



Electrical Safety Standards, Codes & Regulations

Central Tennessee Section of IEEE; August 7, 2018

Rod West, PE CFEI
Senior Staff Engineer
Schneider Electric USA


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Page 1

Introduction

Rod West

- Senior Staff Engineer
 - SE External Affairs & Government Relations, Oxford, Ohio USA
- Married with **5 DAUGHTERS!**
- 27 years of experience in the Electrical Industry
- Inventor on 11 US Patents for Electrical Equipment & Components
- Licensed Professional Engineer (PE) in Indiana & Alabama
- NAFI Certified Fire and Explosion Investigator – CFEI
- Board of Directors Chairman for Whitewater Valley REMC
- Active Member of:
 - Electrical Section of NFPA
 - NEMA LVDE 04
 - IEC 60439-2 Maintenance Team
 - NEC – Principal on Code Making Panel #8
 - 70E – Principal on Technical Committee



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Page 2

Electrical C&S Agenda

Today we will focus on:

1. C&S Background & Change Process
2. Key Concepts, Important Changes and Identify Trends
 - Significant Changes From Cover to Cover of NFPA 70E
 - Not an introductory course, but will touch on some basics / key concepts along the way



Will consider these areas with respect to:

- NEC – National Electrical Code (NFPA 70)
- NFPA 70E – The Standard for Electrical Safety in the Workplace
- OSHA – Occupational Safety and Health Administration

**PLEASE ASK
QUESTIONS!**

Not an endurance test – we will take a couple of short breaks!

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Page 3

Background & Change Process

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Page 4

NEC - Background

Original Code document developed in 1897

- United effort of insurance, electrical & architectural interests
- NFPA became the sponsor in 1911



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Page 5

NEC

- The purpose of the NEC is the practical safeguarding of persons and property from hazards arising from the use of electricity.
- The NEC covers the installation and removal of electrical conductors, equipment, and raceways; signaling and communications conductors, equipment, and raceways; and optical fiber cables and raceways
- The NEC is **not** intended as a design specification or an instruction manual for untrained people.
- The NEC does **not** address work practices. (NFPA 70E does!)

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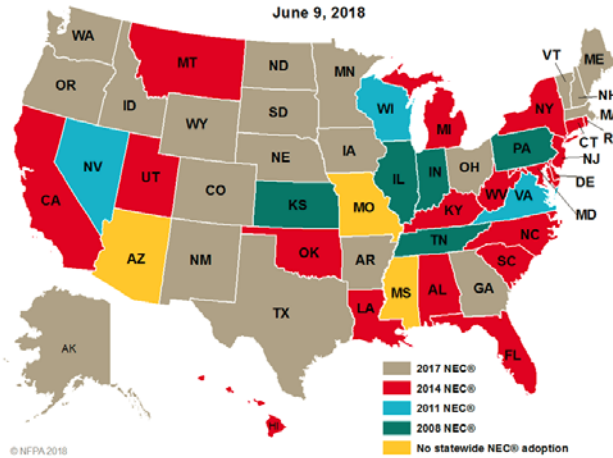
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Page 6

The NEC Adoption

NEC is an Installation Code

- Generally adopted by local or state jurisdictions
- As of June 2018, adoption in the US looks (something) like this:



In Tennessee

- The 2017 NEC was adopted 3/19/2018 and goes into effect 10/1/2018.
- NEC is statewide in TN, except for 30 Local Jurisdictions



Changes to NEC or 70E

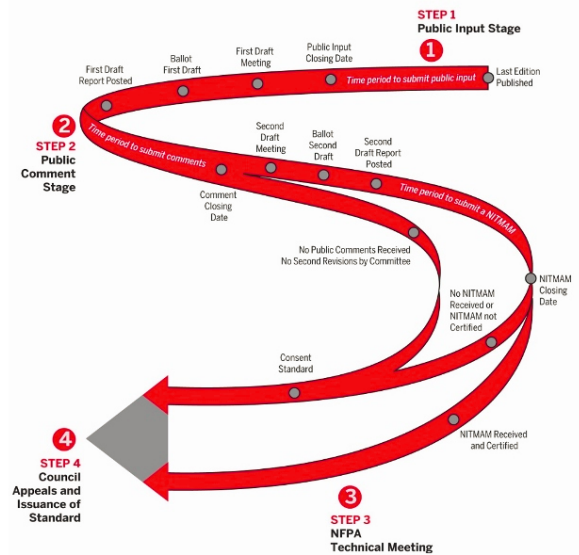
4 Major Steps:

1. **Public Input Stage** (fka Proposals)
2. **Public Comment Stage**
3. NFPA Annual **Technical Meeting**
4. Council **Appeals** and Issuance of Standard

Open Process

- **Anyone** can submit public input or comments

The Standards Development Process



NEC Change Process

■ 19 Code Making Panels, 473 Volunteer Members

- 9 Membership Classifications
- Balance / Various Points of View

3 year Revision Cycle to complete the 4 Major Steps:

- **Public Input / Proposals**
 - 4012 Proposals for 2017 Code
 - Panel Meeting / Action (1235 First Revisions)
 - 3730 Proposals / Public Input for 2020 Code
- **Public Comment**
 - 1513 Comments for 2017 Code
 - Panel Meeting / Action (559 Second Revisions)
- **NFPA Annual Meeting**

1. M *Manufacturer*: A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.
2. U *User*: A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.
3. IM *Installer/Maintainer*: A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.
4. L *Labor*: A labor representative or employee concerned with safety in the workplace.
5. RT *Applied Research/Testing Laboratory*: A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.
6. E *Enforcing Authority*: A representative of an agency or an organization that promulgates and/or enforces standards.
7. I *Insurance*: A representative of an insurance company, broker, agent, bureau, or inspection agency.
8. C *Consumer*: A person who is or represents the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in (2).
9. SE *Special Expert*: A person not representing (1) through (8) and who has special expertise in the scope of the standard or portion thereof.



Page 9

CODE-MAKING PANEL NO. 8

Articles 342, 344, 348, 350, 352, 353, 354, 355, 356, 358, 360, 362, 366, 368, 370, 372, 374, 376, 378, 380, 384, 386, 388, 390, 392, Chapter 9, Tables 1 through 4, Example D13, and Annex C

Larry D. Cogburn, *Chair*
Cogburn Bros., Inc., FL [IM]
Rep. National Electrical Contractors Association

David F. Allen, National Grid, MA [UT]
Rep. Electric Light & Power Group/EEI
David M. Campbell, AFC Cable Systems, Inc., MA [M]
Rep. The Aluminum Association, Inc.
David A. Gerstetter, UL LLC, IL [RT]
Rep. Underwriters Laboratories Inc.
Kenneth W. Hengst, Walker Engineering, Inc., TX [IM]
Rep. Independent Electrical Contractors, Inc.
Pete Jackson, City of Bakersfield, California, CA [E]
Rep. International Association of Electrical Inspectors
David H. Kendall, Thomas & Betts Corporation, TN [M]
Rep. The Vinyl Institute

Richard E. Loyd, R & N Associates, AZ [M]
Rep. Steel Tube Institute of North America
Michael C. Martin, ExxonMobil Research & Engineering, TX [U]
Rep. American Chemistry Council
Paul W. Myers, PCS Nitrogen, OH [U]
Rep. Institute of Electrical & Electronics Engineers, Inc.
Donald R. Offerdahl, Intertek Testing Services, ND [RT]
Rhett A. Roe, IBEW Local Union 26 JATC, MD [L]
Rep. International Brotherhood of Electrical Workers
Rodney J. West, Schneider Electric, OH [M]
Rep. National Electrical Manufacturers Association

Alternates

Richard J. Berman, UL LLC, IL [RT]
(Alt. to David A. Gerstetter)
Rachel Guenther, Thomas & Betts Corporation, TN [M]
(Alt. to David H. Kendall)
J. Grant Hammett, Colorado State Electrical Board, CO [E]
(Alt. to Pete Jackson)
Raymond W. Horner, Allied Tube & Conduit, IL [M]
(Alt. to Richard E. Loyd)
Gary K. Johnson, The Dow Chemical Company, LA [U]
(Alt. to Michael C. Martin)

Stephen P. Poholski, Newkirk Electric Associates, Inc., MI [IM]
(Alt. to Larry D. Cogburn)
Dan Rodriguez, IBEW Local Union 332, CA [L]
(Alt. to Rhett A. Roe)
Frederic F. Small, Hubbell Incorporated, CT [M]
(Alt. to Rodney J. West)
Raul L. Vasquez, Independent Electrical Contractors, TX [IM]
(Alt. to Kenneth W. Hengst)
Dave Watson, Southwire, GA [M]
(Alt. to David M. Campbell)



NEC - Today

“Current” edition is 2017

- There are **5 new articles** in the 2017 NEC



“Next” edition (2020) is already underway

- Public input was solicited soon after release of the 2017 edition
 - Proposals were reviewed in January 2018
 - First Draft issued
- Public Comments can be submitted until the end of August.
 - Will be reviewed in October 2018
- There are currently **4 new articles** being proposed for the 2020 NEC

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NFPA 70E – Standard for Electrical Safety in the Work Place

■ How long has NFPA 70E been around?

- A) Less than 15 years
- B) 15-24 Years
- C) 25-35 Years
- D) Over 35 Years

● Lot of attention recently, but it's not a new standard

- First edition of NFPA 70E was published in 1979.
- 2018 – 1979 = 39 years ago!

● Until the 1995 Edition, focus was on electrocution

- Arc Flash Boundary introduced in 1995



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Page 12

NFPA 70E Background

■ Same Revision Process as the NEC

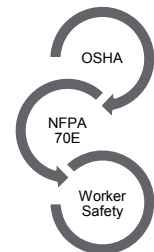
- 3 Year Cycle
 - Lags the NEC by a year
- Current Edition is 2018
 - Issued August 2017
- Next Edition (2021) is already underway
 - Pubic Input / Proposals will be next week (August 12-18, 2018)
 - We received approximately **332** Public Proposals
 - 1 Technical Committee of ~25 voting members



NFPA 70E Background

■ NFPA 70E was created at the request of OSHA

- OSHA recognized the 80/20 Issue: Installations vs Work Practices
 - ~80% of Citations based on **Installation** violations
 - ~80% of Injuries based on **Work Practices**
- Clearly work practices and maintenance of electrical systems are critical to safety – but they are not addressed by the installation Codes such as the NEC.
- NFPA Committee formed in January 1976; First edition published in 1979
 - Only included Part I: Installation Safety Requirements
 - Has grown (and shrunk a time or two) from there.
- **70E is not generally “adopted” by local or state jurisdictions like the NEC.**
 - It is adopted by employers
 - Enforcement is primarily internally and through OSHA.



OSHA - Background



OSHA – Occupational Safety and Health Administration

- Created by Congress with the Occupational Safety and Health Act of 1970 and officially established in April of 1971
- OSHA issues the CFR Code of Federal Regulations - **It's Federal Law.**
- The mission of OSHA is to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.
- Workers have a right to a safe and healthful work place - and - It is the duty of the employers to provide workplaces that are free of known dangers that could harm their employees.



OSHA - Changes

OSHA – Occupational Safety and Health Administration

- Changes can take a really long time...several years.
 - https://www.osha.gov/OSHA_FlowChart.pdf
 - OSHA present requirements in Subpart S date back to 70E-1983
- Four Groups of OSHA Standards: General Industry; Construction; Maritime; Agriculture
- Each group has a large number of rules.
- Our focus is on General Industry & Construction



OSHA – Index of topics

General Industry - 29 CFR 1910 Subpart S—Electrical

§1910.301 Introduction.

Design Safety Standards for Electrical Systems

§1910.302 Electric utilization systems.

§1910.303 General.

§1910.304 Wiring design and protection.

§1910.305 Wiring methods, components, and equipment for general use.

§1910.306 Specific purpose equipment and installations.

§1910.307 Hazardous (classified) locations.

§1910.308 Special systems.

Area of most interest



Safety-Related Work Practices

§1910.331 Scope.

§1910.332 Training.

§1910.333 Selection and use of work practices.

§1910.334 Use of equipment.

§1910.335 Safeguards for personnel protection.

also

1910 Subpart J - General Environmental Controls

§ 1910.147 - The control of hazardous energy (lockout/tagout).

Page 17

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OSHA – Index of topics

Construction

1926 Subpart K - Electrical

1926.400 - Introduction.

1926.402 - Applicability.

1926.403 - General requirements.

1926.404 - Wiring design and protection.

1926.405 - Wiring methods, components, and equipment for general use.

1926.406 - Specific purpose equipment and installations.

1926.407 - Hazardous (classified) locations.

Some very basic requirements here as well

1926.408 - Special systems.

1926.416 - General requirements.

1926.417 - Lockout and tagging of circuits.

1926.431 - Maintenance of equipment.

1926.432 - Environmental deterioration of equipment.

1926.441 - Batteries and battery charging.

1926.449 - Definitions applicable to this subpart.

Page 18

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OSHA – State Plans

OSHA – Occupational Safety and Health Administration

- This presentation addresses Federal OSHA.
- There are 28 OSHA-approved State OS&H Plans.
 - Tennessee is one of the 28.
 - OSHA approves and monitors the 28 State Plans
- State plans are very similar to the federal.
 - May have slightly different or more stringent requirements.
 - May cover government workers (in addition to private sector employees)
 - Required to be at least as effective as OSHA.



Page 19

OSHA - Background

OSHA generally takes a “high level” overview of hazards

- Doesn't go into the details – leaves that to consensus documents such as NFPA 70E
- National consensus standards are used as evidence of hazard recognition and the availability of feasible means of abatement. → The General Duty Clause
- For electrical work, many people say OSHA is the “Shall”, and NFPA 70E is the “How”

OSHA 1910.269 – covers equipment involved with generation, control, transformation, transmission, and distribution of electrical power (e.g., Utility or utility-type installations)

- Newest regulation
- Utility focused



Page 20

OSHA – Electrical Safety is Emphasized

Top 10 Most Frequently Cited Standards by OSHA (Fiscal 2017)

1. Fall protection, construction (29 CFR 1926.501)
2. Hazard communication standard (29 CFR 1910.1200)
3. Scaffolding, general requirements (29 CFR 1926.451)
4. Respiratory protection (29 CFR 1910.134)
5. Control of hazardous energy - lockout/tagout (29 CFR 1910.147)
6. Ladders, construction (29 CFR 1926.1053)
7. Powered industrial trucks (29 CFR 1910.178)
8. Machinery and Machine Guarding (29 CFR 1910.212)
9. Fall Protection–Training Requirements (29 CFR 1926.503)
10. Electrical, wiring methods, components and equipment (29 CFR 1910.305)



Page 21

Foundation / Key Concepts



Page 22

Key Concept: Electrical Safety – Identify Hazards

■ Two primary types of Electrical Hazards

- **Shock**
- **Arc Flash**
- A third hazard, **Arc Blast**, may result from an Arc Flash Event
 - Tremendous temperatures cause explosive expansion
 - Vaporized metal, high pressure, sound, shrapnel



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Page 23

Key Concept: Electrical Safety – Identify Hazards

■ Electric Shock

- Electric current passes through the body
- Varying intensity / duration / resistance / path
- Awareness for a century, but still happens
 - NFPA 70E Annex K:
 - 30,000 Non-fatal shock accidents/year



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Page 24

Key Concept: Electrical Safety – Identify Hazards

■ Arc Flash

- Current passes through plasma / ionized air
- Varying levels of intensity / duration / location
- Extremely high temperatures (up to 35,000° F)
- Majority of hospital admissions are due to arc flash burns, not from shock.
 - Per 70E Annex K, ~2000 people / year are admitted to burn centers with severe arc flash burns.
 - Can and do kill at 3m (10 ft).



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Page 25

Key Concept - What is a Qualified Person?

- NFPA 70E often refers to a Qualified Person..
 - What is a qualified person?
 - Are you qualified? For What?
 - What is an unqualified person?
- Definitions located in Article 100:



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**.

Unqualified Person. A person who is not a qualified person.

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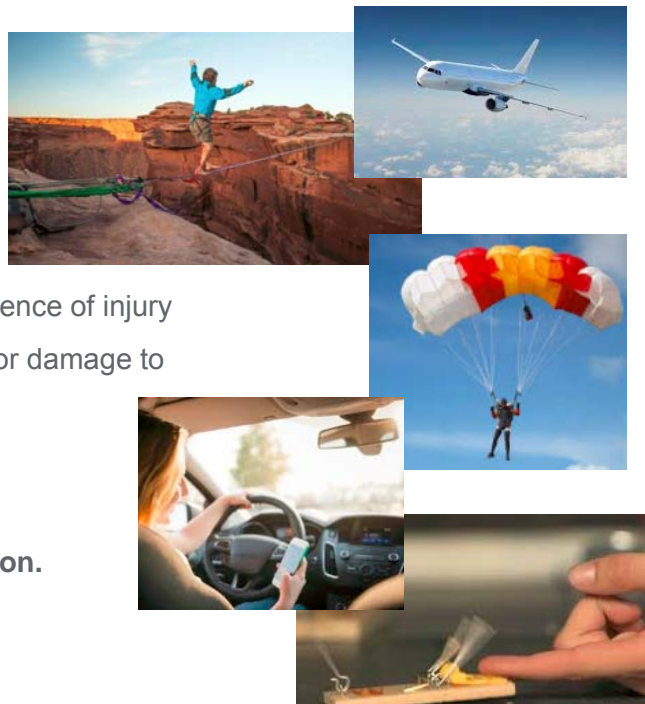
Page 26

NFPA 70E – Key Concept Risk

NFPA 70E Definition of Risk:

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.

Concept of Risk introduced in the 2015 edition.



Page 27

Key Concept – Energized Work

OSHA and NFPA 70E align - The general rule is to put the Equipment in an Electrically Safe Working Condition. (Turned off, LOTO, tested).

- There are a **few specific situations that may permit** energized work where the employer can demonstrate:
 - **Additional Hazards or Increased Risk** – de-energizing introduces additional hazards or increased risk
 - **Infeasibility** – the task is infeasible in a de-energized state due to equipment design or operational limitations
 - **Less than 50 Volts** – when it is determined that there will be no increased exposure to electrical burns or explosion.

Page 28

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70E – Cover to Cover Focusing on 2018 Changes

Article 90 - Introduction

NFPA 70E – Organization of the Standard

- **90** Introduction
 - **Chapter 1 Safety-Related Work Practices**
 - **100** Definitions
 - **105** Application of Safety-Related Work Practices and Procedures
 - **110** General Requirements for Electrical Safety- Related Work Practices
 - **120** Establishing an Electrically Safe Work Condition
 - **130** Work Involving Electrical Hazards
 - **Chapter 2 Safety-Related Maintenance Requirements**
 - **Chapter 3 Safety Requirements for Special Equipment**
 - **Annexes A -**
- Standard has 3 Chapters and 16 Annexes
 - Annexes are informative only
 - Chapter 1 has the bulk of the requirements
 - Organized into Five Articles
 - Chapter 4 was removed in the 2009 edition.
 - Contained installation requirements found in the NEC

NFPA 70E – 2018 Edition – Noteworthy Changes

90.2(A) Covered

- Section 90.2 is the Scope of NFPA 70E
- “Removal” was added to 90.2(A)

90.2 Scope

(A) 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...



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Article 100 – Definitions

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NFPA 70E – 2018 Edition – Noteworthy Changes

100 Arc Flash Hazard

- As mentioned earlier, Article 100 contains the definitions.
- The definition for Arc Flash Hazard and associated IN's were clarified.

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: 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) for examples of tasks that increase the likelihood of an arc flash incident occurring. Page 33



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NFPA 70E – 2018 Edition – Noteworthy Changes

100 Boundary, Arc Flash

- The definition of Arc Flash Boundary was clarified.

Boundary, Arc Flash. When an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm² (5 J/cm²).

+

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/cm² (5 J/cm²) for one second.



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Page 34

NFPA 70E – 2018 Edition – Noteworthy Changes

100 Electrical Safety

- The definition for Electrical Safety was modified.
- Addresses risk reduction – risk control methods are covered in 110.1(H)(3).

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



Page 35

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NFPA 70E – 2018 Edition – Noteworthy Changes

100 Electrical Safety Program

- A new definition was added for Electrical Safety Program.
- An ESP is required by 110.1



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.

Page 36

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NFPA 70E – 2018 Edition – Noteworthy Changes

100 Electrically Safe Work Condition

- The definition for Electrically Safe Work Condition was improved.
- Replaced “ensure” with “verify” - better aligns with changes made in 120.5

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 to verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection.



Page 37

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NFPA 70E – 2018 Edition – Noteworthy Changes

100 Fault Current and Fault Current, Available

- Two *new* definitions added to the standard:

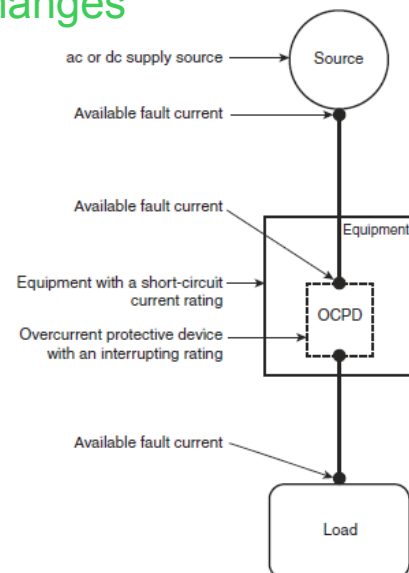
Fault Current. The amount of current delivered at a point on the system during a short-circuit condition.

Fault Current, Available. The largest amount of current capable of being delivered at a point on the system during a short circuit condition.

Informational Note No. 1: A short circuit can occur during abnormal conditions such as a fault between circuit conductors or a ground fault. See Figure 100.0.

Informational Note No. 2: If the dc supply is a battery system, the term *available fault current* refers to the prospective short circuit current.

Page 38



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NFPA 70E – 2018 Edition – Noteworthy Changes

100 Maintenance, Condition of

- A new definition was added for Condition of Maintenance.
- Lists factors to consider when evaluating the condition of equipment.
- NFPA 70B outlines recommended practices for Electrical Equipment Maintenance

Maintenance, Condition of. The state of the electrical equipment considering the manufacturers' instructions, manufacturers' recommendations, and applicable industry codes, standards, and recommended practices.



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Page 39

NFPA 70E – 2018 Edition – Noteworthy Changes

100 Qualified Person

- The definition of qualified person was modified to align with risk assessment.
- Risk reduction is a process which a qualified person must utilize.



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.

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Page 40

NFPA 70E – 2018 Edition – Noteworthy Changes

100 Risk Assessment

- The definition of Risk Assessment was modified to align with the 4 steps.
 - Identify, estimate likelihood, estimate severity, determine protective measures
- Requirements are found in 130.4, 130.5 and 110.1(H) – this defines the term.

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.

Arc flash risk assessment and *Shock risk assessment* are required by 70E.

Page 41

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NFPA 70E – 2018 Edition – Noteworthy Changes

100 Shock Hazard

- The definition of shock hazard was modified to remove “dangerous condition” and to indicate it is related to the flow of current through the body.
- The informational note is new.

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

Informational Note: Injury and damage to health resulting from 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.

Page 42

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NFPA 70E – 2018 Edition – Noteworthy Changes

100 Working Distance

- A *new* definition of working distance was added to improve understanding of this common term.
- Working distance can vary (See D.3.1).
 - Typically 18" for 600V
 - Typically 36" for over 600V.
- Incident energy increases as the distance from the arc source decreases
 - Incident Energy changes by the square of the distance
 - i.e. double the distance, decrease by a factor of 4



Working Distance. The distance between a person's face and chest area and a prospective arc source.

Page 43

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Article 105 – Application of Safety Related Work Practices and Procedures

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NFPA 70E – 2018 Edition – Noteworthy Changes

105.4 Priority

- A *new* requirement to emphasize the focus should be on hazard elimination and not PPE selection.

105.4 Priority. Hazard elimination shall be the first priority in the implementation of safety-related work practices.

Informational Note: Elimination is the risk control method listed first in the hierarchy of risk control identified in 110.1(H).



Page 45

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Article 110 – General Requirements for Electrical Safety Related Work Practices

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NFPA 70E – 2018 Edition – Noteworthy Changes

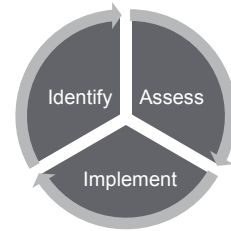
110.1(H) and 110.1(H)(1) Risk Assessment Procedure

- **THE major trend for 2015 and 2018 editions is RISK ASSESSMENT**

(H) Risk Assessment Procedure. The electrical safety program shall include a risk assessment procedure and shall comply with 110.1(H)(1) through 110.1(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 by the employee 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



Page 47

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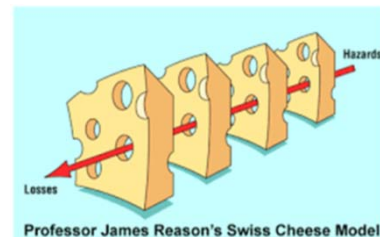
NFPA 70E – 2018 Edition – Noteworthy Changes

110.1(H)(2) Human Error

- A new section adds Human Error as a necessary consideration for the risk assessment procedure.

(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.

Informational Note: The potential for human error varies with factors such as tasks and the work environment. See Informative Annex Q.



Professor James Reason's Swiss Cheese Model

Page 48

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NFPA 70E – 2018 Edition – Noteworthy Changes

110.1(H)(3) Hierarchy of Risk Control Methods

- This *new* section makes the hierarchy of risk control methods a requirement.
- This is a concept that was introduced as an Informational Note in the 2015 edition.

(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

More effective; usually applied at the source; less likely to be affected by human error

Less effective; usually not applied at the source; more likely to be affected by human error

Page 49

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Key Concept – Hierarchy of Risk Controls

- (1) Elimination
- (2) Substitution
- (3) Engineering controls



More Effective

- 1) Elimination – Eliminate the hazard; or an electrically safe work condition (state not the process).
- 2) Substitution – Substitute less hazardous equipment; use non-electrical or battery operated tools; 24 v instead of 120 v control power.
- 3) Engineering Controls – Options that automatically reduce risk; GFCI protection, barriers.

Less Effective

- 4) Awareness – Alert people to the hazard; install permanent or temporary signs, labels, and barricades.
- 5) Administrative Controls – Planning processes, training, permits, job planning, work procedures.
- 6) PPE – Personal Protective Equipment must be available when needed and properly rated for the hazard. Insulated tools, clothing, & gloves.

- (4) Awareness
- (5) Administrative controls
- (6) PPE

Page 50

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NFPA 70E – 2018 Edition – Noteworthy Changes

110.1(B) Inspection

- A new 110.1(B) requires electrical safety programs to address inspection prior to commissioning electrical equipment.

(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.



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Page 51

NFPA 70E – 2018 Edition – Noteworthy Changes

110.1(I) Job Safety Planning and Job Briefing

- A modified section that contains new requirements.

(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 – Documented by qualified person; includes job description, risk assessments, and work procedures

(2) Job Briefing – includes job safety plan and EEWP if required.

(3) Change in Scope – additional planning and briefings in the event of changes

Example of a job briefing form and planning checklist located in Informative Annex I

Identify	
<input type="checkbox"/> Hazards	<input type="checkbox"/> Shock protection boundaries
<input type="checkbox"/> Voltage levels involved	<input type="checkbox"/> Available incident energy
<input type="checkbox"/> Skills required	<input type="checkbox"/> Potential for arc flash (Conduct an arc flash risk assessment.)
<input type="checkbox"/> Any "foreign" (secondary source) voltage source	<input type="checkbox"/> Arc flash boundary
<input type="checkbox"/> Any unusual work conditions	<input type="checkbox"/> Any evidence of impending failure?
<input type="checkbox"/> Number of people needed to do the job	
Ask	
<input type="checkbox"/> Can the equipment be de-energized?	<input type="checkbox"/> Is a standby person required?
<input type="checkbox"/> Are backfeeds of the circuits to be worked on possible?	<input type="checkbox"/> Is the equipment properly installed and maintained?
<input type="checkbox"/> Is an energized electrical work permit required?	
Check	
<input type="checkbox"/> Job plans	<input type="checkbox"/> Safety procedures
<input type="checkbox"/> Single-line diagrams and vendor prints	<input type="checkbox"/> Vendor information
<input type="checkbox"/> Status board	<input type="checkbox"/> Individuals are familiar with the facility
<input type="checkbox"/> Information on plant and vendor resources is up to date	
Know	
<input type="checkbox"/> What the job is	<input type="checkbox"/> Who is in charge
<input type="checkbox"/> Who else needs to know — Communicate!	
Think	
<input type="checkbox"/> About the unexpected event ... What if?	<input type="checkbox"/> Install and remove temporary protective grounding equipment
<input type="checkbox"/> Lock — Tag — Test — Try	<input type="checkbox"/> Install barriers and barricades
<input type="checkbox"/> Test for voltage — FIRST	<input type="checkbox"/> What else ... ?
<input type="checkbox"/> Use the right tools and equipment, including PPE	
Prepare for an emergency	
<input type="checkbox"/> Is the standby person CPR/AED trained?	<input type="checkbox"/> What is the exact work location?
<input type="checkbox"/> Is the required emergency equipment available?	<input type="checkbox"/> How is the equipment shut off in an emergency?
<input type="checkbox"/> Where is it?	<input type="checkbox"/> Are the emergency telephone numbers known?
<input type="checkbox"/> Where is the nearest telephone?	<input type="checkbox"/> Where is the fire extinguisher?
<input type="checkbox"/> Where is the fire alarm?	<input type="checkbox"/> Are radio communications available?
<input type="checkbox"/> Is confined space rescue available?	<input type="checkbox"/> Is an AED available?

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Page 52

NFPA 70E – 2018 Edition – Noteworthy Changes

110.1(J) Incident Investigations

- A *modified* section with a *new* requirement for the written electrical safety program.
- Incidents include events or occurrences that result in, or could have resulted in a fatality or injury.
- Incidents that do not result in fatality, injury, or damage to health are commonly referred to as a “close call” or “near miss.”



(J) Incident Investigations. The electrical safety program shall include elements to investigate electrical incidents.

Page 53

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NFPA 70E – 2018 Edition – Noteworthy Changes

110.2(C) Emergency Response Training

- A *revised* section adds training requirements for methods of safe release of victims.
 - Now includes those responsible for the safe release of victims as well as those exposed to shock hazards.
 - Annual refresher training.
- CPR and AED training requirements remain unchanged, however the annual retraining frequency was replaced.
 - Now says “..shall occur at a frequency that satisfies the requirements of the certifying body.”
 - American Heart Association and Red Cross had different frequencies – this resolves the discrepancy.



Page 54

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NFPA 70E – 2018 Edition – Noteworthy Changes

110.4 Test Instruments and Equipment

- *Revised* language clarifying the use of test instruments and equipment.
- 110.4(E) clarified to indicate that when testing for absence of voltage, the operation of the test instrument can be verified on **any** known voltage source before and after the absence of voltage test.
- Clears up a misconception in some locations that the meter must be checked at the same voltage as the circuit being deenergized.



Page 55

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Article 120 – Establishing an Electrically Safe Work Condition

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NFPA 70E – 2018 Edition – Noteworthy Changes

Article 120 - Establishing an Electrically Safe Work Condition

- Entire article was reorganized into five new sections:
 - 120.1 Lockout / Tagout **Program**
 - 120.2 Lockout / Tagout **Principles**
 - 120.3 Lockout / Tagout **Equipment**
 - 120.4 Lockout / Tagout **Procedures**
 - 120.5 **Process** for Establishing and Verifying an Electrically Safe Work Condition



Page 57

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Section 120.5 Process for Establishing and Verifying an ESWC

Correlates with OSHA 1910.333(B) and 1910.147 and 1910.269(d)

- (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) Release stored electrical energy.
- (5) Release or block stored mechanical energy.
- (6) Apply lockout/tagout devices in accordance with a documented and established procedure.
- (7) Use an adequately rated portable test instrument to test each phase conductor or circuit part to verify it is deenergized. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on any known voltage source.

Page 58

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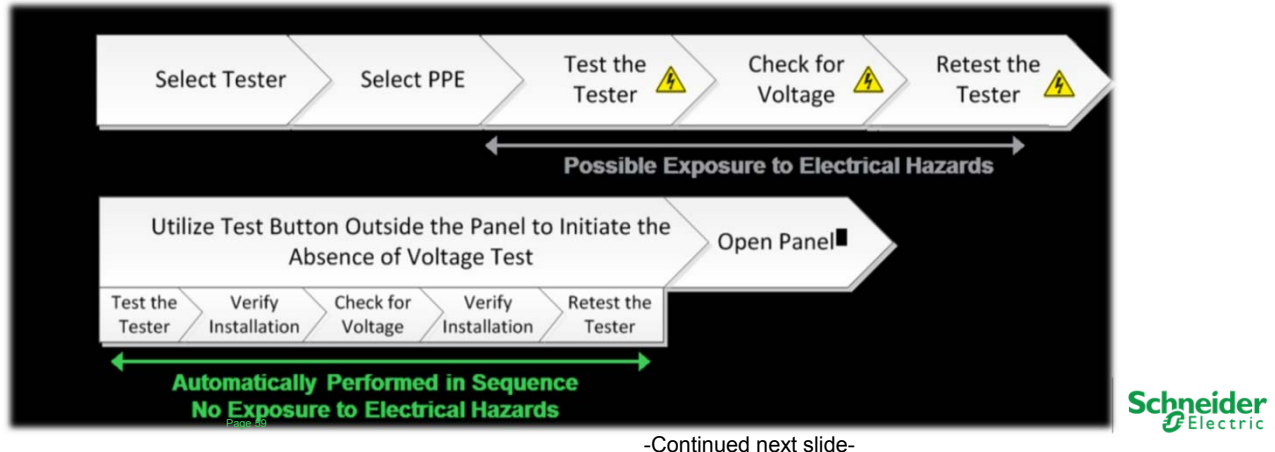
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NFPA 70E – 2018 Edition – Noteworthy Changes



120.5(7) Process for Establishing and Verifying an ESWC - **Exception No. 1**

- A new exception that permits permanently mounted absence of voltage testers.
- Permanently mounted as opposed to portable
- Absence of Voltage Tester – NOT a voltage indicator



-Continued next slide-

NFPA 70E – 2018 Edition – Noteworthy Changes

120.5(7) Process for Establishing and Verifying an ESWC - **Exception No. 1 (continued)**

- Absence of Voltage Tester - Several requirements:
 - Permanently mounted and installed in accordance with instructions
 - Tests the conductors and circuit parts at the point of work
 - Is listed and labeled for the purpose of verifying absence of voltage (UL 1436)
 - Tests each phase conductor phase to phase and phase to ground
 - Verified as operating on any known voltage source before and after verifying absence of voltage
- Presently AVT's are available for Low Voltage Equipment only.



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Article 130 – Work Involving Electrical Hazards

NFPA 70E – 2018 Edition – Noteworthy Changes

130.2 Electrically Safe Work Conditions

- Changes were made for clarity and consistency.
- Highlighting this entire section because **it is important!**

130.2 Electrically Safe Work Conditions. 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. **Boundaries will be discussed later**
- (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.

See Table 130.5(C) for examples that increase the likelihood of an arc flash

Referring quickly to Table 130.5(C)

Examples of some tasks that increase the likelihood of an Arc Flash:

- Voltage 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).
- Application of temporary protective grounding equipment, after voltage test.
- 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.
- Opening voltage transformer or control power transformer compartments.
- Operation of outdoor disconnect switch at 1 kV through 15 kV.

130.2 Electrically Safe Work Conditions. 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.

Page 63

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NFPA 70E – 2018 Edition – Key Concept

130.2(A) Energized Work

- Changes are minor, i.e. relocated informational notes and updating “Normal Operating Condition”.
- These are the conditions that must be met in order to permit Energized Work.
- This section aligns well with OSHA 1910.333(a)(1) and is important – will go through these in detail as well.

130.2(A) Energized Work

(1) Additional Hazards or Increased Risk. 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



Page 64

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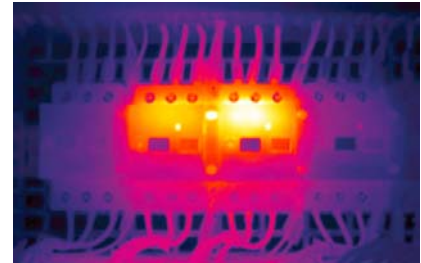
NFPA 70E – 2018 Edition – Key Concept

130.2(A) Energized Work (continued)

130.2(A) Energized Work

(2) Infeasibility. 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 (for example, 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.



Page 65

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NFPA 70E – 2018 Edition – Key Concept

130.2(A) Energized Work (continued)

130.2(A) Energized Work

(3) Equipment Operating at Less Than 50 Volts. 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.



Page 66

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70E Key Concept – Normal Operation



- **Normal operation is generally permitted where all of the following conditions are satisfied:**

- (1) The equipment is properly installed.
- (2) The equipment is properly maintained.
- (3) The equipment is used in accordance with instructions included in the listing and labeling and in accordance with manufacturer's instructions.
- (4) The equipment doors are closed and secured.
- (5) All equipment covers are in place and secured.
- (6) There is no evidence of impending failure.

Typical examples of "normal operation": Reading a panel meter while operating a switch, routine opening or closing of a circuit breaker, switch, contactor, or starter;

"Normal operation" does not generally include insertion or removal (racking) of MCC starter buckets, racking of circuit breakers, removal of bolted covers, or any situation where all of the conditions listed above are not satisfied.

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Page 67

NFPA 70E – 2018 Edition – Noteworthy Changes

130.2(A) Energized Work (continued)

(4) Normal Operating Condition. 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 used in accordance with instructions included in the listing and labeling and in accordance with manufacturer's instructions.
- (4) The equipment doors are closed and secured.
- (5) All equipment covers are in place and secured.
- (6) There is no evidence of **impending failure**.

installed in accordance with applicable industry codes and standards and the manufacturer's recommendations

maintained in accordance with the manufacturer's recommendations and applicable industry codes and standards

such as arcing, overheating, loose or bound equipment parts, visible damage, or deterioration.

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Page 68

NFPA 70E – 2018 Edition – Understanding Work Permits

130.2(B) Energized Electrical Work Permit

- Pretty minor changes – but will cover to make sure we all know what it is.

(B) Energized Electrical Work Permit.

(1) When Required. When work is performed as permitted in accordance with 130.2(A), an energized electrical work permit shall be required and documented under the any of 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

(2) Elements of Work Permit

...(see next slides)

(3) Exemptions to Work Permit

...(see next slides)

Page 69



NFPA 70E – 2018 Edition – Understanding Work Permits

130.2(B) Energized Electrical Work Permit - (2) Elements of a Work Permit (via Sample)

Page 70

ENERGIZED ELECTRICAL WORK PERMIT	
PART I: TO BE COMPLETED BY THE REQUESTER:	
(1) Description of circuit/equipment/job location: _____	Job/Work Order Number _____
(2) Description of work to be done: _____	
(3) Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage: _____	
Requester/Title _____	Date _____
PART II: TO BE COMPLETED BY THE ELECTRICALLY QUALIFIED PERSONS DOING THE WORK:	
(1) Detailed description of the job procedures to be used in performing the above detailed work: _____	Check when complete <input type="checkbox"/>
(2) Description of the safe work practices to be employed: _____	<input type="checkbox"/>
(3) Results of the shock risk assessment: _____	
(a) Voltage to which personnel will be exposed	<input type="checkbox"/>
(b) Limited approach boundary	<input type="checkbox"/>
(c) Restricted approach boundary	<input type="checkbox"/>
(d) Necessary shock, personal, and other protective equipment to safely perform assigned task	<input type="checkbox"/>

NFPA 70E – 2018 Edition – Understanding Work Permits

130.2(B) Energized Electrical Work Permit - (2) Elements of a Work Permit (via Sample)

ENERGIZED ELECTRICAL WORK PERMIT

PART I: TO BE COMPLETED BY THE REQUESTER

(1) Description of anticipated/assigned task: _____ Job/Work Order Number: _____

(2) Description of work to be done: _____

(3) Justification of why the arrangement cannot be arranged at the work inherent until the next scheduled outage: _____

Requester: _____ Date: _____

PART II: TO BE COMPLETED BY THE ELECTRICALLY QUALIFIED PERSONS DURING THE WORK

(1) Detailed description of the job procedure to be used in performing the above detailed work: _____ Check when complete

(2) Description of the safe work practices to be employed: _____

(3) Results of the shock risk assessment: _____

(a) Voltage to which personnel will be exposed _____

(b) Limited approach boundary _____

(c) Restricted approach boundary _____

(d) Necessary shock, personal, and other protective equipment to safely perform assigned task _____

(4) Results of the arc flash risk assessment: _____

(a) Available incident energy at the working distance or arc flash PPE category _____

(b) Necessary arc flash personal and other protective equipment to safely perform the assigned task _____

(c) Arc flash boundary _____

(5) Means employed to restrict the access of unqualified persons from the work area: _____

(6) Evidence of completion of a job briefing, including discussion of any job-related hazards: _____

(7) Do you agree the above-described work can be done safely? Yes No (If no, return to requester.)

Electrically Qualified Person(s) _____ Date _____

Electrically Qualified Person(s) _____ Date _____

PART III: APPROVAL(S) TO PERFORM THE WORK WHILE ELECTRICALLY ENERGIZED:

Manufacturing Manager _____ Maintenance/Engineering Manager _____

Safety Manager _____ Electrically Knowledgeable Person _____

General Manager _____ Date _____

Note: Once the work is complete, forward this form to the site Safety Department for review and retention.

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Page 71

FIGURE J.1 Sample Permit for Energized Electrical Work.

NFPA 70E – 2018 Edition – Understanding Work Permits

130.2(B) Energized Electrical Work Permit

(3) 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

Page 72

QUIZ – WWOS (What Would OSHA Say?)

The scenario and question:



- The manufacturing of integrated circuit components products involves many discrete pieces of equipment whose individual processes are part of the overall manufacturing process.
- Ten pieces of manufacturing equipment fed out of a 480-volt three-phase panel. A new piece of equipment will require a 225-ampere circuit breaker be added to the panel.
- To perform the work in an electrically safe work condition requires the power to the panel to be disconnected and appropriate LOTO devices applied.
- This activity would result in the shutdown of the ten pieces of equipment, causing a significant interruption to the ability to manufacture integrated circuits.



Q: Is the panel considered part of a continuous industrial process, thus allowing the work to be performed with the panel energized using electrical safe work practices, as per Note 2 in OSHA §1910.333(a)(1) and NFPA 70E 130.2(A)?

A: NO - Orderly shutdown of the related equipment and processes **would not** introduce additional or increased hazards, but **merely alter or interrupt production**. De-energization of the equipment **is considered feasible**, and the **exception does not apply**.

<https://www.osha.gov/laws-regs/standardinterpretations/2006-12-19>
Page 73

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QUIZ – WWOS (What Would OSHA Say?)

The scenario and questions:



- The manufacturing of integrated circuit components products involves many discrete pieces of equipment whose individual processes are part of the overall manufacturing process.
- Ten pieces of manufacturing equipment fed out of a 480-volt three-phase panel. One piece of equipment which is fed from a 225-ampere circuit breaker did not power up this morning.
- Electrical maintenance technician (tech) plans to test and troubleshoot.

Q1: Per NFPA 70E, can this work be performed with the panel energized?

A1: YES - If the tech is a qualified person and follows safe electrical work practices, Troubleshooting, including voltage measurements are permitted energized work.: 130.2(A)(2).

Q2: Is an Energized Electrical Work Permit required?

A2: NO - If the tech is a qualified person and follows safe electrical work practices, then the testing and troubleshooting is permitted without an energized electrical work permit.: 130.2(B)(3)



Page 74

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NFPA 70E – Shock Risk Assessment

130.4 Shock Risk Assessment

- Title of the Section changed as well as the addition of two new requirements, (B) and (C).

130.4 Shock Risk Assessment

(A) General. A shock risk assessment shall be performed:

- To identify shock hazards
- To estimate the likelihood of occurrence of injury or damage to health and the potential severity of injury or damage to health
- To determine if additional protective measures are required, including the use of PPE

(B) Additional Protective Measures

Points to 110.1(H) Risk Assessment Procedure and Hierarchy of Risk Control Methods

(C) Documentation

(D) Shock Protection Boundaries

Points to Table 130.4(D)(a) and (b)

(E) Limited Approach Boundary

NFPA 70E – Shock Risk Assessment

Table 130.4(D)(a) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for AC Systems

Nominal System Voltage Range, Phase to Phase ^a	Limited Approach Boundary ^b		Restricted Approach Boundary ^b ; Includes Inadvertent Movement Adder
	Exposed Movable Conductor ^c	Exposed Fixed Circuit Part	
Less than 50 V	Not specified	Not specified	Not specified
50 V–150 V ^d	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
151 V–750 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)
751 V–15 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.7 m (2 ft 2 in.)
15.1 kV–36 kV	3.0 m (10 ft 0 in.)	1.8 m (6 ft 0 in.)	0.8 m (2 ft 9 in.)
36.1 kV–46 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.8 m (2 ft 9 in.)
46.1 kV–72.5 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
72.6 kV–121 kV	3.3 m (10 ft 8 in.)	2.5 m (8 ft 0 in.)	1.0 m (3 ft 6 in.)
138 kV–145 kV	3.4 m (11 ft 0 in.)	3.0 m (10 ft 0 in.)	1.2 m (3 ft 10 in.)
161 kV–169 kV	3.6 m (11 ft 8 in.)	3.6 m (11 ft 8 in.)	1.3 m (4 ft 3 in.)
230 kV–242 kV	4.0 m (13 ft 0 in.)	4.0 m (13 ft 0 in.)	1.7 m (5 ft 8 in.)
345 kV–362 kV	4.7 m (15 ft 4 in.)	4.7 m (15 ft 4 in.)	2.8 m (9 ft 2 in.)
500 kV–550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.6 m (11 ft 8 in.)
765 kV–800 kV	7.2 m (23 ft 9 in.)	7.2 m (23 ft 9 in.)	4.9 m (15 ft 11 in.)

Notes:

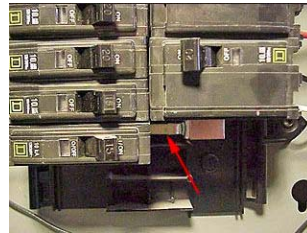
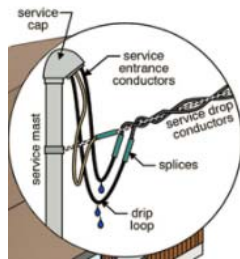
- For arc flash boundary, see 130.5(A).
- All dimensions are distance from exposed energized electrical conductors or circuit part to employee.
- For single-phase systems above 250 volts, select the range that is equal to the system's maximum phase-to-ground voltage multiplied by 1.732.
- See definition in Article 100 and text in 130.4(D)(2) and Informative Annex C for elaboration.
- 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.
- This includes circuits where the exposure does not exceed 120 volts nominal.

A
Common
Row

NFPA 70E – Shock Risk Assessment

Table 130.4(D)(a) Shock Protection Approach Boundaries to Exposed Energized Electrical Conductors or Circuit Parts for AC Systems

Nominal System Voltage Range, Phase to Phase ^a	Limited Approach Boundary ^b		Restricted Approach Boundary ^b ; Includes Inadvertent Movement Adder
	Exposed Movable Conductor ^c	Exposed Fixed Circuit Part	
Less than 50 V	Not specified	Not specified	Not specified
50 V–150 V ^d	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
151 V–750 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)



Limited Approach Boundary

- 10' - movable conductor not under control of the person
- 3½' - fixed conductor

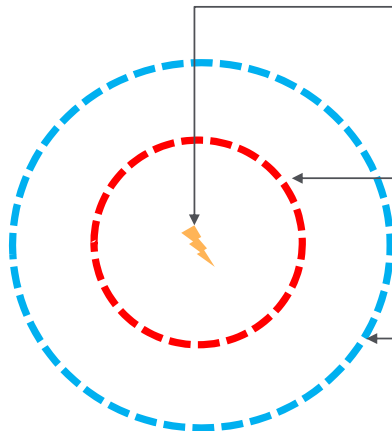
Restricted Approach Boundary
1 ft

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NFPA 70E – Shock Risk Assessment

Section 130.4

- We now know how two of the three boundaries are determined.
- These two boundaries primarily deal with the **shock hazard**.



- **Restricted Approach Boundary** is the inner boundary.
 - No unqualified persons allowed
 - Insulation / PPE required for qualified persons
- **Limited Approach Boundary** is the outer boundary.
 - No unqualified persons allowed without qualified escort
 - Barricades go no closer than this distance (maybe further, based on arc flash boundary).

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NFPA 70E – Shock Threshold for DC systems: 50-100-50 VDC

For 3 years (the 2015 Edition) the shock threshold for DC was increased from 50 to 100 VDC.

- A change to the DC shock threshold

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

(1) Nominal Potential Difference	(3) Limited Approach Boundary		(4) Restricted Approach Boundary; Includes Inadvertent Movement Adder
	(2) Exposed Movable Conductor*	Exposed Fixed Circuit Part	
Less than 50 V	Not specified	Not specified	Not specified
50 V–300 V	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	Avoid contact
301 V–1 kV	3.0 m (10 ft 0 in.)	1.0 m (3 ft 6 in.)	0.3 m (1 ft 0 in.)
1.1 kV–5 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.5 m (1 ft 5 in.)
5 kV–15 kV	3.0 m (10 ft 0 in.)	1.5 m (5 ft 0 in.)	0.7 m (2 ft 2 in.)
15.1 kV–45 kV	3.0 m (10 ft 0 in.)	2.5 m (8 ft 0 in.)	0.8 m (2 ft 9 in.)
45.1 kV–75 kV	3.0 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.)	3.0 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.)

- In 2015 Edition this was increased to 100 VDC
- For 2018 it was **returned to 50 VDC** primarily because of OSHA.
- In Article 320.3 (only) the value of 100 VDC remains, per DOE-Handbook 1092.

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

*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.

Page 79



■ Recall there are two primary types of Electrical Hazards

- Shock 
- Arc Flash 

Page 80



NFPA 70E – Arc Flash Risk Assessment

130.5 Arc Flash Risk Assessment

- Several modifications intended to improve clarity and usability.

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

(C) Additional Protective Measures

(D) Documentation

(E) Arc Flash Boundary

(F) Arc Flash PPE

(G) Incident Energy Analysis Method

(H) Equipment Labeling



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Page 81

Key concept – Incident Energy Analysis / PPE Category Tables

The big picture – Incident Energy Analysis is great, but the Tables are still necessary

- The PPE Category Method (aka the Tables) and an Incident Energy Analysis
 - Two Different ways to determine PPE
 - Until 2018 It was one or the other



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Page 82

Key concept – Evolution of the HRC / PPE Category Tables

A brief history to understand the direction...



- The Tables have been evolving since they were introduced
 - Hazard/Risk Category (HRC) was renamed to PPE Category in the 2015 edition
 - In earlier editions of 70E there were lower PPE requirements for lower risk tasks
 - **Wrong:** A hazard either exists or does not.
 - No more Category “0”
 - Only Arc Rated (AR) rated clothing when there in an Arc Flash hazard
 - Did you know there used to be a “-1” HRC level as well? We removed it in 2009

Continued next slide...

Page 83

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Key concept – Evolution of the HRC / PPE Category Tables

A brief history to understand the direction... (continued)



- “Tables” method totally reworked in the 2015 edition to become a 3 step process
 1. Identify the task and determine if an arc flash is likely
 2. If an arc flash is likely, locate equipment, verify parameters and determine category.
 3. Use category to select the PPE
 - The PPE Categories and the old HRC Categories have the same range
 - 4, 8, 25 and 40 Cal/cm²
- For the 2018 edition, this same general approach remains, Except...
 - The hierarchy of risk controls is required – making it a 4 step process
 - Table use has actually been expanded.

Page 84

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NFPA 70E – Arc Flash Risk Assessment

Estimating the likelihood of occurrence

- A *New* Table in the 2018 edition, Table 130.5(C) to estimate the likelihood of occurrence.
- The Table 130.5(C) can be used when either an Incident Energy Analysis was performed or when the Arc Flash PPE Category Method is used.
- In the past, it was either Category Method or Incident Energy Analysis – there was no mixing of the two



Page 85

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Tables

How to use them..



Step 1

Identify the Task & determine the likelihood of occurrence of an Arc Flash

Page 86

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NFPA 70E – Arc Flash Risk Assessment – Task / Likelihood

Step 1

Using Table 130.5(C) for guidance on Likelihood of Occurrence of an Arc Flash - Examples

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

1 Task Find the task	2 Equipment Condition	3 Likelihood of Occurrence*
For ac systems, work on energized electrical conductors and circuit parts, including voltage testing. For dc systems, working on energized electrical conductors and circuit parts of series-connected battery cells, including voltage 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.	Any Any Abnormal Normal	Yes
Operation of a CB, switch, contactor, or starter. Equipment condition considered to be "normal" if all of the following circumstances apply: <ol style="list-style-type: none"> (1) The equipment is properly installed in accordance with the manufacturer's recommendations and applicable industry codes and standards. (2) The equipment is properly maintained in accordance with the manufacturer's recommendations and applicable industry codes and standards. (3) The equipment is used in accordance with instructions included in the listing and labeling and in accordance with manufacturer's instructions. (4) Equipment doors are closed and secured. (5) Equipment covers are in place and secured. (6) There is no evidence of impending failure such as arcing, overheating, loose or bound equipment parts, visible damage, or deterioration. 	Normal	No Yes No*

Page 87

Tables

How to use them..



Step 2

Additional protective measures / Hierarchy of Risk Control

Page 88

NFPA 70E – Arc Flash Risk Assessment – Risk Control

After determining Likelihood of Occurrence of an Arc Flash ...

- Likelihood of occurrence is significant - Now What?
- Don't jump immediately to PPE.
 - First review the Hierarchy of Risk Controls
 - PPE is the last line of defense – use it to address residual risks
 - If PPE is necessary, then we need to select it



130.5(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)

Page 89

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Tables

How to use them..



Step 3

Determine Severity

Via Incident Energy
analysis

-or-

PPE Category Table

Page 90

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Step 3

NFPA 70E – Severity via PPE Category Method

The **arc flash PPE category method** in accordance with 130.7(C)(15) & Tables 130.7(C)(15) (a)/(b)

Table 130.7(C)(15)(a) Arc-Flash PPE Categories for Alternating Current (ac) Systems

Equipment	Equipment / Parameters	Arc-Flash PPE Category	Arc-Flash Boundary
	1		
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)

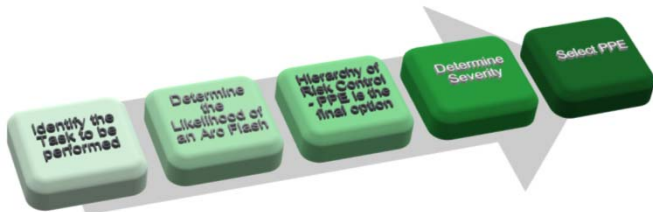
PPE Category

AFB

Tables

How to use them..

Step 4
Select the necessary PPE



Step 4

NFPA 70E –PPE selection with PPE Category Method

Using Table 130.7(C)(15) (c)

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) Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated face shield ^a or arc flash suit hood Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) ^f Heavy-duty leather gloves ^g Leather footwear (SN)
2	Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm ² (33.5 J/cm ²) Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield ^b and arc-rated balaclava Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) ^f Heavy-duty leather gloves ^g Leather footwear
3	Arc-Rated Clothing Selected so That the Arc Rating is at Least 104.7 J/cm ² Arc-rated long-sleeve shirt (AR) Arc-rated pants (AP) 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 ^g Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) ^f Leather footwear
4	Arc-Rated Clothing Selected so That the Arc Rating is at Least 167.5 J/cm ² Arc-rated long-sleeve shirt (AR) Arc-rated pants (AP) 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 ^g Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) ^f Leather footwear

1

Find PPE Category

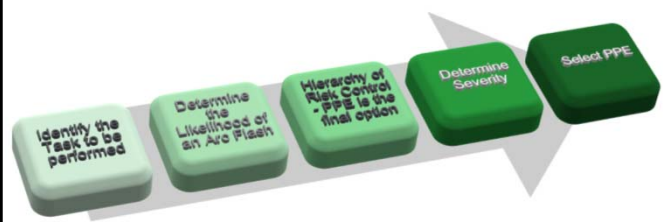
Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm² (33.5 J/cm²)^a
 Arc-rated long-sleeve shirt and pants or arc-rated coverall
 Arc-rated flash suit hood or arc-rated face shield^b and arc-rated balaclava
 Arc-rated jacket, parka, rainwear, or hard hat liner (AN)
Protective Equipment
 Hard hat
 Safety glasses or safety goggles (SR)
 Hearing protection (ear canal inserts)^c
 Heavy-duty leather gloves^d
 Leather footwear

2

Determine PPE

Tables

How to use them..



Step 3 Determine Severity

Via Incident Energy analysis

-or-

PPE Category Table

NFPA 70E – Severity via Incident Energy Analysis

The incident energy analysis method in accordance with 130.5(G)

Informative Annex D Incident Energy and Arc Flash Boundary Calculation Methods

This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Introduction. Annex D summarizes calculation methods available for calculating arc flash boundary and incident energy. It is important to investigate the limitations of any methods to be used. The limitations of methods summarized in Annex D are described in Table D.1.

Table D.1 Limitation of Calculation Methods

Section	Source	Limitation
D.2, D.3, D.4	Ralph Lee paper	
D.5	Doughty/Neal paper	Calculates incident energy for three-phase arc on systems rated 600 V and below; applies to short-circuit currents between 16 kA and 50 kA.
D.6	Ralph Lee paper	Calculates incident energy for three-phase arc in open air on systems rated above 600 V; becomes more conservative as voltage increases.
D.7	IEEE Std. 1584	Calculates incident energy and arc flash boundary for: 208 V to 15 kV, three-phase; 50 Hz to 60 Hz; 700 A to 106,000 A short-circuit current; and 13 mm to 152 mm conductor gaps.
D.8	ANSI/IEEE C2-NEC, Section 410, Table 410-1 and Table 410-2	Calculates incident energy for open air phase-to-ground arcs 1 kV to 500 kV for live-line work.

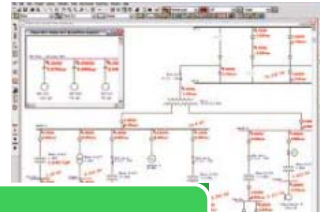
A typical value for the maximum power, P (in MW) in a three-phase arc can be calculated using the following formula:

$$P = [\text{maximum bolted fault, in MVA}] \times 0.707^2 \quad \text{[D.2(b)]}$$

$$P = 1.732 \times V \times I_a \times 10^{-6} \times 0.707^2 \quad \text{[D.2(c)]}$$

The arc flash boundary distance is calculated in accordance with the following formula:

1 Calculate Incident Energy



Steps 1&2 are the same... Step 3

Calculations are based on IEEE 1584 Methods, Ralph Lee work, etc.

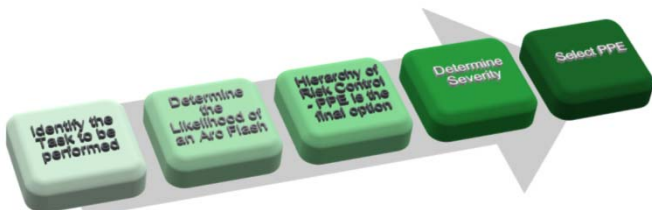
$$E_{MB} = 1038.7 D_B^{-1.4738} I_A [0.0093 F^2 - 0.3453 F + 5.9675]$$

where:
 E_{MB} = maximum 20 in. cubic box incident energy, cal/cm²
 D_B = distance from arc electrodes, in. (for distances 18 in. and greater)
 I_A = arc duration, sec
 F = short-circuit current, kA (for the range of 16 kA to 50 kA)



Tables

How to use them..



Step 4
Select the necessary PPE Based on the Incident Energy Level



Step 4

NFPA 70E – Incident Energy Analysis Method

Using Table 130.5(G)

Table 130.5(G) Selection of Arc-Rated Clothing and Other PPE When the Incident Energy Analysis Method Is Used

<p>Incident energy exposures equal to 1.2 cal/cm² up to 12 cal/cm² Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy^a Long-sleeve shirt and pants or 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) (AN) Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)^c Hard hat Safety glasses or safety goggles (SR) Hearing protection Leather footwear</p>
<p>Incident energy exposures greater than 12 cal/cm² Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy^a Long-sleeve shirt and pants or coverall or arc flash suit (SR) Arc-rated arc flash suit hood Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN) Arc-rated gloves or rubber insulating gloves with leather protectors (SR)^c Hard hat Safety glasses or safety goggles (SR) Hearing protection Leather footwear</p>

1

Determine if
I.E. is >< 12

2

Select PPE

Page 97

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Tables – How to use them

A couple final comments on the PPE Category Tables

Page 98

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NFPA 70E – PPE Category Method aka The Tables



The **arc flash PPE category method** in accordance with 130.7(C)(15) & Tables 130.7(C)(15) (a)(b)(c)

This is all new.

- Don't know the fault clearing time for the upstream OCPD?
 - Informational Note at the end of Table 130.7(C)(15)(a)

Informational Note 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 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.

Page 99

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NFPA 70E – PPE Category Method aka The Tables

The **arc flash PPE category method** in accordance with 130.7(C)(15) & Tables 130.7(C)(15) (a)(b)(c)

This is all new.

- Tables or parameters don't match your specific situation? For Example, if you have:
 - Power systems with greater than the estimated maximum available fault current
 - Power systems with longer than the maximum fault clearing times
 - Situations with less than the minimum working distance



- Then see 130.7(C)(15)...An incident energy analysis shall be required in accordance with 130.5.

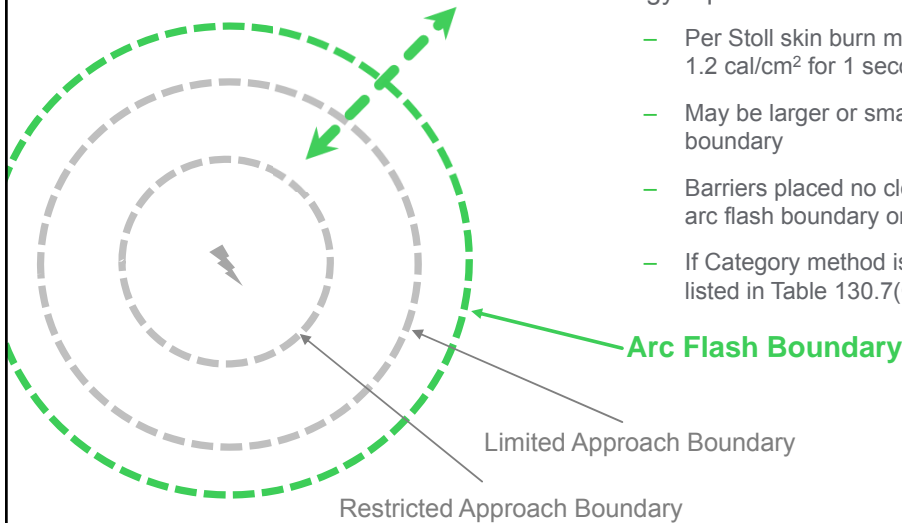
Page 100

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NFPA 70E – Arc Flash Boundary – Where is it?

Arc Flash Boundary is the distance at which the incident energy equals 1.2 cal/cm^2 (5 J/cm^2)

- Per Stoll skin burn model, onset of 2nd degree burn is 1.2 cal/cm^2 for 1 second.
- May be larger or smaller than the limited approach boundary
- Barriers placed no closer than the furthest boundary: arc flash boundary or limited approach boundary
- If Category method is used, Arc-Flash Boundaries are listed in Table 130.7(C)(15)(a) and (b)



NFPA 70E – Arc Flash Risk Assessment - Labeling

130.5(H) Equipment Labeling

(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:
 - 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

No changes to the basic requirements

Exception No. 1 & 2...Did change – will discuss shortly.

2017 NEC also has Labeling Requirements

110.16 Arc-Flash Hazard Warning.

(A) **General.** Electrical equipment, such as switchboards, switchgear, panelboards, industrial control panels, meter socket enclosures, and motor control centers, that is in other than dwelling units, and is likely to require examination, adjustment, servicing, or maintenance while energized, shall be field or factory marked to warn qualified persons of potential electric arc flash hazards. The marking shall meet the requirements in 110.21(B) and shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

(B) **Service Equipment.** In other than dwelling units, in addition to the requirements in (A), a permanent label shall be field or factory applied to service equipment rated 1200 amps or more. The label shall meet the requirements of 110.21(B) and contain the following information:

- (1) Nominal system voltage
- (2) Available fault current at the service overcurrent protective devices
- (3) The clearing time of service overcurrent protective devices based on the available fault current at the service equipment

(4) The date the label was applied

Exception: Service equipment labeling shall not be required if an arc flash label is applied in accordance with acceptable industry practice.

Informational Note No. 1: NFPA 70E-2015, *Standard for Electrical Safety in the Workplace*, provides guidance, such as determining severity of potential exposure, planning safe work practices, arc flash labeling, and selecting personal protective equipment.

Informational Note No. 2: ANSI Z535.4-2011, *Product Safety Signs and Labels*, provides guidelines for the design of safety signs and labels for application to products.

Informational Note No. 3: Acceptable industry practices for equipment labeling are described in NFPA 70E-2015 *Standard for Electrical Safety in the Workplace*. This standard provides specific criteria for developing arc-flash labels for equipment that include nominal system voltage, incident energy levels, arc-flash hazard categories, minimum required levels of personal protective equipment, and so forth.

For reference only – explained on next slides

Key Concept: Arc Flash Equipment Labeling

Requirements for arc flash labeling are found in 2 places:

■ NFPA 70E

- Work Practices related requirement
- Provides **Information** on the Hazard (PPE Selection)



■ 2014 NEC

- Installation requirement
- 110.16 Safety Label to **Warn** of the Arc Flash Hazard



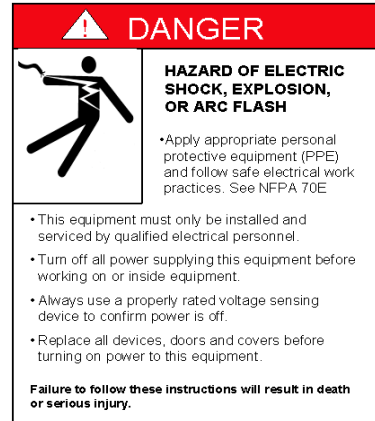
■ 2017 NEC

- Installation requirement
- 110.16(A) Safety Label to **Warn** of the Arc Flash Hazard
- 110.16(B) **Information** for Service Equipment rated 1200 A or more
 - Nominal System Voltage; Available Fault Current at the OCPD; Clearing time of service OCPD based on the available fault current; date label applied
 - Exception allows a 70E label to satisfy 110.16(B)



NFPA 70E – Arc Flash Risk Assessment - Labeling

- **2014 NEC Section 110.16 and 2017 NEC 110.16(A)**
 - Same requirement (no expansion)
- Requirement to **Warn about the Arc Flash Hazard**
 - Must meet the requirements of 110.21(B)
 - ANSI Z535.4 *Product Safety Signs and Labels*
- This Requirement Introduced in 2002 Edition
 - Updates/Changes in 2005, 2008, 2011, 2014 & 2017*
 - (* section # only)
- Must be present - May be field or factory applied.
 - Recall the NEC has installation requirements, so subject to inspection.



Equipment Labeling – Arc Flash

2015 NFPA 70E Section 130.5(C)

Only change for 2018 was to section #: 130.5(H)

- Requirements are for specific information
- (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

Arc Flash Information

Use this information in accordance with applicable OSHA standards, NFPA 70E-2015 and other required safe electrical work practices.	
1.71 cal/cm ²	Incident Energy at a Working Distance of 1 ft 6 in.
1 ft 10 in.	Arc Flash Boundary
208V	Shock hazard when cover is open
3 ft 6 in.	Limited Approach
1 ft 0 in.	Restricted Approach
Eqpt Name: L1A	Q2C: 12345678 Date: 09/10/14
Values produced by a Schneider Electric engineering analysis. Any system modification, adjustment of protective device settings, or failure to properly maintain equipment will invalidate this label. For more information, contact Schneider Electric at 1-888-778-2733. Copyright © 2014 Schneider Electric. All Rights Reserved	

- Introduced in 2009 Edition, expanded in 2012 & 2015 editions
- May be field or factory applied, but requires circuit specific information; therefore generally field applied.
- Also satisfies 110.16(B) in the 2017 NEC

Equipment Labeling – Arc Flash

New for 2018 – there are 2 exceptions to the labeling requirement

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.



- Not retroactive.
- Must be updated when changes occur to the system that could affect the results of the incident energy analysis.
- Keep in mind the incident energy analysis must be reviewed for accuracy at intervals not to exceed 5 years.
 - If the label is inaccurate, the label must be updated.

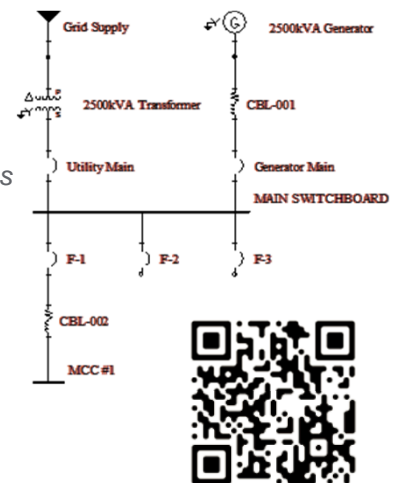
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Page 107

Equipment Labeling – Arc Flash

New for 2018 – there are 2 exceptions to the labeling requirement

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.



- Readily available may be in a binder or perhaps electronically – even QR or bar code links are possible.
- Systems are getting more complex, with multiple sources.
- Limited to “...supervised industrial installations where conditions of maintenance and engineering...”

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Page 108

Arc Flash Labeling

Summary – Key Concept / take away

- Labeling can be a sticky situation (sorry).
- Best practices to consider:
 - Go beyond the minimum requirements
 - Date; engineering contact info; etc.
 - Labels that combine safety message and arc flash info may be acceptable, but watch for mixed messages on the same gear
 - ANSI Z535 colors / signal words
 - Consider Appearance, Format, Location, Languages and Durability
 - Consider how many labels may be necessary
 - Is “worst case” sufficient?
 - What other options are there?
 - Prohibited Approach Boundary no longer appears in the standard – remove from your labels.



Page 109

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NFPA 70E – 2018 Edition – Noteworthy Changes

130.7 Personal and Other Protective Equipment



130.7(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, protective equipment that is designed and constructed for the specific part of the body to be protected and for the

- Most significant change here is the deletion of 2 informational notes:
 - “It is the collective experience ... that normal operation ... is not likely to expose the employee to an electrical hazard.” dealt primarily with normal operation. This is now addressed by 130.2(A)(4)
 - “When incident energy exceed 40 cal/cm²...greater emphasis may be necessary with respect to de-energizing...” was removed. Greater emphasis begins at the threshold for 2nd degree burns (1.2 cal/cm²).

Page 110

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NFPA 70E – 2018 Edition – Noteworthy Changes



130.7(C) Personal Protective Equipment (PPE)

- **When working within the restricted approach boundary, shock PPE is required per 130.4**
- **When working within the arc flash boundary, arc flash PPE is required per 130.5**
- All parts of the body – Head area, eyes, hearing, body, arm/hands, feet...
 - Don't forget the back of the head if it is inside the arc flash boundary (balaclava if under 12 cal/cm²)
- Rubber insulating gloves require leather protectors in vast majority of situations
 - Some changes here, but the general rule remains the same
- Layering – Non melting, flammable fiber garments are permitted as underlayers
 - No melting fibers (nylon, polyester, spandex)
 - Outer layers (jackets, rainwear) must be arc rated as well

Page 111

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NFPA 70E – 2018 Edition – Noteworthy Changes

130.7(C)(7)(c) Maintenance and Use

- **PPE shall be maintained in a safe and reliable condition**
- PPE must be inspected for damage before each day's use or following an incident
 - Insulating gloves are to be air tested along with the visual inspection
 - Periodic **electrical** testing is required. Maximum test intervals of rubber insulating equipment are shown below. Also see OSHA 1910.137(c)(2)

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.

Page 112



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NFPA 70E – 2018 Edition – Noteworthy Changes

130.7(C)(14) Standards for Personal Protective Equipment (PPE)

- **New section 130.7(C)(14)(b) on Conformity Assessment**

(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 accredited independent third-party certification organization

Informational Note: Examples of a process for conformity assessment to an appropriate product standard can be found in ANSI/ISEA 125, *American National Standard for Conformity Assessment of Safety and Personal Protective Equipment.* See Informative Annex H.4.

- A requirement for PPE suppliers, not users of 70E.
- 3 Options to meet this requirement.



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Page 113

NFPA 70E – 2018 Edition – Noteworthy Changes

130.7(C)(14) Standards for Personal Protective Equipment (PPE)

- **New section 130.7(C)(14)(c) on Marking of PPE**

(c) *Marking.* All suppliers or manufacturers of PPE shall provide the following information on the personal protective equipment, 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
- (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

- A requirement for PPE suppliers, not users of 70E.
- Benefits the Users - PPE will be marked with several important pieces of information.
- Look for this on your PPE



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Page 114

NFPA 70E – 2018 Edition – Noteworthy Changes

130.5(C) and 130.7(C)(15)(b) Using the Arc Flash PPE Categories for DC Systems

- The same approach applies for using the AC or DC PPE Category method.
- Some tasks may be different for DC systems (examples shown to right)
- The tasks are intermingled with the AC tasks.
- Hazards and levels may also be different
 - see next slide for PPE Categories-
- Insertion or removal of individual cells or multi-cell units of a battery system or multi-cell units in an open rack.
- Maintenance on a single cell of a battery system or multi-cell units in an open rack.
- Working on energized electrical conductors and circuit parts of series connected battery cells, including voltage testing.
- Working on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source.
- Removal of battery nonconductive intercell connector covers.

Page 115



NFPA 70E – 2018 Edition – Noteworthy Changes

130.7(C)(15)(b) Arc-Flash PPE Categories for DC Systems

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

Equipment	Arc-Flash PPE Category	Arc-Flash Boundary
Storage batteries, dc switchboards, and other dc supply sources Parameters: Greater than or equal to 100 V and less than or equal to 250 V Maximum arc duration and minimum working distance: 2 sec @ 455 mm (18 in.)		
Available fault current less than 4 kA	2	900 mm (3 ft)
Available fault current greater than or equal to 4 kA and less than 7 kA	2	1.2 m (4 ft)
Available fault current greater than or equal to 7 kA and less than 15 kA	3	1.8 m (6 ft)
Storage batteries, dc switchboards, and other dc supply sources Parameters: Greater than 250 V and less than or equal to 600 V 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)

Page 116



- Many battery systems and other dc process systems are in open areas or rooms.
- These categories are based on open-air incident energy calculations.
- Within an enclosure consider additional PPE protection beyond the value shown in this table.
- A multiplier of **as much as 3X** for arc-in-a-box vs open air.



NFPA 70E – Changes Cover to Cover

Table 130.7(C)(15)(c)

Table 130.7(C)(15)(c) Personal Protective Equipment (PPE)

Arc-Flash PPE Category	PPE
1	<p>Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm² (16.75 J/cm²) Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated face shield¹ or arc flash suit hood Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)² Heavy-duty leather gloves³ Leather footwear (SN)</p>
2	<p>Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm² (33.3 J/cm²) Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield¹ and arc-rated balaclava Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)² Heavy-duty leather gloves³ Leather footwear</p>
3	<p>Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm² (104.7 J/cm²) 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 gloves³ Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)² Leather footwear</p>
4	<p>Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40 cal/cm² (167.5 J/cm²) 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 gloves³ Arc-rated jacket, parka, rainwear, or hard hat liner (AN) Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)² Leather footwear</p>

- Table 130.7(C)(15)(c) provides the necessary PPE for each Arc Flash PPE Category: 1, 2, 3 & 4
- The content of this table did not change.
- A clarifying note was added for Hearing Protection (ear canal inserts) as follows:
 - “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.”



NFPA 70E – 2018 Edition – Noteworthy Changes

130.7(E)(4) – Cutting, Removing or Rerouting of Conductors

- A **NEW** section and new informational note:

(4) Cutting, Removing, or Rerouting of Conductors. Where conductors are de-energized in order to cut, remove, or reroute them and conductor terminations are not within sight, such as where they are in a junction or pull box, additional steps to verify absence of voltage or identify the conductors shall be taken prior to cutting, removing, or rerouting the conductors.

Informational Note: Additional steps to be taken include, but are not limited to, remotely spiking the conductors and pulling the conductors to visually verify movement. Nonshielded conductors could be additionally verified with a noncontact test instrument, and shielded conductors could be verified with devices to identify the conductors.



Chapter 2 - Safety Related Maintenance Requirements

NFPA 70E – 2018 Edition – Noteworthy Changes

Chapter 2 Safety Related Maintenance Requirements

In general, the last 2 editions of NFPA 70E have an Increased focus on maintenance

- Primarily these changes have been Incorporated into Chapter 1
- Improper maintenance can
 - Negatively impact the likelihood of an event
 - Increase device clearing time, which can impact severity
 - Create bonding / grounding Issues, which can impact shock risk
- **NFPA 70B is the Recommended practice for Electrical Equipment Maintenance**
- Chapter 2 of 70E which deals with Safety Related Maintenance Requirements is only 4 pages long
 - Only minor clarifications, global wording changes (incident v accident; unintentional v accidental



Chapter 3 - Safety Requirements for Special Equipment

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NFPA 70E – 2018 Edition – Noteworthy Changes

Chapter 3 Safety Requirements for Special Equipment



- **Chapter 3 covers special electrical equipment and modified the general requirements of Chapter 1**
 - Examples include Electrolytic Cells, Batteries and Battery Rooms, Lasers, and R&D Laboratories.
- The only significant change in Chapter 3 is a new Section 320.3(A)(1) and a new Section 350.9
 - Both of these sections modify the DC threshold to 100 VDC (instead of 50 VDC found in Chapter 1).
 - These levels are applicable to Batteries, Battery Rooms and R&D Labs
 - The information was extracted from the Department of Energy (DOE) Electrical Safety Handbook, DOEHDBK- 1092.

Page 122

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Informative Annexes

Annexes are Informational Only

- Informative Annex A: Informative Publications
- Informative Annex B: Reserved
- Informative Annex C: Limits of Approach
- Informative Annex D: Incident Energy and Arc Flash Boundary Calculation Methods
- Informative Annex E: Electrical Safety Program
- Informative Annex F: Risk Assessment and Risk Control
- Informative Annex G: Sample Lockout/Tagout Program
- Informative Annex H: Guidance on Selection of Protective Clothing and Other PPE
- Informative Annex I: Job Briefing and Planning Checklist
- Informative Annex J: Energized Electrical Work Permit
- Informative Annex K: General Categories of Electrical Hazards
- Informative Annex L: Typical Application of Safeguards in the Cell Line Working Zone
- Informative Annex M: Layering of Protective Clothing and Total System Arc Rating
- Informative Annex N: Example Industrial Procedures and Policies for Working Near Overhead Electrical Lines and Equipment
- Informative Annex O: Safety-Related Design Requirements
- Informative Annex P: Aligning Implementation of This Standard with Occupational Health and Safety Management Standards
- Informative Annex Q: Human Performance and Workplace Electrical Safety

Annexes are Informational Only

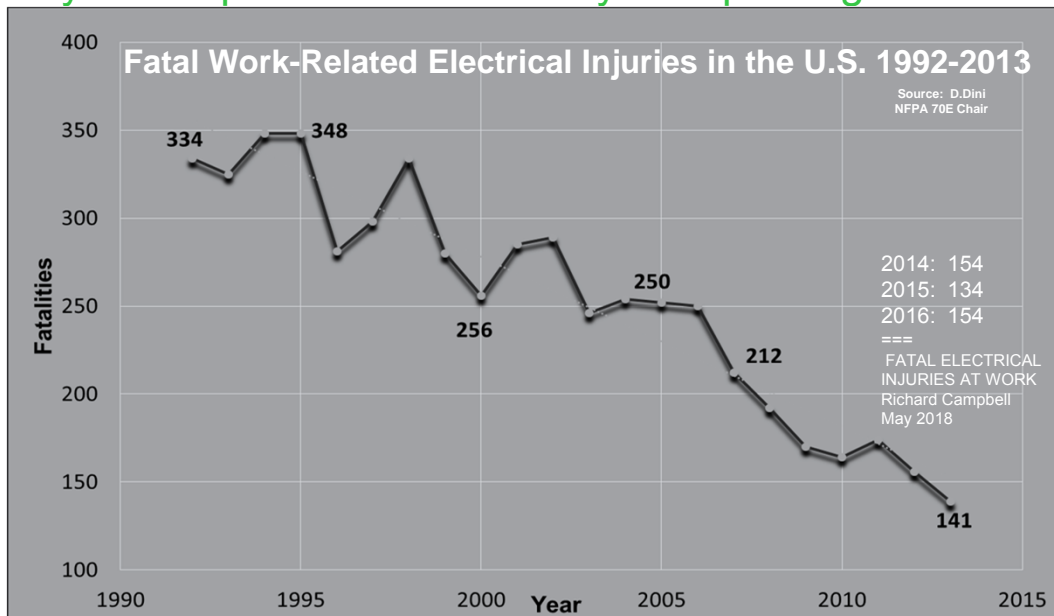
- Informative Annex A: Informative Publications
- Informative Annex B: Reserved
- Informative Annex C: Limits of Approach
- Informative Annex D: Incident Energy and Arc Flash Boundary Calculation Methods
- Informative Annex E: Electrical Safety Program
- **Informative Annex F: Risk Assessment and Risk Control**
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- **Informative Annex O: Safety-Related Design Requirements**
- Informative Annex P: Aligning Implementation of This Standard with Occupational Health and Safety Management Standards
- **Informative Annex Q: Human Performance and Workplace Electrical Safety**

• 4 were modified
• 1 (Q) is new

Page 125



Key Concept – Electrical Safety is Improving!



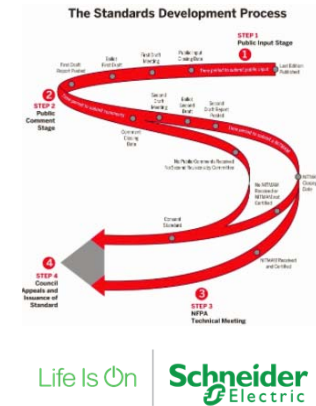
Page 126



NFPA 70E / NEC – Get involved!

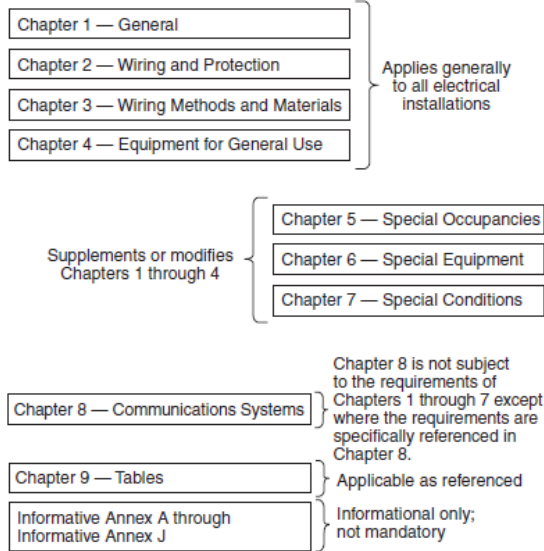
- You don't have to be on a committee to submit proposals or comments.
- The first draft of the 2020 NEC is available
 - **Public Comment Closing Date: August 30, 2018**
- The first draft of the 2021 NFPA 70E is coming
 - First Draft Report Posting Date: February 27, 2019
 - **Public Comment Closing Date: May 8, 2019**

*When comes to Codes and Standards you have 2 choices:
Grin and bear it, or smile and change it!*



The NEC

Key Concept: NEC Arrangement (90.3)



Page 129

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Industry, and the NEC, keep changing!

The 2014 NEC had 4 New Articles:

- 393 - Low Voltage Suspended Ceiling Power Distribution Systems
- 646 - Modular Data Systems
- 728 - Fire Resistive Cable Systems
- 750 - Energy Management Systems

There were 9 New Articles proposed for the 2017 NEC, 5 made it into the next edition:

- 425 – Fixed Resistance and Electrode Industrial Process Heating Equipment
- 691 - Large Scale Photovoltaic (PV) Electric Supply Stations
- 706 - Energy Storage Systems (ESS)
- 710 - Stand Alone Systems
- 712 - DC Microgrids

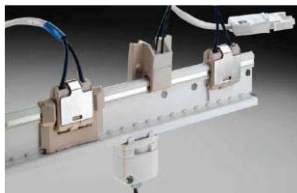
Page 130

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4 New Articles in the 2014 NEC



Article 393 Low Voltage Suspended Ceiling Power Distribution Systems



Supports finished ceiling

Busbar distributes power to listed utilization equipment from a Class 2 power supply

- 30 volts ac (42.4 volts peak) max
- 60 volts dc max

Indoor only



Article 645 Modular Data Systems

New 2014

Prefabricated units rated 600 volts or less consisting of:

- Enclosure
- Multiple racks of IT equipment (e.g. servers)
- Support equipment (distribution, HVAC, etc.)

IN: Some configurations may have the support equipment housed in a separate enclosure



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Page 133

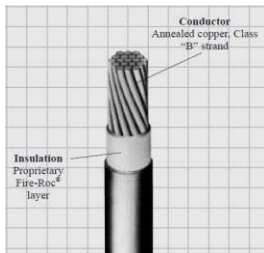
Article 728 Fire Resistive Cable Systems

New 2014



Covers the installation of fire resistive cables, conductors and other system components

- Conduit, supports and couplings
- Boxes and splices



Survivability of critical circuits to ensure continued operation during a specified time under fire conditions

Ability to function during a fire depends upon proper installation

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Page 134

Article 750 Energy Management Systems



Proposed by the Smart Grid Task Group appointed by the TCC

Energy management has become common

- Control of utilization equipment
- Energy storage
- Power production

Restricting control by the energy management system is critical for:

- (1) fire pumps
- (2) health care facilities
- (3) emergency systems
- (4) legally required standby systems
- (5) critical operations power systems



Page 135



5 New Articles for the 2017 NEC



Article 425 – Fixed Resistance and Electrode Industrial Process Heating Equipment



Fixed Industrial Process heating using resistance or electrode heating technology wasn't really addressed in prior editions.

Includes: Boilers, electrode boilers, duct heaters, strip heaters, immersion heaters, process air heaters, or other approved fixed electric equipment used for industrial process heating.



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Article 691 – Large Scale Photovoltaic (PV) Electric Supply Stations



Large Scale PV electric supply (aka Solar Farms) with a generating capacity of no less than 5000 kW and not under exclusive utility control.

Supply Stations that are operated for the sole purpose of providing electric supply but are privately owned

Have specific design and safety features that are unique to large-scale PV facilities



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Article 706 – Energy Storage Systems (ESS)



Permanently installed ESS operating >50 Vac or 60 Vdc
Stand alone or interactive

ESS is one or more components capable of storing energy for use in the future

- Batteries
- Capacitors
- Kinetic Energy (Flywheels, compressed air)

May include inverters or converters

May be self contained, pre-engineered assemblies, or individual components assembled into a system



Page 139

Article 710 – Stand-Alone Systems



PV, Wind, Generator etc.

Electric power production sources operating in a stand alone mode; independent of a production and distribution network

Equipment must be listed or field labeled for intended use

General Requirements

- Output may be less than calculated load but must be larger than largest single load
- Supply conductor size
- May supply 120 V to 120/240 equipment (both sides of the panelboard bus) if there are no 240 outlets
- ESS permitted, but not required
- Addresses back fed circuit breakers



Page 140

Article 712 – Direct Current Microgrids



Covers direct current power distribution system with 1 or more interconnected DC sources, dc-dc converters, dc load, and ac loaded powered by dc-ac inverters

May boost efficiency and provide resiliency (when used with ESS) in the Data & Communication industries.

May be less costly than ac microgrids as synchronization of sources is not necessary

DC loads such as LED lighting, communications equipment, computers, variable speed motor drives, HVAC, etc



A few clarifying or safety related changes in the 2017 NEC

(Time Permitting)

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Page 143

100 Definitions

Readily Accessible

Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to take actions such as to use tools (other than keys), to climb over or under, remove obstacles, or resort to portable ladders

IFN clarifies that the **use of keys to gain access is permitted**



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100 Definitions

Structure

That which is built or constructed, **other than equipment**

Equipment may be mounted on or supported by a structure such as a concrete pad for outdoor equipment



Replace 600 V with 1000 V

- Article 110 is now in alignment with the move from 600V to 1000V found in the 2014 NEC.
- No Impact is intended by this revision.
- Working space tables were revised to reflect the same installation clearances as in the 2014 NEC.



110.3(C) Listing

Product testing, evaluation, and listing (product certification) shall be performed by recognized qualified electrical testing laboratories

Shall be in accordance with applicable product standards recognized as achieving equivalent and effective safety for equipment installed to comply with this *Code*.

See Annex A

Informational Note: (OSHA) recognizes qualified electrical testing laboratories that perform evaluations, testing, and certification...



110.16(B) Arc Flash Hazard Marking

- Applies to service equipment rated 1200 A or more (other than dwelling units)

- Must Mark

- Nominal System Voltage
- Available Fault Current
- Clearing time of overcurrent protective device(s) based on available fault current
- Date applied

Arc Flash Information	
Use this information in accordance with applicable OSHA standards, NFPA 70E-2015 and other required safe electrical work practices.	
1.71 cal/cm ² 1 ft 10 in.	Incident Energy at a Working Distance of 1 ft 6 in. Arc Flash Boundary
208V 3 ft 6 in. 1 ft 0 in.	Shock hazard when cover is open Limited Approach Restricted Approach
Eqpt Name: L1A	QIC: 1534678 Date: 09/16/14
<small>Values produced by a Schneider Electric engineering analysis. Any system modification, adjustment of protective device settings, or failure to properly maintain equipment will invalidate this label. For more information, contact Schneider Electric at 1-888-778-2723. Copyright © Schneider Electric. All Rights Reserved.</small>	

- Exception

- Service equipment labeling shall not be required if an arc flash label is applied in accordance with acceptable industry practice.



110.21(A)(2) Reconditioned Eqpt Markings

- Equipment marking must include:
 - Name, trademark, or other descriptive marking to identify the organization responsible for reconditioning
 - Marking that it has been “Reconditioned” and date of the reconditioning
 - Original listing of the equipment cannot be the sole basis for approval
 - Normal servicing is not considered reconditioning or refurbishing
- Exception for Industrial Occupancies

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210.8(B) Other than Dwellings (GFCI)

- Applies to receptacle outlets
- 150 V to ground or less
- Single phase receptacles expanded from 20 A to **50 A**
- Added 3 phase **up to 100 A**
- Added crawl spaces and unfinished portions of basements not intended as habitable rooms



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210.12 Arc-Fault Circuit-Interrupter Protection

- 210.12(B) Dormitories – expanded to include bathrooms and circuits supplying outlets and devices.
- 210.12(C) Guest Rooms and Guest Suites – expanded to include all 125 V, 15 and 20 A outlets and devices in guest rooms and suites
- 210.12(D) Extensions or Modifications – expanded to cover branch circuit extensions or modifications in dormitory units



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240.67 Arc Energy Reduction

Fuses (Effective 1/1/20)

- Fuses rated 1200 A or higher
- Clearing time of 0.07s or less at the available arcing current or a reduction method must be supplied
- Methods to reduce clearing time shall be one of the following:
 - Differential relaying
 - Energy reducing maintenance switch with local indicator
 - Energy reducing active arc flash mitigation system
 - An approved equivalent means



This requirement is similar to that for circuit breakers in 240.87

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240.87 Arc Energy Reduction

Circuit Breakers

- Added arc energy reduction methods:
 - An **instantaneous trip** setting that is less than the available arcing current
 - An **instantaneous override** that is less than the available arcing current

Unlike the existing methods, these methods have performance consideration requiring the calculation of the available arcing fault.



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406.4(D)(4) AFCI Protection for Receptacle Replacements

- Exceptions were added to not require AFCI protection where:
 - A non-grounding-type receptacle(s) are replaced with a GFCI
 - *It is impracticable to provide an equipment grounding conductor*
 - *A receptacle protected by a listed combination type arc-fault circuit-interrupter circuit breaker is not commercially available*
 - *There is no GFCI/AFCI combination receptacle commercially available*



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406.12 Tamper-Resistant Receptacles

Expanded to all 15 A and 20 A, 125/250 V nonlocking-type receptacles in the following areas

- Dwelling units
- Guest rooms and guest suites of hotels and motels
- Child care facilities
- **Preschools and elementary education facilities**
- **Business offices, corridors, waiting rooms and the like in clinics, medical, and dental offices and outpatient facilities**
- **Subset of assembly occupancies(518.2) to include places of waiting transportation, gymnasiums, skating rinks, and auditoriums**
- Dormitories



Existing exceptions were retained

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408.3(A)(2) Service Panelboards

- Barrier for line side terminations, bus, and exposed energized parts
- Revision aligns with existing requirements for switchboards and switchgear
- Single main panelboard configurations
- Electrical shock protection only, no arc flash energy protection



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422.5 Ground-Fault Circuit-Interrupter (GFCI) Protection for Personnel

- GFCI requirements for appliances consolidated in 422.5
 - Dishwasher and boat hoist branch circuit outlet protection remains in 210.8
- Appliances identified in 422.5(A)(1) through (5) rated 250 volts or less and 60 amperes or less, single or 3-phase
- The GFCI shall be readily accessible, listed and labeled, and located in one or more of the identified locations



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422.6 Listing Required (Appliances)

- New **listing** requirement for all appliances operating at or above 50 V
- Aligns with the 110.27 requirements for protection against contact with live parts



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550.25(B) AFCI Protection (Mobile Homes)

All 120V, 15 and 20 A branch circuits must have AFCI protection



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555.3 Ground-fault Protection

- Applies to marinas, boatyards, and commercial & non-commercial docking facilities
- Trip level reduced from 100 mA to 30 mA
- Section 553.4 for Floating Buildings remains at 100 mA trip level



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690.7 Maximum Voltage

Defines the maximum voltage of PV dc system as the highest voltage between any two circuit conductors or any conductor and ground



One & two family dwellings - 600 V

Circuits in or on other buildings - 1000 V

Allowance to use equipment rated **1500 V maximum without compliance with Article 490** where listed and not in or on a building

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Page 161

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