitter Full Name: Matt Hendrickson
Organization:
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 13:55:15 EDT 2025
Committee: EEW-AAA

Public Comment No. 199-NFPA 70E-2025 [Section No. D.5.1]

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)*~~ - .

All of the methods discussed below assume a static arc, not changing shape in time, but staying in a direct line path between the two electrodes. A lateral magnetic force, plus electrode erosion, results in self extinction that is not predicted by any of the static models. This static assumption is true for models based on circuit theory and plasma physics that does not include dynamic arc behavior. Only an empirical model, based on sufficient data, might predict arc behavior. However, much of the data obtained for the empirical methods is from laboratory tests and does not represent actual systems, including geometry, electrode materials, and gap distances.

This lack of accounting for the dynamic behavior of the arc is the primary reason that arc extinction times are not accounted for in the current models, and the models consistently give higher incident energy values than is measured. An example is that all of the below models will predict a higher incident energy for a higher current. However, tests show that the higher currents result in lower incident energy, due to a shorter arc lifetime due to the magnetic force rapidly elongating the arc.

Testing of dc arcs has not yet been sufficient nor consistently documented, to create adequate empirically-based models. The difficulty in modeling behavior due to magnetic forces is taking into account the geometry of the conductors, and the lack of knowledge of the erosion effects is failure to document the electrode geometries and materials, and the initial and final gap distance.

Nevertheless, there is now sufficient data and dynamic behavior studies to place bounds on the use of the current models.

Statement of Problem and Substantiation for Public Comment

The original PI 208 had 5 paragraphs for a proposed new D.5.1 section.
The Meeting Agenda had the 5 paragraphs, p. 745
The Meeting Meetings proposed an FR for these 5 new paragraphs, p. 160.
The PI Responses created FR 71 and listed the 5 new paragraphs, p. 763.
The FR Statements, listed FR 71, BUT, lost the last 4 paragraphs, and only showed the first paragraph, p. 180

An error occurred between the PI Responses creating the FR 71 and the FR Statement.

This proposed new section is background from recently published literature on dc arc behavior. It is informational and does not contain requirements. It should not be dependent on whether or not changes are accepted in the remaining D.5 sections.

Related Item

• PI 208 • FR 71

Submitter Information Verification

Submitter Full Name: Lloyd Gordon
Organization: Gordon
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jun 03 09:30:45 EDT 2025

Committee:	EEW-AAA

Public Comment No. 232-NFPA 70E-2025 [Section No. D.5.1]

~~**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)*~~ ~~.~~

Statement of Problem and Substantiation for Public Comment

The referenced paper D.5.10(1) states that more work needs to be done, specifically in the topic of obtaining useful data for effect of magnetic forces. There is no defined method for calculating arc flash incident energy affected by the dynamic behavior of DC arcs. The standard should not include content that does not support the intent described by the title of the annex "Incident Energy and Arc Flash Boundary Calculation Methods". This section also has incorrect statement about spatially varying magnetic fields of three phases of a three-phase arc combining to give a net zero effect on the motion of the arc. There are already numerous published papers and recordings of three-phase arc moving away from the source side along conductors due to magnetic field and projecting beyond the conductors. Hence the industry term "horizontal configuration of electrodes". This section should be removed.

Related Item

• FR-71

Submitter Information Verification

Submitter Full Name: Satish Shrestha
Organization: Bentley Systems, Inc
Affiliation: Bentley Systems Inc
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 15:25:44 EDT 2025
Committee: EEW-AAA

Public Comment No. 176-NFPA 70E-2025 [Section No. D.5.2]

D.5.2 Arc Extinction Observations- ~~Provides Voltage/Gap Bounds.~~

~~If~~

Electrode 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)* .~~

$$V_{min} = 1.06 \times g + 100$$ ~~[D.5.2a]~~

~~or~~

$$g_{min} = V - 100 \times 1.06$$ ~~[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~~	

and self-extinguish.

Statement of Problem and Substantiation for Public Comment

The following reference includes tests at 144 V with a final arc gap of 2.5 cm, 260 volts with a final arc gap of 6.9 cm, and tests at 520 volts with a final arc gap of 13.0 cm. In each of these tests there is evidence that the arc sustains itself for a significant amount of time past the point where the table would suggest that the arc would self extinguish.

K. Gray, S. Robert, and T. Gauthier, "Low voltage 100–500 vdc arc flash testing," in 2020 IEEE IAS Electrical Safety Workshop (ESW), 2020, pp.1–7.

The observation is correct but the equation and the table do not account for all the available data about the phenomenon.

Related Item

• First Revision No. 71-NFPA 70E-2024 • Public Input No. 222-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: David Rosewater
Organization: Sandia National Laboratories
Affiliation: Sandia National Laboratories
Street Address:
City:
State:

Zip:	
Submittal Date:	Mon Jun 02 16:10:43 EDT 2025
Committee:	EEW-AAA

Public Comment No. 190-NFPA 70E-2025 [Section No. D.5.2]

~~**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)* .~~

$$V_{min} = 1.06 \times g + 100 \quad \text{~~[D.5.2a]~~}$$

~~or~~

$$g_{min} = V - 100 \times 1.06 \quad \text{~~[D.5.2b]~~}$$

~~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~~

Additional Proposed Changes

File Name	Description	Approved
70E_2027_Annex_D5_CHANGES_ACCEPTED_consolidated.docx	Annex D5 as proposed	

Statement of Problem and Substantiation for Public Comment

The following comments are the consensus recommendations of NFPA 70E 2027 Informative Annex D.5 Task Group formed by NFPA 70E Chair. Members of this group are Ray Crow, Lloyd Gordon (ad hoc), Mike Lang, Wei-Jen Lee, Albert Marroquin, Tony Parsons, Jim Phillips, David Rosewater and Daleep Mohla (Chair).

There are significant errors in the equations in this section and in Table D.5.2. The origin, basis, and or validation of Equations D.5.2a and D.5.2b is not clear, and additional information was not provided in time for TG review. Equation D5.2(b)is incorrectly derived from D.5.2(a). Table D5.2 does not correspond to equation D5.2(a) – i.e., using the equation as shown, the calculations do not yield the values shown in the table. The proposed equations for arc sustainability only consider Gap and Voltage, not other factors such as electrode configuration or arcing current. There are no stated limitations for use of the equations – are they valid for all dc sources, all voltages, all currents?

The fact that there is no definition of "sustainability" also makes application difficult – it is unclear what the recommendation would be for worker protection in systems falling outside the gap/voltage parameters. There exists experimental data (see reference below) that suggests hazardous energy may be released from arcs with final arc gaps greater than the distances in the provided table.

K. Gray, S. Robert, and T. Gauthier, "Low voltage 100–500 vdc arc flash testing," in 2020 IEEE IAS Electrical Safety

Workshop (ESW), 2020, pp.1–7.
Finally, results from these equation reflected in Table D5.2 are substantially different than results of FR58 utilized in Table 130.7(C) (5)(b). Following FR 58, the gap distance where the arc cannot be sustained is 1 mm/volt. This would yield a gap distance for 250 V DC of 250 mm or 25 cm versus 1.4 cm in Table 5.2. This wide disparity would be confusing as both cannot be correct
Recommendation:
Delete the text for D.5.2 from FR-71 and retain the existing text in NFPA 70E 2024 Informative Annex D.5.2.

Related Item

• FR71

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 21:26:06 EDT 2025
Committee: EEW-AAA

D.5 Direct-Current Incident Energy Calculations.

D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.1]}$$

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} = 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).

D.5.2 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.

).5.3 Short Circuit Current and Clearing time

The determination of the short-circuit current is necessary in order to use Table 130.7 (C)(15) and to determine the arcing current.

.
The manufacturer or the equipment supplier is the best source to obtain the data necessary to calculate the dc short-circuit current from sources such as batteries, capacitors, motors, and photovoltaics. The total short-circuit current in the system depends on the total network impedance between the source and the point of the arc fault. The arc duration of the dc arc is determined based on the clearing time of the protective devices typically obtained using the arc current and needs to consider the discharge time of energy storing components as well. The arcing current and protective device clearing time is determined by a qualified person(s) based on system parameters, design and analysis.

The short-circuit current a battery can deliver depends on the total impedance of the short-circuit path.
For lead-calcium batteries, a conservative estimate of the short-circuit current at 25°C is 10 times the battery's 1-minute discharge rating (to 1.75 volts per cell at 25°C with a specific gravity of 1.215).

A more accurate value for a specific application can be obtained from the battery manufacturer or the equipment supplier.

References:

1. IEEE 946-2020, *Recommended Practice for the Design of DC Auxiliary Powers Systems for Generating Stations*

Public Comment No. 231-NFPA 70E-2025 [Section No. D.5.2]

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	Gap Distance, above which arc will quickly extinguish	
(volts)	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

Replace the above with the following, several corrections and clarifications were made.

D.5.2 Arc Extinction as a Function of Voltage and Gap

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. *(see references 1, 2, 3)*

An equation can be written, based on measurements, to provide a lower voltage bound for a given gap distance, a voltage below which, an arc cannot be sustained for that gap (Eq. D.5.2a). Solving for the gap distance, for a given voltage, gives the maximum gap that can sustain an arc, for a given voltage (Eq. D.5.2b). Any gap, above g_{max}, cannot sustain at that voltage.

$V_{min} = ((g*100)/1.06) + 100$ **[D.5.2a]**

or

$g_{gap} = ((V - 100)*1.06)/100$ **[D.5.2b]**

where:

V_{min} = voltage below which an arc can't be sustained for a given gap

g = gap distance (cm)

g_{max} = gap above which an arc can't be sustained (cm) for a given voltage

V = system voltage

Table D.5.2-1 provides a maximum gap distance for various voltages, a gap above which an arc will extinguish at that voltage.

System Voltage (volts)	Gap Distance, above which arc will quickly extinguish cm (inch)
150	0.53 (0.21)
250	1.59 (0.63)
550	4.77 (1.9)
600	5.3 (12.1)
1000	9.54 (3.8)
1500	14.84 (5.84)

Table D.5.2-1 Maximum gap that will sustain an arc vs voltage.

Statement of Problem and Substantiation for Public Comment

The original submission had errors in the equation, and the calculations, was missing units used, and was unclear. This update versions fixes all of those issues.

Related Item

• PI 222 • FR 71

Submitter Information Verification

Submitter Full Name: Lloyd Gordon
Organization: Gordon
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 15:22:20 EDT 2025
Committee: EEW-AAA

Public Comment No. 116-NFPA 70E-2025 [Section No. D.5.3]

D.5.3 Maximum Power Method.

The following method of estimating dc arc flash incident energy *(see reference 4)* 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. 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.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$$

IE m = (0.01 x

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.

$$K_{ab} = \left[0.55 \times In\left(d_{ab}\right)\right] - 0.6 \qquad \textbf{[D.5.3b]}$$

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

Additional Proposed Changes

File Name	Description	Approved
revised_equations_D-5-3.docx	combined 2 equations of D.5.3a into single equation	
max_power_50_pct_proof_from_actual_dc_tests.pdf	maximum power transfer 50% per real world dc arc flash testing	

Statement of Problem and Substantiation for Public Comment

An NFPA 70E task group from the Annexes subcommittee questioned why there are 2 equations (one for getting half the bolted fault current, and the other calculating the maximum power transfer) under D.5.3a, and also questioned why the bolted fault current is reduced by half. This correction seeks to fix the dual equation under one equation number by combining the 2 equations into one, and then explain the one half reduction (which is actually to the power [the product of I x V]), rather than just reducing the current. One way of describing the maximum power transfer theorem (aka Jacobi's law) is that maximum power is transferred when the efficiency is 50%. This is what is also covered in Doan's paper, which is the basis for the equations found in this portion of Annex D since 2012. By re-writing the formula as one, and putting the 50% calculation of power into the denominator (by putting 2 into the denominator to achieve the reduction of the power [I x V] by the desired 50%, both concerns are resolved. In addition, Data from 33 separate DC arc flash tests run on systems from 100-500 V is provided. This supporting data shows that in most cases, during a DC arc flash, both the voltage and the current are reduced over their nominal/beginning or published bolted fault short circuit current values. The product of the two (the power transfer) is below 50% of the nominal voltage times the bolted fault current in 94% of the cases.

Related Item

• 208

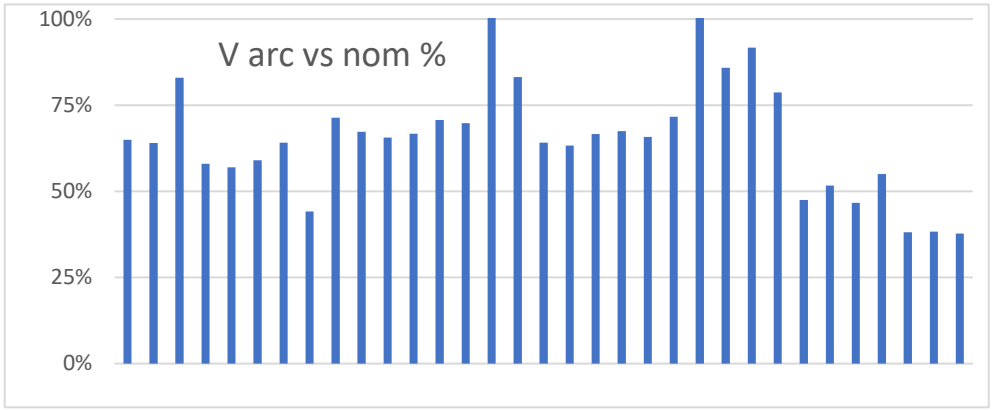
Submitter Information Verification

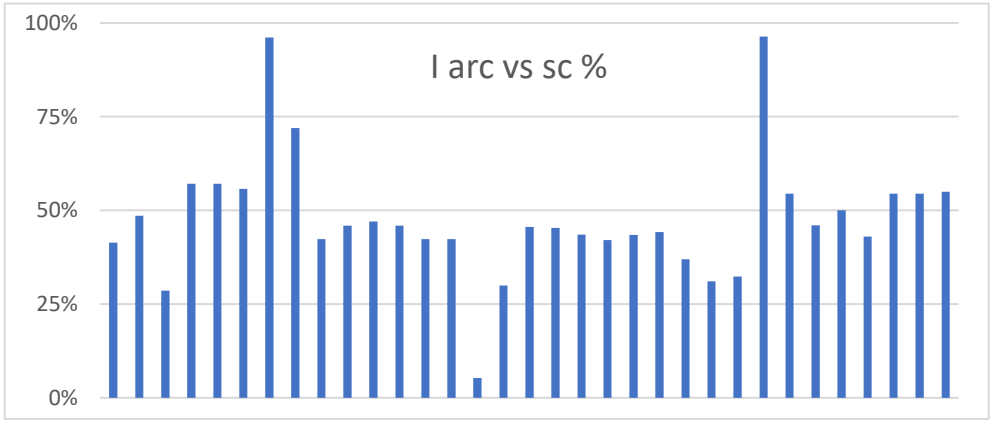
Submitter Full Name: Curtis Ashton
Organization: American Power Systems LLC
Affiliation: East Penn Manufacturing
Street Address:
City:
State:
Zip:

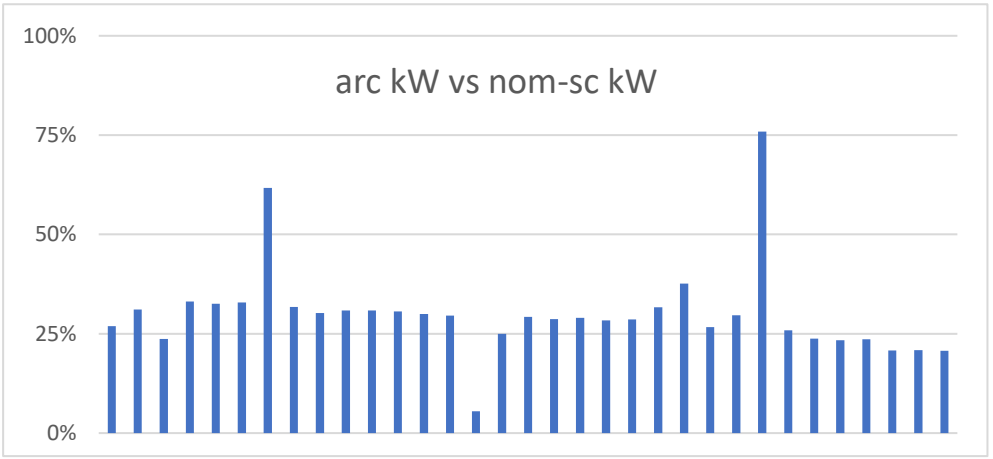
Submittal Date: Mon May 26 20:40:07 EDT 2025
Committee: EEW-AAA

$$IE_m = \frac{0.01 \times V_{sys} \times I_{bf} \times T_{arc}}{2 \times D^2}$$

Vnom	Varc	V arc vs nom %	Isc	Iarc	I arc vs sc %	nom x sc kW	arc kW	arc kW vs nom-sc kW
100	65	65%	7000	2900	41%	700	188.5	27%
100	64	64%	7000	3400	49%	700	217.6	31%
100	83	83%	7000	2000	29%	700	166	24%
100	58	58%	7000	4000	57%	700	232	33%
100	57	57%	7000	4000	57%	700	228	33%
100	59	59%	7000	3900	56%	700	230.1	33%
120	77	64%	1560	1500	96%	187.2	115.5	62%
120	53	44%	5700	4100	72%	684	217.3	32%
120	85.6	71%	17000	7200	42%	2040	616.32	30%
120	80.7	67%	17000	7800	46%	2040	629.46	31%
120	78.7	66%	17000	8000	47%	2040	629.6	31%
120	80.1	67%	17000	7800	46%	2040	624.78	31%
120	84.9	71%	17000	7200	42%	2040	611.28	30%
120	83.8	70%	17000	7200	42%	2040	603.36	30%
120	124.0	103%	17000	900	5%	2040	111.6	5%
120	99.8	83%	17000	5100	30%	2040	508.98	25%
120	77	64%	17000	7750	46%	2040	596.75	29%
120	76	63%	17000	7700	45%	2040	585.2	29%
120	80	67%	17000	7400	44%	2040	592	29%
120	81	68%	17000	7150	42%	2040	579.15	28%
120	79	66%	17000	7380	43%	2040	583.02	29%
120	86	72%	17000	7520	44%	2040	646.72	32%
120	122	102%	17000	6290	37%	2040	767.38	38%
120	103	86%	17000	5279	31%	2040	543.737	27%
120	110	92%	17000	5500	32%	2040	605	30%
240	189	79%	1530	1475	96%	367.2	278.775	76%
240	114	48%	20000	10900	55%	4800	1242.6	26%
240	124	52%	20000	9200	46%	4800	1140.8	24%
240	112	47%	20000	10000	50%	4800	1120	23%
240	132	55%	20000	8600	43%	4800	1135.2	24%
480	183	38%	20000	10900	55%	9600	1994.7	21%
480	184	38%	20000	10900	55%	9600	2005.6	21%
480	181	38%	20000	11000	55%	9600	1991	21%


V arc vs nom %
100%
75%
50%
25%
0%


I arc vs sc %
100%
75%
50%
25%
0%


arc kW vs nom-sc kW
100%
75%
50%
25%
0%

Public Comment No. 117-NFPA 70E-2025 [Section No. D.5.3]

D.5.3 Maximum Power Method.

The following method of estimating dc arc flash incident energy *(see reference 4)* 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. 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.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.3a]}$$

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.~~

$$K_{ab} = \left[0.55 \times In\left(d_{ab}\right)\right] - 0.6 \quad \textbf{[D.5.3b]}$$

~~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~~

Statement of Problem and Substantiation for Public Comment

An NFPA 70E task group from the Annexes subcommittee pointed out that the information provided for DC arc flash arc-in-a-box multipliers is wholly based on AC data rather than DC data, and thus there is no proof that these multipliers represent the proper numbers. Therefore, the original author (me) withdraws these paragraphs until such time as more data can be obtained on DC arc-in-a-box multipliers.

Related Item

• 208

Submitter Information Verification

Submitter Full Name: Curtis Ashton
Organization: American Power Systems LLC
Affiliation: East Penn Manufacturing
Street Address:
City:
State:
Zip:
Submittal Date: Mon May 26 21:13:33 EDT 2025
Committee: EEW-AAA

Public Comment No. 155-NFPA 70E-2025 [Section No. D.5.3]

D.5.3 Maximum Power Method.

The following method of estimating dc arc flash incident energy *(see reference 4)* 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. 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.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.3a]}$$

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.

$$K_{ab} = \left[0.55 \times In\left(d_{ab}\right)\right] - 0.6 \quad \textbf{[D.5.3b]}$$

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

Statement of Problem and Substantiation for Public Comment

The addition of more detail to the arc in a box/enclosure multiplier in D5.3 is very helpful because there is a wide range of enclosure multipliers in existing literature. When designing or working with components that aren't dc panel boards it is very difficult to understand what enclosure multiplier should be used. Based on the literature I have seen anything form a multiplier of 1 up to 3. This can be a significant difference in the required PPE, particularly based on the new section that a factor of 1 to 1.6 is recommended. This can reduce the required PPE to make work easier while still keeping people safe.

Related Item

• Public Input No. 80

Submitter Information Verification

Submitter Full Name: Matt Hendrickson
Organization:
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 02 13:33:18 EDT 2025
Committee: EEW-AAA

Public Comment No. 187-NFPA 70E-2025 [Section No. D.5.3]

D.5.3 Maximum Power Method.

The following method of estimating dc arc flash incident energy *(see reference 4)* 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. 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.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$$

(see propose

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.~~

$$K_{ab} = \left[0.55 \times In\left(d_{ab}\right)\right] - 0.6$$ ~~[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 Because of their size, additional PPE protection is not necessary for typical battery cabinets at an 18 in. (457 mm) working distance (see reference 3). However, due to how energy is reflected, it could be prudent to extend the arc flash boundary for battery cabinets.~~

Additional Proposed Changes

File Name	Description	Approved
Max_power_method.docx	Equations for max power methods with correct units.	

Statement of Problem and Substantiation for Public Comment

First, the section title is DC IE calculation and does not otherwise discuss the arc flash boundary. Because of this, including a long discussion about the dc arc boundary would not be appropriate here. Perhaps in its own section. It is useful to mention that the arc flash IE at the working distance can remain unchanged while the arc boundary can

be extended for some battery equipment. See proposed alternative text.

IEEE 1584 explicitly carves out DC and does not discuss it. Any reference to 1584 should be removed.

Lastly, we propose an editorial change to the maximum power method equation that would make it easier to understand how it works and align it with the changes to the rest of the section (FR-71, PI-223). Currently, it is difficult to compare how the max power method is different from the Ammerman/Sen method. I have proposed a change to the Ammerman/Sen method (PC-183) that includes the minimum set of equations to use it to calculate IE. Both methods calculate IE identically, after determining the arc voltage and arc current differently. It would be very helpful for the Ammerman/Sen method to point back to the max power method but the way the max power method is currently written makes that impossible. This is because the 0.01 cal / J conversion factor implicitly includes the energy unit conversion 0.239 cal / J, the unitless geometry factor 1/4pi, and the unitless assumption that the arc voltage is ½ the system voltage (which is not the case for Ammerman/Sen). Then the max power method rounds the result of 0.009509 to 0.01 to shorten the equation. This approximation alone overestimates the IE by 5.1%, beyond the same calculation performed with appropriate significant digits retained, exasperating the overly conservative result of the maximum power method even further. The proposed alternative equation makes the unit conversion clear, aligns it with Ammerman/Sen, and improves the accuracy of the result without changing the technical basis at all.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 183-NFPA 70E-2025 [Section No. D.5.8]	
Public Comment No. 183-NFPA 70E-2025 [Section No. D.5.8]	

Related Item

• Public Input No. 223-NFPA 70E-2024 • First Revision No. 71-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: David Rosewater
Organization: Sandia National Laboratories
Affiliation: Sandia National Laboratories
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 17:10:20 EDT 2025
Committee: EEW-AAA

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

$$V_{\text{arc}} = 0.5 \times V_{\text{sys}}$$

$$IE_m = \left(0.239 \frac{\text{cal}}{\text{J}}\right) V_{\text{arc}} I_{\text{arc}} \frac{T_{\text{arc}}}{4\pi D^2}$$

Public Comment No. 191-NFPA 70E-2025 [Section No. D.5.3]

~~**D.5.3** Maximum Power Method.~~

~~The following method of estimating dc arc flash incident energy *(see reference 4)* 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. 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.~~

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2$$ ~~[D.5.3a]~~

~~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.~~

$$K_{ab} = \left[0.55 \times In\left(d_{ab}\right)\right] - 0.6$$ ~~[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~~

Additional Proposed Changes

File Name	Description	Approved
70E_2027_Annex_D5_CHANGES_ACCEPTED_consolidated.docx	Annex D5 as proposed	

Statement of Problem and Substantiation for Public Comment

The following comments are the consensus recommendations of NFPA 70E 2027 Informative Annex D.5 Task Group formed by NFPA 70E Chair. Members of this group are Ray Crow, Lloyd Gordon (ad hoc), Mike Lang, Wei-Jen Lee, Albert Marroquin, Tony Parsons, Jim Phillips, David Rosewater and Daleep Mohla (Chair).

The accepted text from FR-71 in D.5.3 add specific “enclosure multipliers” and an equation to modify the arc-flash boundary distance for dc systems. Both of these changes are based on the application of IEEE Std. 1584, which was developed on testing of ac systems, not DC systems. Arcing phenomena in ac and dc systems are different, and there has not been any testing performed to substantiate the validity of applying parameters derived based on ac testing to dc systems. The proposed changes should be deleted, and the existing statements about “arc in a box or enclosure” should be retained.

Recommendation:
Delete the text for D.5.3 from FR-71 and retain the existing text in NFPA 70E 2024 Informative Annex D.5.3.

Related Item

• FR71

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 21:30:53 EDT 2025
Committee: EEW-AAA

D.5 Direct-Current Incident Energy Calculations.

D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.1]}$$

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} = 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).

D.5.2 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.

).5.3 Short Circuit Current and Clearing time

The determination of the short-circuit current is necessary in order to use Table 130.7 (C)(15) and to determine the arcing current.

.
The manufacturer or the equipment supplier is the best source to obtain the data necessary to calculate the dc short-circuit current from sources such as batteries, capacitors, motors, and photovoltaics. The total short-circuit current in the system depends on the total network impedance between the source and the point of the arc fault. The arc duration of the dc arc is determined based on the clearing time of the protective devices typically obtained using the arc current and needs to consider the discharge time of energy storing components as well. The arcing current and protective device clearing time is determined by a qualified person(s) based on system parameters, design and analysis.

The short-circuit current a battery can deliver depends on the total impedance of the short-circuit path.
For lead-calcium batteries, a conservative estimate of the short-circuit current at 25°C is 10 times the battery's 1-minute discharge rating (to 1.75 volts per cell at 25°C with a specific gravity of 1.215).

A more accurate value for a specific application can be obtained from the battery manufacturer or the equipment supplier.

References:

1. IEEE 946-2020, *Recommended Practice for the Design of DC Auxiliary Powers Systems for Generating Stations*

Public Comment No. 234-NFPA 70E-2025 [Section No. D.5.3]

D.5.3 Maximum Power Method.

The following method of estimating dc arc flash incident energy *(see reference 4)* 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. 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.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.3a]}$$

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.~~

$$K_{ab} = \left[0.55 \times In\left(d_{ab}\right)\right] - 0.6 \quad \textbf{[D.5.3b]}$$

~~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~~

Statement of Problem and Substantiation for Public Comment

The paragraph that describes IEEE 1584 incident energy multiplier for large cabinets has incorrect information. For example, using the IEEE 1584 method for a 480V system with 10kA short circuit current, 32mm gap and 1 second arc time, open air (VOA) incident energy is 8.4 cal/cm2 at 18 inches and switchgear (VCB) energy is 18.1 cal/cm2 at 18 inches. This gives a ratio of 2.1, not the "additional 3 percent to 4 percent energy" mentioned in the paragraph. Another concern in this paragraph is that there is no definition of large enclosure and the suggestions made here will lead to confusion to the readers. This paragraph needs to be removed.

Related Item

• FR-71

Submitter Information Verification

Submitter Full Name: Satish Shrestha
Organization: Bentley Systems, Inc
Affiliation: Bentley Systems Inc
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 15:31:27 EDT 2025
Committee: EEW-AAA

Public Comment No. 118-NFPA 70E-2025 [Section No. D.5.4]

D.5.4 Modified ~~Maximum Power Method.~~ DC Arc Maximum Sustaining Time for Battery Systems

Repeated experiments by multiple companies *(see reference 3)* have shown that the maximum power method produces fairly accurate results at around ~~500 Vdc~~ nominal 480 Vdc , where arc sustaining times average about 2 seconds. For lower voltages (~~which are quite common~~ e.g., nominal 12, 24, 36, 48, 125, 250, and 384 VDC), 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.

Additional Proposed Changes

File Name	Description	Approved
max_DC_arc_sustaining_time_graph.pdf	data used to derive equation in D.4	

Statement of Problem and Substantiation for Public Comment

An NFPA 70E task group from the Annexes subcommittee suggested that based on their review of the data, that this section be retitled to talk about modifying arc sustaining time, and that boundaries be set to ensure that users don't apply it to DC systems (such as solar or capacitors) that the battery data does not cover. In addition, the subcommittee asked for examples of lower voltages to which the text was referring when it referred to approximately 500 VDC (nominal 480 VDC). This submission attempts to take those suggestions and questions into account in the renaming of the section, and providing some common voltages seen in telecommunications, utility protective relaying and industrial backup systems, and in UPS DC busses. In addition, the source data (from many different tests run over the past 8 years) used to derive the equation found in this section is provided.

Related Item

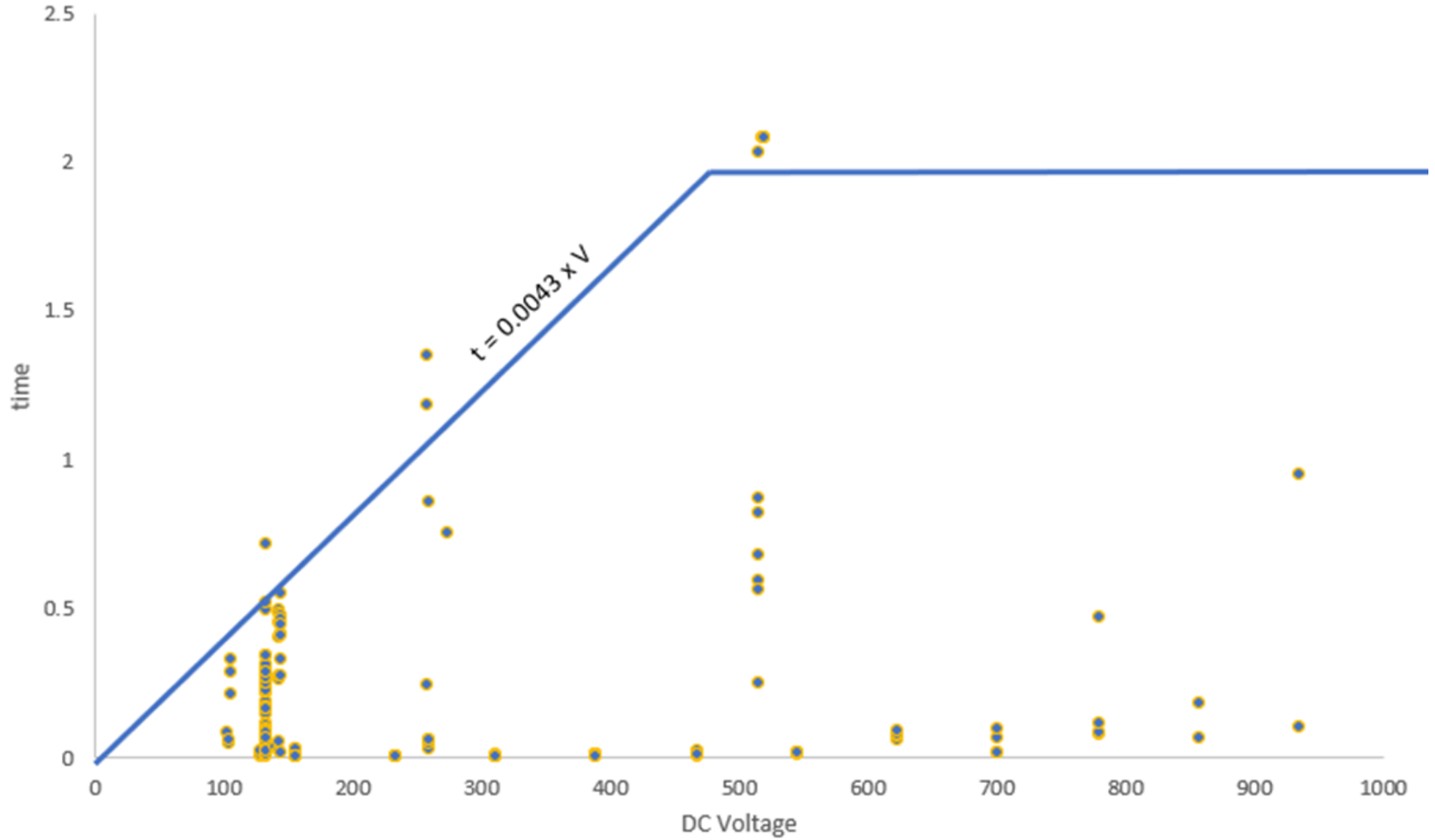
• 223

Submitter Information Verification

Submitter Full Name: Curtis Ashton
Organization: American Power Systems LLC
Affiliation: East Penn Manufacturing
Street Address:
City:
State:
Zip:

Submittal Date: Mon May 26 21:18:29 EDT 2025
Committee: EEW-AAA

Vnom	Vflt	tarc	Vnom	Vflt	tarc	Vnom	Vflt	tarc	Vnom	Vflt	tarc	Vnom	Vflt	tarc
100	104	0.084	120	133	0.058	120	133	0.285	216	234	0.003	480	516	0.25
100	105	0.043	120	133	0.715	120	141	0.034	240	258	0.240	480	516	0.87
100	105	0.060	120	133	0.312	120	144	0.493	240	259	1.35	480	516	0.68
100	106	0.326	120	133	0.097	120	144	0.483	240	259	1.185	480	516	0.59
100	106	0.286	120	133	0.250	120	144	0.454	240	260	0.856	480	516	0.56
100	106	0.214	120	133	0.030	120	144	0.400	240	260	0.027	480	516	0.82
120	130	0.006	120	133	0.089	120	144	0.260	240	260	0.046	480	516	2.03
120	130	0.007	120	133	0.033	120	144	0.272	240	260	0.055	480	519	2.08
120	130	0.009	120	133	0.059	120	144	0.021	240	260	0.06	480	520	2.08
120	130	0.013	120	133	0.081	120	144	0.050	240	274	0.754	480	520	2.08
120	130	0.0045	120	133	0.303	120	145	0.327	288	312	0.0048	504	546	0.011
120	130	0.0065	120	133	0.493	120	145	0.415	288	312	0.005	504	546	0.013
120	130	0.011	120	133	0.221	120	145	0.476	288	312	0.0055	504	546	0.014
120	130	0.0185	120	133	0.338	120	145	0.463	288	312	0.0032	504	546	0.0165
120	133	0.097	120	133	0.165	120	145	0.552	288	312	0.0035	576	624	0.055
120	133	0.019	120	133	0.249	120	145	0.443	288	312	0.0039	576	624	0.07
120	133	0.056	120	133	0.267	120	145	0.410	288	312	0.0041	576	624	0.075
120	133	0.215	120	133	0.274	120	145	0.270	360	390	0.0062	576	624	0.09
120	133	0.266	120	133	0.004	120	145	0.016	360	390	0.0068	648	702	0.015
120	133	0.218	120	133	0.026	144	156	0.022	360	390	0.0075	648	702	0.016
120	133	0.189	120	133	0.054	144	156	0.024	360	390	0.0085	648	702	0.066
120	133	0.141	120	133	0.297	144	156	0.028	360	390	0.0045	648	702	0.097
120	133	0.248	120	133	0.308	144	156	0.0018	360	390	0.005	720	780	0.075
120	133	0.228	120	133	0.011	144	156	0.0018	432	468	0.0098	720	780	0.08
120	133	0.101	120	133	0.009	144	156	0.0019	432	468	0.011	720	780	0.11
120	133	0.116	120	133	0.020	144	156	0.002	432	468	0.014	720	780	0.47
120	133	0.220	120	133	0.171	144	156	0.004	432	468	0.017	792	858	0.065
120	133	0.035	120	133	0.162	216	234	0.0035	432	468	0.02	792	858	0.18
120	133	0.021	120	133	0.342	216	234	0.00385	432	468	0.005	864	936	0.099
120	133	0.170	120	133	0.266	216	234	0.0022	432	468	0.008	864	936	0.95
120	133	0.067	120	133	0.518	216	234	0.0026	432	468	0.008	480	520	2.08
120	133	0.106	120	133	0.064	216	234	0.0028						


2.5
2
1.5
1
0.5
0
time
t = 0.0043 x V
0
100
200
300
400
500
600
700
800
900
1000
DC Voltage

Public Comment No. 156-NFPA 70E-2025 [Section No. D.5.4]

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.

$$T_{arc} = 0.0043 \times V_{sys} \quad \textbf{[D.5.4]}$$

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.

Statement of Problem and Substantiation for Public Comment

The addition of multiple different methods for calculating incident energy to the annex is valuable. There have been multiple papers in the electrical safety workshop documenting the various methods and the challenges and benefits of the methods. This addition allows the broader industry to become aware of the different methods and determine which method best fits the needs of their company

Related Item

• Public Input No. 215

Submitter Information Verification

Submitter Full Name: Matt Hendrickson
Organization:
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 13:36:24 EDT 2025
Committee: EEW-AAA

Public Comment No. 192-NFPA 70E-2025 [Section No. D.5.4]

~~**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.~~

$$T_{arc} = 0.0043 \times V_{sys}$$ ~~[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.~~

Additional Proposed Changes

File Name	Description	Approved
70E_2027_Annex_D5_CHANGES_ACCEPTED_consolidated.docx	Annex D5 as proposed	

Statement of Problem and Substantiation for Public Comment

The following comments are the consensus recommendations of NFPA 70E 2027 Informative Annex D.5 Task Group formed by NFPA 70E Chair. Members of this group are Ray Crow, Lloyd Gordon (ad hoc), Mike Lang, Wei-Jen Lee, Albert Marroquin, Tony Parsons, Jim Phillips, David Rosewater and Daleep Mohla (Chair).

The accepted text from FR-71 does not clarify if this method of modifying the maximum power method applies to batteries, photovoltaic (PV) systems, Converters, Capacitors, etc. The TG consensus is that this method may apply to batteries but would not apply to other dc current/voltage sources, but this is not stated in D.5.4.
The TG reviewed Fig. 1 from Reference 3 of D.5.10. Fig. 1 clearly shows that there are several outlier test points which are not captured under the D.5.4 equation curve. The Authors of Reference 3 indicate that equation D.5.4 was developed by "Curve fitting the results so that most of the points fit under the curve". The use of the term "most" is not a scientifically precise method to apply curve fitting methods (e.g., using one or two standard deviations). Ignoring several of this outliers means that equation D.5.4 can produce under conservative incident energy predictions.
Voltage is not the only factor that should be used to determine arc sustainability and its duration. The gap between conductors, electrode configuration (orientation), and available fault current need to be considered. Foreign contaminants and conductor material are also factors to have been found in certain laboratory tests to increase arc sustainability and cannot be neglected. Allowing this change to remain in NFPA 70E Informative Annex D.5 can create a hazardous condition by generalizing various dc systems operating at various voltages as not capable of producing dc arc-flash incident energy.

Recommendation:
Delete the text for D.5.4 from FR-71.

Related Item

• FR 71

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:

Zip:	
Submittal Date:	Mon Jun 02 21:37:46 EDT 2025
Committee:	EEW-AAA

D.5 Direct-Current Incident Energy Calculations.

D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.1]}$$

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} = 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).

D.5.2 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.

).5.3 Short Circuit Current and Clearing time

The determination of the short-circuit current is necessary in order to use Table 130.7 (C)(15) and to determine the arcing current.

.
The manufacturer or the equipment supplier is the best source to obtain the data necessary to calculate the dc short-circuit current from sources such as batteries, capacitors, motors, and photovoltaics. The total short-circuit current in the system depends on the total network impedance between the source and the point of the arc fault. The arc duration of the dc arc is determined based on the clearing time of the protective devices typically obtained using the arc current and needs to consider the discharge time of energy storing components as well. The arcing current and protective device clearing time is determined by a qualified person(s) based on system parameters, design and analysis.

The short-circuit current a battery can deliver depends on the total impedance of the short-circuit path.
For lead-calcium batteries, a conservative estimate of the short-circuit current at 25°C is 10 times the battery's 1-minute discharge rating (to 1.75 volts per cell at 25°C with a specific gravity of 1.215).

A more accurate value for a specific application can be obtained from the battery manufacturer or the equipment supplier.

References:

1. IEEE 946-2020, *Recommended Practice for the Design of DC Auxiliary Powers Systems for Generating Stations*

Public Comment No. 235-NFPA 70E-2025 [Section No. D.5.4]

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.

$$T_{arc} = 0.0043 \times V_{sys} \quad \textbf{[D.5.4]}$$

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.

Statement of Problem and Substantiation for Public Comment

Where the equation is provided for estimating the maximum sustaining time of DC arcs (equation D.5.4), there needs to be a clear mention of the following ranges and conditions:
1. Applicable voltage range. The paragraph preceding the equation mentions 500Vdc in a statement but does not describe clearly the applicable range of voltage for the equation.
2. Electrode configuration and other conditions of dc arc. Lang and Jones, in their paper "Investigation of Factors Affecting the Sustainability of Arcs Below 250 V", IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 48, NO. 2, MARCH/APRIL 2012, describe that for certain "vertical into barrier" configurations of electrodes, the arc could be sustained for longer durations than for vertical configurations. The example provided has a "chamber configuration", intended to simulate the tight space behind the breakers and around the bus bars in the panelboard. The insulation barrier is able to hold the arc from moving away from the electrodes and rapidly self-extinguishing.
3. Units need to be provided for parameters Tarc and Vsys.

Related Item

• FR-71

Submitter Information Verification

Submitter Full Name: Satish Shrestha
Organization: Bentley Systems, Inc
Affiliation: Bentley Systems, Inc
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 15:38:03 EDT 2025
Committee: EEW-AAA

Public Comment No. 180-NFPA 70E-2025 [Section No. D.5.5]

~~**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).*~~

Statement of Problem and Substantiation for Public Comment

This is not a method of calculating IE

Related Item

• First Revision No. 71-NFPA 70E-2024 • Public Input No. 223-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: David Rosewater
Organization: Sandia National Laboratories
Affiliation: Sandia National Laboratories
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 16:33:53 EDT 2025
Committee: EEW-AAA

Public Comment No. 193-NFPA 70E-2025 [Section No. D.5.5]

~~**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).*~~

Additional Proposed Changes

File Name	Description	Approved
70E_2027_Annex_D5_CHANGES_ACCEPTED_consolidated.docx	Annex D5 as proposed	

Statement of Problem and Substantiation for Public Comment

The following comments are the consensus recommendations of NFPA 70E 2027 Informative Annex D.5 Task Group formed by NFPA 70E Chair. Members of this group are Ray Crow, Lloyd Gordon (ad hoc), Mike Lang, Wei-Jen Lee, Albert Marroquin, Tony Parsons, Jim Phillips, David Rosewater and Daleep Mohla (Chair).

The accepted text from FR-71 incorrectly describes the range of the Stokes arc characteristics method as “0.1 to 1.0 kA” which is technically incorrect. The Stokes method has been documented in at least six technical papers as being capable of reproducing arc current, voltage and resistance values for bolted short-circuit currents up to 20 kA or higher.
Allowing this change to remain in NFPA 70E 2027 would invalidate all the calculations done per existing NFPA 70E 2012 to 2024 Annex D.5.2 which recommended this method be used according to how Ammerman et. All intended. The Stokes/Oppenlander equations only provide the initial step for calculating the arc current, voltage and resistance and DO NOT provide an incident energy calculation method or equations. It cannot be explicitly listed as an incident energy calculation method under a section called “Direct Current Incident Energy Calculations”.

Recommendation:
Delete the text for D.5.5 from FR-71.

Related Item

• FR71

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 21:42:47 EDT 2025
Committee: EEW-AAA

D.5 Direct-Current Incident Energy Calculations.

D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.1]}$$

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} = 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).

D.5.2 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.

).5.3 Short Circuit Current and Clearing time

The determination of the short-circuit current is necessary in order to use Table 130.7 (C)(15) and to determine the arcing current.

.
The manufacturer or the equipment supplier is the best source to obtain the data necessary to calculate the dc short-circuit current from sources such as batteries, capacitors, motors, and photovoltaics. The total short-circuit current in the system depends on the total network impedance between the source and the point of the arc fault. The arc duration of the dc arc is determined based on the clearing time of the protective devices typically obtained using the arc current and needs to consider the discharge time of energy storing components as well. The arcing current and protective device clearing time is determined by a qualified person(s) based on system parameters, design and analysis.

The short-circuit current a battery can deliver depends on the total impedance of the short-circuit path.
For lead-calcium batteries, a conservative estimate of the short-circuit current at 25°C is 10 times the battery's 1-minute discharge rating (to 1.75 volts per cell at 25°C with a specific gravity of 1.215).

A more accurate value for a specific application can be obtained from the battery manufacturer or the equipment supplier.

References:

1. IEEE 946-2020, *Recommended Practice for the Design of DC Auxiliary Powers Systems for Generating Stations*

Public Comment No. 237-NFPA 70E-2025 [Section No. D.5.5]

~~**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).*~~

Statement of Problem and Substantiation for Public Comment

The Ammerman et al paper describes the complete steps to performing DC arc flash calculations and includes the Stokes and Oppenlander method. The Stokes and Oppenlander paper only describes the empirical relationship between the arc current and the arc voltage (or the arc resistance), which allows us to calculate the electrical power into the arc. Since this paper does not describe the calculation of incident energy, it is adequate to include Ammerman et al paper and remove reference to Stokes and Oppenlander paper. This will simplify the standard for the average user of the standard.

Related Item

• FR-71

Submitter Information Verification

Submitter Full Name: Satish Shrestha
Organization: Bentley Systems, Inc
Affiliation: Bentley Systems, Inc
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 15:44:13 EDT 2025
Committee: EEW-AAA

Public Comment No. 208-NFPA 70E-2025 [Sections D.5.5, D.5.6, D.5.7, D.5.8]

Sections D.5.5, D.5.6, D.5.7, D.5.8

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)*.

Replace the above with:

D.5.5 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.5.6 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.5.7 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)* .

Statement of Problem and Substantiation for Public Comment

The changes reflect recommendation by the 2027 NFPA 70E D.5 Task Group.
Edits were made to reflect that
D.5.5 Ammerman/Sen Method, is a method to calculate incident energy,
D.5.6 Stokes/Oppenlander and D.5.6 Paukert, are sets of data used to predict arc resistance.

The original PI included the Kinectrics Physics model and reference. Because there was some objections from the D.5 task group, I left it out of this PC.

Related Item

• PI 223 • FR 71

Submitter Information Verification

Submitter Full Name: Lloyd Gordon
Organization: Gordon
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jun 03 12:19:56 EDT 2025

Committee:	EEW-AAA

Public Comment No. 181-NFPA 70E-2025 [Section No. D.5.6]

~~**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)* .~~

Statement of Problem and Substantiation for Public Comment

This is not a method to calculate arc flash IE.

Related Item

• First Revision No. 71-NFPA 70E-2024 • Public Input No. 223-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: David Rosewater
Organization: Sandia National Laboratories
Affiliation: Sandia National Laboratories
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 16:35:39 EDT 2025
Committee: EEW-AAA

Public Comment No. 194-NFPA 70E-2025 [Section No. D.5.6]

~~**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)* .~~

Additional Proposed Changes

File Name	Description	Approved
.1748915159923	Annex D5 as proposed	

Statement of Problem and Substantiation for Public Comment

The following comments are the consensus recommendations of NFPA 70E 2027 Informative Annex D.5 Task Group formed by NFPA 70E Chair. Members of this group are Ray Crow, Lloyd Gordon (ad hoc), Mike Lang, Wei-Jen Lee, Albert Marroquin, Tony Parsons, Jim Phillips, David Rosewater and Daleep Mohla (Chair).

By themselves the Paukert method equations do not provide an “incident energy calculation method” but only provide the initial step of calculating the arc current, arc voltage and arc resistance. This arc resistance method cannot be explicitly listed as an incident energy calculation method and the proper way to utilize it is as done in the Ammerman method already published in NFPA 70E 2012 to 2024 editions under the existing section D.5.2.

The change from FR-71 states that the Paukert method produces "high arcing current characteristics" yet it does not define what a high arcing current characteristic is. This statement can create confusion. A comparative analysis vs other methods may be required to provide a qualitative statement about how high these arc currents can be.

Recommendation:

Delete the text for D.5.6 from FR-71..

Related Item

• FR71

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 02 21:45:38 EDT 2025
Committee: EEW-AAA

Public Comment No. 240-NFPA 70E-2025 [Section No. D.5.6]

~~**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)* .~~

Statement of Problem and Substantiation for Public Comment

Paukert's paper "Paukert, J., "Th arc voltage and arc resistance of LV fault arcs," in Proc 7th Symp. Switching Arc Phenomena, pp. 49-51, 1993 is not readily available. The Ammerman et al paper describes the complete steps to performing DC arc flash calculations and includes the Paukert method. The Paukert paper only describes the empirical relationship between the arc current and the arc voltage (or the arc resistance), which allows us to calculate the electrical power into the arc. Since this paper does not describe the calculation of incident energy, it is adequate to include Ammerman et al paper and remove reference to Paukert Method. This will simplify the standard for the average user of the standard.

Related Item

• FR-71

Submitter Information Verification

Submitter Full Name: Satish Shrestha
Organization: Bentley Systems, Inc
Affiliation: Bentley Systems, Inc
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 16:22:21 EDT 2025
Committee: EEW-AAA

Public Comment No. 157-NFPA 70E-2025 [New Section after D.5.7]

D.5.8 ETAP Dynamic Transient DC Arc-Flash Incident Energy Calculation Method

This is a method which considers dynamic and transient dc arc current and energy by factoring the effects of conductor erosion, arc elongation and enclosure reflectivity based on various laboratory tests. This method is described in the following references.

(1) A. Marroquin and T. McKinch, "Methods for Evaluating DC ARC-Flash Incident Energy in Battery Energy Storage Systems," in *IEEE Transactions on Industry Applications* , vol. 60, no. 3, pp. 5150-5160, May-June 2024, doi: 10.1109/TIA.2024.3353723.

(1) W. Sekulic, A. Marroquin and P. McNutt, "DC Arc Incident Energy in Photovoltaic Systems: Methods for Evaluation," in *IEEE Industry Applications Magazine* , vol. 28, no. 3, pp. 21-33, May-June 2022,

(1) A. Marroquin, R. Veeraraghavan, W. Gonzalez and M. Ruta, "Application of DC AF Incident Energy Reference Boundary Area Plots In TCCs Considering Input Parameter Variability," in *IEEE Transactions on Industry Applications* , doi: 10.1109/TIA.2025.3561762.

(1) A. Marroquin, C. Carne, W. Brown, T. Landry, “Transient DC Arc-Flash Incident Energy Calculations for Distribution Systems”, in IEEE / IAS ESW 2025, Paper # 9, March 2025

Statement of Problem and Substantiation for Public Comment

Substantiation:

Section D.5.7 from NFPA 70E 2027 FR71 promotes the use of software manufactured by the Canadian company KINECTRICS. Reference 9 of FR71 D.5.10 is a report written by KINECTRICS for Bruce Power which contains over ten (10) references to ArcPro®. The conclusion of the report provided in reference 9 advocates the use of ac 1-phase ArcPro® for dc arc-flash incident energy calculations.

1) Using open-air ac software (ArcPro®) for dc calculations is limited to very specific electrode arrangements such as those of Figure 2 of Reference 9. Series in-line electrodes is not a very common conductor arrangement present in real-life equipment. Advocating a method which neglects other possible electrode arrangements can create liability if the incident energy is under conservative.

2) Other KINECTRICS lab test reports such as those requested by Hydro Quebec[1] have shown that even under the electrode arrangement of Figure 2 of Ref. 9 (using series in-line electrodes) that ArcPro® results can be under conservative by almost 100% because this method does not consider the transient dynamic effect of conductor erosion. NFPA should not advocate the use of specific software packages unless it performs an independent evaluation of its output to ensure the adequacy of the results.

[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.

Related Item

• FR71

Submitter Information Verification

Submitter Full Name: RAGHU VEERARAGHAVAN
Organization: Operation Technology Inc.
Affiliation: ETAP
Street Address:
City:
State:

Zip:
Submittal Date: Mon Jun 02 13:39:57 EDT 2025
Committee: EEW-AAA

Public Comment No. 158-NFPA 70E-2025 [Section No. D.5.7]

~~**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).*~~

Statement of Problem and Substantiation for Public Comment

Delete this section since it creates a commercial advantage.

The newly proposed section in D.5.7 of NFPA 70E FR71 advocates the use of a commercial calculation software for dc systems manufactured by KINECTRICS. This clearly raises commercialism advantages which go against the nature of NFPA 70E. D.5.7 raises a commercial advantage over other software manufacturers including US based software vendors such as ETAP, SKM, EasyPower, and others.

As stated in the reference supporting this proposal, the KINECTRICS commercial software model is based on AC system theory and has not been sufficiently tested or validated for diverse DC applications. Using it as a default method for DC arc flash calculations can lead to inaccurate results and send the wrong message about other available commercial calculation methods not listed in D.5.7.

Related Item

• FR71

Submitter Information Verification

Submitter Full Name: Walter Gonzalez
Organization: Operation Technology
Affiliation: ETAP
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 13:53:31 EDT 2025
Committee: EEW-AAA

Public Comment No. 165-NFPA 70E-2025 [Section No. D.5.7]

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).*

Additional Proposed Changes

File Name	Description	Approved
.1748892067648	D,5,7 Revision	

Statement of Problem and Substantiation for Public Comment

Recommendation:

Revise D.5.7 to include the following clarification:

Other methods are available to calculate the dc arc-flash incident energy which are not listed in this section. NFPA 70E is only a guideline and there are alternative calculation methods to account for various aspects of dc arc flash incident energy calculation. The user is advised to properly research alternative calculation methods and their application viabilities.

Statement of Problem and Substantiation for Public Comment:

The “D 5.7” method refers to a KINECTRICS model for calculating dc arc-flash incident energy through the use of ArcPro software. I run my arc flash analysis for dc systems using ETAP methods, but they are listed here. Without the proposed statement being added, all existing and new calculations using other software may be invalidated.

Related Item

• FR71

Submitter Information Verification

Submitter Full Name: Terrance McKinch
Organization: Nexamp
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 15:14:35 EDT 2025
Committee: EEW-AAA

Public Comment No. 182-NFPA 70E-2025 [Section No. D.5.7]

~~**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).*~~

Statement of Problem and Substantiation for Public Comment

A company's branded calculation model is not appropriate to include in this section. It also does not provide enough information to calculate IE. It should either be renamed, and more detail added or removed entirely.

Related Item

• First Revision No. 71-NFPA 70E-2024 • Public Input No. 223-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: David Rosewater
Organization: Sandia National Laboratories
Affiliation: Sandia National Laboratories
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 16:37:10 EDT 2025
Committee: EEW-AAA

Public Comment No. 195-NFPA 70E-2025 [Section No. D.5.7]

~~**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).*~~

Additional Proposed Changes

File Name	Description	Approved
70E_2027_Annex_D5_CHANGES_ACCEPTED_consolidated.docx	Annex D5 as proposed	

Statement of Problem and Substantiation for Public Comment

The following comments are the consensus recommendations of NFPA 70E 2027 Informative Annex D.5 Task Group formed by NFPA 70E Chair. Members of this group are Ray Crow, Lloyd Gordon (ad hoc), Mike Lang, Wei-Jen Lee, Albert Marroquin, Tony Parsons, Jim Phillips, David Rosewater and Daleep Mohla (Chair).

The TG consensus is that ac and dc arc characteristics and fundamental physical behavior are very different and that theoretical equations developed for ac systems are not applicable to dc systems. The KINECTRICS reference promotes the use of an ac system software application to be used for dc incident energy calculations, and the TG does not have access to the software equations for review to verify applicability to dc systems.

Recommendation:
Delete the text for D.5.7 from FR 71

Related Item

• FR 71

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 21:48:15 EDT 2025
Committee: EEW-AAA

D.5 Direct-Current Incident Energy Calculations.

D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.1]}$$

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} = 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).

D.5.2 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.

).5.3 Short Circuit Current and Clearing time

The determination of the short-circuit current is necessary in order to use Table 130.7 (C)(15) and to determine the arcing current.

.
The manufacturer or the equipment supplier is the best source to obtain the data necessary to calculate the dc short-circuit current from sources such as batteries, capacitors, motors, and photovoltaics. The total short-circuit current in the system depends on the total network impedance between the source and the point of the arc fault. The arc duration of the dc arc is determined based on the clearing time of the protective devices typically obtained using the arc current and needs to consider the discharge time of energy storing components as well. The arcing current and protective device clearing time is determined by a qualified person(s) based on system parameters, design and analysis.

The short-circuit current a battery can deliver depends on the total impedance of the short-circuit path.
For lead-calcium batteries, a conservative estimate of the short-circuit current at 25°C is 10 times the battery's 1-minute discharge rating (to 1.75 volts per cell at 25°C with a specific gravity of 1.215).

A more accurate value for a specific application can be obtained from the battery manufacturer or the equipment supplier.

References:

1. IEEE 946-2020, *Recommended Practice for the Design of DC Auxiliary Powers Systems for Generating Stations*

Public Comment No. 228-NFPA 70E-2025 [Section No. D.5.7]

~~**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).*~~

Statement of Problem and Substantiation for Public Comment

The physics model mentioned in this article is not described in the report referenced by article D.5.10 (7). The referenced report is not readily available. Article 3.2.2 of 2022 ANSI/NFPA Patent Policy & Commercial Terms and Conditions, states "The referenced products or services shall be reasonably available from the referenced sources". This section should be removed from the NFPA 70E standard because the users of the standard will not be able to use the model.

Related Item

• FR-71-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: Satish Shrestha
Organization: Bentley Systems, Inc
Affiliation: Bentley Systems, Inc
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 15:04:29 EDT 2025
Committee: EEW-AAA

Public Comment No. 183-NFPA 70E-2025 [Section No. D.5.8]

D.5.8 Ammerman/Sen Method.

This is a circuit/thermal model that assumes complete conversion of electrical arc energy into thermal energy (see reference 2) . Arc

~~power is determined from an iterative technique constrained by arc power and circuit characteristics (see reference 2)~~
voltage and current are determined together by setting the arc voltage (from a model developed in reference 7) equal to the battery circuit voltage and solving using an iterative method:

(see attachment) (1)

where

is the arc voltage (V)

is the arc current (A)

is the battery voltage (V)

is the internal resistance of the dc source (Ω)

is the electrode gap (mm)

Informational note 1: This equation is only valid if the calculated arc current is greater than the transition current $I_t = 10 + 0.2z_g$. If the calculated arc current is below this value, and the dc source is below 600 volts, then the likelihood of a hazardous arc is low. This occurs when the arc gap is greater than approximately 1 mm per volt (1 in. per 25 volts), see Table 130.5(C)(3).

The incident energy at the working distance is determined by plugging the arc current and voltage calculated using (1) into the following equation:

(see attachment) (2)

where

IE is the incident energy (cal/cm2)

is the arc voltage (V)

is the arc current (A)

is the arc time (s)

is the working distance (cm)

This method does not account for source inductance, electrode erosion, electrode configuration, or self-extinguishing .

Additional Proposed Changes

File Name	Description	Approved
Ammerman_method.docx	Proposed text with equations	

Statement of Problem and Substantiation for Public Comment

This is a helpful addition to D.5 as it provides a more accurate alternative to the maximum power method. However, as the max power method includes the equations from reference 2, the section is not a complete method. An editorial change to this section would be to include the minimum set of equations to implement the Ammerman/Sen Method. Note that if the proposed editorial change to the maximum power method equation (PC-187) is accepted

then the second equation is not necessary. Instead this section could simply point back to that equation for calculating IE once Varc and Iarc are determined.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 187-NFPA 70E-2025 [Section No. D.5.3]	
Public Comment No. 187-NFPA 70E-2025 [Section No. D.5.3]	

Related Item

• First Revision No. 71-NFPA 70E-2024 • Public Input No. 223-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: David Rosewater
Organization: Sandia National Laboratories
Affiliation: Sandia National Laboratories
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 16:41:48 EDT 2025
Committee: EEW-AAA

D.5.8 Ammerman/Sen Method.

This is a circuit/thermal model that assumes complete conversion of electrical arc energy into thermal energy (see reference 2). Arc voltage and current are determined together by setting the arc voltage (from a model developed in reference 7) equal to the battery circuit voltage and solving using an iterative method:

$$V_{\text{arc}} = (20 + 0.534 z_{\text{g}}) I_{\text{arc}}^{0.12} = V_{\text{sys}} - I_{\text{arc}} R_{\text{int}} \quad (1)$$

where

V_{arc} is the arc voltage (V)
I_{arc} is the arc current (A)
V_{sys} is the battery voltage (V)
R_{int} is the internal resistance of the dc source (Ω)
z_{g} is the electrode gap (mm)

Informational note 1: This equation is only valid if the calculated arc current is greater than the transition current $I_t = 10 + 0.2z_g$. If the calculated arc current is below this value, and the dc source is below 600 volts, then the likelihood of a hazardous arc is low. This occurs when the arc gap is greater than approximately 1 mm per volt (1 in. per 25 volts), see Table 130.5(C)(3).

The incident energy at the working distance is determined by plugging the arc current and voltage calculated using (1) into the following equation:

$$IE = \left(0.239 \frac{\text{cal}}{\text{J}}\right) V_{\text{arc}} I_{\text{arc}} \frac{T_{\text{arc}}}{4\pi D^2} \quad (2)$$

where

IE is the incident energy (cal/cm2)
V_{arc} is the arc voltage (V)
I_{arc} is the arc current (A)
T_{arc} is the arc time (s)
D is the working distance (cm)

This method does not account for source inductance, electrode erosion, electrode configuration, or self-extinguishing.

Public Comment No. 196-NFPA 70E-2025 [Section No. D.5.8]

~~**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).*~~

Additional Proposed Changes

File Name	Description	Approved
70E_2027_Annex_D5_CHANGES_ACCEPTED_consolidated.docx	Annex D5 as proposed	

Statement of Problem and Substantiation for Public Comment

The following comments are the consensus recommendations of NFPA 70E 2027 Informative Annex D.5 Task Group formed by NFPA 70E Chair. Members of this group are Ray Crow, Lloyd Gordon (ad hoc), Mike Lang, Wei-Jen Lee, Albert Marroquin, Tony Parsons, Jim Phillips, David Rosewater and Daleep Mohla (Chair).

n:

The NFPA 70E 2012 through 2024 editions already reference this dc arc-flash model and incident energy calculation method. The additional commentary or description of the Ammerman method does not add any technical value for the qualified person performing dc arc-flash incident energy.

Recommendation:
TG Recommends keeping the original text in NFPA 70E 2024 D.5.2 (i.e., the proposed D.5.8 section should become again section D.5.2 with the original text from the 2024 edition).

Related Item

• FR71

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 21:51:34 EDT 2025
Committee: EEW-AAA

D.5 Direct-Current Incident Energy Calculations.

D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.1]}$$

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} = 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).

D.5.2 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.

).5.3 Short Circuit Current and Clearing time

The determination of the short-circuit current is necessary in order to use Table 130.7 (C)(15) and to determine the arcing current.

.
The manufacturer or the equipment supplier is the best source to obtain the data necessary to calculate the dc short-circuit current from sources such as batteries, capacitors, motors, and photovoltaics. The total short-circuit current in the system depends on the total network impedance between the source and the point of the arc fault. The arc duration of the dc arc is determined based on the clearing time of the protective devices typically obtained using the arc current and needs to consider the discharge time of energy storing components as well. The arcing current and protective device clearing time is determined by a qualified person(s) based on system parameters, design and analysis.

The short-circuit current a battery can deliver depends on the total impedance of the short-circuit path.
For lead-calcium batteries, a conservative estimate of the short-circuit current at 25°C is 10 times the battery's 1-minute discharge rating (to 1.75 volts per cell at 25°C with a specific gravity of 1.215).

A more accurate value for a specific application can be obtained from the battery manufacturer or the equipment supplier.

References:

1. IEEE 946-2020, *Recommended Practice for the Design of DC Auxiliary Powers Systems for Generating Stations*

Public Comment No. 241-NFPA 70E-2025 [Section No. D.5.8]

D.5.8 Ammerman ~~/Sen Method~~ et al 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).*

Statement of Problem and Substantiation for Public Comment

This paper was authored by four authors. We should either name all four authors or use the convention Ammerman et al, citing just the principal author.

Related Item

• FR-71

Submitter Information Verification

Submitter Full Name: Satish Shrestha
Organization: Bentley Systems, Inc
Affiliation: Bentley Systems, Inc
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 16:25:10 EDT 2025
Committee: EEW-AAA

Public Comment No. 188-NFPA 70E-2025 [Section No. D.5.9]

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)*.

Statement of Problem and Substantiation for Public Comment

The changes on short circuit current and clearing time from Public Input No. 215 are very valuable. They add more detail to how to determine the best input for dc arc flash calculations. This additional detail has been highlighted in papers at the electrical safety workshop but isn't easy to find for new practitioners. The added detail is a good step to make it easier to the find the information to enable the most accurate DC arc flash calculations.

Related Item

• Public Input No. 215

Submitter Information Verification

Submitter Full Name: Matt Hendrickson
Organization:
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 20:15:01 EDT 2025
Committee: EEW-AAA

Public Comment No. 197-NFPA 70E-2025 [Section No. D.5.9]

D.5.9 Short Circuit Current and Clearing Time~~.~~

The determination of the short-circuit current is necessary to use Table 130.7 (C)(15)(b), to determine the arcing current and the interrupting rating 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)* .~~

overcurrent protective devices. The manufacturer or equipment supplier is the best source to obtain the data necessary to calculate the dc short-circuit current from sources such as batteries, capacitors, motors, and photovoltaics. The total short-circuit current depends on the total network impedance between the source and the point of the fault. The duration of the dc arc is determined by a qualified person based on the clearing time of the overcurrent protective devices using the arcing current. The clearing time might need to consider the discharge time of energy storing components in the circuit as well.
For example, the short-circuit current a battery can deliver depends on the total impedance of the short-circuit path. For lead-calcium batteries, a conservative estimate of the short-circuit current at 25°C is 10 times the battery's 1-minute discharge rating (to 1.75 volts per cell at 25°C with a specific gravity of 1.215). For a more accurate value tailored to a specific application, consult the battery manufacturer or the equipment supplier.

References:

(1) IEEE Std.946-2020, Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations

.

Additional Proposed Changes

File Name	Description	Approved
70E_2027_Annex_D5_CHANGES_ACCEPTED_consolidated.docx	Annex D5 as proposed	

Statement of Problem and Substantiation for Public Comment

The following comments are the consensus recommendations of NFPA 70E 2027 Informative Annex D.5 Task Group formed by NFPA 70E Chair. Members of this group are Ray Crow, Lloyd Gordon (ad hoc), Mike Lang, Wei-Jen Lee, Albert Marroquin, Tony Parsons, Jim Phillips, David Rosewater and Daleep Mohla (Chair).

The text has been revised to eliminate the implied requirement that information must be sourced exclusively from the manufacturer. As equipment is not always procured directly from the manufacturer by the end user, the relevant data may be obtained through multiple channels by either the equipment supplier or the end user.
Clearing time during an arcing fault is determined by qualified personnel based on system design parameters and engineering analysis.
The final paragraph has been removed as it does not offer relevant information or guidance to the intended user of this standard.
The reference to 50% of the short-circuit current has been removed to indicate that Max power is not the only recommended method. The detailed method provides more accurate results, but the arcing current is typically determined using iterative methods.
The previous method which conservatively estimated battery short circuit current has been included in NFPA 70E for

multiple cycles has been removed by FR71. However, this approach remains applicable and should be retained for Lead-Calcium batteries, which continue to represent a substantial portion of installed battery systems.
This conservative estimation approach has been validated by IEEE 946-2020, IEEE Recommended Practice for the Design of DC Power Systems for Stationary Applications. Annex C, Section C.3 of the standard provides detailed calculations and comparisons between actual short-circuit current and estimates based on the battery's 1-minute rating.
IEEE 946-2020Annex C.3 presents a sample calculation for a lead-acid battery. The calculated short-circuit current based on manufacturer data was 11,111 A. In comparison, using the conservative estimate of 10 times the 1-minute ampere rating (to 1.75 V per cell at 25 °C), the result was 11,390 A—within 3% of the calculated value.

Related Item

• FR71

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date: Mon Jun 02 21:54:06 EDT 2025
Committee: EEW-AAA

D.5 Direct-Current Incident Energy Calculations.

D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.1]}$$

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} = 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).

D.5.2 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.

).5.3 Short Circuit Current and Clearing time

The determination of the short-circuit current is necessary in order to use Table 130.7 (C)(15) and to determine the arcing current.

.
The manufacturer or the equipment supplier is the best source to obtain the data necessary to calculate the dc short-circuit current from sources such as batteries, capacitors, motors, and photovoltaics. The total short-circuit current in the system depends on the total network impedance between the source and the point of the arc fault. The arc duration of the dc arc is determined based on the clearing time of the protective devices typically obtained using the arc current and needs to consider the discharge time of energy storing components as well. The arcing current and protective device clearing time is determined by a qualified person(s) based on system parameters, design and analysis.

The short-circuit current a battery can deliver depends on the total impedance of the short-circuit path.
For lead-calcium batteries, a conservative estimate of the short-circuit current at 25°C is 10 times the battery's 1-minute discharge rating (to 1.75 volts per cell at 25°C with a specific gravity of 1.215).

A more accurate value for a specific application can be obtained from the battery manufacturer or the equipment supplier.

References:

1. IEEE 946-2020, *Recommended Practice for the Design of DC Auxiliary Powers Systems for Generating Stations*

Public Comment No. 242-NFPA 70E-2025 [Section No. D.5.9]

~~**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)* .~~

Statement of Problem and Substantiation for Public Comment

The first requirement does not address rectifiers, DC generators and DC motors, which exist in many manufacturing plants. The examples of source cited are battery, EDLC and PV. It is unnecessary to state that the short-circuit current of the source needs to be obtained from the manufacturer.
The second sentence in this section on clearing time states that it needs to be determined by analysis of the battery management system, solar management system, and/or fusing. Since there is no detail or reference provided, this statement does not guide the reader on how to obtain the clearing time and therefore this sentence should be removed.
The second paragraph mentions "Clearing times from arc dynamics are still under study, but the 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)." Since this statement does not help readers with calculation of incident energy and arc flash boundary, this statement should be removed.

Related Item

• FR-71

Submitter Information Verification

Submitter Full Name: Satish Shrestha
Organization: Bentley Systems, Inc
Affiliation: Bentley Systems, Inc
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 16:30:29 EDT 2025
Committee: EEW-AAA

Public Comment No. 198-NFPA 70E-2025 [Section No. D.5.10]

~~**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.~~

Additional Proposed Changes

File Name	Description	Approved
70E_2027_Annex_D5_CHANGES_ACCEPTED_consolidated.docx	Annex D5 as proposed	

Statement of Problem and Substantiation for Public Comment

The following comments are the consensus recommendations of NFPA 70E 2027 Informative Annex D.5 Task Group formed by NFPA 70E Chair. Members of this group are Ray Crow, Lloyd Gordon (ad hoc), Mike Lang, Wei-Jen Lee, Albert Marroquin, Tony Parsons, Jim Phillips, David Rosewater and Daleep Mohla (Chair).

The references in D5.10 need to be deleted as explained below

- Reference 1 should be removed because of Substantiation in D.5.1 (PC No 141)
- Reference 2 should be removed because it is included in D.5.2 as Reference 1 (PC 190)
- Reference 3 should be removed because of Substantiation for D.5.2, D.5.3 and D.5.4 (PC No 190, PC No 191 and PC No 192)
- Reference 4 should be removed because it is already included in D.5.2 as Reference 2 (PC No 190)
- Reference 5 should be removed since TG consensus is that IEEE 1584 cannot be used for DC and also because of Substantiation for D.5.3 (PC No 191)
- Reference 6 should be removed because of Substantiation to D.5.3 (PC No 191)
- Reference 7 should be removed because of Substantiation for D.5.5 (PC no 193)
- Reference 8 should be removed because of Substantiation for D.5.6 (PC No 194)
- Reference 9 should be removed because it is included in D5.2 as Reference 3 (PC No 190)

Related Item

- FR71

Submitter Information Verification

Submitter Full Name: Daleep Mohla
Organization: DCM Electrical Consulting Serv
Affiliation: self
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 02 22:13:31 EDT 2025
Committee: EEW-AAA

D.5 Direct-Current Incident Energy Calculations.

D.5.1 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 2 of D.5.2)*. 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.5.3)* has shown that this calculation is conservatively high in estimating the arc flash value. This method applies to dc systems rated up to 1000 volts.

$$I_{arc} = 0.5 \times I_{bf}$$
$$IE_m = 0.01 \times V_{sys} \times I_{arc} \times T_{arc} / D^2 \quad \textbf{[D.5.1]}$$

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} = 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).

D.5.2 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.

).5.3 Short Circuit Current and Clearing time

The determination of the short-circuit current is necessary in order to use Table 130.7 (C)(15) and to determine the arcing current.

.
The manufacturer or the equipment supplier is the best source to obtain the data necessary to calculate the dc short-circuit current from sources such as batteries, capacitors, motors, and photovoltaics. The total short-circuit current in the system depends on the total network impedance between the source and the point of the arc fault. The arc duration of the dc arc is determined based on the clearing time of the protective devices typically obtained using the arc current and needs to consider the discharge time of energy storing components as well. The arcing current and protective device clearing time is determined by a qualified person(s) based on system parameters, design and analysis.

The short-circuit current a battery can deliver depends on the total impedance of the short-circuit path.
For lead-calcium batteries, a conservative estimate of the short-circuit current at 25°C is 10 times the battery's 1-minute discharge rating (to 1.75 volts per cell at 25°C with a specific gravity of 1.215).

A more accurate value for a specific application can be obtained from the battery manufacturer or the equipment supplier.

References:

1. IEEE 946-2020, *Recommended Practice for the Design of DC Auxiliary Powers Systems for Generating Stations*

Public Comment No. 229-NFPA 70E-2025 [Section No. D.5.10]

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.~~

Statement of Problem and Substantiation for Public Comment

This report is not readily available to the users of the NFPA 70E standard. Article 3.2.2 of 2022 ANSI/NFPA Patent Policy & Commercial Terms and Conditions, states "The referenced products or services shall be reasonably available from the referenced sources". Although the report identifies some key findings and relationships between different parameters, this report does not outline the method to perform arc flash incident energy calculations. To date, there have already been many new findings documented in various published articles.

Related Item

• FR-71-NFPA 70E-2024

Submitter Information Verification

Submitter Full Name: Satish Shrestha
Organization: Bentley Systems, Inc
Affiliation: Bentley Systems Inc
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 15:18:44 EDT 2025
Committee: EEW-AAA

Public Comment No. 236-NFPA 70E-2025 [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 the hazard by replacing 120 volts~~ Replace 120 volt 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

Statement of Problem and Substantiation for Public Comment

The revision from “Reduce energy…” to “Reduce the hazard…” in FR-72 is inaccurate. Hazards are not reduced, increased, greater, lesser, etc. A hazard either is or is not a source of harm.
Simply stating “Replace [x with y] is sufficient and accurate. It also aligns the “Substitution” example with the other risk control method examples, none of which identifies the purpose of the method, rather they each are just an example.

Related Item

• FR 72

Submitter Information Verification

Submitter Full Name: Daniel Roberts
Organization: Electrical Safety Solutions
Street Address:
City:
State:
Zip:

Submittal Date: Tue Jun 03 15:39:55 EDT 2025
Committee: EEW-AAA

Public Comment No. 81-NFPA 70E-2025 [Sections H.4.1, H.4.2]

Sections H.4.1, H.4.2

H.4.1 Introduction.

Section 130.7(C)(14) requires personal protective equipment (PPE) provided by a supplier or manufacturer to conform to appropriate product standards~~- by one of three methods. Additional information for these conformity assessment methods can be found within ANSI/ISEA 125, *American National Standard for Conformity Assessment of Safety and Personal Protective Equipment* . ANSI/ISEA 125 establishes criteria for conformity assessment of safety and PPE that is sold with claims of compliance with product performance standards. ANSI/ISEA 125 contains provisions for data collection, product verification, conformation of quality and manufacturing production control, and roles and responsibilities of suppliers, testing organizations, and third-party certification organizations.~~

H.4.2

~~Level of~~

Conformity. ~~ANSI/ISEA 125,~~

~~*American National Standard for* Conformity~~ ~~*Assessment of Safety and Personal Protective Equipment* , provides for three different levels of conformity assessment: Level 1, Level 2, and Level 3.~~

~~Level 1 conformity is where the supplier or manufacturer is making a self-declaration that a product meets all of the requirements of the standard(s) to which conformance is claimed. A supplier Declaration of Conformity for each product is required to be made available for examination upon request.~~

~~Level 2 conformity is where the supplier or manufacturer is making a self-declaration that a product meets all of the requirements of the standard(s) to which conformance is claimed, the supplier or manufacturer has a registered ISO 9001 (*Quality management systems*) quality management system or equivalent quality management system, and all testing has been carried out by an ISO 17025, *General requirements for the competence of testing and calibration laboratories* , accredited testing laboratory. A supplier Declaration of Conformity for each product is required to be made available for examination upon request.~~

~~Level 3 conformity is where the~~ products are certified by an ISO 17065, *Conformity assessment — Requirements for bodies certifying products, processes and services*, accredited independent third-party certification organization (CO). All product testing is directed by the CO, and all changes to the product must be reviewed and retested if necessary. Compliant products are issued a Declaration of Conformity by the CO and products are marked with the CO's mark or label.

Statement of Problem and Substantiation for Public Comment

Consistency with First Revision No. 53-NFPA 70E-2024 [Section No. 130.7(C)(14)] ensuring that the PPE provides appropriate protection.

ISO/IEC17065 establishes the Conformity assessment requirements for bodies certifying products, processes and services, mixing multiple references attempting to allow a gap for different multiple ways of Conformity Assessment processes by losing the objective on Safety and protection should not be allowed.

PPE for any risk should always be a reliable protection without any doubt for the user, and safety standards should always keep the objective for the highest protection of people.

NFPA 70E should provide clear guidance to unexperienced and experienced people about the best possible accurate practice-protection responsibilities.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 82-NFPA 70E-2025 [Section No. H.4.3]	

Related Item

• FR No. 53-NFPA 70E-2024 [Section No. 130.7(C)(14)]

Submitter Information Verification

Submitter Full Name: Alan Campos
Organization: FIRE WORK WEAR SAS
Street Address:
City:
State:
Zip:
Submittal Date: Tue May 13 12:18:42 EDT 2025
Committee: EEW-AAA

Public Comment No. 82-NFPA 70E-2025 [Section No. H.4.3]

~~**H.4.3** Equivalence.~~

~~While there are three levels of conformity assessment described in ANSI/ISEA 125, *American National Standard for Conformity Assessment of Safety and Personal Protective Equipment* , the levels are not to be considered as equivalent. Users are cautioned that the level of rigor required to demonstrate conformity should be based on the potential safety and health consequence of using a product that does not meet a stated performance standard. A higher potential safety and health consequence associated with the use of a noncompliant product should necessitate a higher level of conformity assessment.~~

Statement of Problem and Substantiation for Public Comment

Equivalences has always being biased by particular interests not based on safety neither on people protection.

Safety Standards should not allow any flexibility window for risks neither as people safety should doubtlessly be the unique objective.

NFPA 70E should provide clear guidance to unexperienced and experienced people about the best possible accurate practice-protection responsibilities.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 81-NFPA 70E-2025 [Sections H.4.1, H.4.2]	Conformity assessment requirements are clear. Trying to build gaps on processes do not add value to safety and protection

Related Item

• FR No. 53-NFPA 70E-2024 [Section No. 130.7(C)(14)]

Submitter Information Verification

Submitter Full Name: Alan Campos
Organization: FIRE WORK WEAR SAS
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 13 12:39:27 EDT 2025
Committee: EEW-AAA

Public Comment No. 4-NFPA 70E-2025 [Section No. I.2]

I.2 Job Safety Planning Checklist.

Figure I.2 illustrates considerations for a job safety planning checklist.

Figure I.2 Sample Job Safety Planning Checklist.

I cannot click and make changes on checklist itself. Therefore:

Line item 1a and 1d should be changed to (1a) Equipment operating at greater than 50 V (as this is the threshold for further action. A NO answer indicates an electrically safe work condition but does not tell you to proceed to the forthcoming line items.) Should change (1d) to Abnormal operating condition as normal operating condition is under engineering control. As it stands YES tells tells you to proceed to lower level controls (which you should not have to if equipment is properly engineered). NO answer again indicates an electrically safe work condition but does not tell you to proceed to the forthcoming line items, when are intended to safeguard in a non-engineered control situation).

Line item 4 indicates "if line 3 or 4 are yes" which duplicates it's own line item. I believe this should read "if line 2 or 3 are yes".

Job Safety Planning Checklist

Equipment:				
Task:				
Location:				
Qualified submitter:			**Date:**	

Section A, General

Mark "Y" or "N" as appropriate

No.	Item	Yes	No	Instructions
1.	Is there justification for the energized work? a. Equipment operating at less than 50 volts b. Additional hazard or increased risk c. Infeasible to de-energize d. Normal operating condition			*If **No**, the equipment must be placed in an electrically safe working condition.* *If **Yes**, complete 1a, 1b, and 1c, and shock and arc flash risk assessments are required to determine the appropriate hazard controls.* *Proceed to Line 2.*
2.	Will the worker be exposed to energized parts?			*If **No**, a shock risk assessment is discretionary and completing Sections B and C is optional.* *Proceed to Line 3.*
3.	Is there an arc flash hazard?			*If **No**, arc flash risk assessment is discretionary and completing Sections D or E and F is optional.* *Proceed to Line 4.*
4.	Were any of the answers to Questions 3 or 4 yes?			*If **No**, further risk assessment is discretionary.* *If **Yes**, proceed to Line 5.*
5.	Did the arc flash risk assessment determine that additional protective measures are required?			*If **No**, completing Parts D or E and F is discretionary.* *If **Yes**, Part D or E is required to be completed.* *Proceed to Line 6.*
6.	Is the required working distance available?			*If **Yes**, proceed to Line 7.* *If **No**, additional risk assessment is required before completing Section D or E or performing any work.* *Proceed to Line 7.*

Section B, Shock Hazard Information

Use Table 130.4(E)(a) for ac system boundaries or Table 130.4(E)(b) for dc system boundaries

7.	Voltage between phases: Limited approach boundary: Restricted approach boundary:	*Establish the shock boundaries.* *Proceed to Line 8.*

Section C, Shock Control Information

Mark "Y" or "N" as appropriate

8.	Will the task require the worker to cross the restricted approach boundary?			*If **No**, shock protection controls are discretionary* *Proceed to Section D or E as appropriate.* *If **Yes**, shock protection controls are required.* *Proceed to Line 9.*
9.	Will rubber insulating gloves and leather protectors be used for the task?			*If **Yes**, proceed to Line 10.* *If **No**, proceed to Line 11.*
10.	Minimum glove class required for insulating gloves			*Establish minimum glove class.* *Proceed to Line 11.*
11.	Will insulating blankets be used for the task?			*If **Yes**, proceed to Line 12.* *If **No**, proceed to Line 13.*
12.	Minimum voltage rating for insulating blankets			*Establish minimum voltage rating.* *Proceed to Line 13.*

NFPA 70E (p. 1 of 2)

Mark "Y" or "N" as appropriate

13.	Are insulated or insulating hand tools required for the task?			*If **Yes**, proceed to Line 14.* *If **No**, proceed to Section D or E as applicable.*
14.				*Identify the hand tools, including the minimum voltage rating required.* *Proceed to Section D or E as applicable.*

Section D, Arc Flash Control Information — Incident Energy Analysis Method

Use information from incident energy study

15.	Incident energy: Working distance: Level of PPE: Minimum arc rating of clothing: Arc flash boundary:	***Include:** the arc flash boundary **and** at least one of the following: the incident energy and the working distance **or** the level of PPE **or** the minimum arc rating of clothing.* *Proceed to Section F.*

Section E, Arc Flash Hazard Control Information — Arc Flash PPE Category Method

Use Table 130.7(C)(15)(a) for ac systems or Table 130.7(C)(15)(b) for dc systems

16.	Determine the estimated available fault current and clearing times for the task. Available *fault* current: Overcurrent device clearing time:	

Mark "Y" or "N" as appropriate

17.	Do the estimated available fault current and clearing times for the task exceed the maximum allowed by Table 130.7(C)(15)(a) or Table 130.7(C)(15)(b)?			*If **Yes**, an incident energy analysis is required.* *If **No**, proceed to Line 18.*
18.	Arc flash boundary:			*Proceed to Line 19.*
19.	Arc flash PPE category: Working distance:			*Proceed to Line 20 and 21, Section F.*

Section F, Arc-Rated Clothing and Other Arc Flash Protection Equipment Information

20.	Minimum arc rating in cal/cm^2 for protective clothing and other PPE	*Establish the required arc-rated clothing and other PPE.*
21.		*List the required arc-rated clothing and other arc flash PPE.* ***PPE Category Method:** Use 130.7(C)(15)(c) and Table 130.7(C)(15)(c).* ***Incident Energy Analysis Method:** Use 130.5(G) and Table 130.5(G).*

Section G, Energy Source Controls

22.		*List all sources of electrical supply to the specific equipment.* *Include location and method to lock or tag.* *Include method to verify and test for absence of voltage.* *List temporary protective grounding equipment.*

Section H, Work Procedures and Special Precautions

23.		*List specific work procedures required to complete the task.* *List any special precautions needed to safely complete the task (i.e., discharge time for capacitors).*

NFPA 70E (p. 2 of 2)

Statement of Problem and Substantiation for Public Comment

ANNEX I (Job Safety Planning Checklist) gives some contradictory and confusing direction. Suggested changes to Line 1 and 4 should be clarified to ensure flow of the Job Safety Planning Checklist.

Related Item

• PI

Submitter Information Verification

Submitter Full Name: Paul Zoubek
Organization: Zoubek Consulting
Street Address:
City:
State:
Zip:

Submittal Date: Fri Feb 21 16:25:05 EST 2025
Committee: EEW-AAA

Public Comment No. 71-NFPA 70E-2025 [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.

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.

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.

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 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.

Since January 1, 2015, federal OSHA 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 Other Information.

For additional information, the following documents are available:

Occupational Injuries From Electrical Shock and Arc Flash Events Final Report, Richard Campbell and David Dini, 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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_40.pdf	70E_CN40	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 40 appeared in the First Draft Report on First Revision No. 74.

The Correlating Committee requests that the Technical Committee review Informative Annex K to address the concerns in the ballot comment.

Related Item

• First Revision No. 74

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee

Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:39:36 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 40-NFPA 70E-2025 [Annex K]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:56:34 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review Informative Annex K to address the concerns in the ballot comment.

FR-74-NFPA 70E-2024

Ballot Results

✔ **This item has passed ballot**

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned
Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All
Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 103-NFPA 70E-2025 [Section No. K.1]

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 annually 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.

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.~~

Statement of Problem and Substantiation for Public Comment

"Annually" is added in the third sentence to clarity that the stated statistic is an annual average. The last sentence in K.1 is deleted because there have been additional information and requirements added to this edition to address thermal hazards. Examples include FR-83, FR-91, FR-103.

Related Item

• FR-74

Submitter Information Verification

Submitter Full Name: Louis Barrios
Organization: Retired
Affiliation: American Petroleum Institute (API)
Street Address:
City:
State:
Zip:

Submittal Date: Tue May 20 14:54:58 EDT 2025
Committee: EEW-AAA

Public Comment No. 239-NFPA 70E-2025 [Section No. K.1]

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.

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~~ contact thermal hazard (see term and definition in Article 100) . While this hazard is addressed by the requirements of this standard, it is not discussed in this informative annex .

Statement of Problem and Substantiation for Public Comment

Since the new term "contact thermal hazard" and definition have been added to Article 100, and a few requirements related to the hazard can now be found in the standard (primarily in Chapter 3), this paragraph should be updated to align with these revisions.

Related Item

• FR 74

Submitter Information Verification

Submitter Full Name: Daniel Roberts
Organization: Electrical Safety Solutions
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jun 03 16:07:01 EDT 2025
Committee: EEW-AAA

Public Comment No. 72-NFPA 70E-2025 [Annex L]

Informative Annex L Typical Application of Safeguards in the Cell Line Working Zone

This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

L.1 Application of Safeguards.

This informative annex 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.

L.3 Electrical Power Receptacles.

Power supply circuits and receptacles in the cell line area for portable electric equipment should meet the requirements of 668.21 of *NFPA 70*, *National Electrical Code*. However, it is recommended that receptacles for portable electric equipment not be installed in electrolytic cell areas and that only pneumatic-powered portable tools and equipment be used.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_41.pdf	70E_CN41	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 41 appeared in the First Draft Report on First Revision No. 75.

The Correlating Committee requests that the Technical Committee review the text in L.1 (6) in Informative Annex L regarding "(or grounded)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

Related Item

• First Revision No. 75

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:
Submittal Date: Fri Apr 04 10:41:08 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 41-NFPA 70E-2025 [Sections L.1, L.2]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:57:10 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the text in L.1 (6) in Informative Annex L regarding "(or grounded)" that does not comply with the NEC Style Manual Section 3.5.1.1. Parenthetical expressions shall be avoided and revised to comply with the NEC Style Manual.

FR-75-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.

Public Comment No. 73-NFPA 70E-2025 [Section No. O.1]

O.1 Introduction.

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.

Additional Proposed Changes

File Name	Description	Approved
70E_CN_42.pdf	70E_CN42	

Statement of Problem and Substantiation for Public Comment

NOTE: The following CC Note No. 42 appeared in the First Draft Report on First Revision No. 76.

The Correlating Committee requests that the Technical Committee review the numbering sequence since O.1 was deleted and renumber O.1.1 and O.1.2 in Informative Annex O. Consider adding titles in the subdivisions where appropriate for consistency throughout this annex.

Related Item

- First Revision No. 76

Submitter Information Verification

Submitter Full Name: CC Notes
Organization: NEC Correlating Committee
Street Address:
City:
State:
Zip:

Submittal Date: Fri Apr 04 10:42:38 EDT 2025
Committee: EEW-AAA

Correlating Committee Note No. 42-NFPA 70E-2025 [Section No. O.1]

Submitter Information Verification

Committee: NEC-AAC
Submittal Date: Thu Jan 16 08:57:39 EST 2025

Committee Statement and Meeting Notes

Committee Statement: The Correlating Committee requests that the Technical Committee review the numbering sequence since O.1 was deleted and renumber O.1.1 and O.1.2 in Informative Annex O. Consider adding titles in the subdivisions where appropriate for consistency throughout this annex.

FR-76-NFPA 70E-2024

Ballot Results

This item has passed ballot

12 Eligible Voters
3 Not Returned
9 Affirmative All
0 Affirmative with Comments
0 Negative with Comments
0 Abstention

Not Returned

Holub, Richard A.
McDaniel, Roger D.
Porter, Christine T.

Affirmative All

Gallo, Ernest J.
Hickman, Palmer L.
Hittinger, David L.
Jackson, Peter D.
Kendall, David H.
Krueger, Kyle
Manche, Alan
Osborne, Robert D.
Williams, David A.