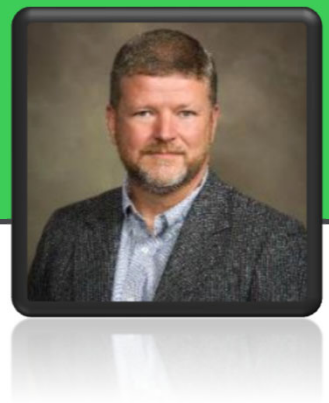
IEEE Central Tennessee Section – Music City Power Quality Group

Rodney West, PE, CFEI
Oxford, Ohio USA

November 2, 2021
9:00 – 12:00

Presenter



- Rod West, PE, CFEI
- Married with 5 (yes five) daughters
- Senior Staff Engineer at Schneider Electric
- Located in Oxford, Ohio
- 30 Years experience in the Electrical Industry
- 12 Patents for Electrical Equipment
- NAFI Certified Fire and Explosion Investigator
- Board Chair Whitewater Valley REMC
- Member of NEC CMP-8
- Member of NFPA 70E
- Chair of NFPA 70B

Our focus will be on 3 things today:

1. The NFPA Codes and Standards Development Process
2. NFPA 70E – The Standard for Electrical Safety in the Workplace
3. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance

The NFPA Trinity – Guidance throughout the equipment lifecycle

- **NFPA 70** – The National Electrical **Code** (NEC)
  - Contains electrical equipment installation requirements.

- **NFPA 70E** – **Standard** for Electrical Safety in the Workplace
  - Contains work practices for working on or near electrical equipment.

- **NFPA 70B** - **Recommended Practice** for Electrical Equipment Maintenance
  - Contains preventative maintenance information for electrical equipment.
  - Evolving from a Recommended Practice to a Standard

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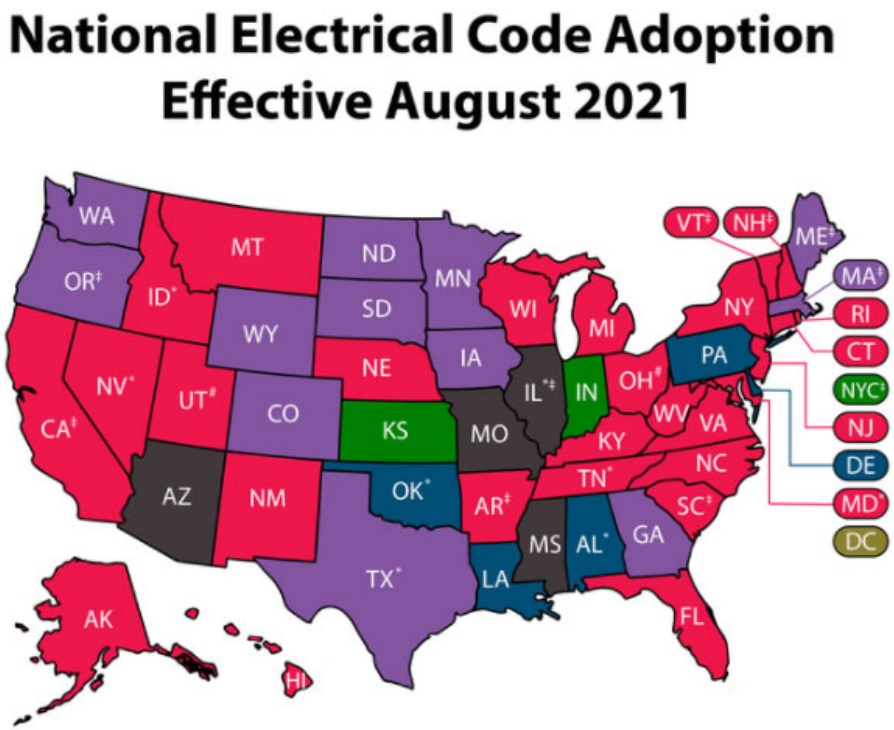
Codes and Standards Change



Courtesy of ESFi – The Electrical Safety Foundation International

Why does the map look like this?

What about the other standards?

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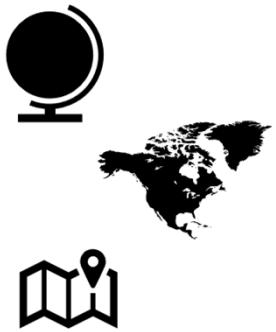
Codes, Standards, Equipment, Tools and Methods Change

Why does the map look like this?

- The NEC is **updated regularly**
  - 3 Year Cycle – To Frequent? Not Frequent enough?
  - Trying to keep up with new technologies, applications, etc

- The NEC is **adopted irregularly**
  - NEC is an Installation Code that is generally adopted by local or state jurisdictions.



What about the other standards?

- NEC, NFPA 70B and NFPA 70E are all on 3-year cycles.
- 70B and 70E are adopted by employers.
  - No Map – global, national, local
- All use the same standards development process.

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NFPA
Standards Development Process
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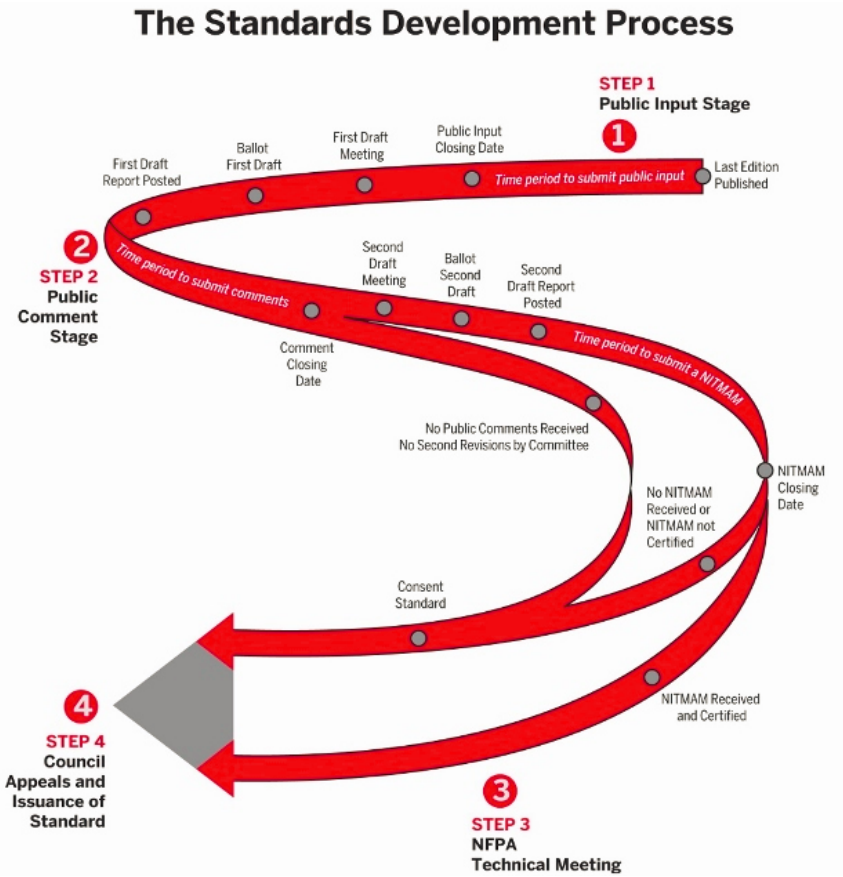
Public

NFPA Standards Development

4 Major Steps:

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

- More on this in a bit…



NFPA Standards Development

An Open ANSI Process - Anyone can submit ideas or comments

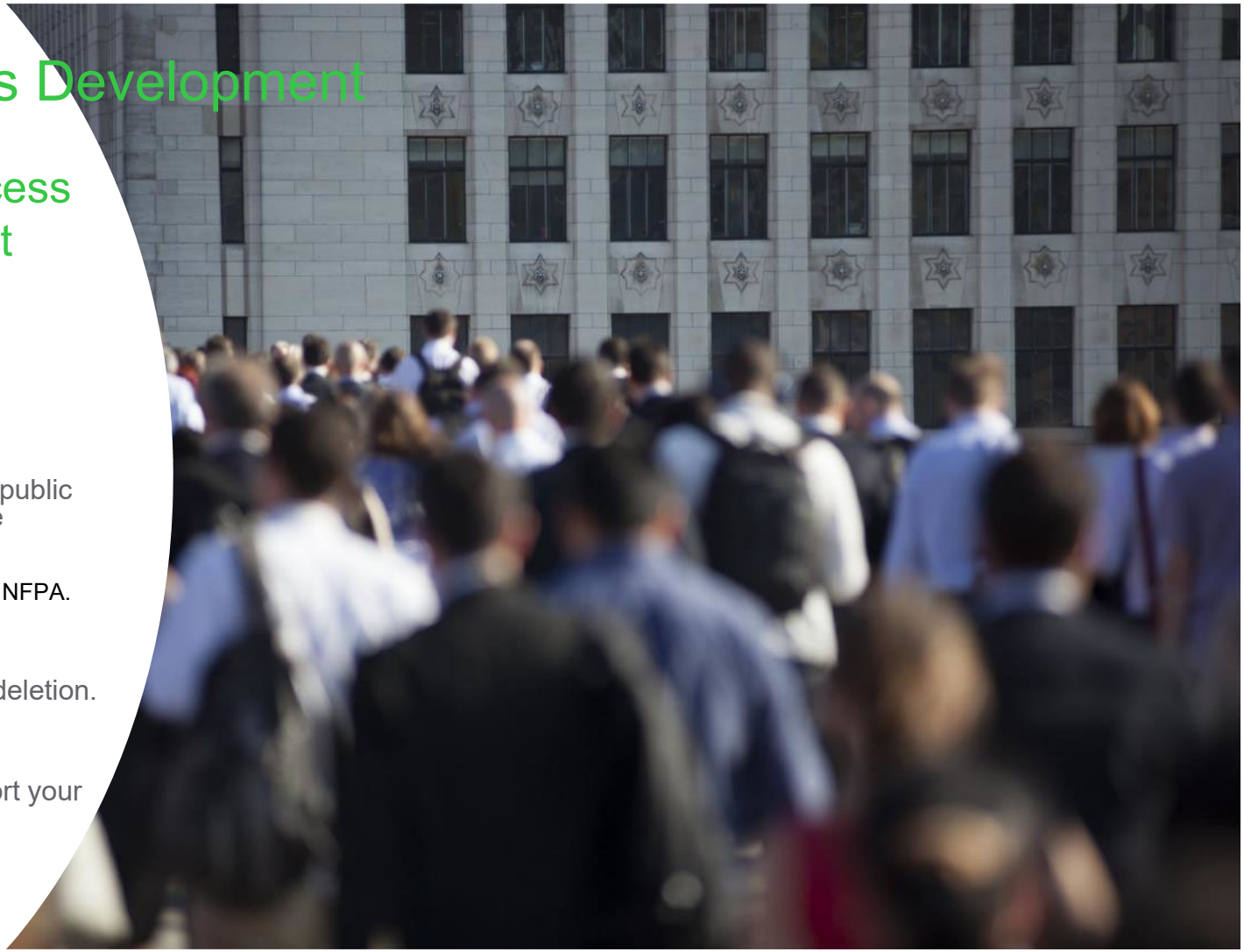
Yes – you have a voice!

NFPA accepts public input and public comments through an on-line submission system.

- Do not have to be a member of NFPA.

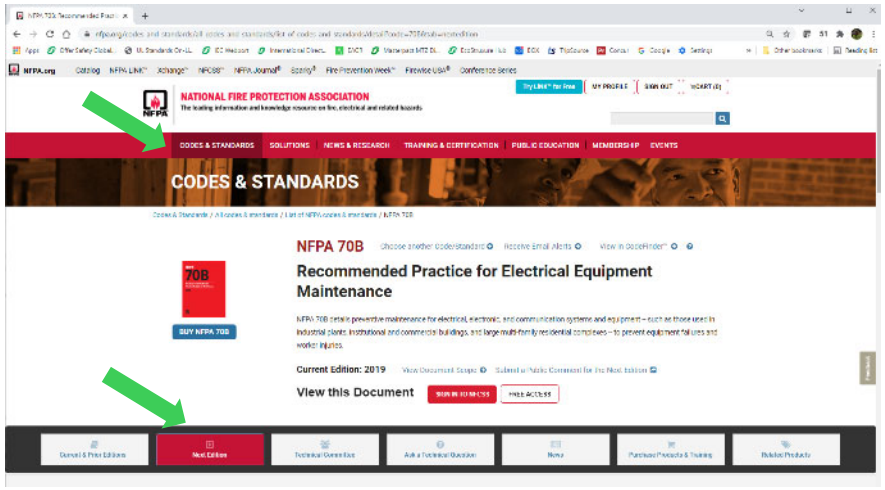
Suggest a change, addition or deletion.

Provide substantiation to support your suggestion.

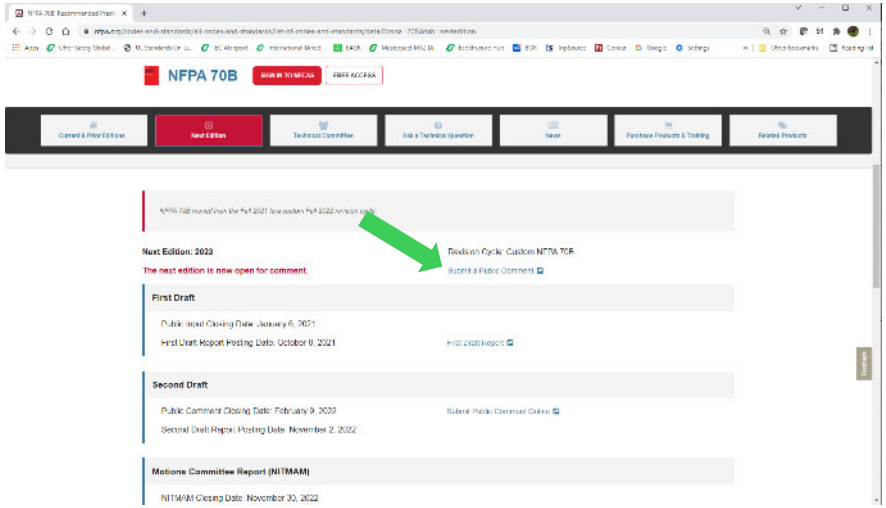


NFPA Standards Development

Submitting a PI or PC



On the NFPA website select the Code or Standard of Interest, then select Next Edition



If the Code or Standard is open for public input or public comment there will be a link.

NFPA Standards Development

Codes and Standards Technical Committees

A Technical Committee reviews each Public Input and Public Comment.

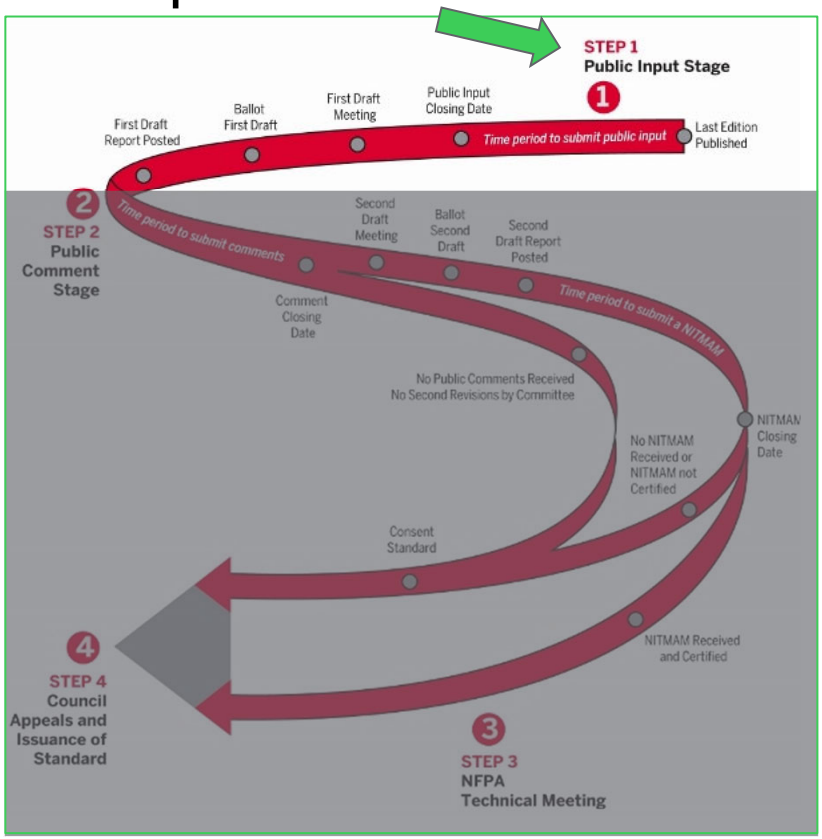
- May make a revision based on the input / comment.
- May reject the input / comment.
- Committee statement explaining the action.

Technical Committees are balanced.

Members represent their principal interest category.

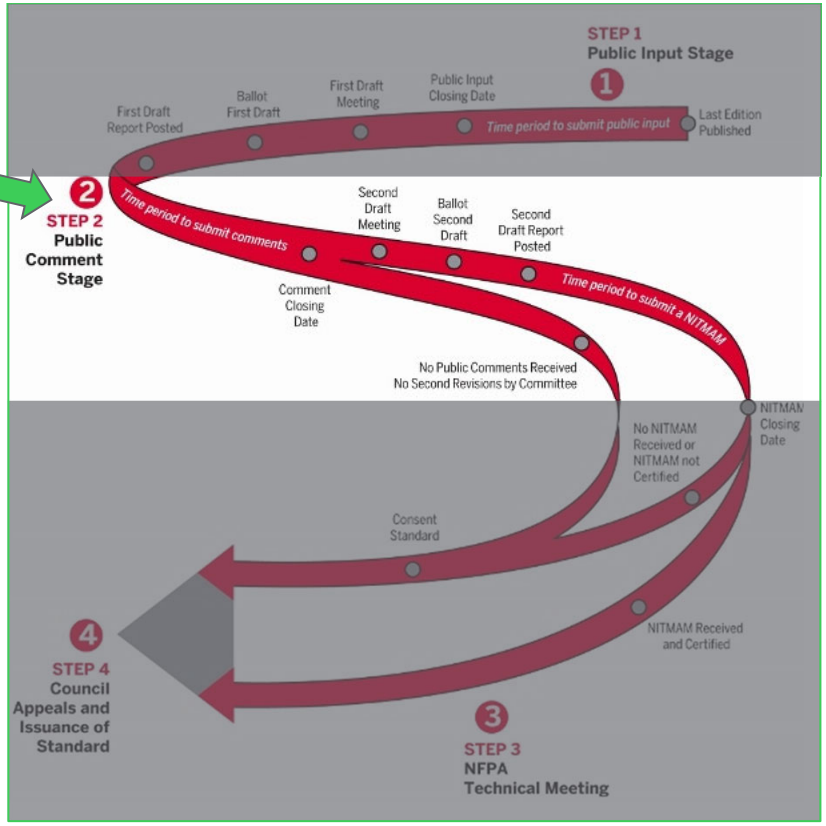
Standards Development Step 1 – Public Input

- At the start of the process, input is accepted from the public, Technical Committee (TC) or other committees
- Every public input is reviewed by the TC
- TC holds a multi-day First Draft Meeting to revise Standard
  - Simple majority hand vote to be placed on written ballot
  - Written ballot follows – 2/3 Majority to change the standard
- First Draft Report publicly posted on the NFPA Doc Info Page



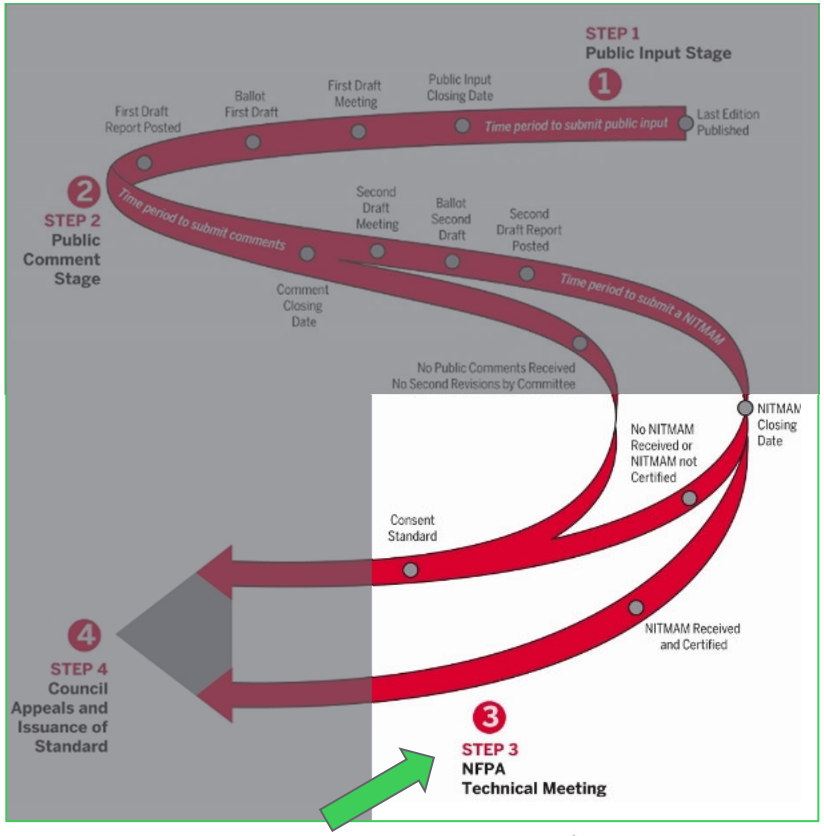
Standards Development Step 2 – Public Comment

- Comments accepted on First Draft following posting of First Draft Report.
  - No “new” material.
- Every comment is reviewed by the TC.
- TC holds multi day Second Draft Meeting to revise Standard
  - Simple majority hand vote to be placed on written ballot
  - Written ballot follows – 2/3 Majority to change the standard
- Second Draft Report publicly posted on the NFPA Doc Info Page



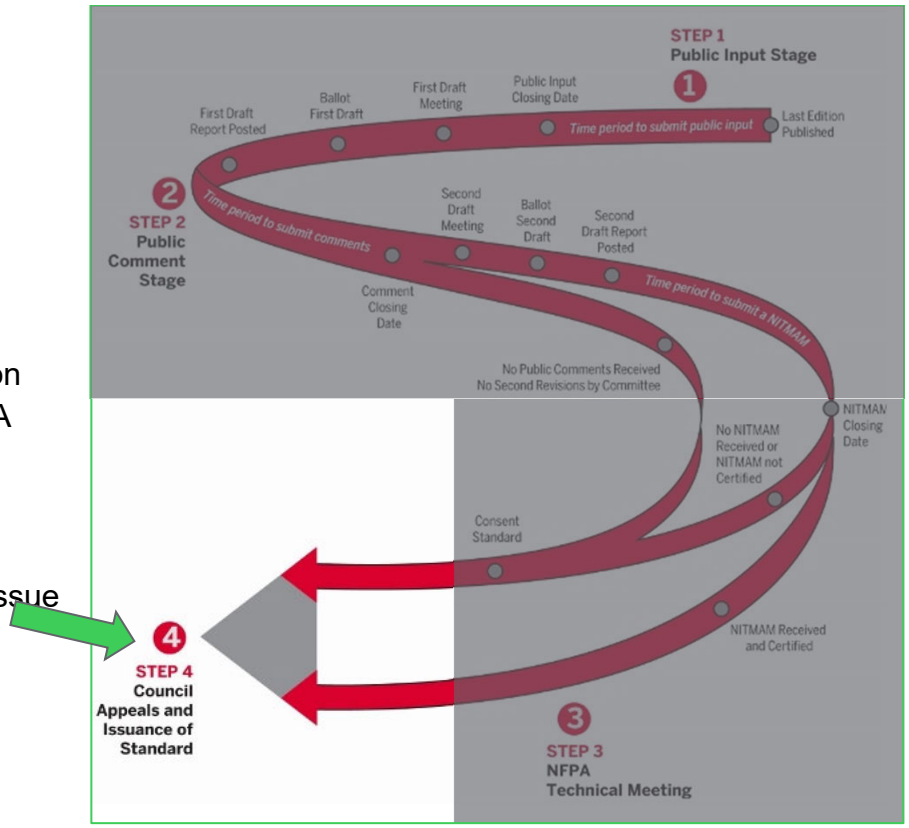
Standards Development Step 3 – NFPA Technical Meeting

- After second draft is posted, the document is mostly complete.
  - There is still an opportunity to make a motion before the NFPA membership.
  - Notice of Intent to Make a Motion (NITMAM) can be filed following the posting of Second Draft Report
- NITMAMs are reviewed and valid motions are certified by the Motions Committee for presentation at the NFPA Technical Meeting
- NFPA membership meets (June) at the NFPA Technical Meeting to act on Standards with “Certified Amending Motions” (CAM)
  - CAMSs are presented to NFPA members present at the meeting
  - CAMs voted on by NFPA members present at the meeting



Standards Development Step 4 – Issuance of Standard

- Final Step in the Process
- Relatively rare
- Notification of intent to file an appeal to the Standards Council on Technical Meeting action must be filed within 20 days of the NFPA Technical Meeting
- Standards Council decides, based on all evidence, whether to issue the standard or to take other action



NFPA Standards Development

- **NFPA Website provides information on the next edition**
  - Schedules
  - Notices
  - Public Input and Public Comment

    https://www.nfpa.org/Codes-and-Standards/All-Codes-and-Standards/List-of-Codes-and-Standards

  - Select the code or standard
  - Select the <Next Edition> tab

- **Free Access to ANY NFPA Code, Standard or Recommended Practice:**

  https://www.nfpa.org/Codes-and-Standards/All-Codes-and-Standards/Free-access


NFPA 70 E
The Standard for Electrical Safety in the Workplace
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NFPA 70E – Standard for Electrical Safety in the Workplace

- **How long has NFPA 70E been around?**
  - **A) Less than 10 years**
  - **B) 10-19 Years**
  - **C) 20-39 Years**
  - **D) 40+ Years**

- Lot of attention recently, but it's not a new standard
  - First edition of NFPA 70E was published in 1979.
  - 2021 – 1979 = 42 years ago!
- Until the 1995 Edition, focus was on electrocution
  - Arc Flash Boundary introduced in 1995

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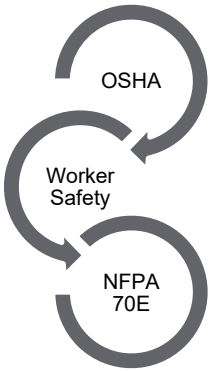
NFPA 70E and OSHA – The foundation



- **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 when working on or near electrical systems have safety implications.
  - NFPA Committee formed in January 1976; First edition published in 1979
    - Only included Part I: Installation Safety Requirements
    - Has grown (and shrunk) since then.

NFPA 70E and OSHA – The foundation

OSHA – Occupational Safety and Health Administration

- Created by Congress with the Occupational Safety and Health Act of 1970, established in 1971.
- Code of Federal Regulations (CFR) - **Federal Law.**
- Workers have a right to a safe and healthful workplace - and - It is the duty of the employers to provide workplaces that are free of known dangers that could harm their employees.

OSHA establishes the requirements

- 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

NFPA 70E helps you meet the requirements

- For electrical work, many people say OSHA is the "Shall", and NFPA 70E is the "How"

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NFPA 70E – Fast Facts

- **Same Standards Development Process as the NEC**

- 3 Year Cycle
  - Lags the NEC by a year
- Current Edition is 2021
- Next Edition (2024) is already underway
  - 357 Public Input / Proposals reviewed in August 2021
  - Ballots were issued October 20, 2021
  - First Draft will then be published; Public Comment period begins
  - Public Comments Closing Date will be May 31, 2022
- One Technical Committee of ~26 voting members

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NFPA 70E – What is in the Standard

NFPA 70E is 113 pages long and contains many requirements.

A high-level overview of some of the major contents…

- **Chapter 1** – Safety Related Work Practices
- **Chapter 2** – Safety Related Maintenance Requirements
- **Chapter 3** – Safety Requirements for Special Equipment
- **Informative Annexes**

NFPA 70E – Chapter 1 – Safety Related Work Practices

Chapter 1 is the heart of the standard.

- Chapter 1 contains Articles 90 – 130
  - **Article 90** – **Purpose** / Scope / Arrangement
  - **Article 100** – **Definitions**
  - **Article 105** – Application

NFPA 70E – Chapter 1 – Safety Related Work Practices

90.1 Purpose. The purpose of this standard is to provide a practical safe working area for employees relative to the hazards arising from the use of electricity.

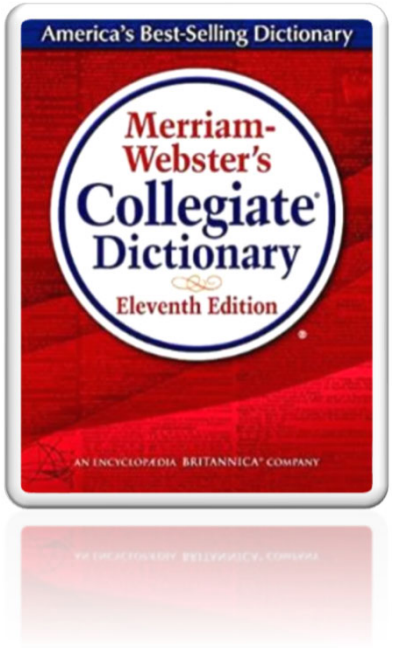
But what are the hazards arising from the use of electricity?

I'll come back to this in Article 130...

NFPA 70E – Chapter 1 – Safety Related Work Practices

Article 100 Definitions

- Definitions are essential to the proper application of the standard.
- Definitions apply wherever the terms are used throughout the standard. A couple of examples:
  - ***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.*
  - ***Guarded.*** *Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger. [70:100]*
- Definitions can not contain requirements, but if you are trying to apply a requirement, look to see if the terms are defined in Article 100.
- Commonly defined general terms are not included.
  - Merriam-Webster's Collegiate Dictionary, 11th edition, is the source for the ordinarily accepted meaning



NFPA 70E – Chapter 1 – Safety Related Work Practice

Chapter 1 contains Articles 90 – 130

- **Article 110** – General Requirements
  - **The First Priority is Hazard Elimination**
  - **There are some Energized Work Exceptions**
  - **Electrical Safety Program** *(Will discuss later)*
    - Risk Assessment
    - Hierarchy of Risk Controls
  - Training Requirements
  - Host / Contractor Responsibilities
  - Test Instruments and Equipment

NFPA 70E – Chapter 1 – Safety Related Work Practices

Article 110 – Hazard Elimination is the FIRST PRIORITY, in other words, The general rule is to put Electrical Equipment into an Electrically Safe Work Condition.

An **Electrically Safe Work Condition is 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 absence of voltage**, and, if necessary, temporarily grounded for personnel protection.

70E - Is energized work permitted?

Working in an **electrically safe working condition is the general rule**.

There are a **limited situations** in NFPA 70E 110.4 and OSHA 1910.333(a) where energized work may be permitted.

If the **employer can demonstrate** that …

(1) Deenergizing introduces additional Hazards or Increased Risk.

(2) Deenergizing is Infeasible

(3) Circuit is operating at less than 50 Volts

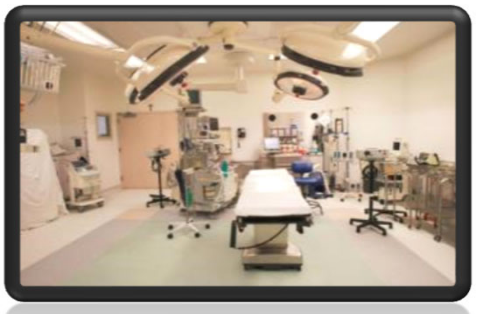
(4) Normal Operation.

Let's look at each of these…

Where is energized work permitted?

(1) Additional Hazards or Increased Risk

- Energized work can be permitted where the employer can demonstrate that de-energizing introduces additional hazards or increased risk.

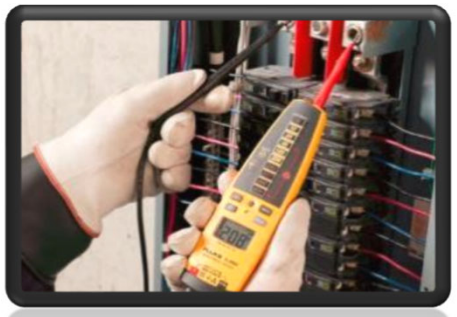


Examples of additional hazards or increased risk include interruption of life-support equipment, deactivation of emergency alarm systems, and shutdown of hazardous location ventilation equipment.

Where is energized work permitted?

(2) Infeasibility

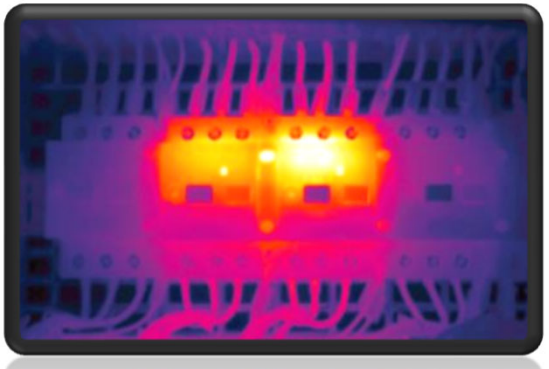
- Energized work can be permitted where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations.



Examples of work that might be performed because of infeasibility due to equipment design or operational limitations include performing diagnostics and testing of electric circuits that can only be performed with the circuit energized.

Infeasibility due to the equipment being a part of a "continuous industrial process" ties back to the introduction of additional hazards.

Infeasibility is not the same as inconvenient.



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Where is energized work permitted?

(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.

Where is energized work permitted?

(4) Normal Operation

- Normal operation is generally permitted where a normal operating condition exists and **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.

- Examples: Routine opening or closing of a circuit breaker, switch, contactor, or starter. These are tasks do not expose the worker to electrical hazards.

NFPA 70E – Chapter 1 – Safety Related Work Practices

Chapter 1 contains Articles 90 – 130

- **Article 120** – Establishing an Electrically Safe Work Condition (ESWC)
  - Lockout / Tagout Program
    - Program
    - Principles
    - Equipment
    - Procedures
    - **Process**

NFPA 70E – Chapter 1 – Safety Related Work Practices

Process for Establishing and Verifying an Electrically Safe Work Condition (ESWC)

Abbreviated here – additional and more detailed steps may be required in your situation!

1. Determine sources of Electrical Supply
2. Disconnect from sources
3. If possible, visually verify blades or disconnected position
4. Apply lockout devices
5. Use a test instrument to verify absence of voltage
   - Verify tester / test for absence of voltage / verify tester
   - Traditional portable meters are the default; an exception permits permanently mounted absence of voltage testers.

   - Until an ESWC exists and has been verified, proceed as if the circuit is energized!

Let's take a break

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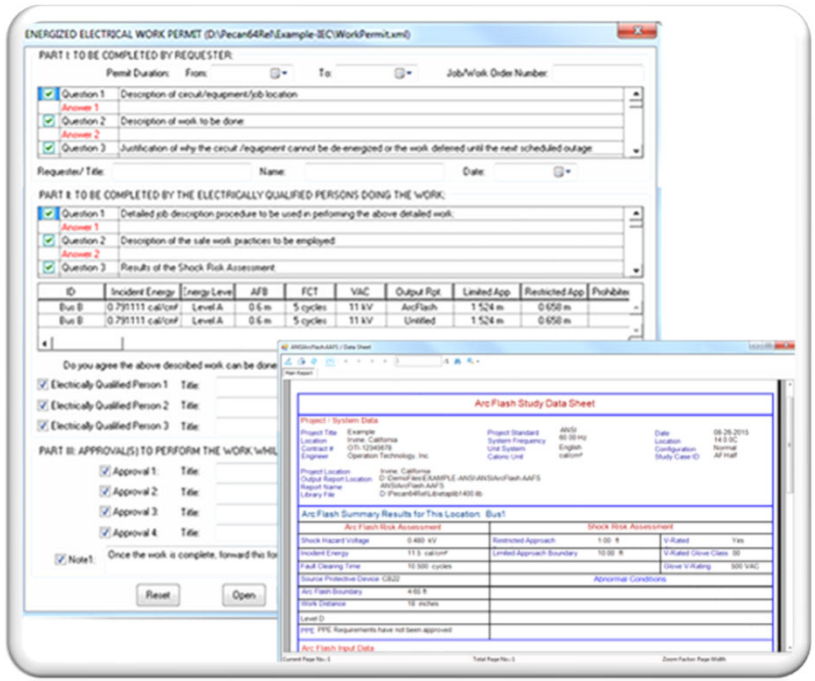
NFPA 70E – Chapter 1 – Safety Related Work Practices

Chapter 1 contains Articles 90 – 130

- **Article 130** – Work Involving Electrical Hazards
  - Where permitted by 110.4
  - Energized Work Permit
  - **Identify Hazards / Risk Assessment**
  - **Tables**
    - Approach Boundaries
    - Estimation of Likelihood
    - PPE Categories
  - **Equipment Labeling**
  - PPE and other Tools and Equipment



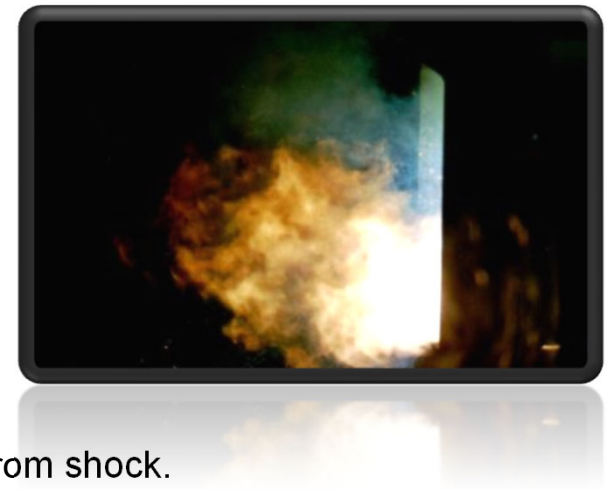
NFPA 70E – Identify Electrical Hazards

- **Two primary types of Electrical Hazards**
  - **Shock**
  - **Arc Flash**
  - A third hazard, **Arc Blast**, may result from an Arc Flash Event

70E - Identify the Hazards - Shock

- **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 incidents/year

70E- Identify the Hazards – Arc Flash



- **Arc Flash**
  - Current passes through plasma / ionized air
  - Varying levels of intensity / duration / location
  - Extremely high arc 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).

- **Arc Blast**
  - Appears to be a function of containment, fault current, …

NFPA 70E requires Risk Assessments

Risk is a combination of **two** things:

1. **Likelihood** of occurrence of injury or damage to health

2. **Severity** of injury or damage to health that results from a hazard.

Risk Assessment

You perform risk assessments every day:

70E requires electrical safety programs to include a **risk assessment procedure**

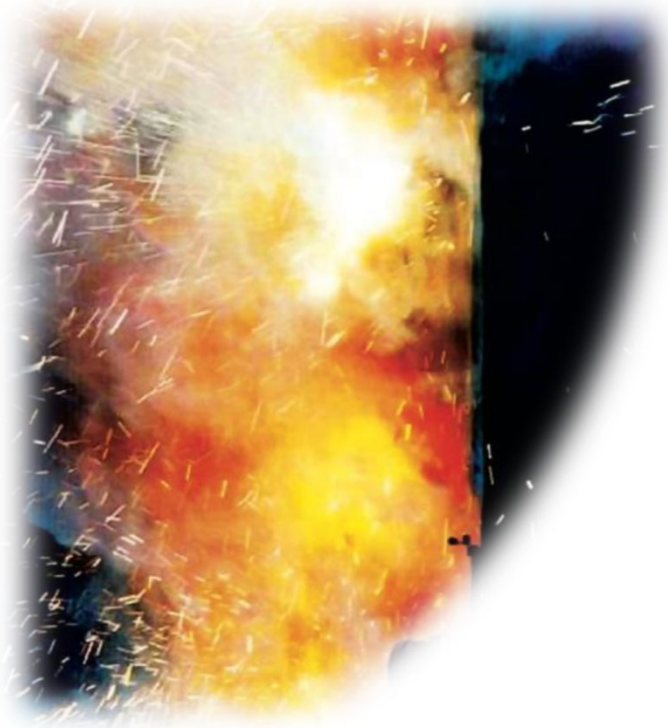
Per NFPA 70E 110.5, Risk assessment is part of Job Planning and has 3 steps:

1. **Identify hazards**
2. **Assess risks**
3. **Implement risk control according to the hierarchy of risk control methods**

Let's walk through these steps…

Risk Assessment

(1) Identify hazards
- ✓ We already did this – Shock and Arc Flash
- ✓ We will end up with a risk assessment for each



(2) Assess risks

(3) Implement risk control according to the hierarchy of risk control methods

Risk Assessment

(1) Identify hazards
- ✓ We already did this – Shock and Arc Flash
- ✓ We will end up with a risk assessment for each

(2) Assess risks
- Consider using the **tables** for guidance here

(3) Implement risk control according to the hierarchy of risk control methods

NFPA 70E – Chapter 1 – Safety Related Work Practices

Table Review – Table 130.4(E) **Shock Protection** – Approach boundaries

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

(1)	(2)	(3)	(4)
	Limited Approach Boundary[b]		
Nominal System Voltage Range, Phase to Phase[a]	Exposed Movable Conductor[c]	Exposed Fixed Circuit Part	Restricted Approach Boundary[b]; Includes Inadvertent Movement Adder
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

130.4(E)(a) For AC & (b) for DC

"Exposed Moveable Conductor" column is generally used for overhead power lines.

Provides LIMITED approach boundary

- Unqualified Persons

Provides RESTRICTED approach boundary

- Qualified Persons

NFPA 70E – Chapter 1 – Safety Related Work Practices

Table Review – Portions of Table 130.5(C) **Arc Flash – Likelihood**

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

Task	Equipment Condition[a]	Likelihood of Occurrence[b]
Reading a panel meter while operating a meter switch.	Any	No
Performing infrared thermography and other non-contact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers.		
Working on control circuits with exposed energized electrical conductors and circuit parts, nominal 125 volts ac or dc, or below without any other exposed energized equipment over nominal 125 volts ac or dc, including opening of hinged covers to gain access.		
Examination of insulated cable with no manipulation of cable.		
For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack.		
For ac systems, work on energized electrical conductors and circuit parts, including electrical testing.	Any	Yes
Operation of a CB or switch the first time after installation or completion of maintenance in the equipment.		
For dc systems, working on energized electrical conductors and circuit parts of series-connected battery cells, including electrical testing.		
Removal or installation of CBs or switches.		
Opening hinged door(s) or cover(s) or removal of bolted covers (to expose bare, energized electrical conductors and circuit parts). For dc systems, this includes bolted covers, such as battery terminal covers.	Normal	No
Application of temporary protective grounding equipment		
Operation of a CB, switch, contactor, or starter.		
Voltage testing on individual battery cells or individual multi-cell units.		
Removal or installation of covers for equipment such as wireways, junction boxes, and cable trays that does not expose bare, energized electrical conductors and circuit parts.		
Opening a panelboard hinged door or cover to access dead front overcurrent devices.		
Removal of battery nonconductive intercell connector covers.		

Notes

Both ac and dc systems

Task Based

Equipment Condition – Any, Normal and Abnormal.

- See 110.4(D)

Likelihood of Occurrence

- Yes – Should be considered likely to occur
- No - not likely to occur

NFPA 70E – Chapter 1 – Safety Related Work Practices

Table Review –Table 130.5(C)(15)(a) **Arc Flash PPE Categories**

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

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 volts and below Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	1	485 mm (19 in.)
Panelboards or other equipment rated greater than 240 volts and up to 600 volts Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	900 mm (3 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 42 kA available fault current; maximum of 0.33 sec (20 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	4.3 m (14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Maximum of 35 kA available fault current; maximum of up to 0.5 sec (30 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	6 m (20 ft)
Other 600-volt class (277 volts through 600 volts, nominal) equipment 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)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	4	12 m (40 ft)

Notes

130.5(C)(15)(a) for ac; and (b) for dc systems

Equipment and Circuit Based

PPE Categories replaced the old HRC Categories a few years ago.

Must meet all parameters; if not, calculate incident energy

Determine category – then select PPE

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NFPA 70E – Chapter 1 – Safety Related Work Practices

Table Review –Table 130.5(C)(15)(c) **Personal Protective Equipment**

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

Arc-Flash PPE Category	PPE
1	**Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm^2 (16.75 J/cm^2)[a]**
	Arc-rated long-sleeve shirt and pants or arc-rated coverall
	Arc-rated face shield[b] or arc flash suit hood
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[f]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[c]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[d]
	Leather footwear[e] (AN)
2	**Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm^2 (33.5 J/cm^2)[a]**
	Arc-rated long-sleeve shirt and pants or arc-rated coverall
	Arc-rated flash suit hood or arc-rated face shield[b] and arc-rated balaclava
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[f]
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[c]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[d]
	Leather footwear[e]
3	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm^2**

Notes

130.5(C)(15)(c) PPE Categories are only applicable when tables (a) or (b) were used.

PPE Categories 1, 2, 3, & 4

Do not mix PPE Category method with incident energy analysis.

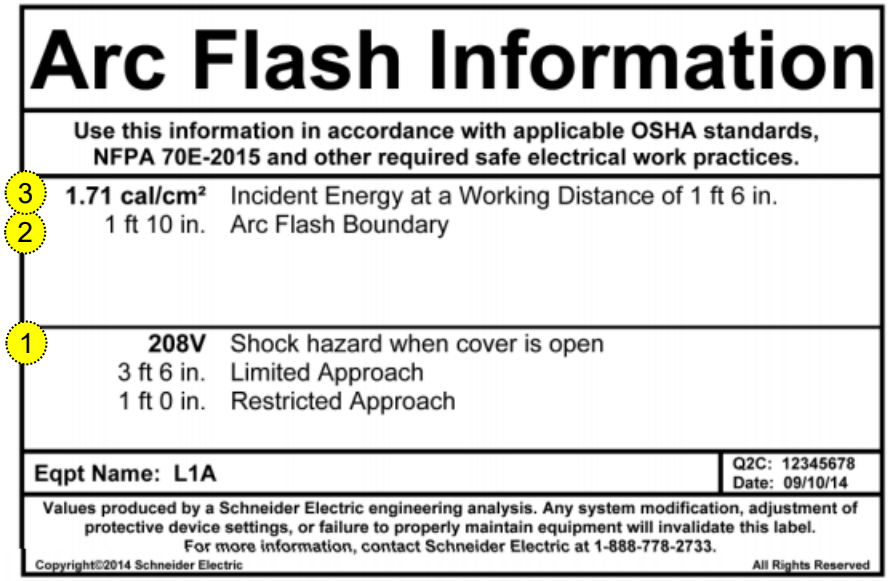
AN – As Needed

SR – Selection Required

NFPA 70E – Chapter 1 – Safety Related Work Practices

Equipment Labeling – Section 130.5(H)

Label electrical equipment that is likely to require examination, adjustment, serving, or maintenance while energized.



Arc Flash Information

Use this information in accordance with applicable OSHA standards, NFPA 70E-2015 and other required safe electrical work practices.

3 **1.71 cal/cm²** Incident Energy at a Working Distance of 1 ft 6 in.

2 1 ft 10 in. Arc Flash Boundary

1 **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.

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E
- This equipment must only be installed and serviced by qualified electrical personnel.
- Turn off all power supplying this equipment before working on or inside equipment.
- Always use a properly rated voltage sensing device to confirm power is off.
- Replace all devices, doors and covers before turning on power to this equipment.

Failure to follow these instructions will result in death or serious injury.

Notes

Minimum Label Requirements:

(1) Nominal System Voltage

(2) Arc Flash Boundary

(3) At least one of the following:

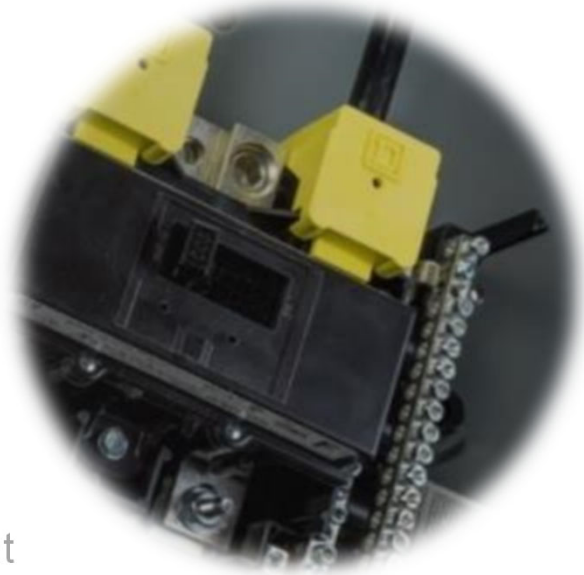
a) Available Incident Energy and Working Distance - or - Arc Flash PPE Category

b) Minimum arc rating of clothing

c) Site specific level of PPE

Supplement NEC 110.16 and 110.21 Markings

Risk Assessment



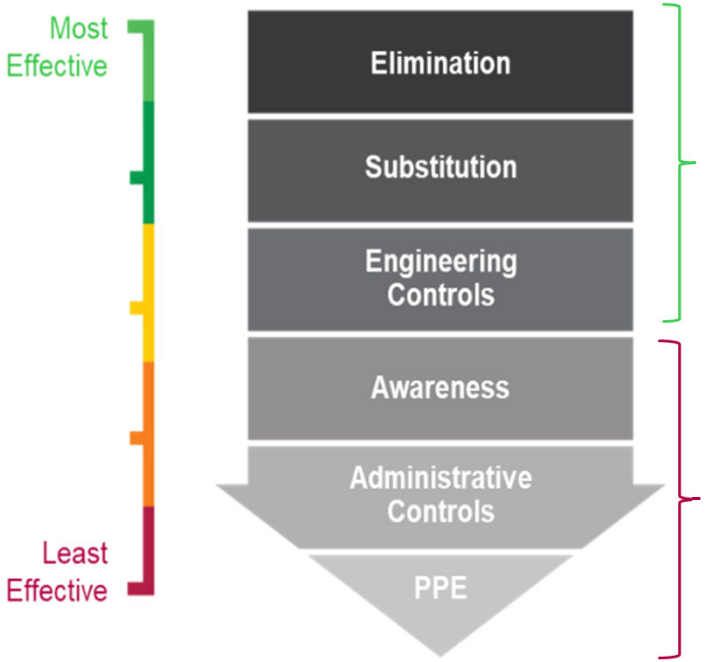
(1) Identify hazards
- ✓ We already did this – Shock and Arc Flash
- ✓ We will end up with a risk assessment for each

(2) Assess risks
- ✓ Likelihood is Primarily Task Dependent
- ✓ Severity is Primarily Circuit and Equipment Dependent

(3) Implement risk controls according to the hierarchy of risk control methods
- ✓ 70E has a hierarchy risk control methods in 110.5(H)(3).

Risk Control

Hierarchy – Most preferred at top; Least preferred at bottom



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

Hierarchy of Risk Control

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

More Effective

Less Effective

1) Elimination – Eliminate the hazard; Establish an electrically safe work condition (The 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 – Passive and active features that automatically reduce risk; GFCI protection, guarding and barriers.
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

Hierarchy of Risk Control

Helpful info not Found in 70E

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

More Effective

1) Elimination – Eliminate the haz y safe work condition (The state – not the process).

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3) **Engineering Controls – Passive and active features that automatically reduce risk; GFCI protection, guarding and barriers.**

4) Awareness – Alert people to the hazard; install permanent or temporary signs, labels, and barricades.

Less Effective

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

Engineering Controls – One way to evaluate Arc Flash Mitigation methods is to categorize them.

Helpful info not Found in 70E

Avoidance:
Help isolate personnel from the vicinity of the hazard but the arc flash hazard remains unaffected.

Prevention:
Reduces the likelihood of an arc event without necessarily altering the arc flash severity levels.

Containment:
Effectively contains and redirects the arc flash fault and its by-products away from personnel.

Reduction:
Lower the incident energy level by clearing the arc fault more quickly.

- All arc-flash mitigation solutions fit into one or more of these four categories
- Understanding what the solutions in these categories do…and what they don't do…is key to understanding how to develop an arc-flash mitigation strategy

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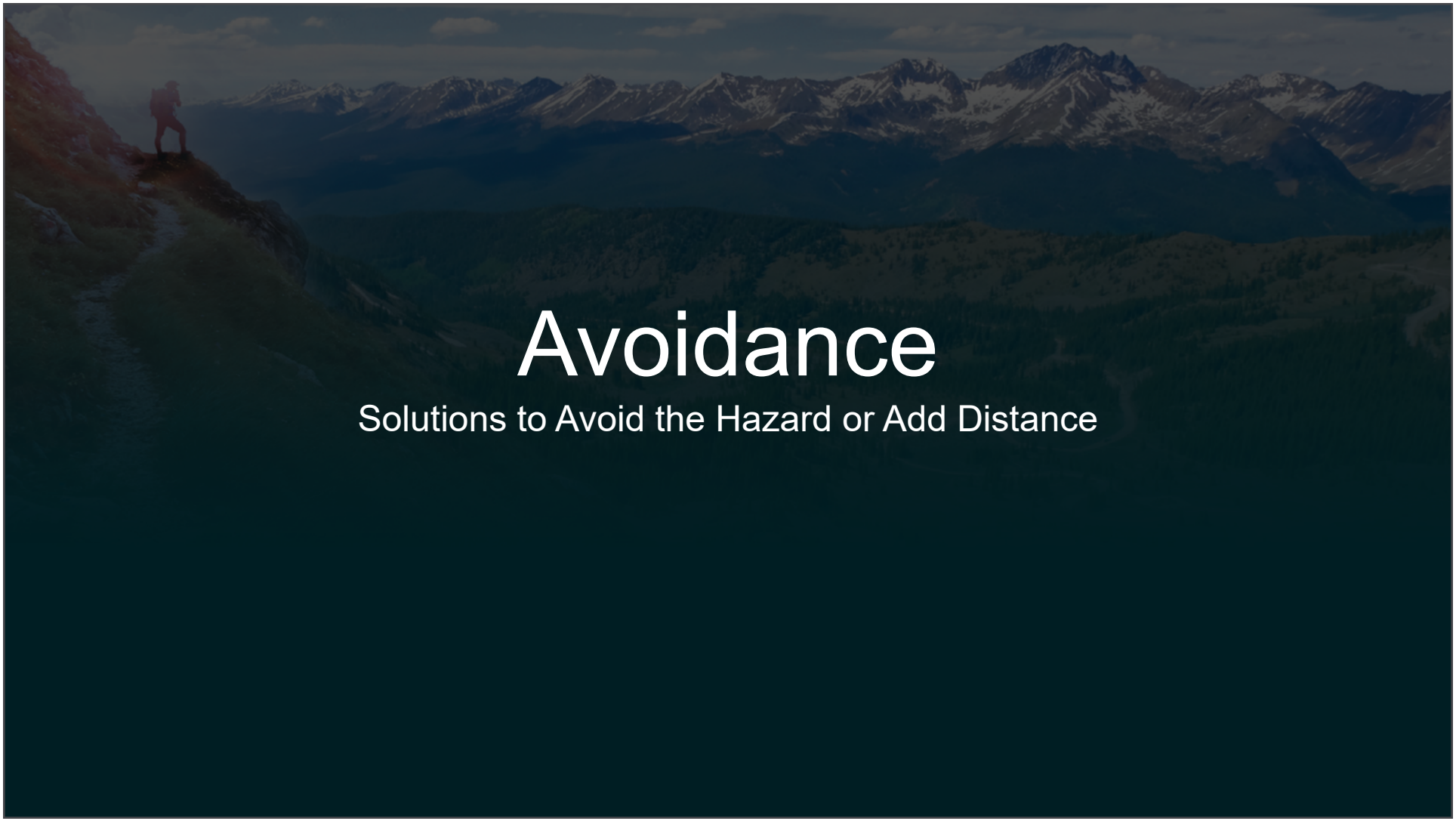
Avoidance
Solutions to Avoid the Hazard or Add Distance

Avoidance

Helpful info not Found in 70E

Solutions to Avoid the Hazard or Add Distance

One way to reduce the likelihood of electrical incidents is to introduce measures that allow personnel to be in a lower risk area. Avoidance measures can be effective in removing the worker from, or increasing the distance to, the exposed energized parts. Avoidance solutions reduce both the likelihood and severity to personnel, but arc flash hazard levels remain unaffected.

Arc Flash Mitigation Types	Protection during operation	Protection during maintenance / abnormal operation	Reduced incident energy (cal / cm^2)	Recovery time	Impact on footprint	Impact on commissioning	Modifying existing equipment	CapEX	OpEX
Remote operation	Yes	No	Yes[4]	NA	Low	None	Easily	$$	$
Time delay switch (TDS) Operation	Limited	No	Yes[4]	NA	None	None	Easily	$$	$
Absence of voltage tester	Limited	No	Yes[4]	NA	None	None	Possible	$$	$
InfaRed (IR) Windows	Limited	No	Yes[4]	NA	None	None	Easily	$$	$
Close door racking	Limited	No	No	NA	None	None	Possible	$$	$
Remote racking system	Yes	No	Yes[4]	NA	None	None	Easily	$$	$
Partial de-energization / Load redundancy multiple sources (Main-Tie-Main)	Limited	Limited	Limited	Partial Operation Hours/days	High	Medium	Difficult	$$$	$

Remote Operation / Remote racking

Helpful info not Found in 70E

- New and modernization applications.
- Various solutions for electrically and mechanically operated breakers (MO converted to EO).
- Handheld remote operators.
- Hardwired control panels
- Digital communications to HMI operator panels
- Smart mobile devices.
- Hardwired or digital communications to remote Power Operations or SCADA workstations.

Absence of Voltage Testers (AVT)

Helpful info not Found in 70E

- One step of establishing an Electrically Safe Work Condition is to verify absence of voltage.
- Allows confirmation of absence-of-voltage without exposure to potentially live conductors or circuit parts.
- AVTs:
  - Are permanently mounted.
  - Are listed and labeled for testing for absence of voltage.
    - UL 1436 - Standard for Outlet Circuit Testers and similar indicating devices
  - Test each conductor phase to phase and phase to ground
  - Perform a self test on a known voltage before and after test to verify operation.

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Prevention
Solutions to lower likelihood and Risk

Prevention

Helpful info not Found in 70E

Solutions that help lower Likelihood and Risk

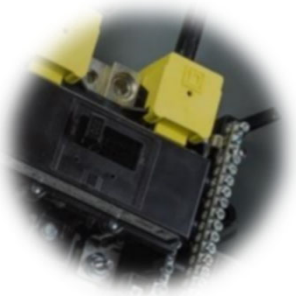
One of the best ways to prevent and control risk is to ‘design out’. Multiple technologies exist that help prevent or reduce the likelihood of an arc event. This is done by including prevention considerations in designs and are particularly important for critical applications.

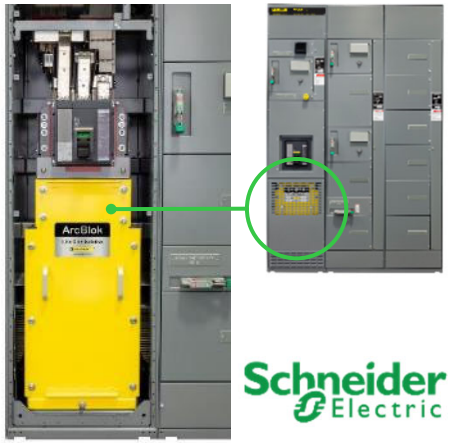
Prevention by design Arc flash mitigation types	Protection during operation	Protection during maintenance / abnormal operation	Reduced incident energy (cal / cm^2)	Recovery time	Impact on footprint	Impact on commissioning	Modifying existing equipment	CapEx	OpEx
Barriers / ANSI compartmentalization	Yes	Limited	No	N/A	None	Low	Application dependent	$$	$$
High resistance grounding	Limited	Limited	No	N/A	Low	High	Possible	$$$	$$
Gas insulated switchgear	Yes	Limited	No	N/A	Improves	Medium	No	$	$
Shielded solid insulated switchgear	Yes	Limited	No	N/A	Improves	Medium	No	$	$
IR thermographic study	Increases exposure	Increases exposure	No	Predictive	None	None	N/A	$	$$$
Continuous thermal monitoring	Alert only	Alert only	No	Predictive	Low	Low	Possible	$$$	$
Continuous humidity monitoring	Alert only	Alert only	No	Predictive	None	Low	Easily	$$	$

Barriers and Compartmentalization

Helpful info not Found in 70E

- There are various types of “Barriers”.
  - Insulation — Section barriers
  - Terminal barriers — Bus Shutters
  - ANSI compartmentalization — etc
- Barriers may address one hazard and not another
  - Shock — Arc Flash — Both?
- The hazard remains, but Risk is reduced.
  - Barriers may reduce likelihood, but impact on severity may be unknown.
- Some Solutions are tested to verify that they reduce the risk of both Shock and the Arc flash hazards – even on the line side.





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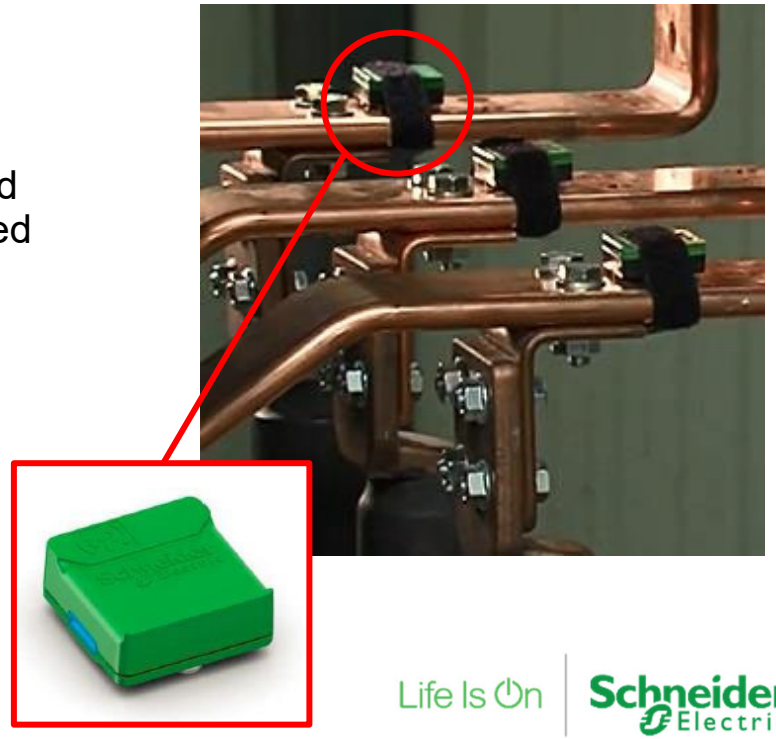
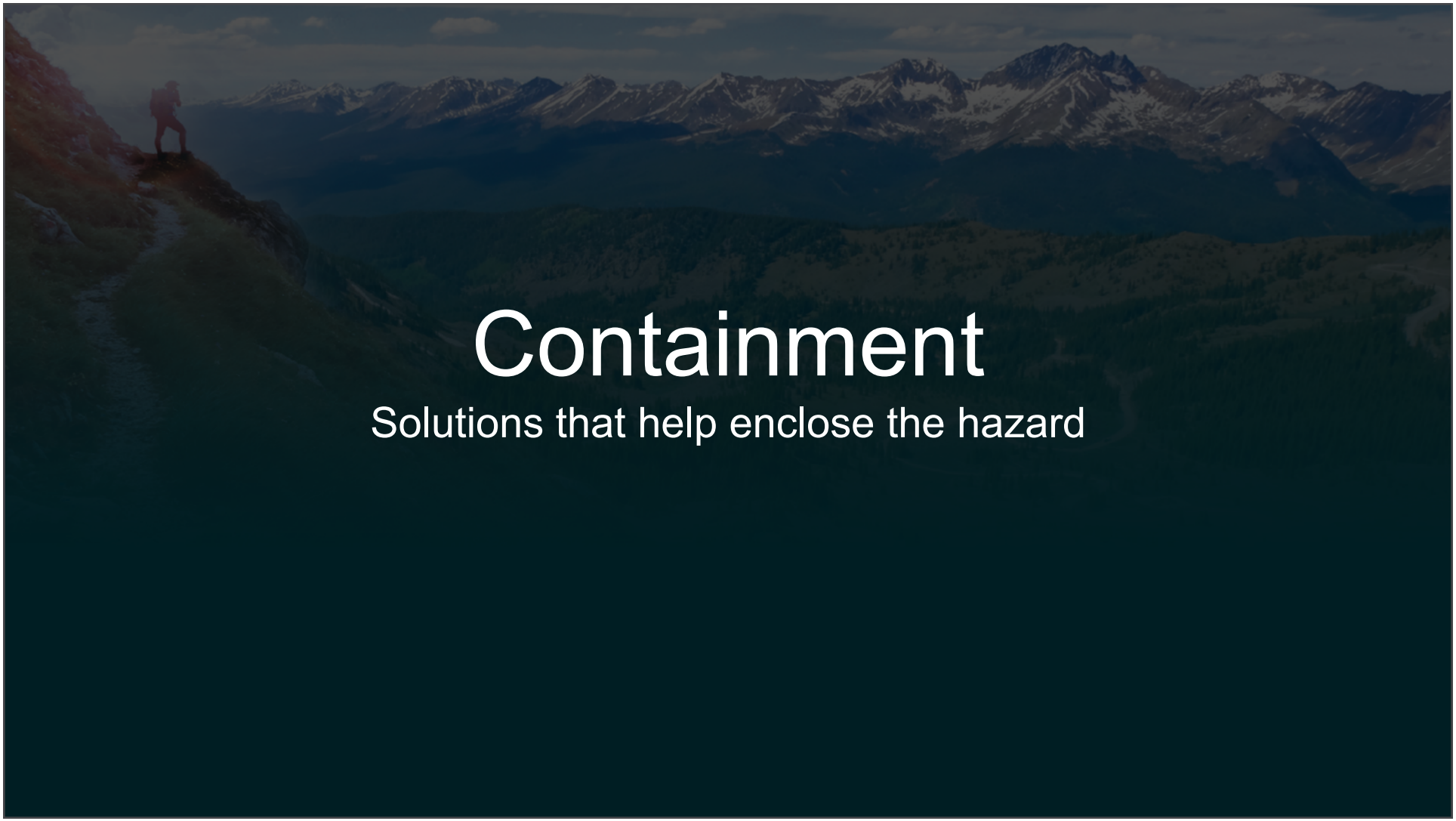
Continuous Monitoring

Helpful info not Found in 70E

- Sensors at key measuring locations - in lieu of thermographic inspection.
  - Opening of doors or removal of covers is not required to access equipment for inspection, reducing the need for exposure to energized parts.
  - Continuous monitoring catches events not seen during inspections.
  - May predict events prior to occurrence for corrective actions.
  - **Thermal** and **Humidity** Monitoring is available for some equipment types.




Containment
Solutions that help enclose the hazard

Containment

Helpful info not Found in 70E

Solutions that help Enclose the Hazard

These solutions typically feature an enclosure that is reinforced enough to contain and redirect the high pressure and heat produced during an arc flash event.

Containment Arc flash mitigation types	Protection during operation	Protection during maintenance / abnormal operation	Reduced incident energy (cal / cm^2) [1-2-3]	Recovery time	Impact on footprint	Impact on commissioning	Modifying existing equipment	CapEx[5]	OpEx[5]
Arc resistant	Yes	No	No	Weeks / months	Medium	Low	No	$$$$$	$

Notes: 1. Based on clearing time and typical range of fault currents. 2. At the operator (18 inches). 3. Incident energy is reduced by adding distance between the operator and the hazard, the hazard level remains unchanged. 4. Costs are ranked for typical application but may vary based on actual application implemented. 5. Capital expenditures, operating expenditures

Arc flash mitigation types	Application notes
Arc resistant	Enclosures designed to contain or safely vent off an arc flash event. Tested per IEEE C37.20.7 • Available on a limited number of equipment types • Equipment must be installed within its ratings for maximum arcing current and arcing duration • Impact to footprint due to ducting and venting into 'secure areas' • Vent ducts obstruct space and need clearance. New hazardous regions introduced in venting areas

Arc Resistant Equipment

Helpful info not Found in 70E

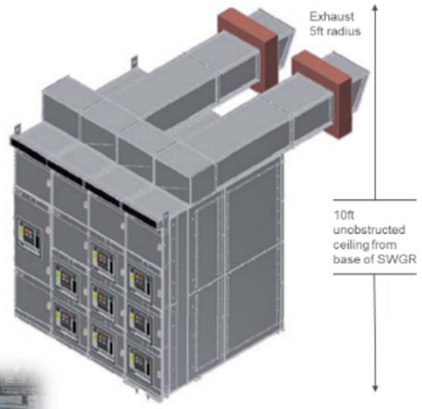
- Performance verified in accordance with ANSI C37.20.7
  - Provides additional protection for personnel performing normal operating duties under normal operating conditons: opening/closing switching devices, connecting/disconnect withdrawable parts, reading of metering instruments
- AR Gear was initially limited to Medium Voltage
  - Now also includes
    - Low Voltage Switchgear
    - Low Voltage MCC's
    - Low Voltage Switchboards
    - Other types of equipment
- Arcing Short-circuit Current – Equipment short-time current rating or short-circuit current rating
- Arcing Duration – Historically 0.5s, now depends upon the equipment type

Arc Resistant Construction

Helpful info not Found in 70E

Generally, a Heavy-Duty Construction

- Internal arc gas management system (IAGMS)
- Inter Bay and Inter Compartment Barriers
- Inter Phase Barriers
- Standard front doors, Reinforced rear doors and side covers
- Baffle and plenum exhaust options



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Reduction
Solutions that lower incident energy

Reduction

Helpful info not Found in 70E

Solutions that lower incident energy

The most effective way to reduce incident energy levels in an electrical system is to reduce the duration of the arc by clearing the arcing fault from the system in the shortest amount of time possible.

Reduction Arc flash mitigation types	Protection during operation	Protection during maintenance/abnormal operation	Reduced incident energy (cal/cm^2)	Recovery time	Impact on footprint	Impact on commissioning	Modifying existing equipment	CapEx	OpEx
Energy-reducing maintenance switch	Limited	Limited	Less than 8/12	Hours/days depending on ERMS switch been turn on	None	Low	Possible	$$	$
Circuit breaker with instantaneous or override below arcing level	Limited	Limited	Less than 8/12	Hours/days	None	Medium	Limited	$$	$
Adaptive settings	Limited	No	Less than 40	Weeks/months	None	Low	Possible	$	$
Current-limiting circuit breakers/fuses	Limited	Limited	Less than 8/12	Hours/days	Medium	Low	Limited	$$	$
Digital-multifunction relay	Yes	Yes	Less than 40	Weeks/months	Low	High	Possible	$	$
Zone-selective interlocking	Yes	Yes	Less than 12	Hours/days depending on calorie availability	None	Medium	Possible	$$	$
Differential protection	Limited	Limited	Less than 8/12	Hours/days	Low	High	Possible	$$$	$
Transfer trip scheme (virtual main)	Yes	Yes	Less than 8/12	Hours/days	Low	Medium	Possible	$$	$
Arc flash detection device (optical sensors)	Yes	Yes	Less than 8/12	Hours/days	Medium	Medium	Application dependent	$$	$
High-speed shorting switch (quenchers)	Yes	Yes	Less than 1.2	Hours/days	High	High	Possible	$	$
Line side isolation with passive reduction	Yes	Yes	Less than 1.2	Hours/days	Low	Low	Possible	$	$

Energy Reducing Maintenance Switch

Helpful info not Found in 70E

- Worker engages maintenance mode during work; After maintenance, returns to normal setting.
- No intentional delay - Temporarily reduces the pickup and/or time delay settings.
- Effective if the maintenance mode settings result in a faster clearing time – based on actual fault current levels.

- Note – temporary adjustment of the instantaneous trip setting to achieve arc energy reduction is NOT permitted.

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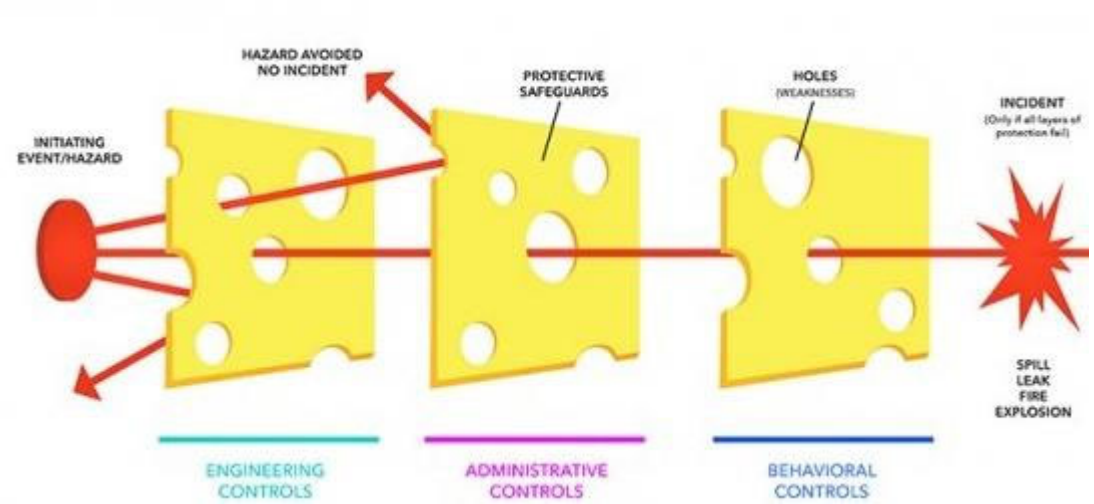
James T. Reason's "Swiss Cheese" Model

Helpful info not Found in 70E

Generally, avoiding an incident is the result of several layers of protection.

There is no "silver bullet" arc flash or shock protection scheme.

The best mitigation schemes use multiple differing layers.



Hierarchy of Risk Control

Helpful info not Found in 70E

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

More Effective

1) Elimination – Eliminate … lly safe work condition (The state – not the process).

2) Substitution – Substitute less haz… ient; use non-electrical or battery-operated tools; 24 v instead of 120 v control power.

3) **Engineering Controls – Passive and active features that automatically reduce risk; GFCI protection, guarding and barriers.**

4) Awareness – Alert people to the hazard; install permanent or temporary signs, labels, and barricades.

Less Effective

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

NFPA 70E – Chapter 2 – Safety Related Maintenance Requirements

Chapter 2 – Safety Related Maintenance Requirements

- Chapter 2 of NFPA 70E is only 4 pages long
- Very general safety related maintenance requirements
- Focus is on Awareness of Safety related work practices
- Does not prescribe specific maintenance methods or testing procedures.

NFPA 70E – Chapter 3 – Safety Requirements for Special Equipment

Chapter 3 – Safety Requirements for <u>Special Equipment</u>

310 – Electrolytic Cells

320 – Batteries and Battery Rooms

Some special permissions for up to 100 Vdc

330 – Lasers

340 – Power Electronic Equipment

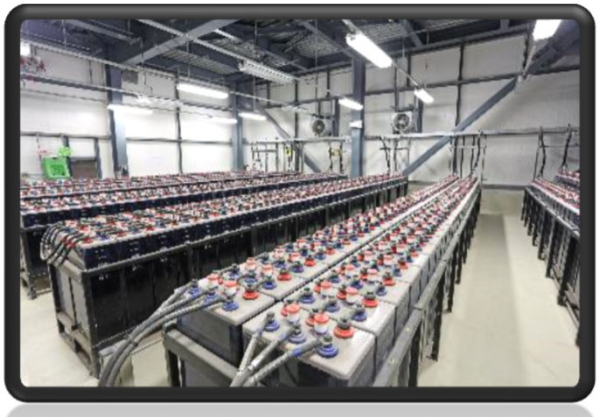
350 – R & D Laboratories

Custom, specialized Equipment (National Labs, R&D, etc)

360 – Capacitors

Newest Article – Use with Annex R

Discharging, Some special permissions for up to 100 V



NFPA 70E – Informative Annexes

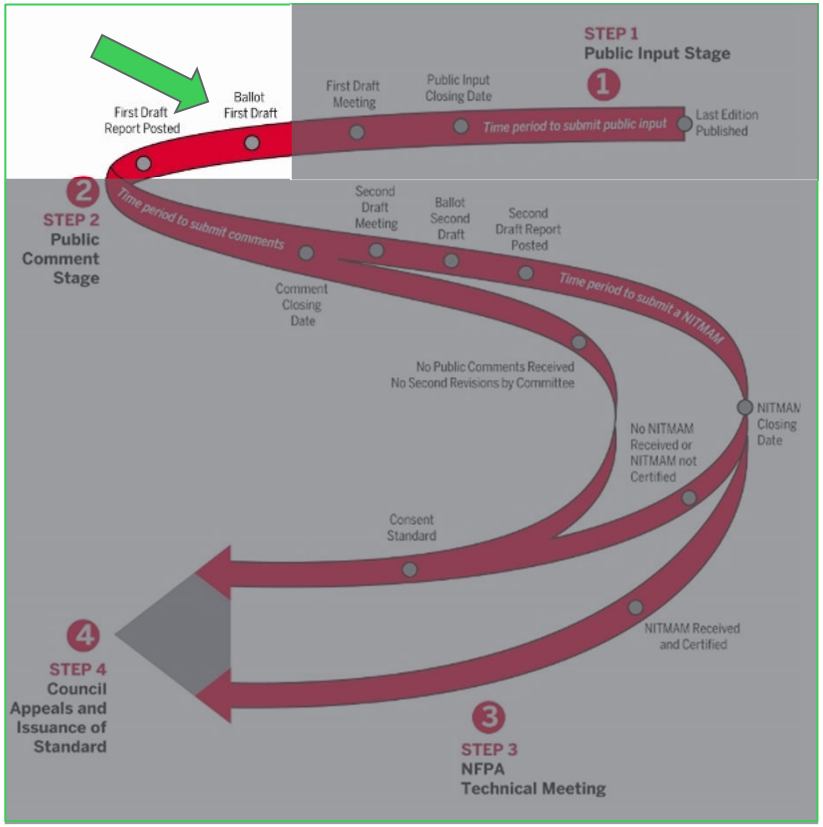
Informative Annexes A though R

- Informative, contain no mandatory requirements.
- Good source for **forms**
  - Safety Planning, Work Permit, etc.
- Good source for **programs**
  - LOTO, Electrical Safety
- Good source for **technical information**
  - Incident Energy calculation methods, working with capacitors

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

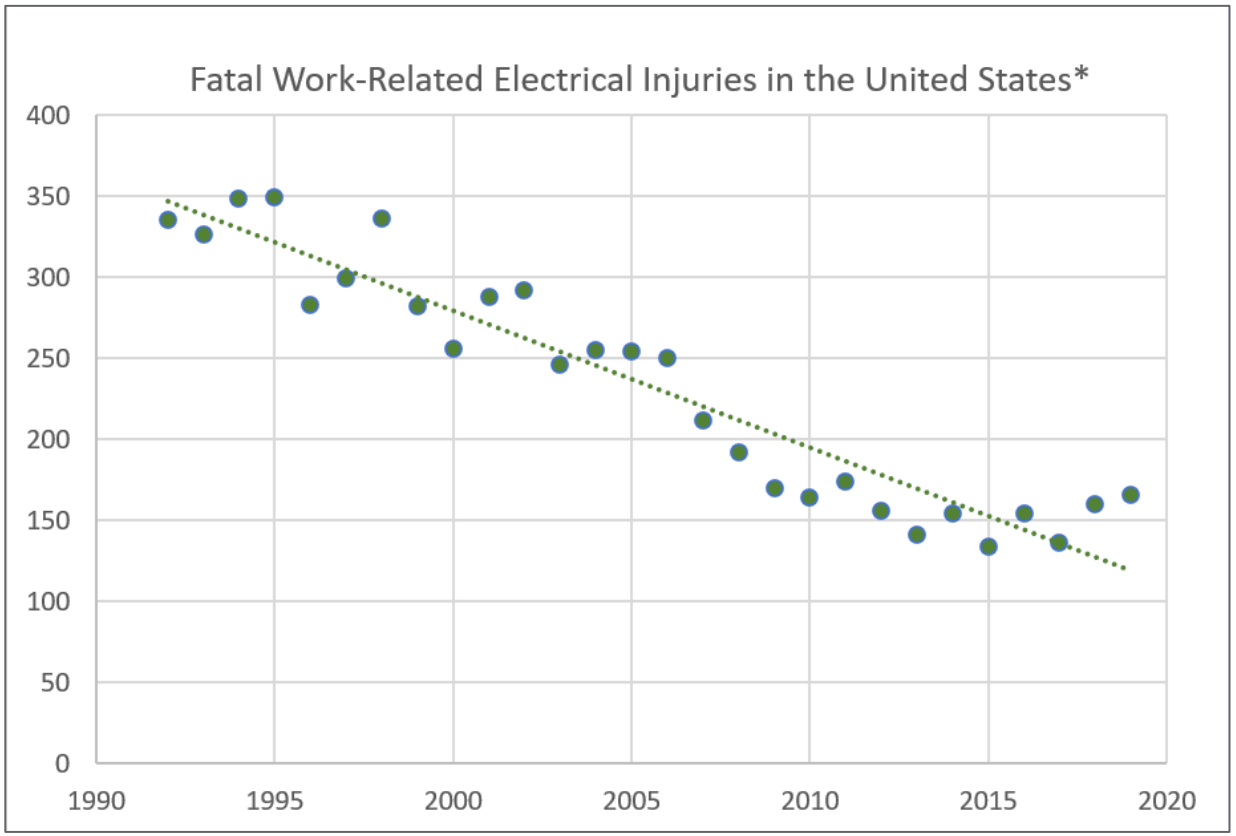
NFPA 70E – 2024 Edition - Where are we in the Process?

- Near the end of Step 1.
- The Technical Committee met in August 2021.
  - Ballots are out for voting now.
  - The First Draft will Post in March 2022.
  - Available for Public Comment until May 31, 2022.
  - Get involved - Submit Comments!
    - https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70E&tab=nextedition



Fatal Work-Related Electrical Injuries in the US

* Data Sources: The Fire Protection Research Foundation, U.S. Bureau of Labor Statistics (BLS), and the Census of Fatal Occupational Injuries (CFOI)



Is the electrical safety culture changing?

YES!

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Let's take a break

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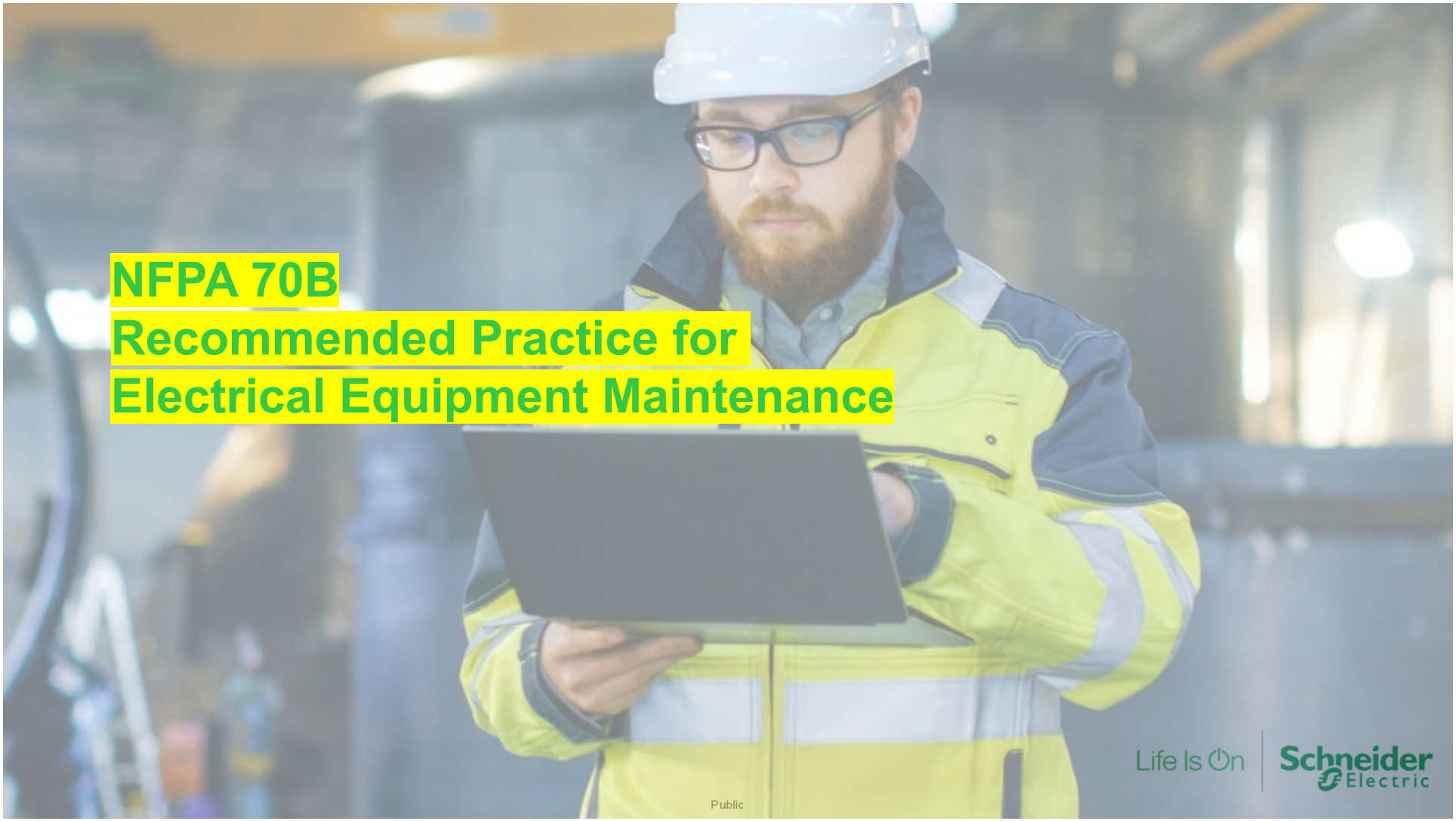
NFPA 70B
Recommended Practice for
Electrical Equipment Maintenance
Life Is On
Schneider Electric
Public

NFPA 70B Foundation

- **Adopted in 1975, currently the 2019 edition**
  - "The purpose of this recommended practice is to reduce hazards to life and property that can result from failure or malfunction of industrial-type electrical systems and equipment."
- **Today: 70B is a Recommended Practice** that encourages the use of an Electrical Maintenance Program.
  - Recommended Practices have no mandatory language (should)
- **Tomorrow: 70B will transition to a Standard**
  - Standards have mandatory language (shall)
- **Early in the change process, but what is in the First Draft?**

NFPA 70B – What is in the First Draft

- 38 Chapters – a couple are “Reserved” without content.
- Informative Annexes (A, B, C…M)
- Content from the existing 2019 has been either reworded in the new chapters, moved to the annexes, or deleted
- Want more detail? Let’s look into some chapters…

NFPA 70B – What is in the First Draft

- First 10 Chapters Contain Fundamental & Common Topics:
  1. Administration
  2. Referenced Publications
  3. Definitions
  4. Safety
  5. **General**
  6. System Studies
  7. **Fundamental Tests**
  8. **Test Methods**
  9. Haz Location Equip
  10. **Maintenance Intervals**

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Chapter 5 General

Requires the Development of an Electrical Maintenance Program (EMP).

Electrical Maintenance Program (EMP).

A managed program of inspecting, testing, monitoring, analyzing, and servicing electrical systems and equipment with the purpose of maintaining safe operations and production by reducing or eliminating system interruptions and equipment breakdowns.

Elements of a EMP include…

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Chapter 5 General

5.2.4.2 The Electrical Maintenance Program (EMP) **shall include the following elements**:

(1) An electrical safety program that addresses the condition of maintenance

(2) Identification of personnel responsible for implementing each element of the program

(3) Survey and analysis of electrical equipment and systems to determine maintenance requirements and priorities

(4) Developed and documented maintenance procedures for all equipment within the scope of the EMP

(5) A plan of inspections, servicing, and suitable tests

(6) A maintenance, equipment, and personnel documentation and records-retention policy

(7) A process to prescribe, implement, and document corrective measures based on collected data

(8) A process for incorporating design for maintainability in electrical installations

(9) A program review and revision process that considers failures and findings for continuous improvement

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Chapter 7 Fundamental Tests

- Methods to evaluate electrical terminations and connections
  - Infrared Thermography
  - Thermal Sensors
  - Contact Resistance by Millivolt Drop
  - Torque Verification
- Newly Installed Hardware
  - Torque
- Insulation Resistance Testing
- Infrared Thermography

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Chapter 8 Test Methods

- Testing Category Types
  - 1 – Online Standard test – equipment connected to the source of supply
  - 1A – Online Enhanced Test – Same as 1 but not typical / additional info
  - 2 – Offline Standard test – equipment disconnected from source of supply
  - 2A – Offline Enhanced Test – Same as 2 but not typical / additional info
- Requirements for Testing Personnel
- Requirements for Test Equipment
- Requirements for Test Records

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Chapter 8 – Requires Condition of Maintenance Indication – Labels or similar

This is a result of the Equipment Condition Assessment which is required by Chapter 10.

Equipment **condition** is categorized into one of three levels:

1. Serviceable (Good)
2. Limited Service (Identifiable gaps)
3. Non-Serviceable (Poor)

Chapter 10 Intervals are influenced by this equipment **condition**.

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Chapter 8 Condition – *Also addressed in Section 10.2.1*

- Condition of Maintenance – Condition 1
  1. Serviceable
     - Passes all tests and is electrically and mechanically sound

(1) The equipment appears in like new condition.
(2) The enclosure is clean, dry, and tight.
(3) The equipment type is suitable for the environmental conditions.
(4) The equipment is not subjected to harsh chemicals, contaminants, or extreme operating conditions.
(5) No unaddressed notifications from the continuous monitoring system have occurred.
(6) There are no active recommendations from predictive techniques.

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Chapter 8 Condition – *Also addressed in Section 10.2.1*

- Condition of Maintenance – Condition 2
  2. Limited Service
     - Issues that are not detrimental to the protective operation or design

(1) The enclosure appears to be deteriorated due to age, use, or abuse.
(2) There is evidence of prior arcing or overheating.
(3) There is loose or bound equipment parts.
(4) There is visible damage.
(5) There are unused openings.
(6) There is evidence of corrosion or deterioration.
(7) There is visible insulation degradation.
(8) There is build-up of contaminants, dust or debris.
(9) There have been unaddressed notification from the continuous monitoring system.
(10) There are active recommendations from predictive techniques

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Chapter 8 Condition – *Also addressed in Section 10.2.1*

- Condition of Maintenance – Condition 3
  3. Nonserviceable
     - Problems that are detrimental to the proper electrical or mechanical operation of the equipment

(1) There is evidence of active arcing or overheating.

(2) There is evidence of severe corrosion or deterioration.

(3) There is an active notification from the continuous monitoring system.

(4) There are urgent actions identified from predictive techniques.

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Chapter 10 Maintenance Intervals

Where manufacturer does not provide intervals, use maintenance intervals provided in Table 10.1.2

* Low-Voltage Busway example shown…note 3 intervals based on Condition.

		Equipment Condition Assessment			
Product	**Scope of Work**	**Condition 1**	**Condition 2**	**Condition 3**	**Reference**
Low-voltage busway	Maintenance and testing	60 months	36 months	12 months	20.4.8
Uninterruptible power supplies	Visual inspection	6 months	3 months	1 month	28.3.8
	Routine maintenance	12 months	6 months	3 months	28.3.8
	System tests	36 months	24 months	12 months	28.5
	Battery tests	See Stationary Batteries and Chargers	See Stationary Batteries and Chargers	See Stationary Batteries and Chargers	15.9.4
	Test run, exercise	1 month	1 month	1 month	28.3.5

Notes: AN - as necessary

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Chapter 10 – 10.2.2 - Criticality can impact intervals

EMP Intervals modified by **criticality** assessment.

Criticality Considerations:

- Threat to safety or the environment
- High-cost equipment damage
- Business or process continuity

In addition to criticality, 10.2.3 and 10.2.4 consider Environment and Loading conditions

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- 10.1.3 Technology can modify EMP intervals
- Language allows for **Continuous Monitoring**
  - Based on actual conditions 24/7
  - Real time data via sensors
  - Sensors enable alarms and notifications

  - May not replace all inspections, but may change interval

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- 10.1.3 Technology can modify EMP intervals
- Language allows for **Predictive Techniques**
  - Typically monitor more than one input (current, voltage, temperature, humidity, etc)
  - Software or advisors analyze and interpret data based on dynamic behavior rules for components or equipment
  - Provide recommended maintenance actions before alarm set points are reached

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- Chapters 11 – 36 are Equipment Specific:
  11. Power and Distribution Transformers
  12. Substations and Switchgear
  13. Panelboards and Switchboards
  14. **Busways**
  15. Circuit Breakers (LV/MV)
  16. Fuses
  17. Switches
  18. Power Cables
  19. Cable Tray
  20. - *35. More types of equipment - you get the idea*
  36. Stationary Standby Batteries
  37. Instrument Transformers (Reserved)
  38. Control Power Transformers (Reserved)

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Chapter 10 - Interval Based Maintenance

- Generally, each Equipment Chapter will provide a Checklist
  - Visual Inspection
  - Mechanical Servicing
  - Cleaning
  - Lubrication
  - Testing

- Let's look at one example…

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Chapter 14 Busways

14.2 Frequency of Maintenance in accordance with Chapter 10.

14.3.1 Visual Inspection

14.3.1* Visual Inspection.

Busways shall be visually inspected in accordance with Table 14.3.1.

Table 14.3.1 Busway Visual Inspections

No.	Task	Busways Rated 600 Volts or Less	Busways Rated Over 600 Volts	Notes
		Test Type*	Test Type*	
1	Visually inspect the physical condition of the busway and associated fittings.	1	1	Look for evidence of moisture contamination, corrosion, and excessive buildup of dust, dirt, or debris.
2	Visually inspect anchorage, hangers, and alignment of busway system.	1	1	Look for loose connections and twisting or bending of lifted supports.
3	Visually inspect all areas near electrical joints, terminations, and connections.	2	2	Visually check connections to be certain that they are clean and secure and show no signs of overheating or discoloration.
4	Confirm physical orientation in accordance with manufacturer's labels.	1	1	
5	Examine outdoor busway to ensure that weepholes are not obstructed and that the joint shield is installed correctly.	1	1	
6	Inspect ventilation openings on busway and associated fittings.	1	1	
7	Look for signs of deterioration of visible seals and gaskets.	1	1	Outdoor and drip-resistant busway can contain seals and gaskets.

*Types specified in accordance with Section 8.4, as follows: 1 = online standard test, 1A = online enhanced test, 2 = offline standard test, 2A = offline enhanced test.

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Chapter 14 Busways

14.3.2 Mechanical Servicing

14.3.2 Mechanical Servicing.

Busways shall be mechanically serviced in accordance with Table 14.3.2.

Table 14.3.2 Busway Mechanical Servicing

No.	Task	Busways Rated 600 Volts or Less Test Type*	Busways Rated Over 600 Volts Test Type*	Notes
1	Adjust or repair anchorage or hangers to ensure proper support of the busway.	2	2	
2	Exercise plug-in unit operating mechanisms and external operators to confirm they operate to their full ON and OFF positions.	2	NA	
3	Confirm operation of mechanical interlocks and padlocking means of plug-in units.	2	NA	
4	Clean ventilation openings and weep holes.	2	2	
5	Inspect overcurrent protective devices and switches located inside plug in units.	2	NA	See Chapter 15 for information on circuit breakers.
		-	-	See Chapter 16 for information on fuses.
		-	-	See Chapter 17 for information on switches.
6	Inspect forced-air cooling system.	NA	2	Verify operation of forced air cooling that could be included in metal enclosed bus systems.
7	Inspect for loose, open, or missing covers or doors on busways and associated fittings.	2	2	Inspect all plug-in openings, plug-in units, and joints between busway sections. Some covers are not designed to be removed for inspection.

NA: Not applicable.

*Types specified in accordance with Section 8.4, as follows: 1 = online standard test, 1A = online enhanced test, 2 = offline standard test, 2A = offline enhanced test.

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Chapter 14 Busways

14.3.3 Cleaning

14.3.4 Lubrication

14.3.5 Electrical Tests

14.3.5* Electrical Tests.

Busways shall be electrically tested in accordance with Table 14.3.5.

Table 14.3.5 Busway Electrical Tests

No.	Task	Busways Rated 600 Volts or Less Test Type*	Busways Rated Over 600 Volts Test Type*	Notes
1	Inspect bolted electrical connections for high resistance.	1 and 2	1 and 2	See Chapter 7.
2	Perform insulation resistance tests.	2	2	See A.14.3.5 for additional information.
3	Perform a dielectric withstand voltage test.	NA	2	See A.14.3.5 for additional information.
4	Verify operation of busway space heaters.	NA	2	
5	Perform insulation power-factor or dissipation-factor tests.	NA	2A	
6	Perform online partial-discharge survey.	NA	1A	

NA: Not applicable.

*Types specified in accordance with Section 8.4, as follows: 1 = online standard test, 1A = online enhanced test, 2 = offline standard test, 2A = offline enhanced test.

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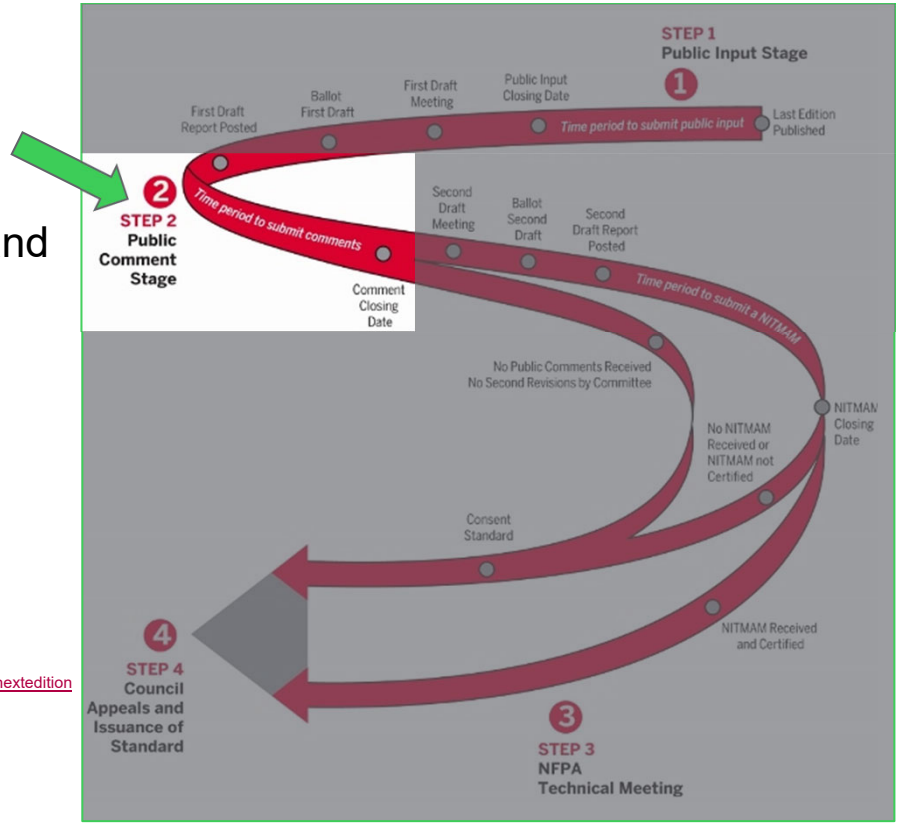
Chapter 10 - Interval Based Maintenance

- "Your mileage may vary…"

- In addition to the suggested intervals and tests, the standard also contains some language to
  - Modify intervals based on performance issues
  - Addressed "enhanced" or optional tests

NFPA 70B - Where are we in the Process?

- Beginning of Step 2.
- The Technical Committee met in March of 2021 and written ballots have been circulated.
  - The First Draft was posted October 8, 2021.
  - Available for Public Comment until February 9, 2022.
  - Get involved - Submit Comments!
    - https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70B&tab=nextedition



Summary

- The NFPA Codes and Standards Development Process
  - Better understanding of the process and when/how you can participate
- Overview of Two of the standards in the NFPA trinity:
  - NFPA 70 – The National Electrical Code (NEC)
  - NFPA 70E – The Standard for Electrical Safety in the Workplace
  - NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
- **Thank you** for your participation!

What questions do you have?

Further Information / Useful Links

- NFPA Website – Development of Codes and Standards
  - Schedules / Notices / Submit Public Input and Public Comment
    - https://www.nfpa.org/Codes-and-Standards/All-Codes-and-Standards/List-of-Codes-and-Standards
  - Select the standard
  - Select the <Next Edition> tab

- Free Access to ANY NFPA Code, Standard or Recommended Practice:
  - https://www.nfpa.org/Codes-and-Standards/All-Codes-and-Standards/Free-access

- Additional safety related engineering control information from SE
- https://go.schneider-electric.com/US_202109_Web-Gating-Safety-Content-Hub_Safety-Content-Hub-TY.html