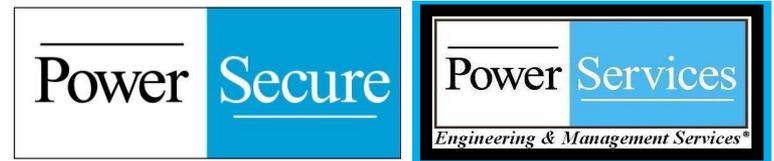


Electrical Safety, Arc Flash Mitigation, and Lessons Learned



Presented For:

**2016 IDEA Annual Conference
MicroGrid Workshop**



Presented By:
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Safety Moment



Results of Arc Flash





- **Standards Overview**
- **2015 NFPA 70E Changes**
- **Mitigation Techniques**
- **Lessons Learned**

Standards Overview



Occupational Safety and Health
Administration (OSHA)



National Electrical Safety Code
(NESC)

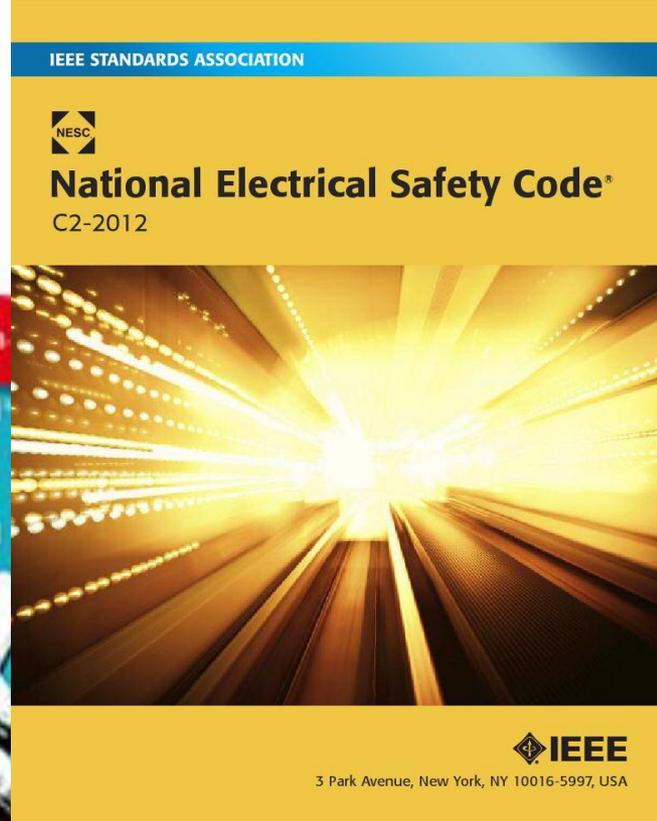
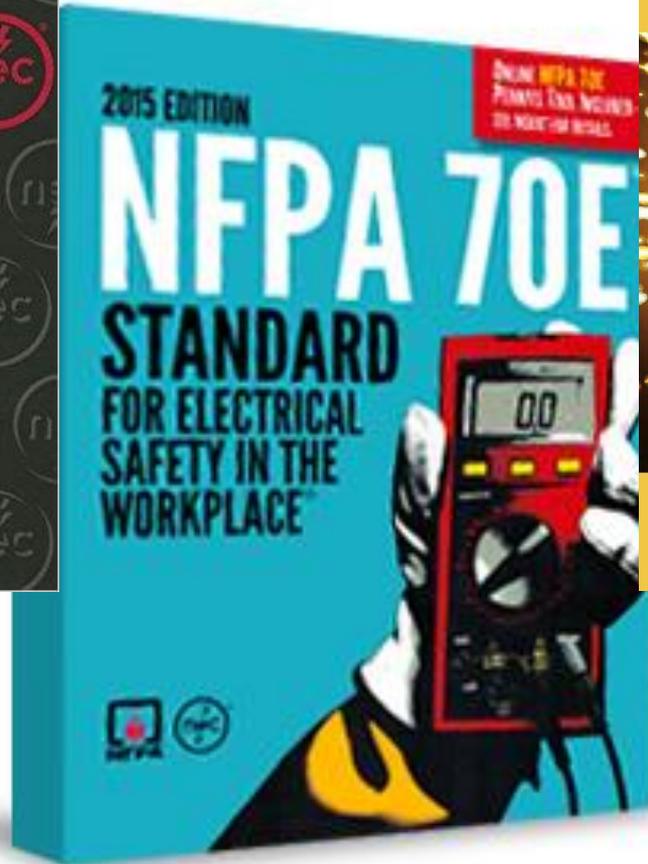
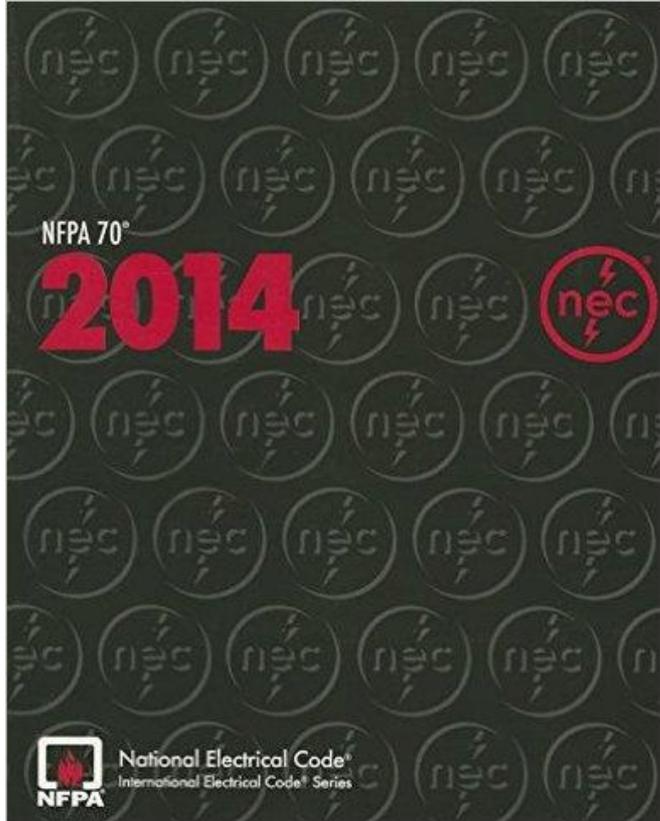


National Fire Protection Association
(NFPA 70 & NFPA 70E)

IEEE Standard 1584



Standards Overview



Standards Overview



First Goal: Go Home Safely Each Day



Standards Overview



Second Goal: Avoid These Guys





OSHA Likely Will Enforce NEC, NESC, and NFPA 70E Under the “General Duty Clause”





OSHA Enforces NFPA 70E Under the “General Duty Clause”

A section of the OSHA Act of 1970, known as the “General Duty Clause” requires employers to furnish a workplace which is free from **recognized hazards** which may cause or are likely to cause death or serious physical harm.

Standards Overview



- Determine Areas of Need
- Perform Study
- Receive Report
- Install Stickers

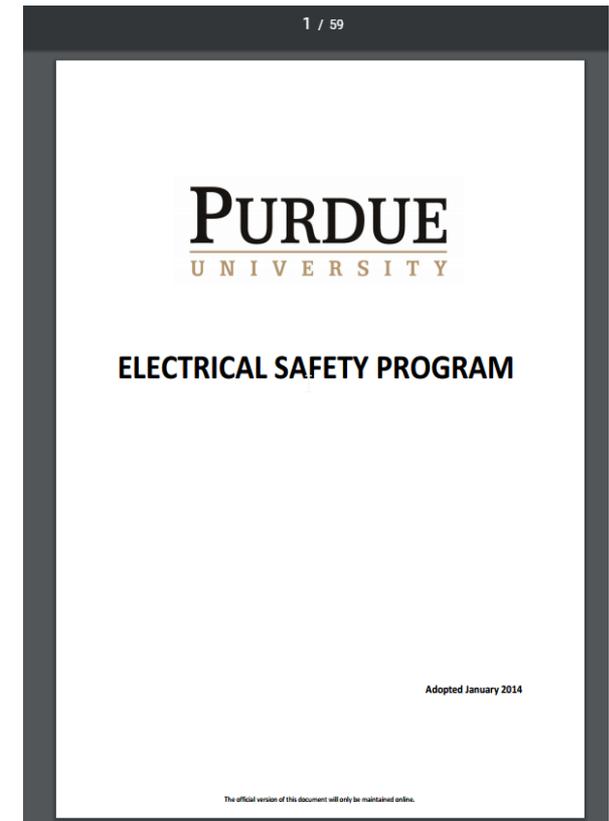


	WARNING
Arc Flash and Shock Hazard Appropriate PPE Required	
24 inch	Flash Hazard Boundary
3	cal/cm ² Flash Hazard at 18 inches
480 VAC	Shock Hazard when Cover is removed
42 inch	Limited Approach
12 inch	Restricted Approach - 500 V Class 00 Gloves
1 inch	Prohibited Approach - 500 V Class 00 Gloves
Date: 6/28/2001	
Bldg. ECR #1 Equipment Name: Slurry Pump Starter	

Standards Overview



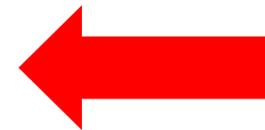
- **Electrical Safety Program**
- **NFPA 70E Compliance**
- **Training**
- **Work Rules**
- **PPE**
- **Permit Process**



Discussion Topics



- **Standards Overview**
- **2015 NFPA 70E Changes**
- **Mitigation Techniques**
- **Lessons Learned**





Old Term: Arc Flash Analysis

**New Terms: Incident Energy Analysis and
Arc Flash Hazard Assessment**

NFPA 70E 2015 Changes



Task Table – 130.7(C)(15)(A)(a)

ARTICLE 130 — WORK INVOLVING ELECTRICAL HAZARDS

130.7

Table 130.7(C)(15)(A)(a) Arc Flash Hazard Identification for Alternating Current (ac) and Direct Current (dc) Systems

Task	Equipment Condition*	Arc Flash PPE Required
Reading a panel meter while operating a meter switch	Any	No
Normal operation of a circuit breaker (CB), switch, contactor, or starter	All of the following: The equipment is properly installed The equipment is properly maintained All equipment doors are closed and secured All equipment covers are in place and secured There is no evidence of impending failure	No
	One or more of the following: The equipment is not properly installed The equipment is not properly maintained Equipment doors are open or not secured Equipment covers are off or not secured There is evidence of impending failure	Yes
For ac systems: Work on energized electrical conductors and circuit parts, including voltage testing	Any	Yes
For dc systems: Work on energized electrical conductors and circuit parts of series-connected battery cells, including voltage testing	Any	Yes
Voltage testing on individual battery cells or individual multi-cell units	All of the following: The equipment is properly installed The equipment is properly maintained Covers for all other equipment are in place and secured There is no evidence of impending failure	No



Old Versions: <125kVA Exception, 130.3

2015 Version: Code is Silent

7 *Exception No. 1: An arc flash hazard analysis shall not be required where all of the following conditions exist:*

(1) The circuit is rated 240 volts or less.

(2) The circuit is supplied by one transformer.

(3) The transformer supplying the circuit is rated less than 125 kVA.

NFPA 70E 2015 Changes



Minimum Thermal Recommended Protection (Based on NFPA 70E-2009)

<u>Flash Hazard Risk Category</u>	<u>Range of Calculated Incident Energy</u>	<u>Min. PPE Rating</u>	<u>Clothing Required</u>
0	0 to 1.2 cal/cm ²		4.5-14.0 oz/yd ² untreated cotton
1	1.2+ to 4 cal/cm ²		Arc rated FR shirt and pants or coverall
2	4+ to 8 cal/cm ²		Arc rated FR shirt and pants or coverall
3	8+ to 25 cal/cm ²	25 cal/cm ²	Arc rated FR shirt and pants or coverall and arc flash suit
4	25+ to 40 cal/cm ²	40 cal/cm ²	Arc rated FR shirt and pants or coverall and arc flash suit



Note: At each level, the clothing and/or clothing system rating must meet the required minimum level based upon the arc energy exposure.

NFPA 70E 2015 Changes



2015 NFPA 130.7(C)(16) Personal Protective Equipment

PPE
Category

PPE

1 Arc-Rated Clothing, Minimum Arc Rating of 4
cal/cm² (see Note 1)

Arc-rated long-sleeve shirt and pants or arc-rated
coverall

Arc-rated face shield (see Note 2) 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)

Heavy duty leather gloves (see Note 3)

Leather footwear (AN)

NFPA 70E 2015 Changes



2015 NFPA 130.7(C)(16) Personal Protective Equipment

PPE
Category

PPE

- 2 Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm² (see Note 1)
Arc-rated long-sleeve shirt and pants or arc-rated coverall
Arc-rated flash suit hood or arc-rated face shield (see Note 2) 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)
Heavy duty leather gloves (see Note 3)
Leather footwear

NFPA 70E 2015 Changes



2015 NFPA 130.7(C)(16) Personal Protective Equipment

PPE
Category

PPE

3 Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of

25 cal/cm² (see Note 1)

Arc-rated long-sleeve shirt (AR)

Arc-rated pants (AR)

Arc-rated coverall (AR)

Arc-rated arc flash suit jacket (AR)

Arc-rated arc flash suit pants (AR)

Arc-rated arc flash suit hood

Arc-rated gloves (see Note 1)

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)

Leather footwear

NFPA 70E 2015 Changes



2015 NFPA 130.7(C)(16) Personal Protective Equipment

PPE
Category

PPE

4 Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40 cal/cm^2 (see Note 1)

Arc-rated long-sleeve shirt (AR)

Arc-rated pants (AR)

Arc-rated coverall (AR)

Arc-rated arc flash suit jacket (AR)

Arc-rated arc flash suit pants (AR)

Arc-rated arc flash suit hood

Arc-rated gloves (see Note 1)

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)

Leather footwear



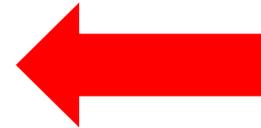
Practicality Sometimes Sneaks It's Way into Code Books!

Table H.2 Simplified Two-Category, Arc-Rated Clothing System

Clothing ^a	Applicable Tasks
Everyday Work Clothing Arc-rated long-sleeve shirt with arc-rated pants (minimum arc rating of 8) <i>or</i> Arc-rated coveralls (minimum arc rating of 8)	All arc flash PPE category 1 and arc flash PPE category 2 tasks listed in Table 130.7(C)(15)(A)(a), Table 130.7(C)(15)(A)(b), and Table 130.7(C)(15)(B) ^b
Arc Flash Suit A total clothing system consisting of arc-rated shirt and pants and/or arc-rated coveralls and/or arc flash coat and pants (clothing system minimum arc rating of 40)	All arc flash PPE category 3 and arc flash PPE category 4 tasks listed in Table 130.7(C)(15)(A)(a), Table 130.7(C)(15)(A)(b), and Table 130.7(C)(15)(B) ^b



- **Standards Overview**
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- **Mitigation Techniques** ←
- **Lessons Learned**





Goal: Reduce Incident Energy (E)

$$E = 4.184 C_f E_n \left(\frac{t}{0.2} \right) \left(\frac{610^x}{D^x} \right)$$

Source: IEEE-1584, eq. 5.2(6)

Mitigation Tips and Tricks



Reduce Clearing Time

Increase Sensitivity of Breakers / Relays



Mitigation Tips and Tricks



Reduce Clearing Time

Increase Sensitivity of Breakers / Relays



Maintenance Mode Indicating Light

	ARM's Selector Switch	
FP5020	Position A	Position B
Relay Settings Group	Group 2 Maintenance Mode	Group 1 Normal Mode
Relay Contact Input	CI-7	CI-8





Reduce Clearing Time

NEC 240.87

240.87 Non-instantaneous Trip. Where a circuit breaker is utilized without an instantaneous trip, documentation shall be available to those authorized to design, install, operate or inspect the installation as to the location of the circuit breaker(s).

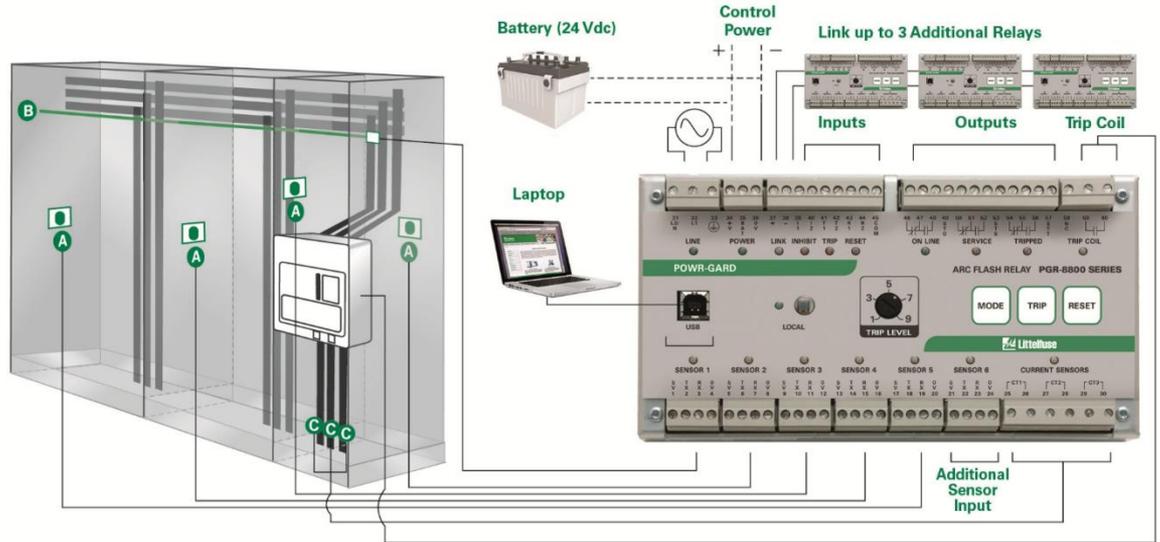
Where a circuit breaker is utilized without an instantaneous trip one of the following or approved equivalent means shall be provided:

- (A) Zone-selective interlocking
- (B) Differential relaying
- (C) Energy-reducing maintenance switching with local status indicator

Mitigation Tips and Tricks



Reduce Clearing Time Bus Differential and Arc Detection Relays





Goal: Reduce Incident Energy (E)

$$E = 4.184 C_f E_n \left(\frac{t}{0.2} \right) \left(\frac{610^x}{D^x} \right)$$


Source: IEEE-1584, eq. 5.2(6)

Mitigation Tips and Tricks



Increase Distance Remote Operation



Mitigation Tips and Tricks



Increase Distance

Remote Racking Device



Mitigation Tips and Tricks



Increase Distance

Local Operation Device





Increase Distance

Broomstick





- **Standards Overview**
- **2015 NFPA 70E Changes**
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Lessons Learned



Sometimes Red is OK



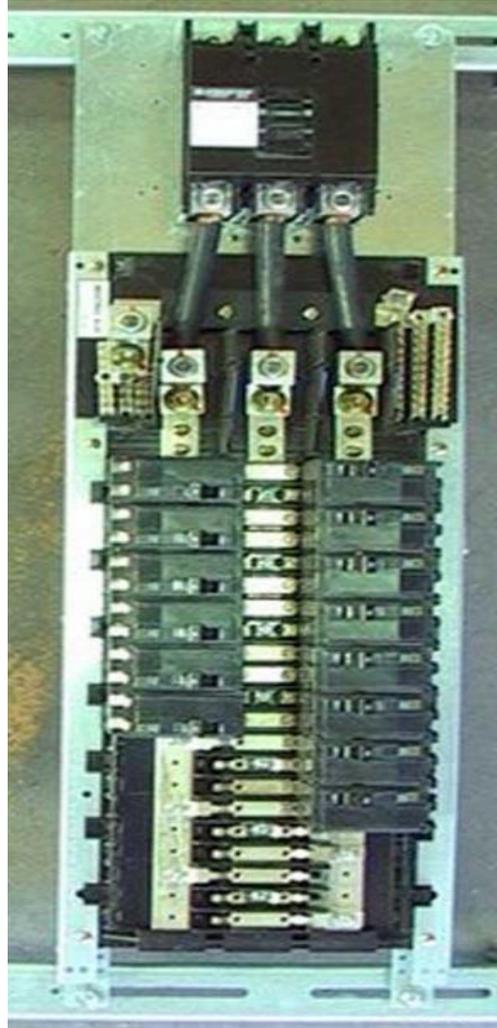
Lessons Learned



- **Is Hot Work Necessary?**
- **Is Shutdown a Problem?**
- **How Is Your System Impacted?**



Main Breaker in Common Enclosure





What Do You Analyze?

130.3 Working While Exposed to Electrical Hazards.

Safety-related work practices shall be used to safeguard employees from injury while they are exposed to electrical hazards from electrical conductors or circuit parts that are or can become energized. The specific safety-related work practices shall be consistent with the electrical hazards and the associated risk. Appropriate safety-related work practices shall be determined before any person is exposed to the electrical hazards involved by using both shock risk assessment and arc flash risk assessment. Only qualified persons shall be permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition.





WWED – What Would Edd Design

- Arc Resistant Type 2B (12% Cost Adder)
- Portable Remote Racking Device
- Electronically Operated Breakers
 - ◆ Mains on 480V Class
 - ◆ All Breakers on 5kV+ Class
- Compartmentalized Mains
 - ◆ Services
 - ◆ Downstream of Transformers 150kVA+
- Robot and Chicken Switch for Older Equipment
- Broom



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