Applying the 2012 NFPA 70E

Arc Flash Standard

Suncoast Industrial Services, Inc.

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Suncoast Industrial Services, Inc

Suncoast

- Suncoast Industrial is an Electrical Engineering and Contracting firm in North Florida. We provide a variety of services including:
  - Arc Flash, Coordination and Thermal Imaging Studies
  - Design Build of electrical systems (Florida CA 5942)
  - Process Control Solutions
    - We have worked extensively with Allen-Bradley and Rockwell Automation
    - We are well versed in various HMI products including RSView, Intellution/Fix32 and Wonderware
    - If you can imagine it we can make it reality.
  - Electrical Contracting (Florida EC-0001022)

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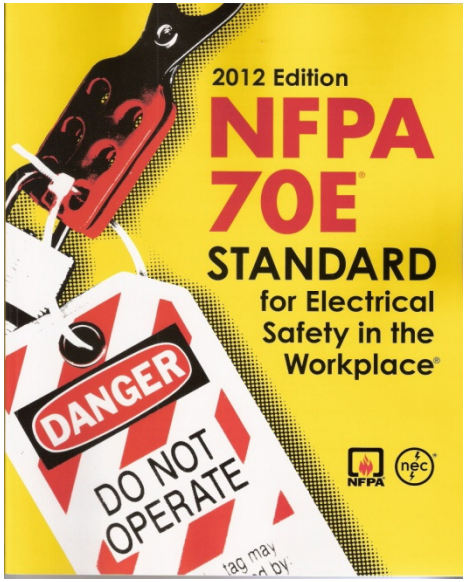
Agenda

- Electrical Hazards
- Codes & Standards
- Introduction to NFPA 70E 2012



- NFPA 70E 2012
  - Labeling
  - Safety Program
  - 'Live' Work Permits
  - Approach and Arc Flash Boundaries
  - Personal Protective Equipment (PPE)
- Minimizing Arc Flash Hazards (Risks)

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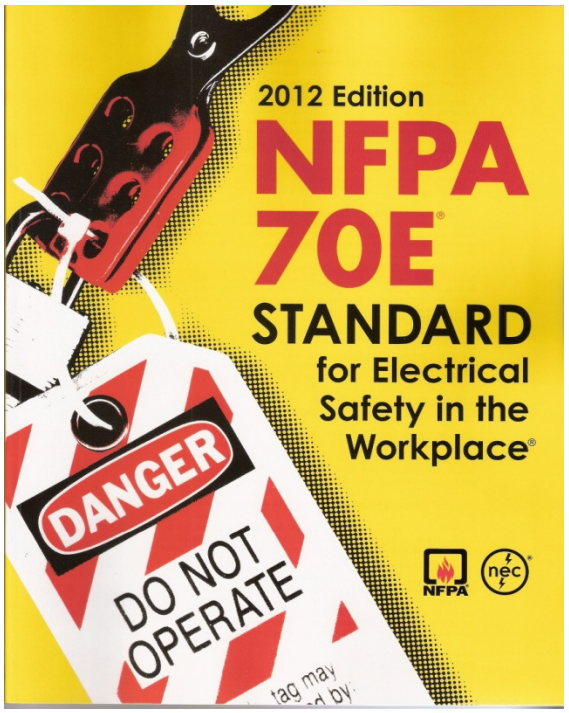

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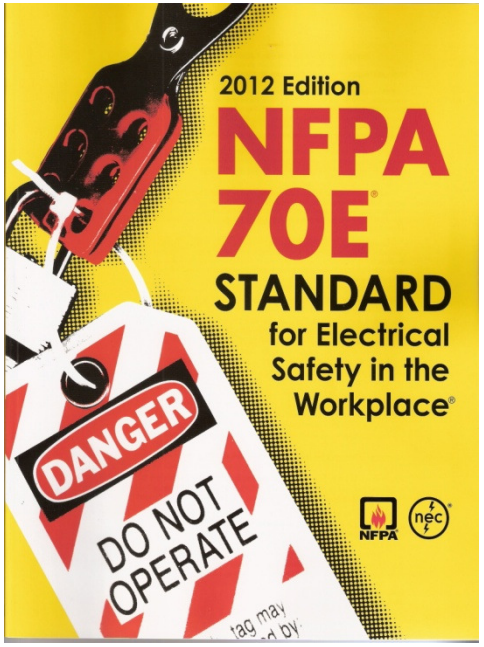

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Electrical Hazard

Definition - A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn or blast.

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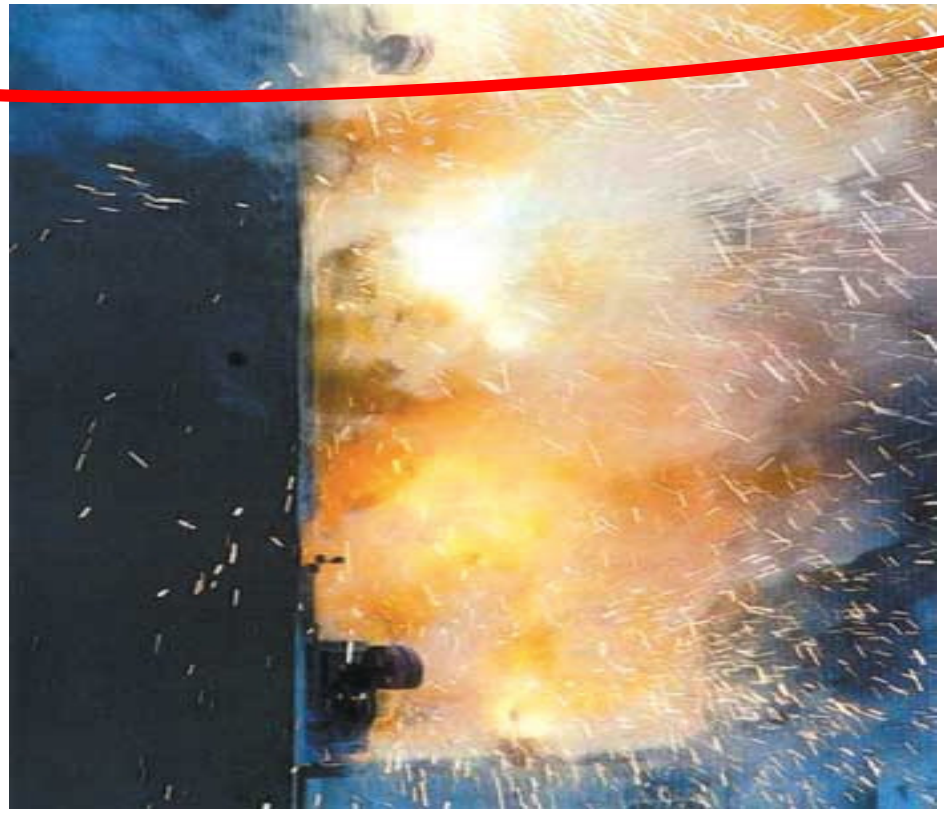

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Electrical Shock

- Over 30,000 nonfatal electrical shock accidents occur each year
- National Safety Council
  - 1,000 fatalities each year due to electrocution
  - Half of them while servicing equipment 600V or under
- NFPA 70E defines 50V as the threshold which requires isolation before servicing (NFPA 70E 130.2)

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Electrical Shock

- **Levels of AC current to cause shock & electrocution**

1 mA	**Not perceptible**
5 mA	**Slight shock**
4 – 6 mA	**Trip range of GFI devices**
6 – 25 mA	**Painful shock**
9 – 30 mA	**Loss of muscle control,**
	May not be able to “let go”
40 mA for 1 sec.	**Ventricular Fibrillation Threshold**
50 – 150 mA	**Respiratory Arrest**

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Characteristics of an Arc Flash

Characteristics of an Arc Flash

- When an arc fault occurs, the arc creates a plasma, which has a much lower impedance or much higher conductivity than air
- The energy produced melts components, flooding the air with conductive particles
- Copper expands to 67,000 times its original volume when vaporized
- The flash occurs instantaneously, releasing a huge amount of energy in a very short period of time

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Terminology

- **Incident Energy** – The energy generated during the arc flash event that is impressed on a surface, such as a human body, at a specific distance from the arc (Units = cal/cm²)

Which will have the higher current potential?

Arcing

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Circuit Breaker and Fuse Characteristics

Circuit Breaker and Fuse Performance Relating to Fault Currents

- Circuit breakers and fuses are traditionally designed to interrupt rapidly in **bolted** fault conditions
- Arc faults occur at lower current levels
- Greater **incident energy** can be allowed to pass when the current is at a lower value
- New device designs will reduce the incident energy

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Causes of Arc Flash

- Mechanical
  - Accidental touching, dropping of tools or metal parts
  - Closing into faulted lines
  - Loose connections

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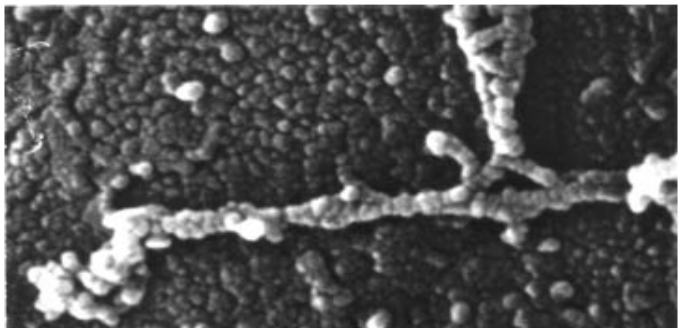
Causes of Arc Flash

- Environmental
  - Dust, impurities, corrosion at contact surfaces



  - Failure of insulating materials

  - Snapping of leads due to force – human, rodents or birds

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Arc Flash

- Thermal impacts of arc flash temperatures

145°F	Curable Burn
205°F	Cell Death
700°F	Clothing Ignition
1,400°F	Burning Clothing
1,800°F	Metal Droplets
9,000°F	Surface of the Sun

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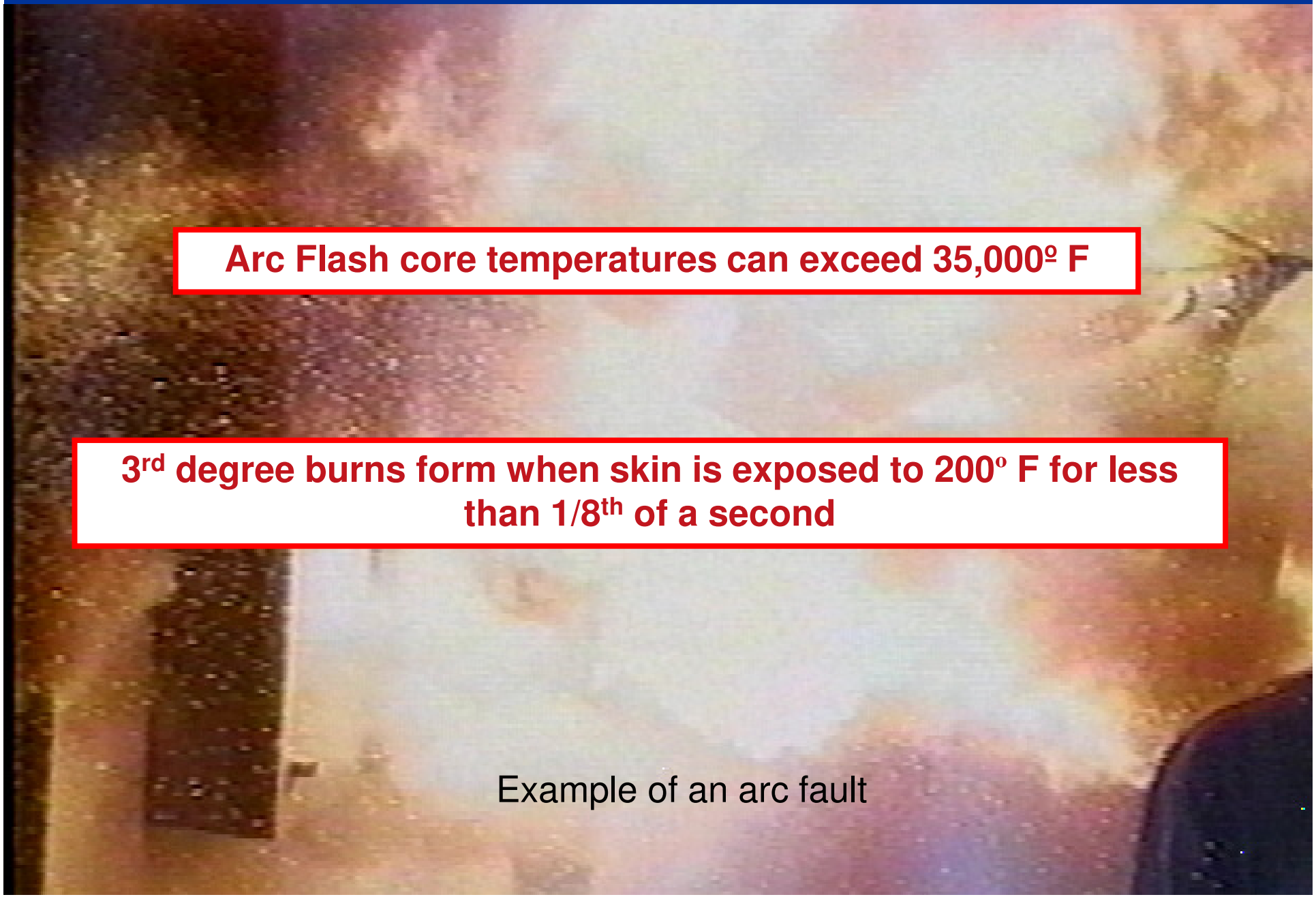
Arc Flash



Arc Flash core temperatures can exceed 35,000º F

3rd degree burns form when skin is exposed to 200º F for less than 1/8th of a second

Example of an arc fault

Arc Flash Burn

- Over 2,000 severe injuries/year
- Can kill at distances of 10 ft
- Cost of treatment can exceed $1,000,000/case
  - Does not include litigation fees or process loss
- Treatment can require years of rehabilitation
- Victim may never return to work or retain quality of life

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Arc Blast

- High pressure
  - Copper expands 67,000 times as it vaporizes
  - Air expands when vaporized
  - Sound pressure > 160dB (car horn 115dB)
  - Debris accelerated to 700 mph
- People killed with no external sign of injury

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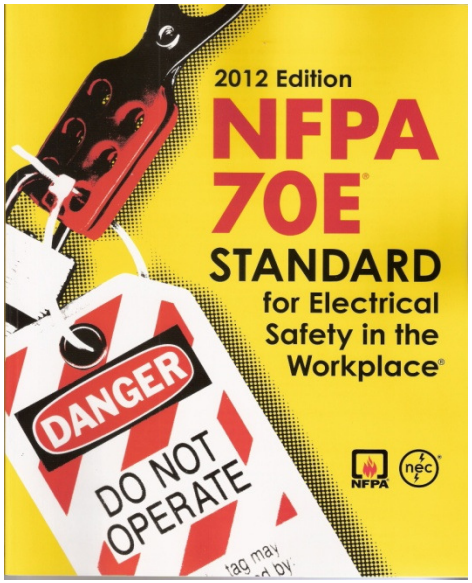

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Codes & Standards

- National Electrical Code 2014 - NFPA 70 – 2014 Edition

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Codes & Standards

- National Electrical Code 2014 - NFPA 70 – 2014 Edition
- OSHA 1910 Subchapter S – Occupational Safety & Health Act

U.S. Department of Labor
Occupational Safety & Health Administration

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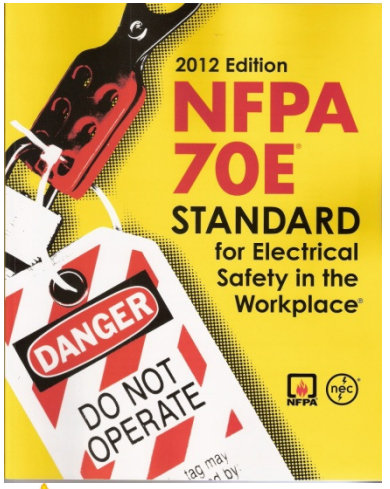
- NFPA 70E – Standard for Electrical Safety in the Workplace - 2012



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What is NFPA 70E ?

- The *Standard for Electrical Safety in the Workplace*
  - Referenced in both the NEC and OSHA regulations regarding *safe electrical work practices*

U.S. Department of Labor
Occupational Safety & Health Administration

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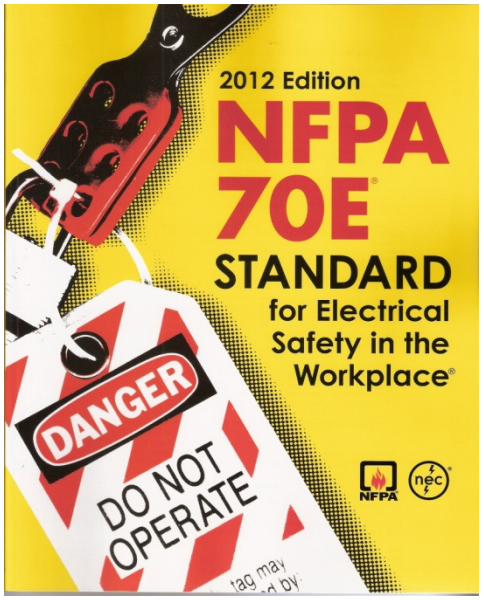

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NFPA 70E Covers Electrical Safety in the Workplace

- Three Main Sections (2012):
  1. Safety-Related Work Practices
  2. Safety-Related Maintenance Requirements
  3. Safety Requirements for Special Equipment

- Arc-Flash is Covered in Section 1, Article 130 (mainly) and Annex D

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NFPA 70E 2012

Electrically Safe Work Condition

- A state in which the conductor or circuit part to be worked on or near has been:
  - Disconnected from energized parts
  - Locked/tagged in accordance with established standards
  - Tested to ensure the absence of voltage
  - Grounded if determined necessary

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NFPA 70E 2012

- Definitions and formulas to calculate Arc Flash and Shock Hazard Boundaries
- Default tables for Arc Flash levels and Personal Protective Equipment (PPE) required for specific tasks
- Includes mandates for:
  - Electrical Safety Program
  - 'Live' Work Permits
  - Safe Work Practices (including PPE)
  - Training

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NFPA 70E – 2012 Revisions

- Word–Smithing & Re-numbering
  - Replaced “FR” – Flame Resistant with “AR” – Arc Rated
  - Dropped “Protection” from “AFB”
- Added DC (Direct Current) requirements
- PPE Changes
  - Require Balaclava (Head Sock) under Face Shield – limited to 12 cal/ cm^2
  - Leather Gloves – Heavy Duty

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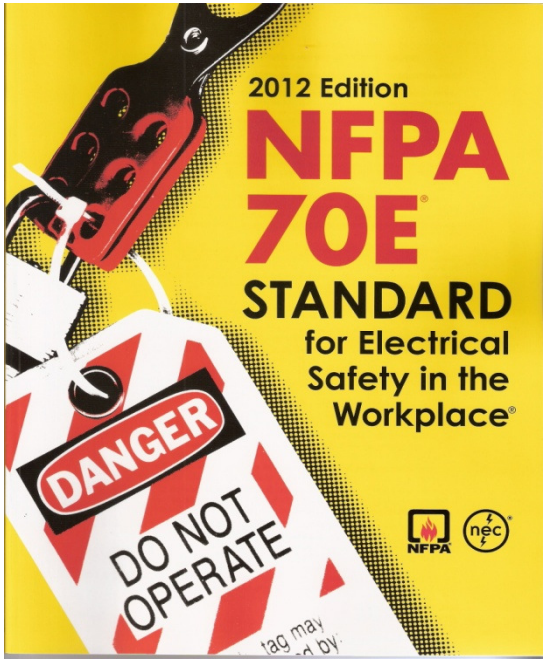

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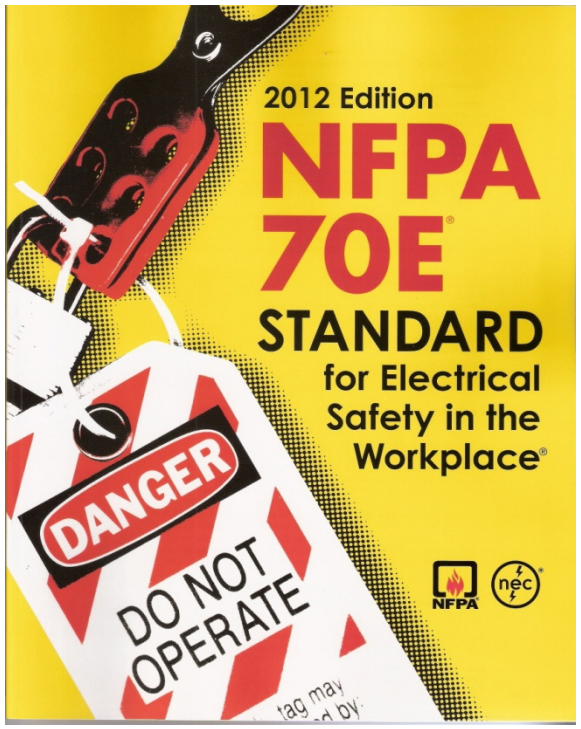

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Labeling Requirement

- NFPA 70E 130.5(c) (also NEC 110.16)

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

  (1) At least one of the following:
  - a. Available incident energy and the corresponding working distance.
  - b. Minimum arc rating of clothing
  - c. Required level of PPE
  - d. Highest Hazard/ Risk Category (HRC) for the equipment

  (2) Nominal system voltage
  (3) Arc flash boundary

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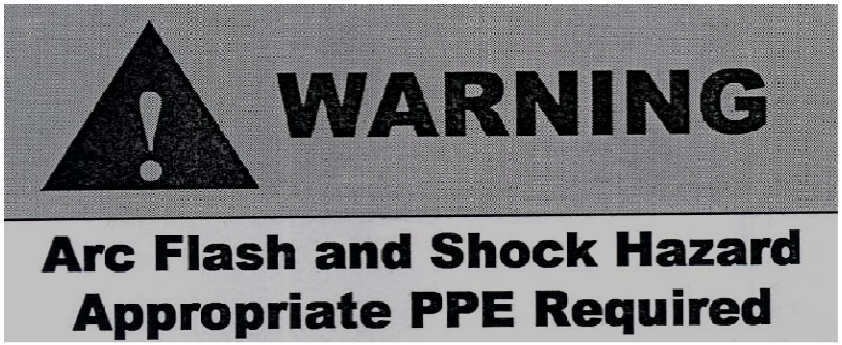
Previous Labeling Example

The Minimum Requirement

Under NFPA – 70E - 2009



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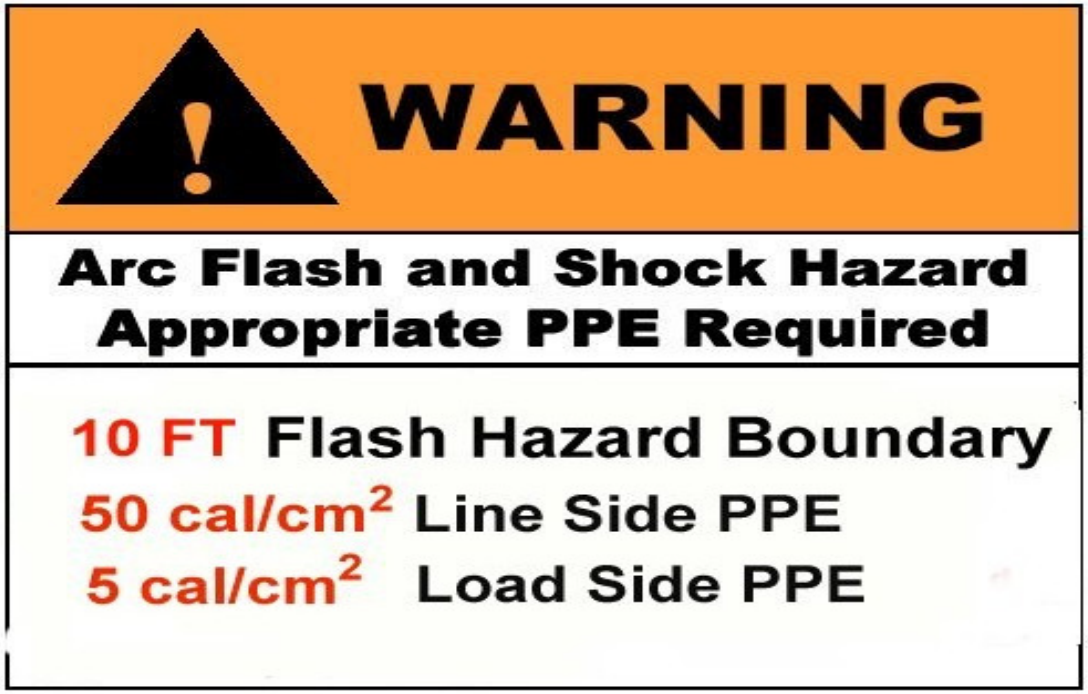
Previous Labeling Example

Large U.S. Refining Customer



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Current Labeling Example

Seminole Generating Station

WARNING			
ARC FLASH & SHOCK HAZARD APPROPRIATE PPE REQUIRED			
ARC FLASH HAZARD (CAL/CM2) @ 18"	23.4	ARC FLASH BOUNDARY	110"
		LIMITED APPROACH BOUNDARY	42"
SGS - PPE CATEGORY	#4	RESTRICTED APPROACH BOUNDARY	12"
SHOCK PPE	GLOVE CLASS 00	PROHIBITED APPROACH BOUNDARY	1"
	V-RATING 500		
EQUIPMENT ID:	USS 1CSB23	PPE	Coveralls with an ATPV of 11 and a Full length flash coat with an ATPV of 40 along with Leggings with an ATPV of 40. Voltage Rated Gloves & Tools (as needed) Safety Glasses, Ear Plugs, Arc Rated Leather Gloves Leather Work Shoes, Natural Fiber Underware
FED FROM:	USS 1CSB23 MAIN		
LABEL# XXX	7JUL12		

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Labeling - Going Forward

The user should establish a labeling philosophy that is consistent throughout the facility and supports their Electrical Safety Program

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How are Arc Flash Levels Determined?

- NFPA 70E Provides Two Methods
  - Tables in Article 130
    - These tables tend to place you in Category 2 or 4 and are not the most accurate method.
  - Calculation
    - ANNEX D provides various equations to calculate the available Arc Flash Boundaries and Levels
      - Example: FLASH PROTECTION BOUNDARY (Empirical)
      - $DB = \{4.184\ CfEn\ (t/0.2)(610^{x}/E_{B})\}^{1/x}$ (D.8.5a)
      - DB = Boundary Distance (mm)
      - V = System Voltage (KV)
      - Ibf = Available Short-circuit Current (KA)
      - t = Seconds
      - EB = Incident Energy (1.2 cal/cm² at Flash Protection Boundary)
    - These calculations combined with a full survey of all protective devices and fault levels can be used to produce an assessment of the Arc Flash Hazard for your facility.

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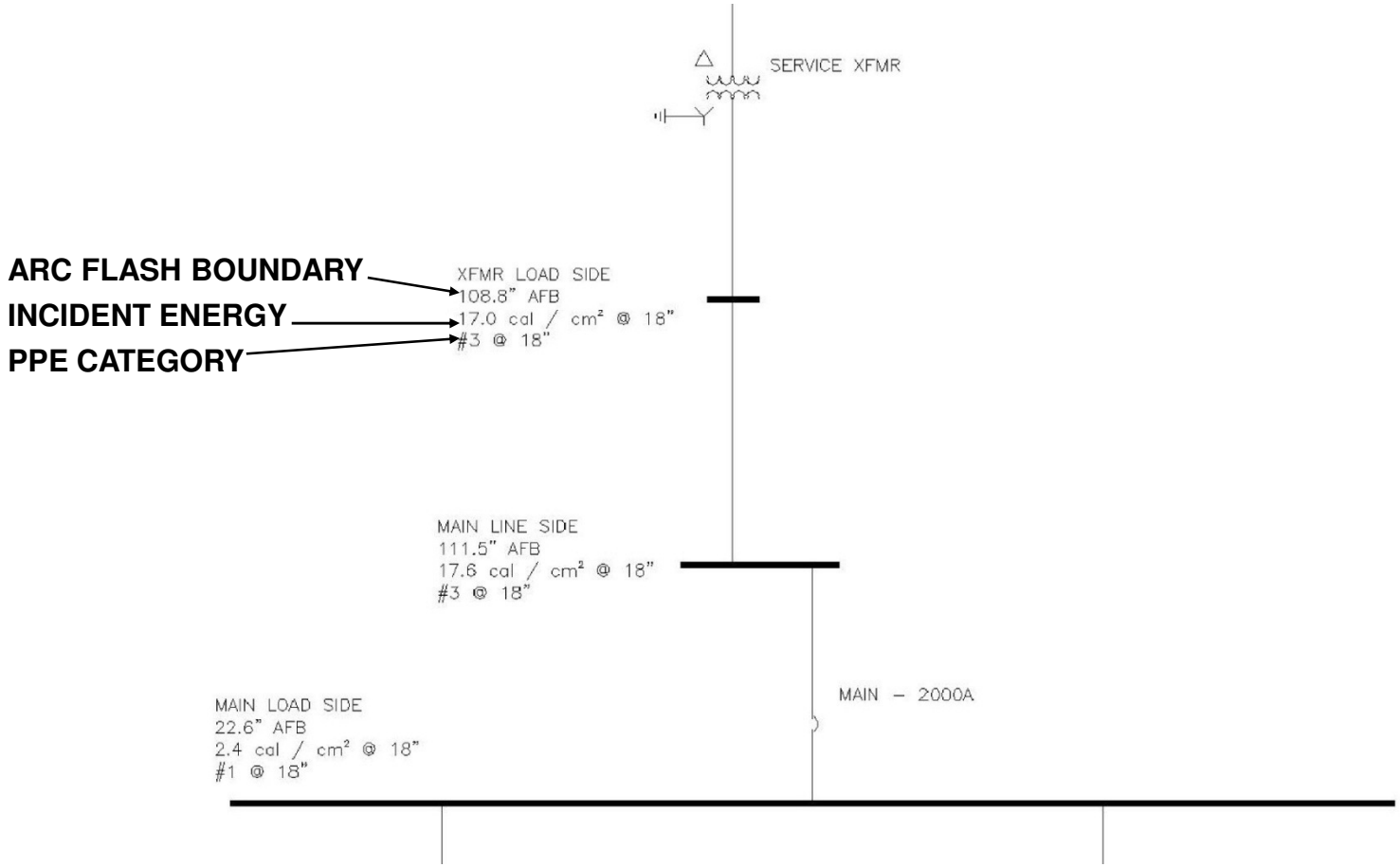
Single Line Overview



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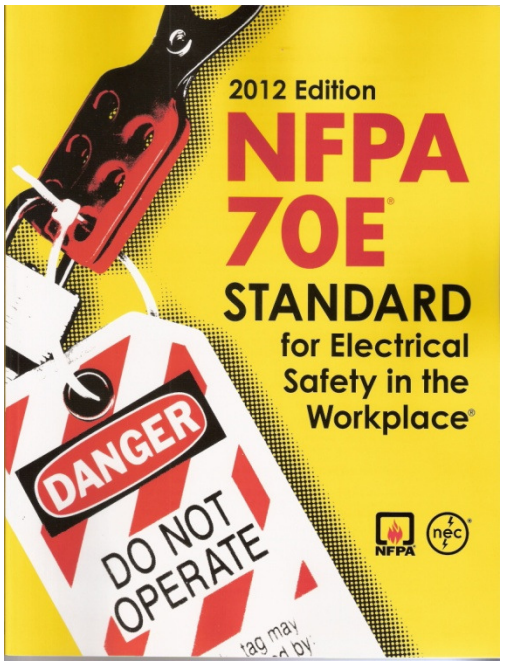

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Electrical Safety Program

- Employer shall implement an overall Electrical Safety Program
  - Provides awareness and self-discipline of the potential electrical hazards to employees
- Electrical Safety Principles, Controls and Procedures – (Sample Annex E)

- Use proper tools
- Assess people's abilities
- Identify and eliminate the hazard

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- All equipment is considered energized until proven otherwise

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- Purpose of task
- Limits of approach
- Equipment details

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- Hazard/Risk Evaluation Procedure – (Sample Annex F)

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- Electrical Safety Principles, Controls and Procedures – (Sample Annex E)
- Hazard/Risk Evaluation Procedure – (Sample Annex F)
- Job Briefing – (Sample Annex I)

- Work procedures involved
- Special precautions
- PPE requirements

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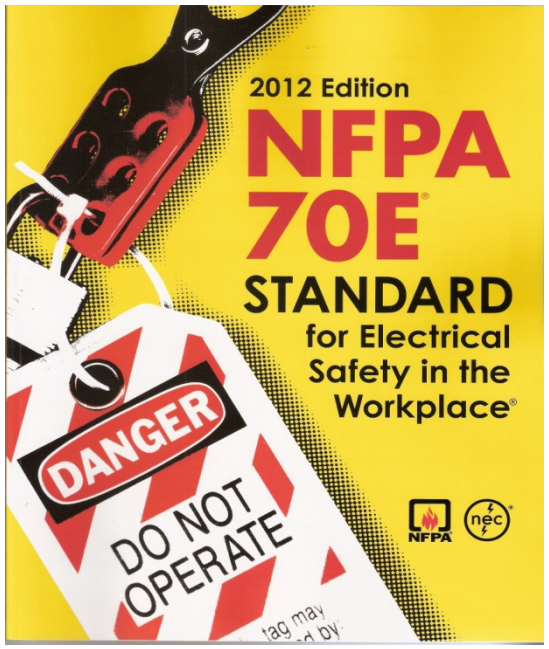

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‘LIVE’ Work Permits

Definition - Safe Electrical Work Practices

- Specific **practices used** to **protect employees** from the **hazards of electricity** when working on or near exposed electrical conductors, equipment or circuits parts that are or may be energized
- The practices are used when it is infeasible to disconnect (lock or tag out) equipment or circuits from their energy source to perform the work

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‘LIVE’ Work Permits

Energized Electrical Work

- Parts may only be worked on in a live condition if it can be demonstrated that deenergizing them:
  - Introduces additional or increased hazards
    - Interruption of life support equipment
    - Shutdown of hazardous location ventilation equipment
  - Is infeasible due to equipment design or operational limitations. This includes performing diagnostics and testing

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‘LIVE’ Work Permits

Is an Energized Electrical Work Permit required?

- If live parts are not placed in an electrically safe work condition:
  - Work to be performed shall be considered energized electrical work
  - Work shall be performed by **written permit only** (Sample Annex J)

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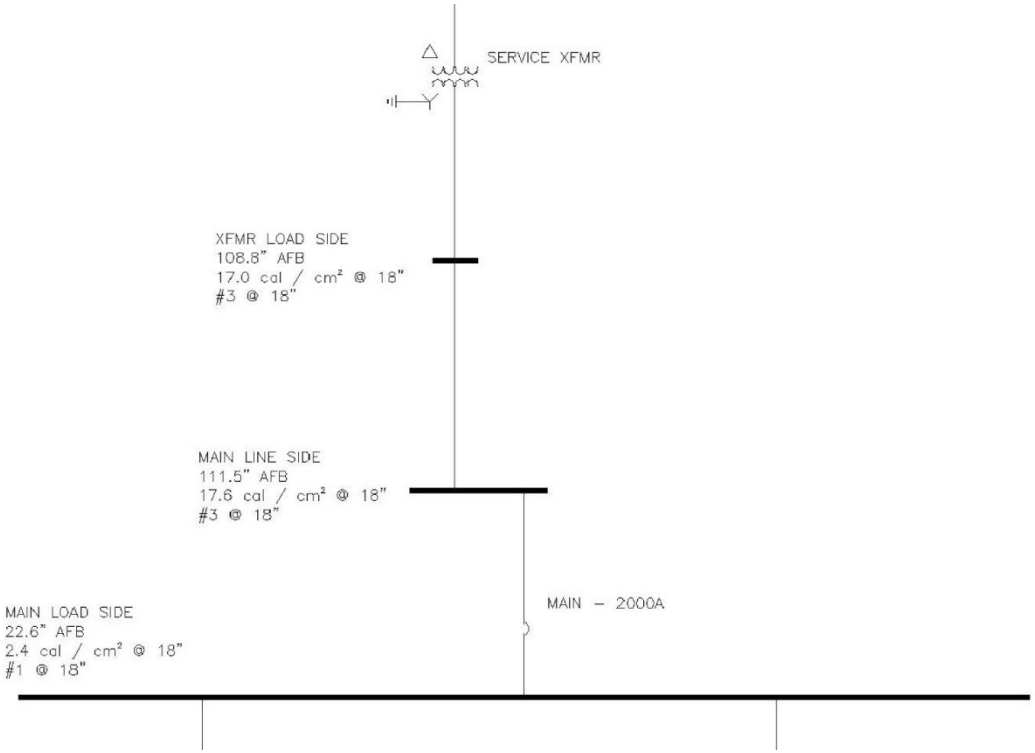
Energized Work Permit



Some software packages can automatically generate work permits by clicking on the bus you plan to work on.

In order to work on the Line Side of the 2000A breaker in this example the permit would look as follows.

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Energized Work Permit (Generated by EasyPower 9.0)

ENERGIZED ELECTRICAL WORK PERMIT

PART I: TO BE COMPLETED BY THE REQUESTER:

Job Work Order Number:_____

1. Description of circuit/equipment/job location: **MAIN LINE SIDE**
   Other
2. Description of work to be done:
   Work on incoming source or main protective device
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 job description procedure to be used in performing the above described work:

2. Description of the Safe Work Practices to be employed:

Shock hazard: **0.48 kV**	Shock Boundary: **1' - 0"**	V-rated Gloves: **Yes**
Flash Hazard: **17.6 cal/cm2**	Flash Boundary: **9' - 4"**	V-rated Tools: **Yes**
HC Reduction: **0**	Required PPE: **#3**	Work Distance: **1' - 6"**
Cotton underwear plus FR shirt & FR pants plus FR coverall		

3. Means employed to restrict the access of unqualified persons from the work areas:

4. Evidence of completion of a Job Briefing including discussion of any job-specific hazards:
   See Attached Job Briefing Report

5. 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.

Job Briefing and Planning Checklist

Job Briefing and Planning Checklist

Identify

- ☐ What are the hazards?
- ☐ Potential for arc flash
- ☐ What voltage levels are involved?
- ☐ Unusual work conditions
- ☐ What skills are required?
- ☐ Is this a multiple-person job?
- ☐ "Foreign" voltage source present?

Ask

- ☐ Can the equipment be de-energized?
- ☐ Is a "standby person" required?
- ☐ Are there possible backfeeds of the circuits to be worked on?

Check

- ☐ Job Plans
- ☐ Safety procedures
- ☐ One lines and vendor prints
- ☐ Vendor Information
- ☐ Status Board
- ☐ Individuals familiar with facility?
- ☐ For up-to-date information on plant and vendor resources

Know

- ☐ What is the job?
- ☐ EasyPower one-line has been printed, reviewed, and attached to energized work permit?
- ☐ Who is in charge?
- ☐ Who else needs to know?.....Communicate!

Think

- ☐ About the extra event…What if?
- ☐ Use the right tools and equipment, including PPE
- ☐ Lock-Tag-Test-Try
- ☐ Install barriers and barricades
- ☐ Test for voltage – FIRST
- ☐ What else…?
- ☐ Install and remove grounds

Prepare for an emergency

- ☐ Standby person CPR trained
- ☐ What is the exact work location?
- ☐ Telephone location?
- ☐ How is the equipment shut off in an emergency?
- ☐ Fire alarm locations?
- ☐ Where is the emergency equipment?
- ☐ Confined space rescue available if required?
- ☐ Is the required emergency equipment available?
- ☐ Emergency phone numbers?
- ☐ Radio communications available?
- ☐ Extinguisher?

‘LIVE’ Work Permits

Exemptions to Work Permit

- Work performed by **qualified persons**
  - Testing
  - Troubleshooting
  - Voltage measuring

Safe work practices and PPE must be provided and used

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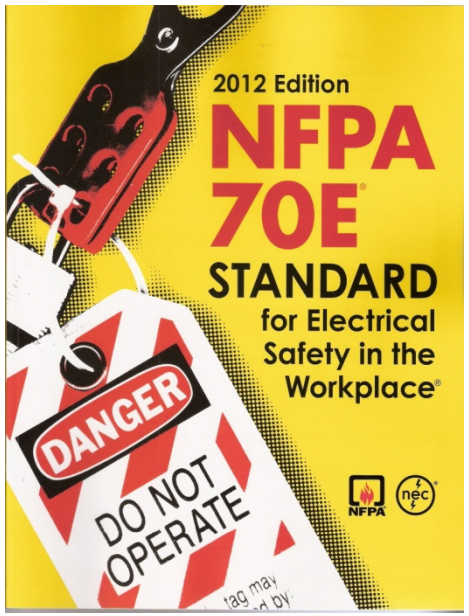

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  → Approach and Arc Flash Boundaries

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Approach Boundaries

There are four different types of approach boundaries in the standard:

- Limited Approach Boundary
  - Unqualified persons advised of possible hazards and must be escorted
- Restricted Approach Boundary
  - Unqualified persons not allowed
- Prohibited Approach Boundary
  - Safe work practices required by qualified persons
- Arc Flash Boundary
  - Must wear appropriate PPE

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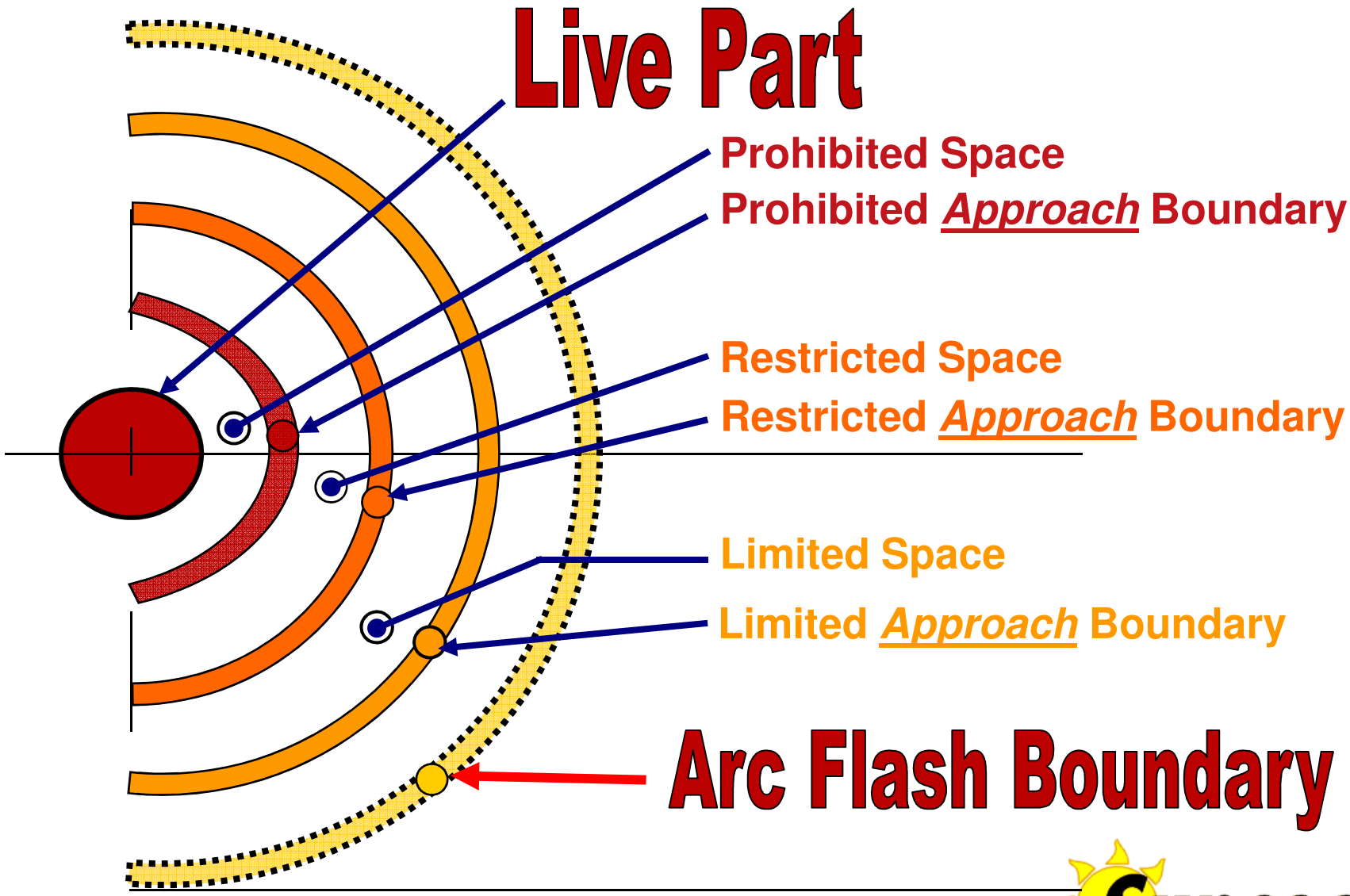
Limits of Approach



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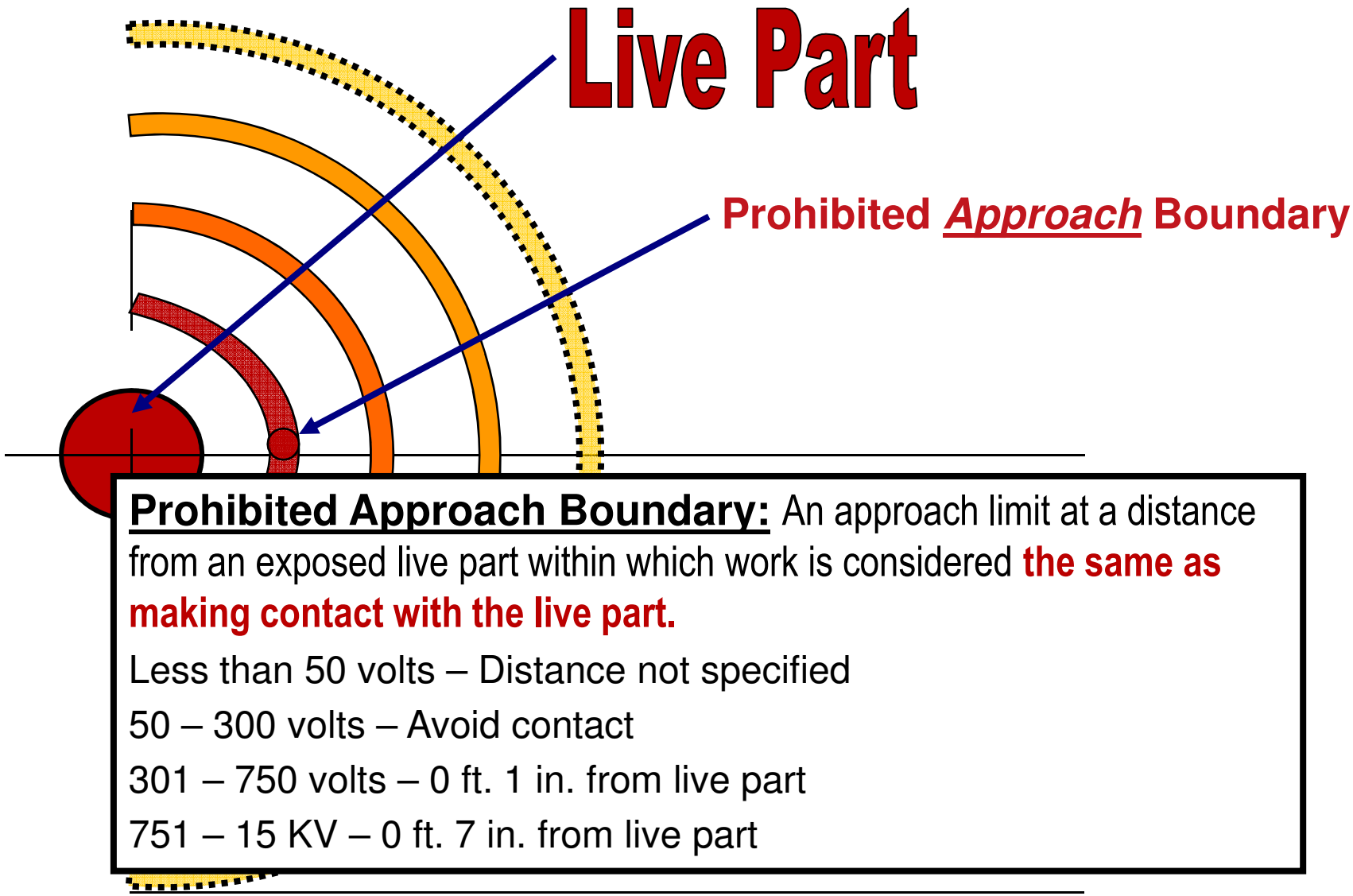
Limits of Approach



Prohibited Approach Boundary: An approach limit at a distance from an exposed live part within which work is considered **the same as making contact with the live part.**

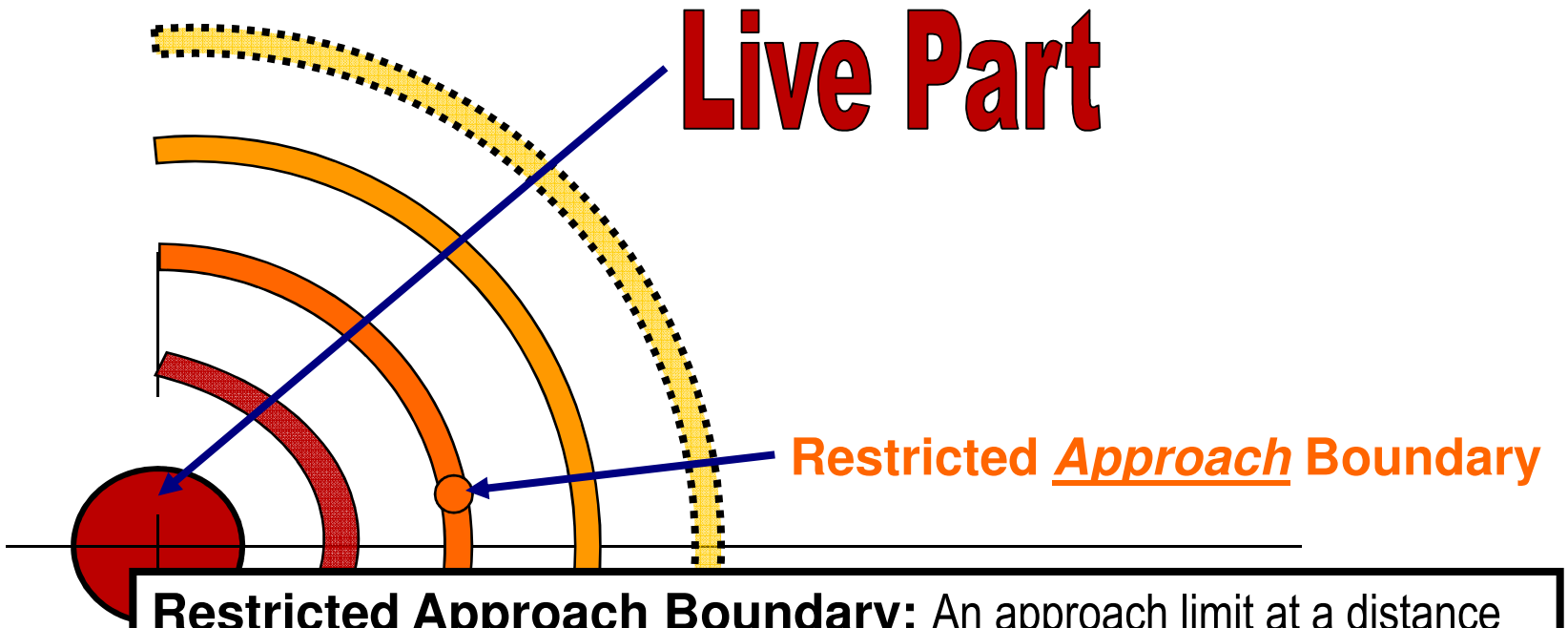
Less than 50 volts – Distance not specified

50 – 300 volts – Avoid contact

301 – 750 volts – 0 ft. 1 in. from live part

751 – 15 KV – 0 ft. 7 in. from live part

Limits of Approach



Restricted Approach Boundary: An approach limit at a distance from an exposed live part within which there is an **increased risk of shock, due to electrical arc-over and inadvertent movement**, for personnel working in close proximity to the live part.

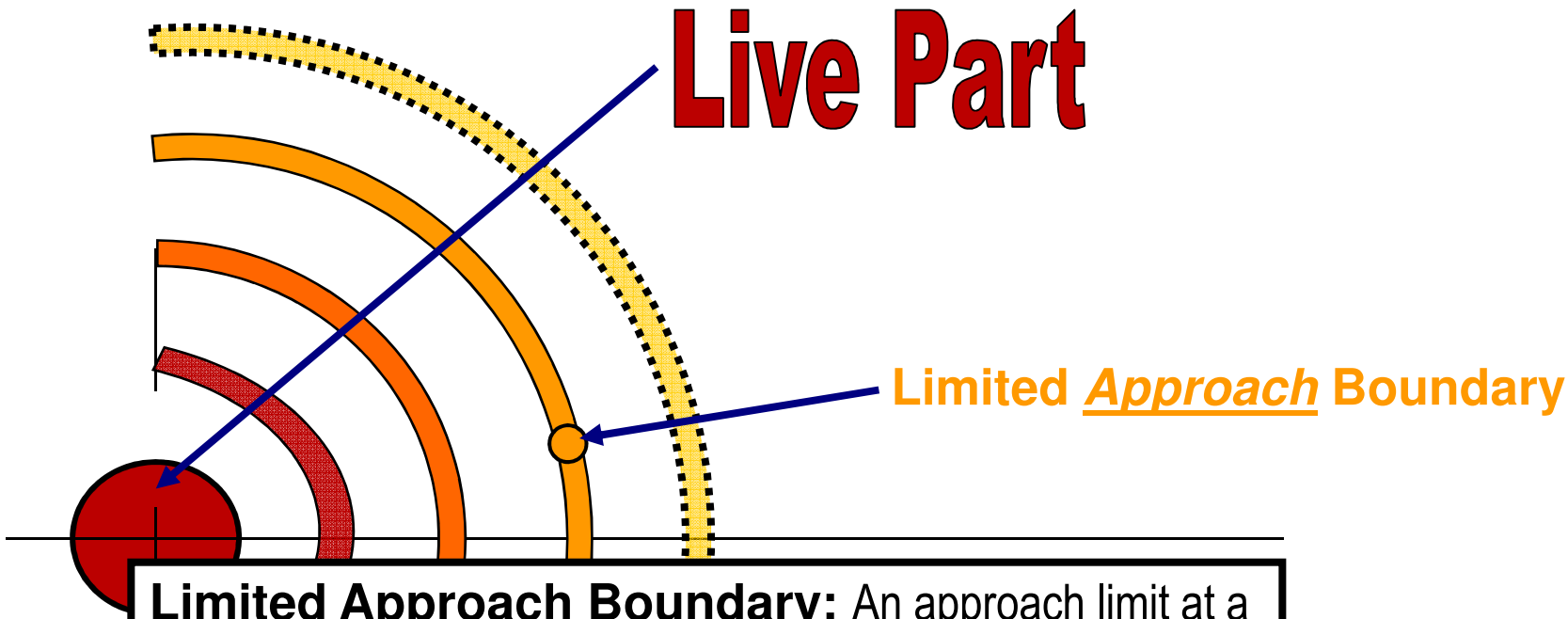
Less than 50 volts – Distance not specified

50 – 300 volts – Avoid contact

301 – 750 volts – 1 ft. 0 in. from live part

751 – 15 KV – 2 ft. 2 in. from live part

Limits of Approach



Limited Approach Boundary: An approach limit at a distance from exposed live part within **which a shock hazard exists.**

Exposed moveable conductor	Exposed fixed circuit part

Less than 50 volts – **Distance not specified/Dist. not spec'd.**

50 – 300 volts – 10 ft. 0 in. / 3 ft. 6 in.

301 – 750 volts – 10 ft. 0 in. / 3 ft. 6 in.

751 – 15 KV – 10 ft. 0 in. / 5 ft. 0 in.

Arc Flash Boundary

Definition – Arc Flash Boundary

An approach limit at a distance from exposed live parts within which a person could receive a second-degree burn if an electrical arc flash were to occur

- **Personal Protective Equipment (PPE)** and/or **Arc Rated (AR)** clothing are required when working within the Arc Flash Boundary

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Arc Flash Boundary

- The Arc Flash Boundary is the distance at which 1.2 cal/ cm^2 incident energy is available.
- The default Tables list AFB as:
  - 19” for 240V and below equipment
  - 30” for 480V Panelboards
  - 53” for 480V MCC’s with 2 cycle protection
  - 165” for 480V MCC’s with 20 cycle protection
  - 422” (35’) for 6.9KV Motor Starters
  - 36” to 72" for DC equipment below 250VDC

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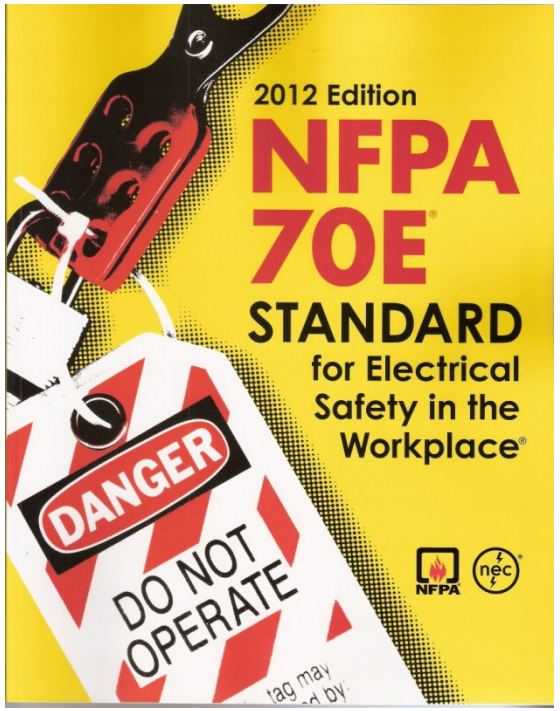
Agenda

- Electrical Hazards
- Codes & Standards
- Introduction to NFPA 70E 2012



- NFPA 70E 2012
  - Labeling
  - Safety Program
  - 'Live' Work Permits
  - Approach and Arc Flash Boundaries

  ⟶Personal Protective Equipment (PPE)
- Minimizing Arc Flash Hazards (Risks)

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Personal Protective Equipment (PPE)

When tasks are performed within the Arc Flash Boundary:

- Use the Hazard /Risk Category Classification Form for Voltage and Task to Identify the Hazard and Risk Category or find the Hazard/Risk Category based on energy calculations
  - Many good software packages are available

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Hazard Level

Hazard Level		
Hazard/Risk Category	**Range of Incident Energy (Cal/cm^2)**	**Required Minimum Arc Rating of PPE (Cal/cm^2)**
0	0 – 1.2	N/A
1	1.2 – 4	4
2	4 – 8	8
3	8 – 25	25
4	25 - 40	40

Guidelines based on NFPA 70E 2012

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Personal Protective Equipment (PPE)

Arc Rated (AR) Clothing

ATPV= Arc Thermal Performance Value (cal/cm²)

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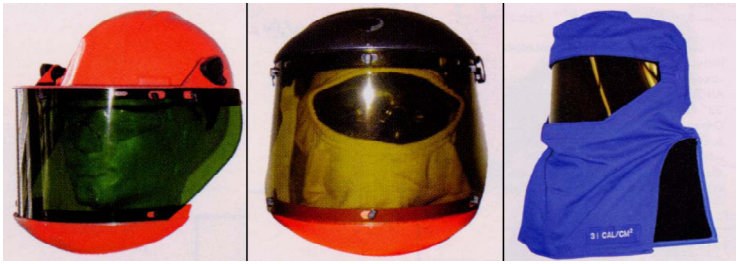
Personal Protective Equipment (PPE)

Headgear



Personal Protective Equipment (PPE)

Gloves and Boots

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PPE Category 0

- Protective Clothing, Nonmelting or Untreated Natural Fiber
  - Shirt (long sleeve)
  - Pants (long)

- Protective Equipment
  - Safety glasses or safety goggles
  - Hearing protection
  - Heavy duty leather gloves

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PPE Category 1

- Arc-Rated Clothing, Minimum Rating 4 cal/cm2
  - Long sleeve shirt and pants or coverall
  - Arc-rated face shield or suit hood

- Protective Equipment
  - Hard hat
  - Safety glasses or safety goggles
  - Hearing protection
  - Heavy duty leather gloves
  - Leather work shoes

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PPE Category 2

- Arc-Rated Clothing, Minimum Rating 8 cal/cm2
  - Long sleeve shirt and pants or coverall
  - Arc-rated face shield and balaclava or suit hood

- Protective Equipment
  - Hard hat
  - Safety glasses or safety goggles
  - Hearing protection
  - Heavy duty leather gloves
  - Leather work shoes

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PPE Category 3

- Arc-Rated Clothing Selected so That the System meets Minimum Rating 25 cal/cm2
  - Long sleeve shirt and pants or coverall
  - Arc-rated arc flash suit and hood
  - Arc-rated gloves

- Protective Equipment
  - Hard hat
  - Safety glasses or safety goggles
  - Hearing protection
  - Leather work shoes

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PPE Category 4

- Arc-Rated Clothing Selected so That the System meets Minimum Rating 40 cal/cm2
  - Long sleeve shirt and pants or coverall
  - Arc-rated arc flash suit and hood
  - Arc-rated gloves

- Protective Equipment
  - Hard hat
  - Safety glasses or safety goggles
  - Hearing protection
  - Leather work shoes

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Personal Protective Equipment (PPE)

Steps need to be taken regarding PPE

- Select PPE based on arc flash hazard assessment
- Provide information/labels on PPE on ATPV rating
- Train employees on use and selection of PPE
- Provide regular inspection, care and maintenance of PPE
- Document use and maintenance of PPE
- Dispose of PPE after useful life has ended

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Agenda

- Electrical Hazards
- Codes & Standards
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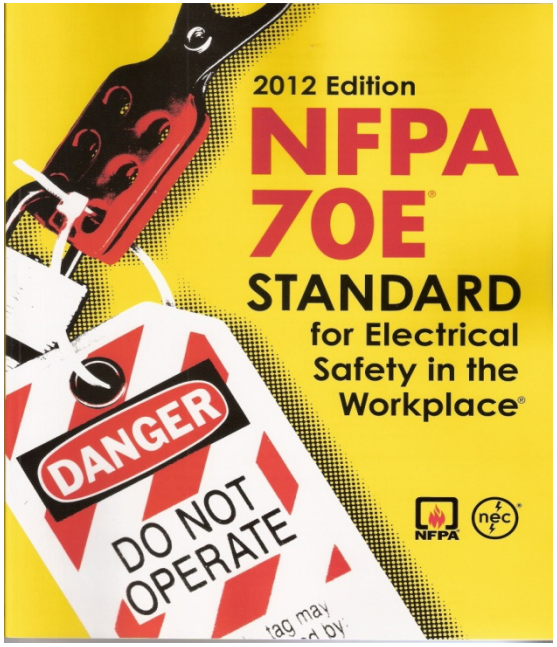

- NFPA 70E 2012
  - Labeling
  - Safety Program
  - 'Live' Work Permits
  - Approach and Arc Flash Boundaries
  - Personal Protective Equipment (PPE)

⟶Minimizing Arc Flash Hazards (Risks)

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Risk Reduction Techniques

Guidelines for reducing the risk of arc flash

- Ongoing safety training
- Identify all possible sources of electrical energy
- Maintenance program
- Remote monitoring/operation
- When possible, visually verify device is open
- Perform lock out/tag out
- Test voltage on each conductor for verification
- Ensure workers are appropriately protected with suitable PPE

Avoid Arc Flash incidents with PREVENTION

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Going Forward

NFPA 70E compliance steps

- Perform arc flash hazard analysis on all electrical equipment
- Label electrical equipment to notify of the arc flash hazard
- Obtain the proper tools and PPE
- Provide employee/contractor training
- Develop and implement the proper work place policies, procedures and methods

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SUMMARY

What is the purpose of all of these regulations?

SAFETY!

- Create a safe work environment
- Ultimately reduce the number of injuries and fatalities caused by electrical hazards (Electric Shock, Arc Flash and Arc Blast)

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Thank You!

SECTIONS OF THIS PRESENTATION HAVE BEEN REPRODUCED BY PERMISSION FROM THE ALLEN BRADLEY AUTOMATION FAIR 2004 TECHNICAL SESSION ON NFPA 70E 2004

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TEST

GRU Deerhaven
Arc Flash Hazard Training

1. The Standard for Electrical Safety in the Workplace is NFPA 70E-2012 – (p3)

   True False

2. An electrical hazard is defined as a dangerous condition such that contact or equipment failure can result in electrical shock, arc flash burn, thermal burn or blast. (p6)

   True False

3. To create an electrically safe work condition, the lock- out/tag-out procedure must be followed and equipment tested to ensure the absence of voltage. (p27)

   True False

4. The Arc Flash warning labels on electrical equipment list the incident energy (cal/cm^2), Hazard Category, Arc Flash Boundary and required PPE. (p32)

   True False

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TEST

5. Everyone entering an Arc Flash Boundary must wear appropriate PPE. (p53)

   True False

6. PPE stands for Personal Protection Equipment and AR stands for Arc Rated . (p58)

   True False

7. There are five (5) PPE Categories: 0 = lowest, 4 = highest. (p66-70)

   True False

8. The PPE Categories are assigned by the range of incident energy (cal/cm^2). (p66-70)

   True False

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TEST

9. When working on equipment rated PPE category 2, the required PPE is: Coveralls with ATPV rating of 8, voltage rated gloves where required. Arc Rated face shield with Arc Rated balaclava or Arc Rated hood. Voltage rated insulating gloves with leather protectors. (p68)

   True False

10. GRU is a great place to work.

    True False

Name_____Signature_____Date_____

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