




**BCH CONSULTING**  
ELECTRICAL SAFETY SPECIALISTS



## Electrical Safety In the Workplace



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### 1910 Subpart S

The Code of Federal Regulations (CFR) 1910, Subpart S Is the electrical safety regulations for industry

- Horizontal Standard
- Enforceable as law
- Rarely Revised
- Focus on What not How



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### Safety-Related Work Practices

- 1910.332 — Training.
- 1910.333 — Selection and use of work practices.
- 1910.334 — Use of equipment.
- 1910.335 — Safeguards for personnel protection.

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### General Duty Clause

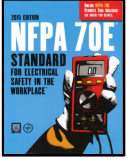
Employers shall furnish a place of employment which are free from:

- Hazards that are likely to cause death
- Serious physical harm to his employees

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

- Consensus standard developed at OSHA request.
- Standard for electrical safety in the workplace.
- OSHA is the shall
- NFPA70E is the how



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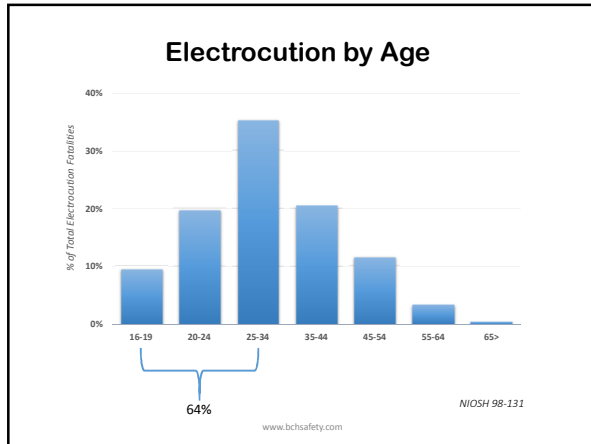
### Why is electrical Safety Training Important?

U.S. Annual Averages

- 30,000** Nonfatal electrical shock accidents
- 1,000** Electrocutions. Less than 600 volts
- 4<sup>th</sup>** fourth leading cause of fatalities
- +2,000** Severe arc flash burns

NFPA70E Annex k page 90  
Bureau of Labor Statistics (BLS), occupational fatalities from 2003 to 2010

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### How electricity affects the body

- 1 ma barely perceptible
- 16 ma Can't let go
- 20 ma paralysis of respiratory muscles
- 100 ma ventricular fibrillation
- 2 amps cardiac standstill and internal organ damage
- 15/20 amps before common household breaker opens

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### Emergency Response

If you see someone getting shocked:

- Do not grab them!
- Turn-off the power
- Pull them to safety using a non-conductive Item. (Stage safety equipment)
- Report all shocks to management

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### Secondary injuries

Many electrical workers have been seriously injured or worse after being shocked and thrown from a ladder

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### What makes a Person a "Qualified" Electrical Worker?

NFPA 70E 110.4(D)(1)  
Only qualified persons shall perform tasks such as testing, Troubleshooting, and voltage measuring

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### Qualifications

**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 and avoid the hazards involved.

NFPA 70E Article 100

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## How do we create an electrically safe work condition?



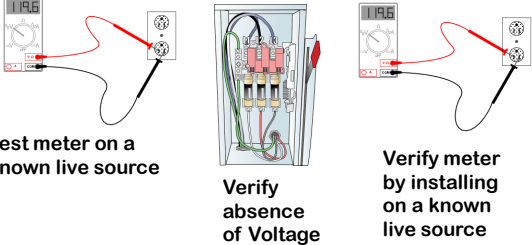
Identify all sources of power  
Deenergize equipment  
Open disconnect switch or breaker  
LO/TO  
Verify contacts are open – visually  
Test all phase to phase and to ground  
Employ safety grounds above 600 volts

NFPA 70E Article 120.1 page 19

**CONDITIONS MUST BE MET FOR EQUIPMENT TO BE CONSIDERED DE-ENERGIZED**

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## Live-Dead-Live (LDL)



Test meter on a known live source

Verify absence of Voltage


Verify meter by installing on a known live source

NFPA 70E Article 110.4(A)(5) page 19

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## Test Instruments

- Direct Contact Volt Meter when measuring 600 volts or less
- Should be a Cat III or IV @ 600 volts
- Shall be Rated for the voltage being measured
- Test leads should also be rated Cat III and IV
- Inspect before use




Article 110.4 page 18

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## CAT IV Meter

- Three-phase at utility connection, any outdoor conductors
- Electricity meters
- Outside and service entrance, service drop from pole to building
- Run between meter and panel



## CAT III Meter


- Switchgear and three phase motors
- Bus and feeders in industrial plants
- Lighting systems in larger buildings



Fluke ABC's of multimeter safety

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## Proximity Voltage Sensors



Can be thrown off if:

- Tip touches grounded metal
- Cable is buried in a bundle
- User is isolated from ground
- Won't detect through shielding on cables

**First Check Only**

Fluke ABC's of multimeter safety

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## Limits of Approach

- **Limited Approach Boundary** – No **unqualified** person shall be permitted to approach nearer than the limited approach boundary of energized conductors and circuit parts.
- **Restricted Approach Boundary** - No **qualified** person shall approach any exposed energized conductors closer than the restricted approach boundary unless insulated or guarded.

NFPA 70E 130.4(C)(1) page 25  
NFPA 70E 130.4(D)(1) page 25

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Nominal Voltage	Limited Approach Boundary		Restricted Approach Boundary
	Exposed Movable Conductors	Exposed Fixed Circuits	
< 50	Not Specified	Not Specified	Not Specified
50 v - 150 v	10 ft	3 ft. 6 in.	Avoid Contact
151 v - 750 v	10 ft	3 ft. 6 in.	1 ft
751 v - 15 kv	10 ft	5 ft.	2 ft. 2 in.

NFPA 70E table 130.4 (D)(a) AC Table page 26  
NFPA 70E table 130.4 (D)(b) DC Table page 26

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### What are the approach distances?

Restricted Approach Qualified with PPE → 1 ft.

Limited Approach (unqualified) → 3 ft. 6 in.

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### Knowledge Check

Switch is in the off position  
Do I need gloves to perform a Live-dead-live test?

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### Protective Barriers or Shields

Rubber insulating material meeting can be an effective way to prevent inadvertent contact with energized conductors.

NFPA 70E 130.7(D)(1)(f) page 41  
Material must meet ASTM Standards listed in table 130.7(F)

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### Shock Risk Assessment

A shock risk assessment shall determine:

- Voltage to which personnel will be exposed
- Boundary requirements
- PPE necessary in order to minimize the possibility of electric shock to personnel.

NFPA 70E 130.(4)(A)

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### Voltage Rated Gloves

- Inspect before first use each day
- Check expiration date
- Use leather protectors
- Use correct size, type and rating
- Must meet ASTM D120-09, Standard Specification for Rubber Insulating Gloves.

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## One size does not fit all

Your glove size is the measurement in inches around the palm of your hand. If you are right-handed, measure your right hand. If you are left-handed, measure your left hand.



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## Always Wear Your Gloves

Color on the tag not the color of the glove determines the rating

Max. Usage Voltage AC / DC	Glove Tag
500 / 750	<b>10</b> (Orange tag)
1,000 / 1,500	<b>10</b> (Red tag)
7,500 / 11,250	<b>10</b> (White tag)
17,000 / 25,500	<b>10</b> (Yellow tag)
26,500 / 39,750	<b>10</b> (Green tag)
36,000 / 54,000	<b>10</b> (Blue tag)

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## Working without leathers

You can remove your leather protectors under the following conditions:

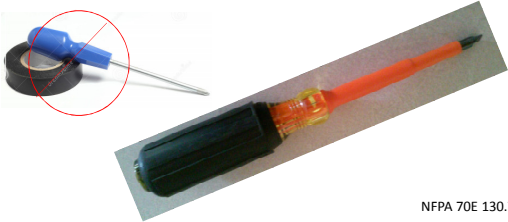
- Use Class 00 glove up to 250v AC and 375v DC
- For higher voltages, one class above the voltage being worked on and only if the employer can demonstrate that the possibility of physical damage to the gloves is small
- *One time only. Gloves used without protectors must be dielectrically tested before further use*
- *Leathers offer arc flash protection*

OSHA 1910.137(c)(2)(vii)

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## Insulated Tools

Use insulated tools when working inside the restricted approach boundary or where tools might make accidental contact.




NFPA 70E 130.7(D)(1)

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## Insulated Tool Requirements

- Rated for the voltage
- Constructed for the environment
- Inspected prior to use
- ASTM F1505 compliant
- Look for Double Triangle Symbol




130.7(D)(1) Insulated Tools and Equipment  
Pg. 40

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## Type and Class of Hard Hats




Class G or General Tested to withstand 2,200 volts  
Class E or Electrical tested to withstand 20,000 volts  
Class C or Conductive No electrical protection  
ANSI/ISEA Z89.1-2009 standard



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### Foot Protection Requirements

Shoe type	NFPA 70E Reference	Requirement
 (DI) Dielectric overshoes or boots	130.7(C)(8) Table 130.7(C)(14) 130.5(E)(3)	When protection against step or touch potential required
 (EH) Electrical Hazard shoes or boots	130.7(C)(8)	None Best Practice for electrical workers
 Standard Performance Heavy leather shoes or boots	130.(C)(16) Table (H.3(b))	When exposed to arc flashes greater than or equal to 4 cal/cm <sup>2</sup>

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### Look for the EH Rating




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### Assured Equipment Grounding Conductor Program (AEGC)

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### AEGC Program Requirements


- Grounding Conductors shall be tested for continuity
- Each cord set shall be visually inspected before each day's use for external defects.
- Tested for correct attachment of the equipment grounding conductor.
- Tests shall be performed : before first use, before equipment is returned to service following any repairs.
- At intervals not to exceed 3 months NFPA 70E 110.4 (C)(2)

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**Energized Work is allowed by permit when it is infeasible to deenergize**

**Infeasible – Troubleshooting or interruption of a vital process.**

NFPA 130.2(A)




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### Energized Electrical Work Permit

- Required - Performing work, within the *restricted approach boundary*
- *When parts are not exposed but interaction could increase the likelihood of an arc flash injury*
- Not Required -Testing, troubleshooting, and voltage measuring

NFPA 70E 130.2(B)(1)



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## What is an Arcing Fault?



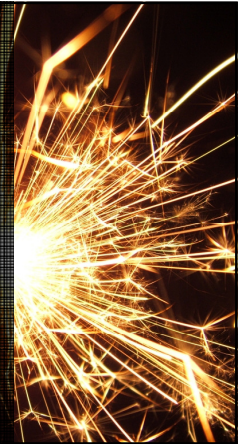
Characterized by electric current traveling through the air.  
In the case of the arcing fault the air contains contaminants that permit the electrical potential to break-down the normally good air insulation.

NFPA Definition

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## What are the Causes of Arcing Faults?

- Spark Discharge
- Accidental touching
- Accidental dropping of tools
- Mechanical failure – conductive part falling

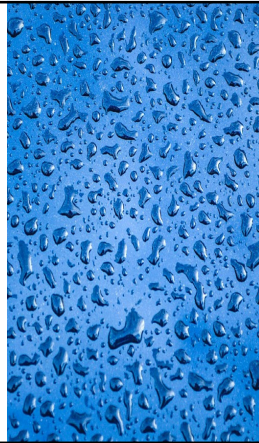


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## Contributing Causes

### Equipment Condition

- Dust & Impurities buildup
- Corrosion
- Condensation
- Insulation Failure
- Over-voltage



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## What is an Arc Flash?

Electric arcs produce temperatures up to 35,000 degrees Fahrenheit. Arcs spray droplets of molten metal at high-speed and pressure. Shrapnel can penetrate the body. Blast pressure waves have thrown workers across rooms and knocked them off ladders. Pressure on the chest can be higher than 2000 lbs./sq. ft. Arc flashes can and do kill at distances of 3 m (10 ft.).



NFPA 70E ANNEX K

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## Label Requirements

Electrical equipment shall be field-marked with a label.



NFPA 70E 130.5(2)(D)

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## Incident Energy


The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event.

Incident Energy



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## Amount Incident Energy



- Amount of available fault current
- Nominal Voltage
- Buss spacing
- Size of the enclosure
- Clearing times of upstream O.C.P.D.


NFPA 70E Article 130.5(3) informational note 2

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## 2<sup>nd</sup> Degree Burns

1.2 cal/cm<sup>2</sup> will result in a second degree burn.

NFPA 70e 130.7(C)(6)  
Employees shall wear arc-rated clothing whenever there is possible exposure to incident energy level for a second degree burn (1.2 cal/cm<sup>2</sup>)



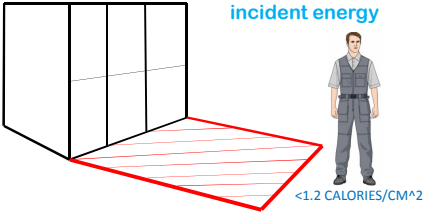
Third Degree Burn

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## Arc Flash Boundary

Requirements for stepping inside the Arc Flash Boundary:

- Must be qualified
- Nonqualified must be escorted
- Wear PPE rated for the incident energy

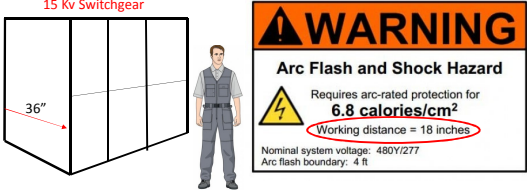


<1.2 CALORIES/CM<sup>2</sup>

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## Working Distance

The dimension between the possible arc point and the head and body of the worker positioned in place to perform the assigned task.



15 kV Switch gear has a default working distance of 36 inches

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## What is an ARC Flash Hazard?

- **Arc Flash Hazard.** A dangerous condition associated with the possible release of energy caused by an electric arc.

*Informational Note No. 1:*  
An arc flash hazard may exist when energized electrical conductors or circuit parts are exposed.

Article 100 page 10

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## What is an ARC Flash Hazard?

- When energized electrical conductors or circuit parts are within equipment in a **guarded** or **enclosed condition**, provided a person is **interacting** with the equipment in such a manner that could cause an electric arc.

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## What is an ARC Flash Hazard?

Informational Note No. 2:  
See Table 130.7(C)(15)(A)(a) for examples of activities that could pose an arc flash hazard.

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## Is task this an arc flash hazard?

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

NFPA 70E table 130.7(C)(15)(A)(a)  
Page 35

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## Is task this an arc flash hazard?

Removal of bolted cover to exposed bare energized conductors



Removal of bolted covers (to expose bare energized electrical conductors and circuit parts). For dc systems, this includes bolted covers, such as battery terminal covers.	Any	Yes
--	-----	-----

NFPA 70e table 130.7(C)(15)(A)(a)

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## ARC Flash Risk Assessment

An arc flash risk assessment shall be performed and shall:

- Determine if an arc flash hazard exists.
- If an arc flash hazard exists, the risk assessment shall determine:
  - a. Appropriate safety-related work practices
  - b. The arc flash boundary
  - c. The PPE to be used within the arc flash boundary

Informative Annex F of NFPA 70E provides details for performing risk analysis

NFPA 70E ARTICLE 130.5

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## Normal Operation of a Disconnect



600 volts or less

Is operating a common 480 volt disconnect switch an arc flash Hazard?

- Is the equipment properly installed?
- Is the equipment properly maintained?
- Is there evidence of impending failure?
- Are the doors or covers properly secured?
- Is the operator qualified?
- Risk assessment needs to determine if this is applicable.

NFPA 70e table 130.7(C)(15)(A)(a)

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## What can cause an Arc Flash?



### Interacting with energized equipment.

- Energized work when not permitted
- Human error
- Unsafe work practices-not using insulated tools or barriers while working on energized equipment

### Poorly maintained Equipment.


- Dust and dirt collecting inside equipment
- Loose or overheated connections
- Water intrusion

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## Body Protection

Employees shall wear arc-rated clothing wherever there is possible exposure to an electric arc flash above the threshold incident energy level for a second degree burn

**1.2 cal/cm<sup>2</sup>**



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## Determine the Arc Rating by reading the label

- Arc Rated Apparel must meet the performance specifications of ASTM F1506
- Arc Thermal Performance Value (ATPV) Arc Rating in cal/cm<sup>2</sup>


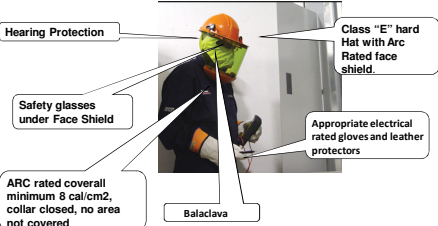


Table 130.7(C)(14) Standards on Protective Equipment

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### NFPA 70E Table H.2 Simplified Two-Category, Arc-Rated Clothing System



**> 1.2 cal/cm<sup>2</sup> to < or equal to 8 cal/cm<sup>2</sup>**

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### NFPA 70E Table H.2 Simplified Two Category, Arc-Rated Clothing System



**PPE Example: > 8 cal/cm<sup>2</sup> to < or equal to 40 cal/cm<sup>2</sup>**

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## Personal Protective Equipment

**< 1.2 cal/cm<sup>2</sup>**

- Non-Melting clothing (including long sleeved shirt and pants)
- Standard PPE \*
- Appropriate Gloves
- Face Shield as Needed

NFPA 70E TABLE H.3(b)



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## How do we protect ourselves?

- Eliminate Exposure - Create an electrically safe work condition
- Use safe work practices
  - Insulated tools
  - Barriers and Barricades
  - Energized Electrical Work Permit and brief
  - Use test equipment properly
  - Perform risk assessments
  - Use properly maintained PPE that's rated for the task
- Maintain Electrical Equipment

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