

NFPA 70E SERIES

2015 NFPA 70E - Standard for Electrical Safety in the Workplace

Significant Changes To Standard



NFPA 70E

- ▶ Requirements for safe work practices
- ▶ Addresses hazards:
 - Shock
 - Arc Flash/Blast
- ▶ Requirements for shock and arc flash boundaries
- ▶ Requirements personal protective equipment
- ▶ Additional Training Requirements to be considered “Qualified”
- ▶ Energized Electrical Work Permit



Significant Changes in 2015 Standard

- Safety Related Maintenance Requirements 90.2(A)
- “Bare Hand Work” – Best served by “utility regulations”
- ‘Energized Work Permit’ - Definition Updated 130.2(B)(1)
- ‘Qualified Person’ re-defined to correlate with OSHA 1910.399
- Removal of “Prohibited Approach Boundary”
- New requirements for Electrical Safety Program to include condition of maintenance 110.1(B)
- Audit of field work compliance not to exceed 1 year 110.1(I)(2)
- Location, sizing, application of temporary grounding identified as part of job planning 120.3(A)
- Clarification of ‘Normal Operation’ 130.2(A)(4)
- Incident Energy vrs Clothing Category 130.5(D)
- Field Marking Requirements process changes 130.5(D)

Significant Changes in 2015 Standard

- Boundary Changes 130.6(D)
- Conductive Objects 130.6(D)
- PPE Table Changes 130.7(C)(15)(A)(a) – 130.7(C)(15)(A)(b) - 130.7(C)(15)(B)
- Removal/Redefine of ‘Category 0’ 130.7(C)(16)
- Insulated Tool requirements 130.7(D)(I)
- Barricade Requirements 130.7(E)(2)
- Risk Assessment Before Cutting or Drilling 130.10
- Host Company (Owner) responsibility 205.3
- Test instrument requirements 110.4(A)(5) – 250.4
- Battery Risk Assessment 320.3(A)(1) – 320.3(A)(1)

Safety Training Requirements

NFPA 70E ~ 110.2

- All employees who face a risk of electrical hazards..
 - Trained to understand the specific hazards..
 - Trained in safety related work practices..
 - Trained in procedural requirements for Personal Protective Equipment (PPE)
 - Trained to understand the relationship between the hazard and possible injury
- Emergency Procedures – Employs Exposed
 - Methods of release
 - Regularly Instructed In CPR & AED and verified annually



Electrical Safety Program 110.1

The employer shall implement and document an overall electrical safety program that directs activity appropriate to the risk associated with electrical hazards.

The electrical safety program shall be implemented as part of the employer's overall occupational health and safety management system, when one exists.



Electrical Safety Program 110.1

Elements of the program shall include:

- Maintenance
 - Consideration of condition
- Awareness and Self Discipline
- Program Principals
 - Basis of program
 - Examples in annex 'E'
- Control
 - How Measured and Monitored
- Procedures for Safe Work
- Risk Assessments
- Job Briefing Requirements
 - Annex 'I'
- Audit Requirements



“Qualified” person



“A qualified person shall be trained and knowledgeable *in* the construction and operation of equipment or a specific work method and be trained to *identify* and avoid the electrical hazards that may be present with respect to that equipment or work method”

“Qualified” person

Additional requirements:

Trained to recognize the hazards present

Such persons shall also be familiar with

- The use of the precautionary techniques
- Electrical policies and procedures
- Personal protective equipment
- Insulating and shielding materials
- Insulated tools and test equipment



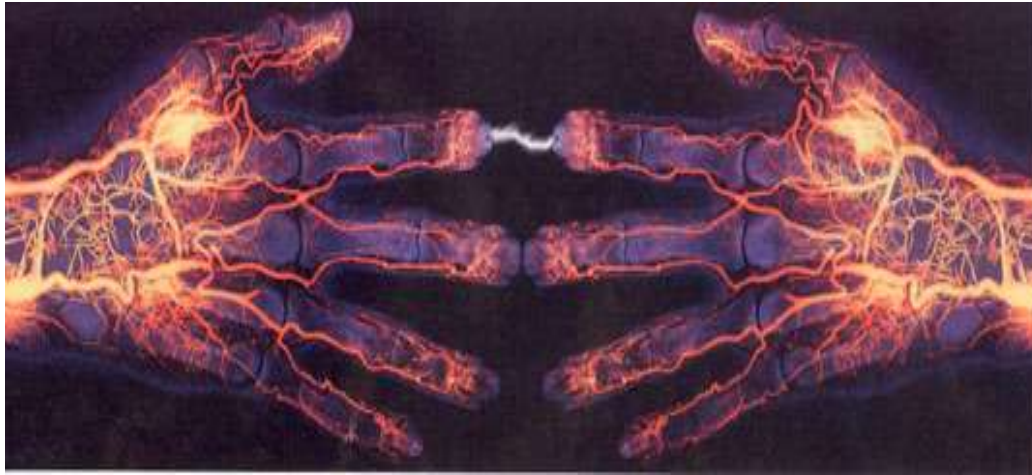
“Qualified” person

In addition, to be permitted to work within the limited approach of exposed energized conductors and circuit parts >50Volts. **shall be trained in all of the following:**

- The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment
- The skills and techniques necessary to determine the nominal voltage of exposed live parts
- The minimum approach distances specified in this section corresponding to the voltages to which the qualified employee will be exposed, and,
- The decision making process necessary to be able to do the following:
 - Perform the job safety planning
 - Identify electrical hazards
 - Assess the associated risk
 - Select the appropriate risk control methods from the hierarchy of controls (110.1(G)) including proper PPE

Dangers of Electricity

Electric Shock



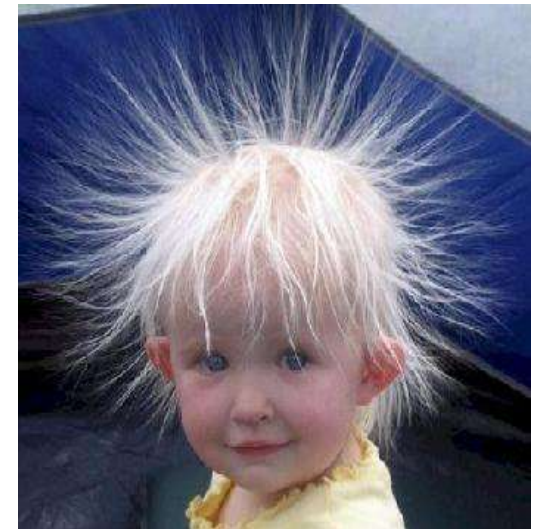
Arc Flash

Arc Blast

By The Numbers

How Often	Number	Effect
United States Annual Average	4,000	Non-Disabling electrical contact injuries
United States Annual Average	3,600	Disabling electrical contact injuries
Every Day	1	Person is electrocuted in the workplace
Electrocutions are	4th	Leading cause of traumatic occupational fatalities
Each year	+2,000	Workers are sent to burn centers with electrical burns

- An average of one person is electrocuted in the home every 36 hours
- Electrocution is fourth in work related fatalities with a majority of these incidents occurring at 600 volts or less
- There are four main types of electrical injuries:



Electrocution and Shock

Factors that determine severity of electric shock

- Amount of current
- Path of current
- Duration of shock
- Body Resistance
- Voltage
- Frequency
- AC or DC



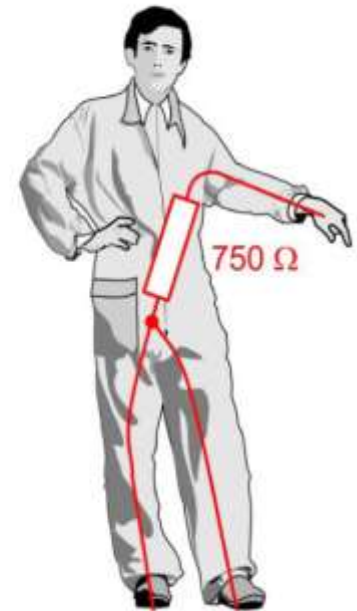
Current Magnitudes

CURRENT A/C	PHYSIOLOGICAL PHENOMENA	FEELING OR LETHAL INCIDENCE
60HZ		
< 1mA	None	Imperceptible
1mA	Perception threshold	
2-10mA	Sensation of shock	Not painful, muscle control maintained
5mA		Ground Fault Circuit Interrupter Operates
10-20mA	Paralysis Threshold of Arms	Cannot release hand grip, victim may be thrown clear
20-50mA	Respiratory Paralysis	Breathing Stoppage (frequently fatal)
50-100mA	Fibrillation Threshold (0.5%)	Heart action discoordinated (probably fatal)
100-200mA	Fibrillation Threshold (99.5%)	
>200mA	Tissue Burning	Non fatal unless vital organs are burned

DC Current	Physiological Phenomena
0-4 mA	Perception Threshold
4-15 mA	Surprise
15-80 mA	Reflex Action
80-160 mA	Muscular Inhibition
160-300 mA	Respiratory Failure
>300 mA	Usually Fatal

Typical Human Resistor Values

Current path	Resistance of body
Hand - hand	1000Ω
Hand – foot	750Ω
Hand – feet	500Ω
Hand - chest	450Ω
Hands - chest	230Ω
Hands - posterior	300Ω



Accidental contact with the HV battery of a hybrid car, a photovoltaic array, DC charging station. If the insulation is faulty, it is possible that the following current flows:

Hand – to – Hand

$$I = E/R = 288\text{V}/1000\text{ohm} = .288\text{A} = 288\text{mA}$$

First Aid



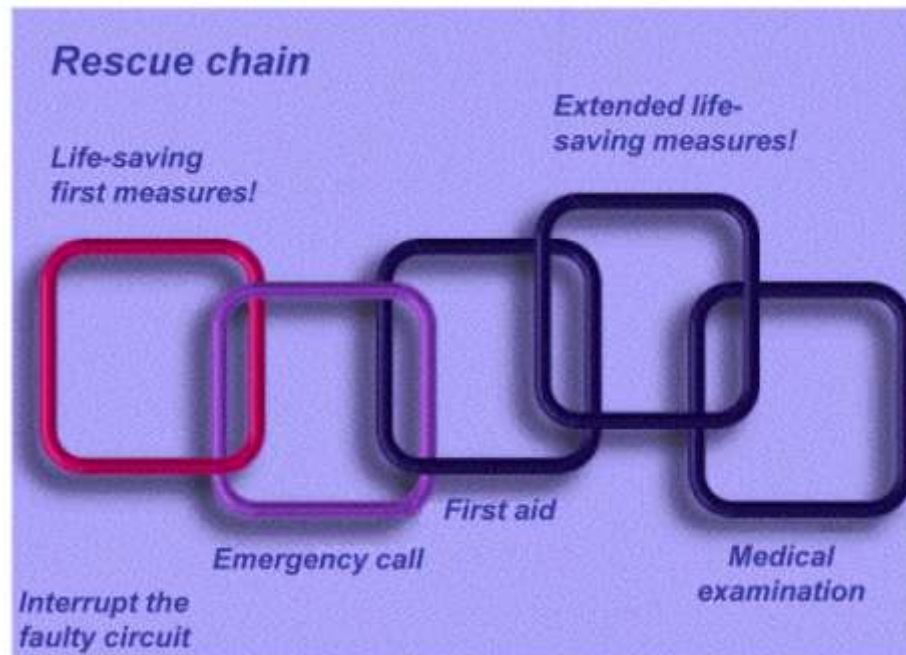
Some basic first aid practices

This section is not intended to replace first aid training

Immediate Response

Contact Release

- Shall be trained in methods of *safe release*
- Annual refresher requirement

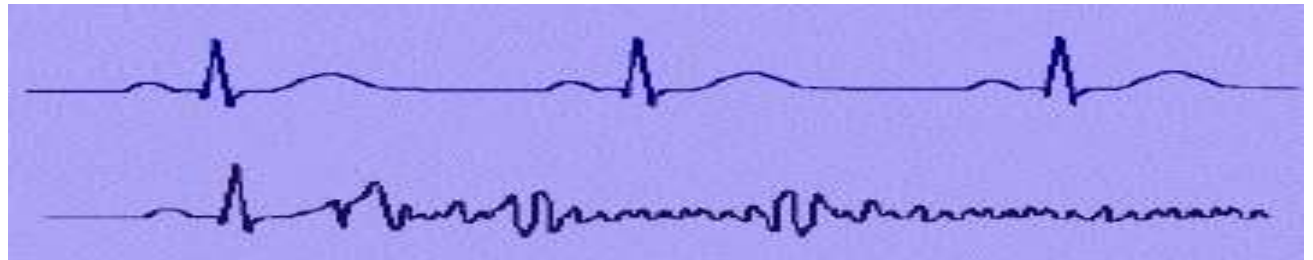


First Aid Training

OSHA 1910.269 (b)

“When employees are performing work on or associated with exposed lines or equipment energized at *50 volts or more*, persons trained in first aid including cardiopulmonary resuscitation (CPR) and (AED) shall be trained and available” AND anybody working inside the limited approach.

“At a fixed location (i.e. shop, plant, etc.), ensure that enough people are trained in first aid so that a victim can be reached within four minutes. At remote fixed locations where this may not be possible, then all of the individuals working must be first aid trained”



110.2(C)(2) – (3) – (4)

First Aid, Emergency Response, and Resuscitation.

- (a) Employees responsible for responding to medical emergencies shall be trained in first aid and emergency procedures.
- (b) Employees responsible for responding to medical emergencies shall be trained in cardiopulmonary resuscitation (CPR). Refresher training shall occur annually.
- (c) Employees responsible for responding to medical emergencies shall be trained in the use of an automated external defibrillator (AED) if an employer's emergency response plan includes the use of this device. Refresher training shall occur annually.

Training Verification.

Employers shall verify at least annually that employee training required by this section is current.

Documentation.

The employer shall document that the training required by this section has occurred.

Response to Electric Shock

IMMEDIATE - Confusion, amnesia, headache, breathing stops, heart stops, burn

SECONDARY - Paralysis, muscular pain, vision abnormalities, swelling, headache, and cardiac irregularities

LONG RANGE - Paralysis, speech/writing disorders, loss of taste, and other disorders as a result of nerve tissue damage



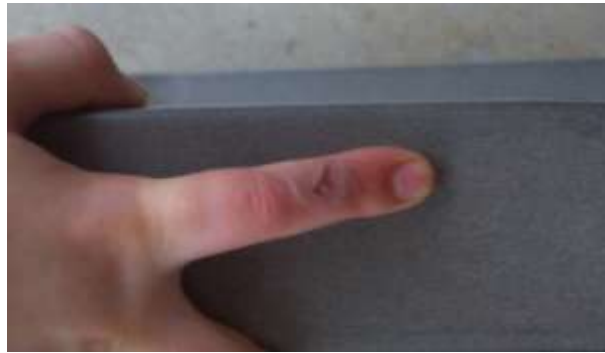
Electrical Burns

Most common shock-related, nonfatal injury

Occurs when you touch electrical wiring or equipment that is improperly used or maintained

Typically occurs on the hands

Very serious injury that needs immediate attention



ARC FLASH



Arc Flash

- ▶ An arc flash occurs when electrical current passes through air
- ▶ This most often occurs in power systems when:
 - Making or breaking a circuit
 - Bridging a insulating air gap with a more conductive object
- ▶ The heat generated can be devastating
 - A fire usually burns at 800-1000 degrees
 - Steel melts at around 1,800 degrees
 - The surface of the sun is estimated to be about 7,000 degrees
 - An arc flash can be up to 36,000 degrees! That's 20 times the temperature that steel melts and 5 times as hot as the sun!
- ▶ This extreme heat causes other hazards



Arc Flash Hazards

Heat – An arc flash can be up to 36,000 degrees

- FR clothing can minimize extent of burns
- FR clothing is available up to 100 Cal/cm²



Ultraviolet (UV) light

- Can cause damage to retinas, possible causing blindness
- Coating on eye protection is designed to filter out some of the UV light



Arc Flash Hazards

Pressure

- When copper vaporizes it expands to 67,000 times the volume of solid copper
- The air in the vicinity of the arc is heated and expands rapidly
- A study conducted by Dr. Ralph Lee revealed that a 10kV – 100kA arc created a pressure of 400 lbs/ft² at a distance of 3.3 feet! This is about 10 times the pressure a conventional wall is built to withstand so such an arc could destroy a conventional wall from 40 feet away!



Arc Flash Event 10-15-2012



Gloves



Arc Rated Face Shield



Breaker Cubical

Circumstance:

A Facility associate was changing a breaker in a 480 volt MCC panel.

When connecting the wire to the lug, the energized line wire grounded causing an arc blast / flash. Panel was identified as a HRC 2.

PPE Used and Identified on the panel label

- Class 00 gloves with outer leather protectors
- Cotton undershirt
- Cotton long sleeve shirt
- FR HRC rated outer clothing
- Cotton pants
- Ear plugs
- Hard hat with arc flash shield.

The associate sustained no injury due to following electrical safety work practices. DMAT's training and foresight prevented a serious injury during high risk work.

Flash Hazard Analysis

There are several methods used to determine the incident energy of an arc flash event:

- Use the tables from the NFPA 70E (Recently Updated)
 - The tables have limitations (Notes section)
 - They make several assumptions
 - Best used as a temporary solution
 - *'in lieu of'*
- Use the NFPA 70E equations (Lee method)
 - Simple, can be done by hand using a calculator
 - Spread Sheet
- Use the IEEE 1584 equations
 - Most accurate method, but very complicated
- Purchase a software suite (SKM, ETAP, EasyPower, to name a few)
 - Very expensive but easy to use
- Contract someone else to do it
 - Probably the best solution for smaller companies

130.3.A.1 2015 Action Based Risk Table Example

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

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

Label Requirements

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

(1) Nominal system voltage

(2) Arc flash boundary

(3) At least one of the following:

- Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(A)(b) or Table 130.7(C)(15)(B) for the equipment, but not both
- Minimum arc rating of clothing
- Site-specific level of PPE

NFPA 70 E 2012

‘...shall be field marked, with all label containing... all the following’

 WARNING	
Arc Flash and Shock Hazard	
Appropriate PPE Required	
35 inch	Flash Hazard Boundary
3.5 cal/cm ²	Flash Hazard at 18 inches
Category 1	FR Shirt & Pants + Arc-Rated Face Shield & Hearing Protection
480 VAC	Shock Hazard when cover is removed
00	Glove Class
42 inch	Limited Approach
12 inch	Restricted Approach
1 inch	Prohibited Approach
Bus: B CASTER MCC1 Prot: USS12-12	

At least one of the following:

- Incident Energy & Working Distance
- Clothing HRC Rating
- Required PPE
- Highest Equipment HRC

Nominal System Voltage

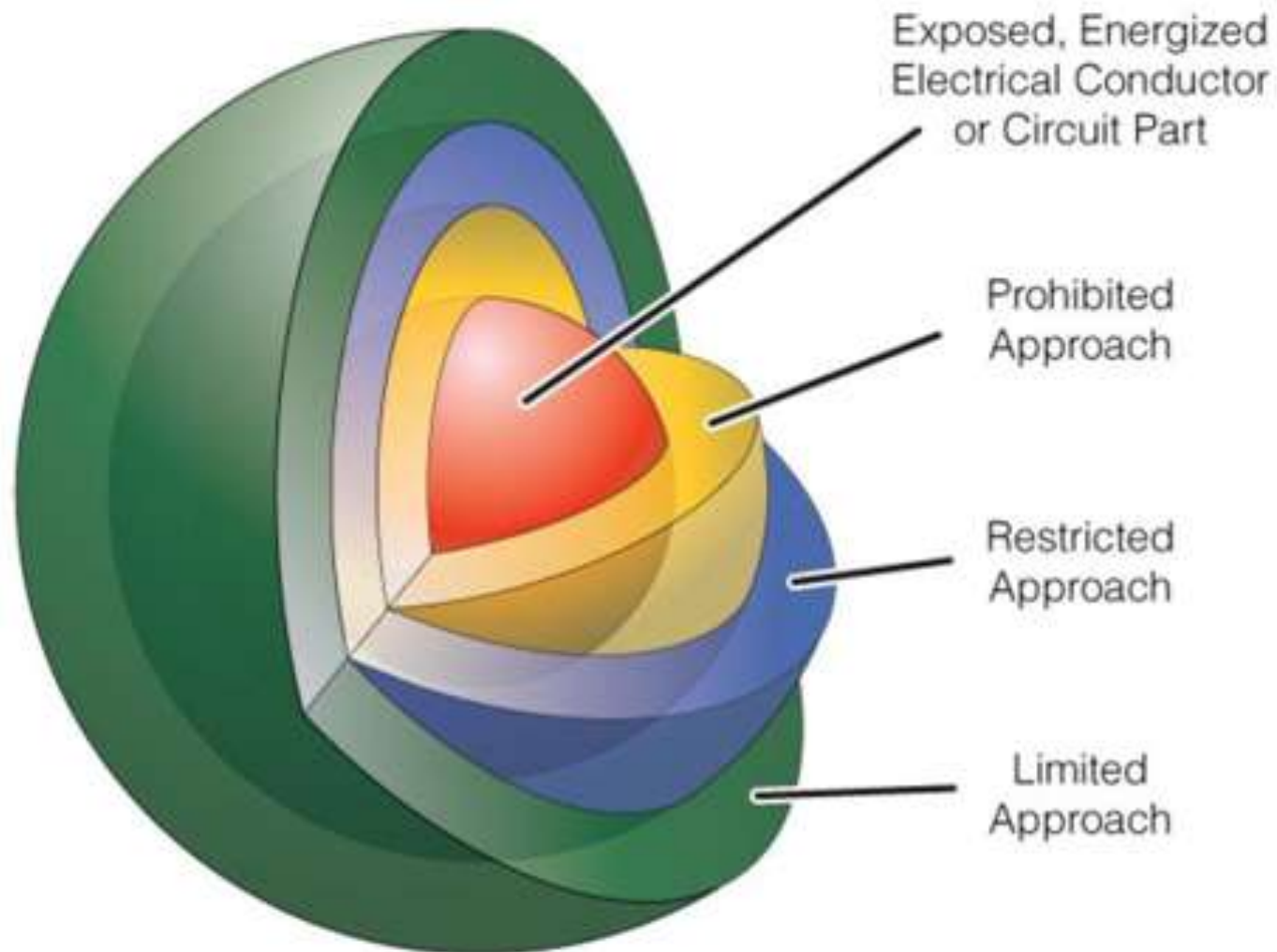
Arc Flash Boundary

NEC REQUIREMENTS FOR LABELING

Personal Protective Equipment



Personal Protective Equipment



Shock Protection

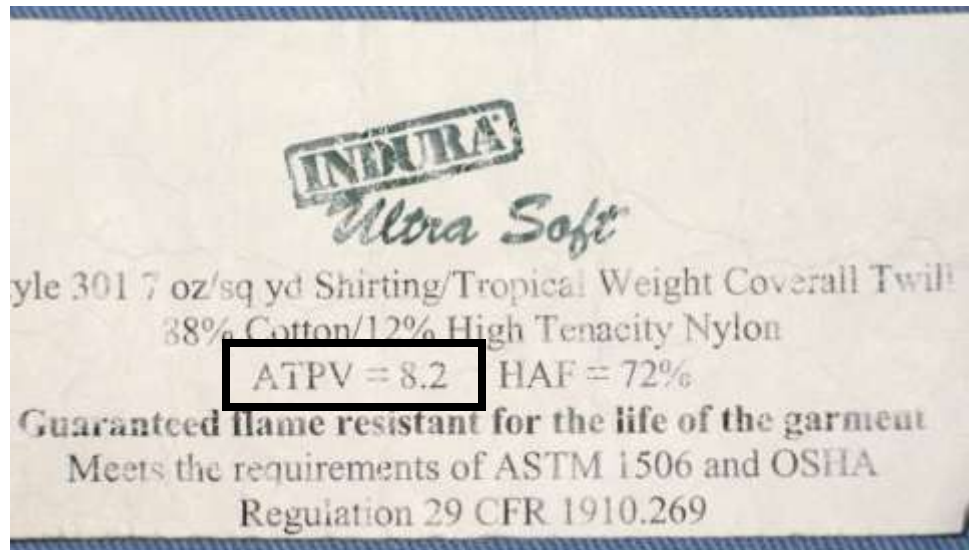
Personal Protective Equipment



Flash Protection

F-1506 Label

- ▶ Arc Thermal Performance Value (ATPV) is defined as the arc incident energy required to cause the onset of second-degree burn and is represented in cal/cm^2 . This rating is the result of a testing procedure (ASTM F-1959) that measures the amount of thermal protection a FR fabric would give a wearer if the person were exposed to an electric arc.
- ▶ Alternatively the material may have an EBT (Energy Break-open Threshold) rating. EBT is defined as the average of the 5 highest incident energy exposure values below the Stoll curve where the specimen did not exhibit break-open. EBT is reported when ATPV cannot be measured due to FR fabric break open.



Typical Protective Clothing



Basic Electrical PPE Category – 0

Protective Clothing –
Nonmelting or Untreated
Natural Fibers => 4.5
oz/yd²

Shirt - Long Sleeve
Pants – Long

FR Protective Equipment

Safety Glasses
Hearing Protection – Ear Canal Insert
Leather Gloves – (AN)

PPE Level

0 to 1.2 Cal / cm²

Typical Protective Clothing



Hazard Risk Category – 2

FR Minimum Arc
Rating of 8

Arc Rated Long Sleeve Shirt
Arc Rated Pants
Arc Rated Coverall
Arc Rated Face Shield and Balacava
Arc Flash Suit Hood
Arc Rated Jacket, Parka or Rainwear (AN)

FR Protective
Equipment

Hard Hat
Safety Glasses or Safety Goggles (SR)
Hearing Protection (Ear Canal Inserts)
Leather Gloves
Leather Work Shoes

Typical Protective Clothing

Hazard Risk Category – 4

FR Minimum Arc
Rating of 40
(Note 1)

Arc Rated Long Sleeve Shirt (AR) (Note 9)
Arc Rated Pants (AR) (Note 9)
Arc Rated Coverall (AR) (Note 9)
Arc Rated Flash Suit Jacket (AR) (Note 9)
Arc Rated Flash Suit Pants (AR) (Note 9)
Arc Rated Flash Suit Hood (Note 9)
Arc Rated Jacket, Parka or Rainwear (AN)

FR Protective
Equipment

Hard Hat
FR Hard Hat Liner (AR)
Safety Glasses or Safety Goggles (SR)
Hearing Protection (Ear Canal Inserts)
Arc Rated Gloves (Note 2)
Leather Work Shoes



Safety Gloves

Employees shall wear rubber insulating gloves where there is a danger of arm and hand injury from electrical shock and burns due to contact with live parts.



Gloves used shall be of the appropriate voltage class

Glove selection

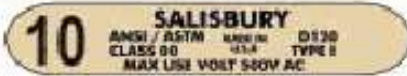
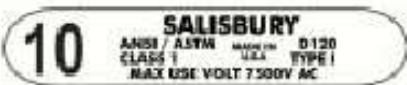
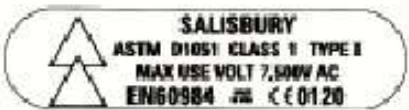
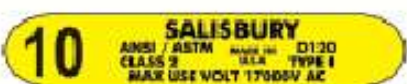
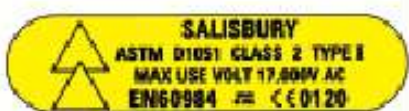
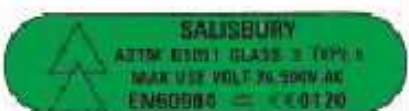
Glove size is important to ensure a proper fit and dexterity

Size is inches around the palm of your hand

Leather Protectors:

- Required for penetration protection
- *If gloves used without, then must be re-tested prior to next use*



Class Color	Proof Test Voltage AC / DC	Max. Use Voltage AC / DC	Rubber Molded Products Label	Insulating Rubber Glove Label	Insulating Rubber Dipped Sleeve Label
00 Beige	2,500 / 10,000	500 / 750		 10 SALISBURY ANSI / ASTM MAX. USE VOLT. D120 CLASS 0 U.S.A. TYPE I MAX USE VOLT 500V AC	
0 Red	5,000 / 20,000	1,000 / 1,500		 10 SALISBURY ANSI / ASTM MAX. USE VOLT. D120 CLASS 0 U.S.A. TYPE I MAX USE VOLT 1000V AC	 SALISBURY ASTM D1051 CLASS 0 TYPE I MAX USE VOLT 1,000V AC EN60984 $\approx$ $\leq$ 0120
1 White	10,000 / 40,000	7,500 / 11,250		 10 SALISBURY ANSI / ASTM MAX. USE VOLT. D120 CLASS 1 U.S.A. TYPE I MAX USE VOLT 7500V AC	 SALISBURY ASTM D1051 CLASS 1 TYPE I MAX USE VOLT 7,500V AC EN60984 $\approx$ $\leq$ 0120
2 Yellow	20,000 / 50,000	17,000 / 25,500		 10 SALISBURY ANSI / ASTM MAX. USE VOLT. D120 CLASS 2 U.S.A. TYPE I MAX USE VOLT 17000V AC	 SALISBURY ASTM D1051 CLASS 2 TYPE I MAX USE VOLT 17,000V AC EN60984 $\approx$ $\leq$ 0120
3 Green	30,000 / 60,000	26,500 / 39,750		 10 SALISBURY ANSI / ASTM MAX. USE VOLT. D120 CLASS 3 U.S.A. TYPE I MAX USE VOLT 26500V AC	 SALISBURY ASTM D1051 CLASS 3 TYPE I MAX USE VOLT 26,500V AC EN60984 $\approx$ $\leq$ 0120
4 Orange	40,000 / 70,000	36,000 / 54,000		 10 SALISBURY ANSI / ASTM MAX. USE VOLT. D120 CLASS 4 U.S.A. TYPE I MAX USE VOLT 36000V AC	 SALISBURY ASTM D1051 CLASS 4 TYPE I MAX USE VOLT 36,000V AC EN60984 $\approx$ $\leq$ 0120

Glove Testing



(Courtesy Reed City Power Line)

Gloves are required to be lab tested:

- Prior to first use
- Every six months
- Prior to next use if used without protectors

The tests include:

- Dielectric test at voltage on previous chart
- Air test
- Cleaning
- Visual inspection

Glove inspection

Gloves shall be inspected prior to each use

The inspection should include:

Visual inspection checking for:

- **Cracks**
- **Punctures**
- **Ozone damage**
- **Snags**
- **Embedded material**

Air test



TOOL & TEST EQUIPMENT

USE AND SAFETY

Digital measuring instrument



Electrical test equipment Inspection

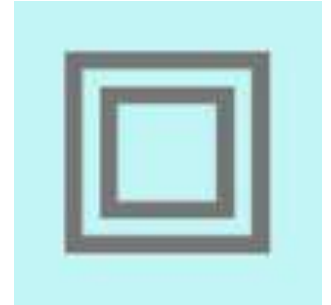
► Visually check meter for:

- UL listed (or equivalent)

— **Double insulated**

Probes should be inspected for:

- Shrouded connectors, finger guards
- Insulation not melted, cut, cracked, etc.
- Probe tips: not loose or broken off



Electrical test equipment Inspection

Finally, ensure the meter and leads are rated for the installation category you will be working in



Hot stick / Shotguns

Insulated tools for working on energized parts

Wood PVC or fiberglass

Inspected for:

- Integrity
- Cleanliness
- Insulation



Tested every 2 years if primary means of protection

Job Brief

Before starting each job, the employee in charge shall conduct a job briefing with the employees involved.

Documented Job Briefs

- Energized Work Permit
- Complex LOTO
- Contractors onsite

The briefing shall cover such subjects as:

- Hazards associated with the job
- Work procedures involved
- Special precautions
- Energy source controls
- Personal Protective Equipment Requirements



LOTO Procedures

There are ~~three~~ forms of hazardous energy control :

- ~~Individual employee control~~
(~~Removed By Amendment To The OSHA Act~~)
 - ~~Ex Clean/Inspect~~
 - ~~No lock required if disconnect is visible~~
- Simple lockout/tagout
 - Qualified person performing lockout for sole purpose of work
 - Not required to be written for each application
- Complex lockout/tagout
 - Written plan
 - Designated person in charge
 - Documented Job Brief



Energized Electrical Work Permit

PART I: TO BE COMPLETED BY THE REQUESTER:

Job/Work Order Number _____

1) Description of circuit/equipment: _____

2) Description of work to be done: _____

3) Reason(s) why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage: _____

Requester/Title _____ Date _____

← Justification

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: _____ Check when Complete ☐

2) Results of the Risk Hazard Analysis:

a) Determination of the Risk Protection Boundary: _____ ☐

b) Protective Clothing Required: _____ ☐

c) Personal Protective Equipment Required: _____ ☐

3) Determination of Approach Boundaries to Live Parts: _____ ☐

4) Considerations needed for Unqualified Persons: _____ ☐

5) Training/Preparation Needed: _____ ☐

6) Notification to affected employees on the area of the work to be performed: _____ ☐

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

Electrically Qualified Person(s) _____ Date _____

Electrically Qualified Person(s) _____ Date _____

← From label or equation
← Per table 130.7(C)(10)
← Per Table 130.7(C)(9)(a)
← Per table 130.2(C)

← 2 Qualified persons must agree it is safe

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

←

←

←

←

Manufacturing Manager _____ Maintenance/Engineering Manager _____

Safety Manager _____ Electrically Knowledgeable Person _____

General Manager _____ Date _____

Authorization

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

2015 LIMITS OF APPROACH

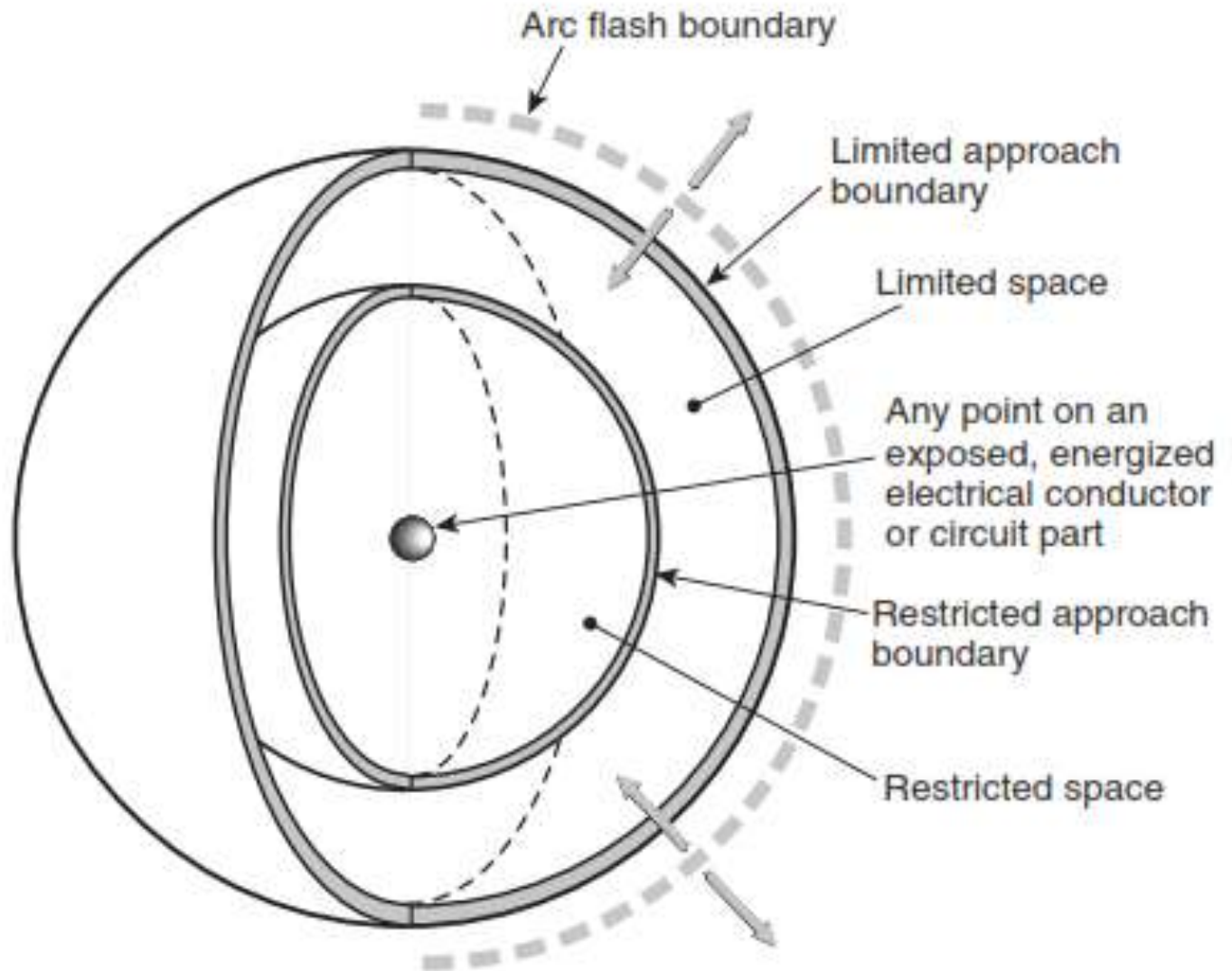


Figure C.1.2.3 Limits of Approach.

NFPA 70E Approach Boundaries

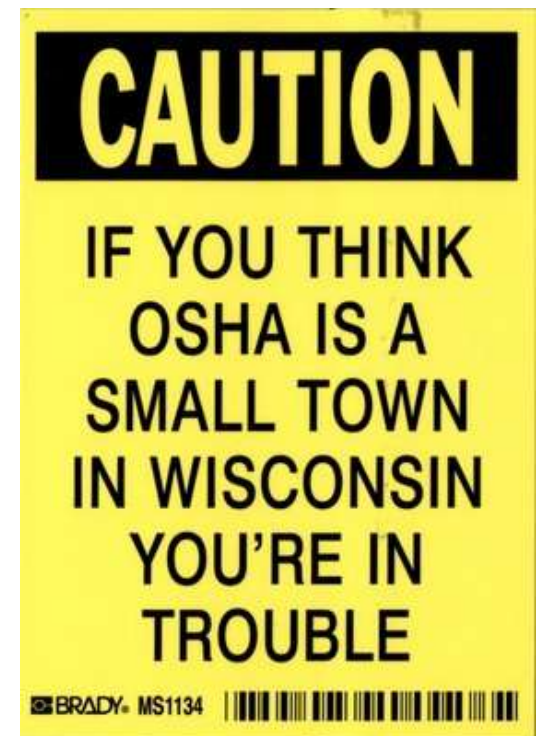
FROM NFPA 70E(2012) 130.4

Alternating Current (AC) Shock Protection Boundaries				
	Limited			
Voltage Range	Movable	Fixed	Restricted	Prohibited
0-50 VAC	Not Specified		Not Specified	Not Specified
51-300 VAC	10'0"	3' 6"	Avoid Contact	Avoid Contact
301-750 VAC	10'0"	3' 6"	12"	1"

Direct Current (DC) Shock Protection Boundaries				
	Limited			
Voltage Range	Movable	Fixed	Restricted	Prohibited
0-100 VDC	Not Specified		Not Specified	Not Specified
100-300 VDC	10'0"	3'6"	Avoid Contact	Avoid Contact
301-1000 VCD	10'0"	3' 6"	12"	1"



Trained and competent
You are not 10 foot tall and bulletproof!
There is no substitute for experience
BE SAFE!!!







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