Georgia Tech Research Institute

Electrical Safety, Arc Flash/Blast Injury Prevention for Worker

Note: The training materials were developed under NFPA 70E 2009 Edition

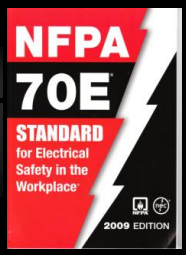
1

NFPA 70E ELECTRICAL SAFETY

Presented by:

GTRI – REGION 4

Thomas Dean
Steven Owen
Steve Davis



Note: The training materials were developed under NFPA 70E 2009 Edition

Understanding Electrical Hazards

Shock

Over 30,000 non-fatal electrical shock accidents occur each year

Over 600 people die from electrocution each year

Electrocution remains the fourth (4th) highest cause of industrial fatalities

Most injuries and deaths could be avoided

Note: The training materials were developed under NFPA 70E 2009 Edition

Georgia Tech Research Institute

This training course was produced under grant number SH-1942-09-06-F13 from OSHA, USDOL. It does not Necessarily reflect the views or policies of the US Department of Labor, nor does mention of trade names, commercial products, or organizations imply endorsement By the US Government.

Note: The training materials were developed under NFPA 70E 2009 Edition

PART 1: INTRODUCTION

Electrical Safety
OSHA & NFPA 70E

for
Maintenance Techs, Electricians and others working on or near exposed energized electrical conductors, parts or equipment operating at 50 volts or more

Note: The training materials were developed under NFPA 70E 2009 Edition

LEARNING OBJECTIVES:

- ***Why Electrical Safety and Arc Flash Protection?***
- ***What is electrical safety?***
- ***What does electrical safety consist of ?***
- ***What does electrical safety look like?***
- ***How does electrical safety apply to your workplace?***
- ***Which standards apply to electrical safety?***
- ***How to Recognize Electrical Hazards in the Workplace***

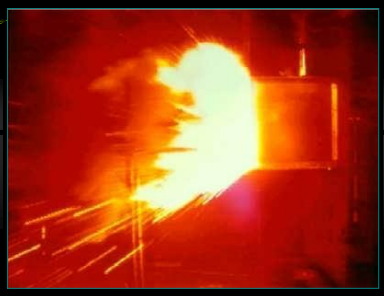
Note: The training materials were developed under NFPA 70E 2009 Edition

LEARNING OBJECTIVES:

- ***How to Identify Electrical Hazards in the Workplace***
- ***How to Establish an Electrical Safe Work Condition***
- ***How to Evaluate Voltage & Arc Flash Hazard Potential - Tables vs. Calculation***
- ***How to Properly Select & Use PPE***
- ***How to Perform Work on or Near Energized Parts***
- ***Electrical Safe Work Practices***
- ***How To Properly Measure Electrical Voltage & Amperage - Meter Safety***

Note: The training materials were developed under NFPA 70E 2009 Edition

Why Electrical Safety & Arc Flash Protection



Note: The training materials were developed under NFPA 70E 2009 Edition

Arc Flash Injuries

- ✓ Electric shock
- ✓ Severe burns
- ✓ Blindness
- ✓ Blast injuries
  - ✓ Shrapnel wounds
  - ✓ Lung blast injuries
  - ✓ Ruptured eardrums
  - ✓ Pressure wave injuries

Note: The training materials were developed under NFPA 70E 2009 Edition

Severity Factors

Power – amount of energy at the arc

Distance – of the worker to the arc

Time – duration of the arc exposure

Note: The training materials were developed under NFPA 70E 2009 Edition

Electric Shock Injury – Burn

Note: The training materials were developed under NFPA 70E 2009 Edition

Electric Shock Injury – Burn

Note: The training materials were developed under NFPA 70E 2009 Edition

Severe Burns from Arc Flash

Arc flash	up to 35,000°F
Sun	9,900°F

Note: The training materials were developed under NFPA 70E 2009 Edition

Blindness

- ✓ Flash of light is so intense it can damage vision.

Note: The training materials were developed under NFPA 70E 2009 Edition

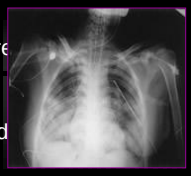
Shrapnel Wounds

Material and molten metal can hit the body at over 700 miles per hour.

Note: The training materials were developed under NFPA 70E 2009 Edition

Blast Lung Injury (BLI)

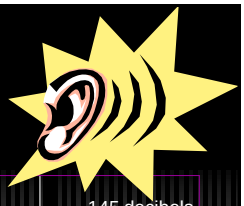
- ✓ Arc blast can cause inhalation injuries. For example:
  - ✓ Inhaling high temperature copper vapor
  - ✓ More than 100 toxic substances can be found in the fumes.



BLI + Burns = Greater chance of death

Note: The training materials were developed under NFPA 70E 2009 Edition

Hearing Damage



Arc blast at 2 feet	145 decibels
Jet engine at 200 feet	132 decibels
Pain threshold	130 decibels

Note: The training materials were developed under NFPA 70E 2009 Edition

Arc-Flash

Skin Temperature	Time of skin temperature	Damage caused
110 °F	6 Hours	Cell breakdown starts
158 °F	1 sec.	Total cell destruction
176 °F	0.1 sec	Curable burn
200 °F	0.1 sec	Incurable 3rd degree burns

Pressure Wave Injuries

Arc blast can throw a worker:
- Off a ladder
- Into nearby walls or equipment.

2000 lbs/ft^2 pressure on the body can cause:
- Concussion
- Collapsed lungs
- Other internal injuries

Note: The training materials were developed under NFPA 70E 2009 Edition

What is Electrical Safety

Note: The training materials were developed under NFPA 70E 2009 Edition

What is Electrical Safety

Protecting workers from the unexpected start-up, or unexpected reenergization of equipment, circuits, or parts while maintenance is being performed.
Protecting workers from exposure to live electrical parts

Includes overhead and underground electrical distribution, including systems, equipment, circuits, and parts.

IT IS MANDATORY!

Note: The training materials were developed under NFPA 70E 2009 Edition

What is Electrical Safety

Documented Electrical Safe Work Practices Programs
Selection, Use, Maintenance, Storage of Proper PPE
Employee Training

Note: The training materials were developed under NFPA 70E 2009 Edition

Who's Responsible for Safety?

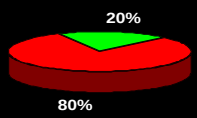
The "Employer" is responsible for
- OSHA requirements
- Electrical Safety Program
- Safety Policies and Procedures
- Safety Training

The "Employee" is responsible for
- Implementing procedures

The "Owner" is inherently responsible for
- Contractors on site

Note: The training materials were developed under NFPA 70E 2009 Edition

Inexperience = Accidents



- Employees Who Have Less Than 12 Months Experience at a Different or New Task, Account For 80% of ALL Accidents

Note: The training materials were developed under NFPA 70E 2009 Edition

Which Standard Applies? OSHA or NFPA 70E

Don't forget … OSHA solicited the services of the NFPA to establish new rules and regulations in a standard that OSHA could choose to enforce. (Mid 1990's).

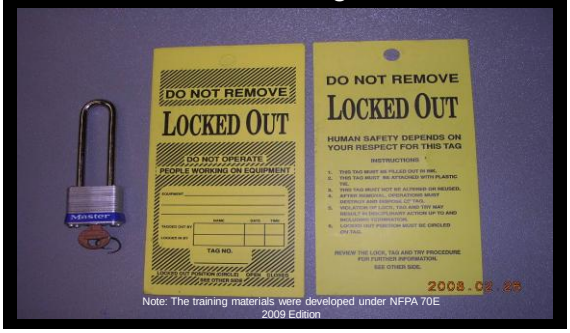
- ✓ This became known as NFPA 70E – 2000.

Note: The training materials were developed under NFPA 70E 2009 Edition

What Does Electrical Safety Look Like?

Note: The training materials were developed under NFPA 70E 2009 Edition

Lockout Tagout



Note: The training materials were developed under NFPA 70E 2009 Edition

Gloves

Note: The training materials were developed under NFPA 70E 2009 Edition

Dated Insulated Gloves

Note: The training materials were developed under NFPA 70E 2009 Edition

Leather Gloves

Note: The training materials were developed under NFPA 70E 2009 Edition

Voltage Rated Gloves

CLASS	PROOF VOLTAGE	COLOR	MAX USE Volts
OO	1,000	BEIGE	500
O	5,000	RED	1,000
1	10,000	WHITE	7,500
2	20,000	YELLOW	17,000
3	30,000	GREEN	26,500
4	40,000	ORANGE	36,000

Note: The training materials were developed under NFPA 70E 2009 Edition

Gloves

- **130.7 Personal and Other Protective Equipment.**
- Personal Protective Equipment.
  - Arc Flash Protective Equipment.
  - Leather or FR gloves shall be worn where required for arc flash protection.
  - **Where insulating rubber gloves are used for shock protection, leather protectors shall be worn over rubber gloves.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Voltage Rated Gloves & Tool Testing

- ✓ MSHA Requires testing yearly
- ✓ Federal OSHA Requires testing every 6 month
- ✓ Tested date is marked on gloves, equipment and hot sticks
- ✓ Must be inspected and field tested before each use (visual and roll-up test)

Note: The training materials were developed under NFPA 70E 2009 Edition

Does not meet requirements of 120.1(5) – NFPA 70E

Note: The training materials were developed under NFPA 70E 2009 Edition

Meter Safety-Does meet requirements of 120.1(5) – NFPA 70E

Note: The training materials were developed under NFPA 70E 2009 Edition

Voltage Rated Tools

Note: The training materials were developed under NFPA 70E 2009 Edition

How Does Electrical Safety Apply to Your Workplace

Note: The training materials were developed under NFPA 70E 2009 Edition

What Voltages are Present?

120V
480V
4160V

Note: The training materials were developed under NFPA 70E 2009 Edition

What Voltages are Present?

- ✓ 7.2KV
- ✓ 13.8KV
- ✓ 14.4KV

Note: The training materials were developed under NFPA 70E 2009 Edition

What Voltages are Present?

- ✓ 20KV
- ✓ 138KV
- ✓ 345KV
- ✓ 500KV
- ✓ 750KV

Note: The training materials were developed under NFPA 70E 2009 Edition

What Voltages are Present?

Note: The training materials were developed under NFPA 70E 2009 Edition

Based on Voltages & Hazards Present - Establish Procedures

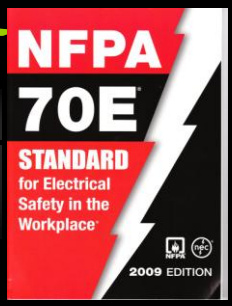
- ✓ Determine Voltage & Arc Flash Hazards
- ✓ Determine Who is Exposed
- ✓ Determine Protective Measures
- ✓ Determine OSHA Requirements
- ✓ Determine What NFPA 70E Procedures that Will be Followed

Note: The training materials were developed under NFPA 70E 2009 Edition

Which Standards Apply?

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E – 2009 Edition



Note: The training materials were developed under NFPA 70E 2009 Edition

Which Standard Applies?
OSHA or NFPA 70E

OSHA

- ✓ 1910.269 Over 600 Volts
- ✓ 1910.331-335 600 Volts or Less
- ✓ 1910.132(d) Hazard Assessment
- ✓ 1910.137 PPE
- ✓ 1910.331-335 600 Volts or Less
- ✓ 1910.269 Over 600 Volts

Note: The training materials were developed under NFPA 70E 2009 Edition

Standards

US National Fire Protection Association
-Standard NFPA 70E

Canadian Standards Association
-Standard Z-462

Institute of Electrical & Electronics Engineers
-Standard 1584

Canadian Electrical Code
-Rule 2-306

US Occupational Safety & Health Administration

Occupational Health & Safety Act
-Applicable regulations

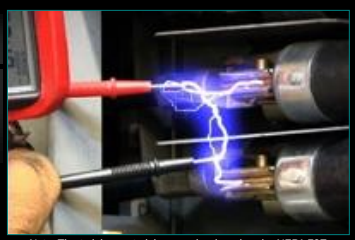
Note: The training materials were developed under NFPA 70E 2009 Edition

How to Recognize Electrical Hazards in the Workplace

Note: The training materials were developed under NFPA 70E 2009 Edition

What is an Electric Arc?

An electric arc is a short circuit through the air.



Note: The training materials were developed under NFPA 70E 2009 Edition

Characteristics of an Electric Arc

- An electric arc will oscillate and escalate if not constrained.
- A single-phase electric arc can engulf a second or third conductor in only two cycles.
- An electric arc's current propels the arc away from the power source.

Note: The training materials were developed under NFPA 70E 2009 Edition

What Causes Arc Flash?

- Dust, impurities, corrosion, condensation, animals
- Spark discharge from:
  - Accidental touching
  - Dropping tools
- Over-voltages across narrow gaps
- Failure of insulating materials
- Equipment failure

Note: The training materials were developed under NFPA 70E 2009 Edition

Forms of Arc Flash Energy

- Noise
- Expansion
- Vaporization
- Thermal radiation

Note: The training materials were developed under NFPA 70E 2009 Edition

Human Body Resistance

- **Hand to hand resistance = 1000 ohms**
- **120 VAC circuit**
- **Ohms Law formula;**
  - **I = E / R**
  - **120 / 1000 = 0.120 amps (120 milliamps)**

Note: The training materials were developed under NFPA 70E 2009 Edition

Human Body Resistance

Human body resistance (hand to hand) across the body is about 1000Ω

Ohms Law: I = V / R (Amps.)
V = 480 volts / 1000 Ω
= 0.48 amps (480 mA)

The National Electrical Code® considers 5 mA to be the safe upper limit for children and adults.

Note: The training materials were developed under NFPA 70E 2009 Edition

How Can We Get Shocked

- **Shock**
  - **electricity travels in closed circuits**
  - **shock occurs when the body becomes part of the electrical circuit**
  - **(1) short circuit**
  - **(2) ground fault**
  - **(3) metallic part of enclosure becomes energized**

Note: The training materials were developed under NFPA 70E 2009 Edition

Shock

***Current*, *Not Voltage* causes Electric Shock**

- **0.5 - 3 mA** - Tingling sensations
- **3 - 10 mA** - Muscle contractions and pain
- **10 - 40 mA** - "Let-go" threshold
- **30 - 75 mA** - Respiratory paralysis
- **100 - 200 mA** - Ventricular fibrillation
- **200 - 500 mA** - Heart clamps tight
- **1500 + mA** - Internal organs start to burn

Note: The training materials were developed under NFPA 70E 2009 Edition

Human Body Resistance

- SKIN
  - outer layer of skin "horny layer" provides resistance to electricity but varies from individual to individual
- HEART
  - controlled by internal electrical impulses and disturbed by outside electrical impulses causing fibrillation and halting of pumping action. Death can quickly occur.
- MUSCLE
  - also controlled by electrical impulses
    - shock can result in loss of muscular control and lack of ability to release an electrical conductor

Note: The training materials were developed under NFPA 70E 2009 Edition

Human Body Resistance

- **The Severity of Shock affected by:**
  - amount of current
  - path of the current
  - length of time
- **The severity of the shock can cause tremendous damage than is visible.**
- Most common= Burns
- **Three types of burns**
  - electrical
  - arc
  - thermal contact
  - ***Electrical burns are the result of current flowing through the tissues or bones***

Note: The training materials were developed under NFPA 70E 2009 Edition

Humans Body Resistance continued….

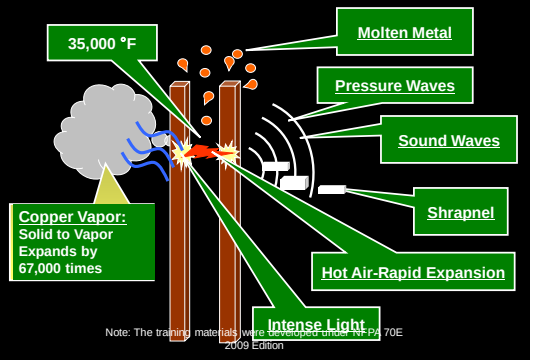
Note: The training materials were developed under NFPA 70E 2009 Edition

You know about shock, don't forget ...

- **Arc**
  - arc burns make up a large portion of the injuries from electrical malfunction
  - electrical arcs can occur due to poor electrical contact or failed electrical insulation
- **Blast**
  - pressure developed by the near instantaneous heating of the air surrounding the arc an from the expansion of the metal as it is vaporized

Note: The training materials were developed under NFPA 70E 2009 Edition

Electrical Arc



Note: The training materials were developed under NFPA 70E 2009 Edition

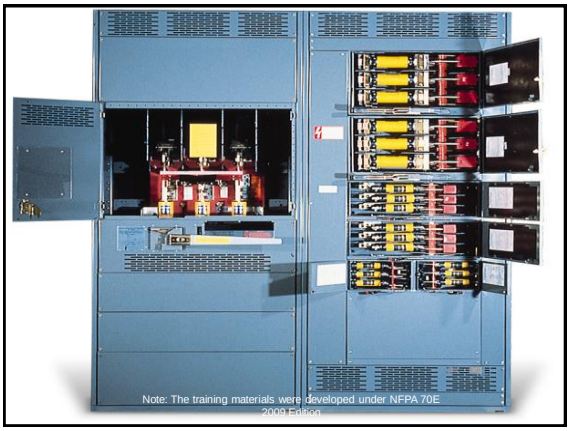
Electrical Arc Burn Injuries

- ✓ Occur from high temperature sources
- ✓ Deep and slow to heal
- ✓ Involve large areas of body
- ✓ Distance from arc determines severity

Note: The training materials were developed under NFPA 70E 2009 Edition

Do You Have Any Equipment Such As…

Note: The training materials were developed under NFPA 70E 2009 Edition



Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

480V Fused Disconnect

Note: The training materials were developed under NFPA 70E 2009 Edition

Current Limiting Fuse

Note: The training materials were developed under NFPA 70E 2009 Edition

480V Starter Cabinet

Note: The training materials were developed under NFPA 70E 2009 Edition

Current Limiting Fuse

Note: The training materials were developed under NFPA 70E 2009 Edition

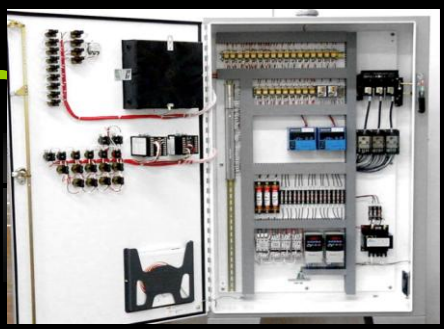
Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Do You Have Any Plant or Construction Electrical Voltage or Arc Flash Hazards Such As…

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

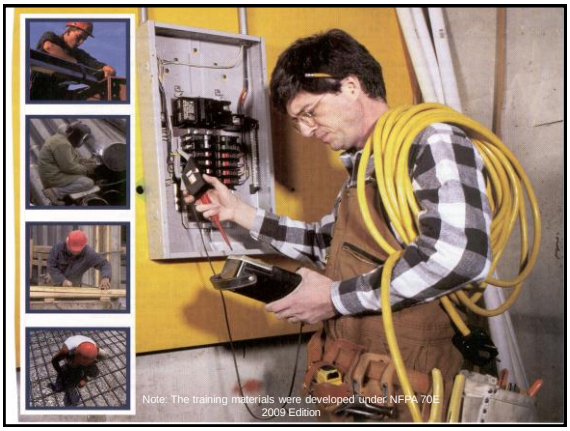


Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition



Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

How to Establish a Electrical Safe Work Condition

Note: The training materials were developed under NFPA 70E 2009 Edition

Best Solution - Take Equipment to a Zero Energy State and Lock it Out

Note: The training materials were developed under NFPA 70E 2009 Edition

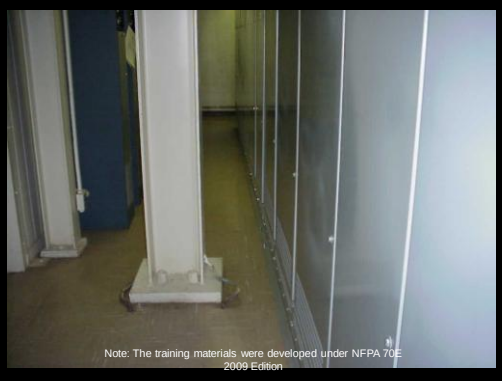
The Most Electrical Dangerous Jobs

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Remove Bolted Cover



Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

The Next Level Down

Dangerous Electrical Jobs

Note: The training materials were developed under NFPA 70E 2009 Edition

The Next Level Down

Dangerous Electrical Jobs

Note: The training materials were developed under NFPA 70E 2009 Edition

The Next Level Down

Dangerous Electrical Jobs

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Before Starting Work On or Near Energized Parts

1. Design Electrical Systems for Safety
2. Use Appropriate Voltage Rated Insulated Tools
3. Use Appropriate PPE, including FR Clothing

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Insulated Screwdrivers

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Fuses

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

How to Evaluate Voltage & Arc Flash Hazard Potential

Note: The training materials were developed under NFPA 70E 2009 Edition

Before Work Can Proceed On or Near Exposed Energized Parts

We Must Perform:

- ✓ **Shock Hazard Analysis**
- ✓ **Shock Protection Boundary**
- ✓ **Arc Flash Analysis**
- ✓ **Arc Flash Boundary**

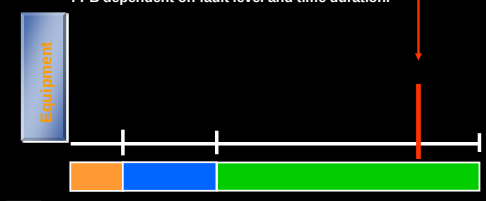
Note: The training materials were developed under NFPA 70E 2009 Edition

Calorie Studies vs. Tables

- **Calorie Studies**
  - **Performed by Professionals**
  - **Determines Exact Hazards**
  - **Costly**
- **Tables**
  - **Can be Used Effectively**
  - **Must Know How to Navigate**
  - **Can Use to Select Proper PPE**

Note: The training materials were developed under NFPA 70E 2009 Edition

Flash Protection Boundary (FPB)
Must wear appropriate PPE
FPB dependent on fault level and time duration.



Prohibited Shock Boundary: **Qualified Persons Only. PPE as if direct contact with live part**

Restricted Shock Boundary: **Qualified Persons Only**

Limited Shock Boundary: **Qualified or Unqualified Persons***
*** Only if accompanied by Qualified Person**

Note: shock boundaries dependent on system voltage level

Note: The training materials were developed under NFPA 70E 2009 Edition

Limited Approach Boundary

The *limited approach boundary* is a shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which is not to be crossed by unqualified persons unless escorted by a qualified person.

Note: The training materials were developed under NFPA 70E 2009 Edition

Restricted Approach Boundary

A *restricted approach boundary* is a shock protection boundary to be crossed only by qualified persons (at a distance from a live part) which, due to its proximity to a shock hazard, requires the use of shock protection techniques and equipment when crossed.

Note: The training materials were developed under NFPA 70E 2009 Edition

Prohibited Approach Boundary

A *prohibited approach boundary* is a shock protection boundary to be crossed only by qualified persons (at a distance from a live part) which, when crossed by a body part or object shall require the same protection as if direct contact is made with a live part.

Note: The training materials were developed under NFPA 70E 2009 Edition

Default Flash Protection Boundary *

- ✓ 600 volt systems = 4 feet (Ralph Lee Formulae)
- ✓ Above 600 volt systems = distance at which 1.2 cal/cm^2 (slow clearing time)
- ✓ Above 600 volt systems = distance at which 1.5 cal/ cm^2 (clearing time of 0.1 sec or less)
- ✓ * 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Selecting Flash Protection

1. Calculate incident energy and select PPE based upon that calculation.
2. Select hazard/risk category based on task, *then* select PPE based upon hazard/risk category.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009

- ✓ **130.3 Arc Flash Hazard Analysis.**
- ✓ An arc flash hazard analysis shall determine the ARC Flash Protection Boundary ***and the personal protective equipment that people within the Arc Flash Protection Boundary shall use.***

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70 E

- ***The arc flash hazard analysis shall be updated:***
  - ***when a major modification or renovation takes place.***
  - ***It shall be reviewed periodically, not to exceed 5 years, to account for changes in the electrical distribution system that could affect the results of the arc flash hazard analysis.***

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009

- The arc flash hazard analysis shall take into consideration:
  - the design of the over-current protective device and
  - it's opening time, including its condition of maintenance.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009

- 130.3 con't. Exception No. 1: ***An arc flash hazard analysis shall not be required where all of the following conditions exist:***
- (1) The circuit is rated 240 volts or less.
- (2) The circuit is supplied by one transformer.
- (3) The transformer supplying the circuit is rated less than 125 kVA.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009

- 130.3 con't. Exception No. 2: ***The requirements of 130.7(C)(9), 130.7(C)(10), and 130.7(C)(11) shall be permitted to be used in lieu of a detailed incident energy analysis.***

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E

PPE Selection
Use of Tables Exercise

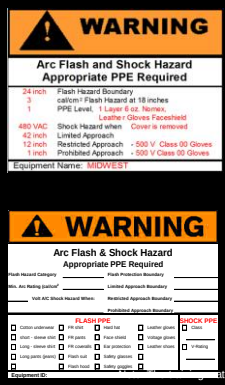
Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E – 2009

Section 130.3(C)
NFPA 70E – 2009

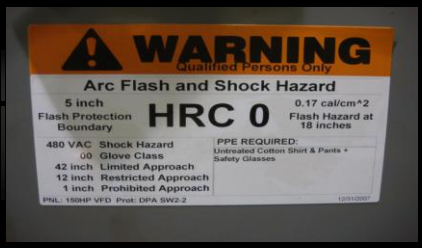
Arc Flash Hazard
Marking Requirement

Note: The training materials were developed under NFPA 70E 2009 Edition



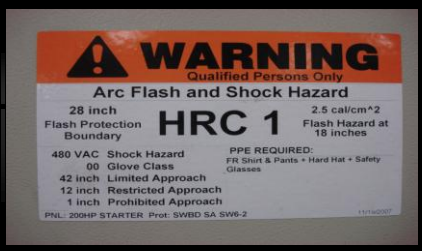
Note: The training materials were developed under NFPA 70E 2009 Edition

Label Electrical Systems



Note: The training materials were developed under NFPA 70E 2009 Edition

Label Electrical Systems

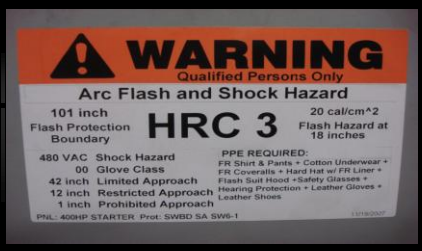


Note: The training materials were developed under NFPA 70E 2009 Edition

Label Electrical Systems

Note: The training materials were developed under NFPA 70E 2009 Edition

Label Electrical Systems



Note: The training materials were developed under NFPA 70E 2009 Edition

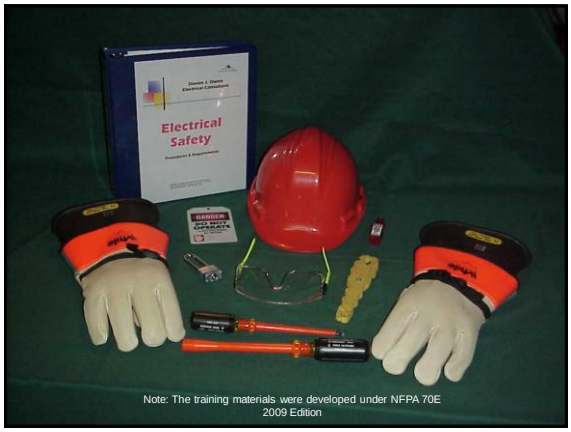
How to Select & Use PPE

Note: The training materials were developed under NFPA 70E 2009 Edition

Safeguards for Personnel Protection
1910.335

- ✓ **Use of Protective Equipment 1910.335(a)(1)**
  - ✓ Use of insulated rubber gloves
    - ✓ Various Classes
    - ✓ Inspection of Protective Equipment
    - ✓ Inspection Methods
    - ✓ Storage of Insulating Equipment
    - ✓ Leather Protectors
    - ✓ Inspection and Testing of Insulating Equipment

Note: The training materials were developed under NFPA 70E 2009 Edition



Note: The training materials were developed under NFPA 70E 2009 Edition

Voltage Rated Gloves

CLASS	PROOF VOLTAGE	COLOR	MAX USE Volts
OO	1,000	BEIGE	500
O	5,000	RED	1,000
1	10,000	WHITE	7,500
2	20,000	YELLOW	17,000
3	30,000	GREEN	26,500
4	40,000	ORANGE	36,000

Note: The training materials were developed under NFPA 70E 2009 Edition

Voltage Rated Gloves & Tool Testing

- ✓ Federal OSHA Requires testing every 6 months
- ✓ MSHA Requires testing every year
- ✓ Tested date is marked on gloves, equipment and hot sticks
- ✓ Must be inspected and field tested before each use (visual and roll-up test)

Note: The training materials were developed under NFPA 70E 2009 Edition

Personal Protective Equipment…

✓ **Use electrical rated protective equipment when working in areas where there is a potential electrical hazard.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Preventing Electrical Hazards - PPE

- ☒ Proper foot protection (not tennis shoes)
- ☒ Rubber insulating gloves, hoods, sleeves, matting, and blankets
- ☒ Hard hat (insulated - nonconductive)

Note: The training materials were developed under NFPA 70E 2009 Edition

Preventing Electrical Hazards - PPE

- ☒Proper foot protection (not tennis shoes)
- ☒Rubber insulating gloves, hoods, sleeves, matting, and blankets
- ☒Hard hat (insulated - nonconductive)

veloped under NFPA 70E

More on PPE ...

- ✓**Use, store & maintain your Electrical PPE in a safe, reliable condition**
- ✓**Wear nonconductive head protection**
- ✓**Wear protective equipment for the eyes or face wherever there is danger of injury to the eyes or face**

Note: The training materials were developed under NFPA 70E 2009 Edition

PPE Inspection…

- ✓ **Electrical PPE with any of the following defects may not be used**
  - ✓ **A hole, tear, puncture, or cut**
  - ✓ **Ozone cutting or ozone checking (the cutting action produced by ozone on rubber under mechanical stress into a series of interlacing cracks)**

Note: The training materials were developed under NFPA 70E 2009 Edition

AND….

- ✓ **Any of the following texture changes: swelling, softening, hardening, or becoming sticky or inelastic.**
- ✓ **An embedded foreign object**
- ✓ **Any other defect that damages the insulating properties**

Don't use defective Electrical PPE!

Note: The training materials were developed under NFPA 70E 2009 Edition

PPE Testing

- ✓ Rubber insulating line hose
  - ✓ Upon indication that insulating value is suspect
- ✓ Rubber insulating covers
  - ✓ Upon indication that insulating value is suspect.

Note: The training materials were developed under NFPA 70E 2009 Edition

PPE Testing

- ✓ Rubber insulating blankets
  - ✓ Before first issue and every 12 months
- ✓ Rubber insulating gloves
  - ✓ Before first issue and every 6 months
- ✓ Rubber insulating sleeves
  - ✓ Before first issue and every 12 months

Note: The training materials were developed under NFPA 70E 2009 Edition

Safeguards for Personnel Protection
1910.335

- ✓Insulating Equipment Failing to Pass Inspection
- ✓Rubber Insulating Line Hose and Covers
- ✓Head Protection
- ✓Flash Protection

Note: The training materials were developed under NFPA 70E 2009 Edition

Insulated Tools
1910.335 (a)(2)

- ✓Whenever employees are working near exposed energized parts, they must use insulated tools.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009

- ✓130.3(C) Equipment Labeling. ***Equipment shall be field marked with a label containing the available incident energy …***
- ✓***or required level of PPE.***

Note: The training materials were developed under NFPA 70E 2009 Edition

Alerting Techniques
1910.335 (b)

- ✓Safety Signs and Tags
- ✓Barricades
- ✓Alternate Alerting Techniques

Note: The training materials were developed under NFPA 70E 2009 Edition

Electrical Switching Operations

- ✓Major cause of personnel injury
  - ✓Mechanism
  - ✓Prevention
    - ✓Wearing safely glasses
    - ✓Wearing gauntlet-type gloves
    - ✓Standing to one side of the switch, not in front of it.
    - ✓Use the hand nearest the switch to operate the handle.
    - ✓Turn the opposite way of the switch as it is operated.

Note: The training materials were developed under NFPA 70E 2009 Edition

Electric Switching Operations

Prevention continued....

Keep personnel 1.2 meters to either side - away from the front of the switch.

Selection of the side to stand at will depend on the proximity of the handle to one side or the other.

The hinges are as likely to rupture as the latch is to burst.

Firm and smart operation is desirable, never indecisive “teasing” of the switch.

Following these steps will minimize injury if an electrical explosion were to occur.

Note: The training materials were developed under NFPA 70E 2009 Edition

This is closer to what it should look like!

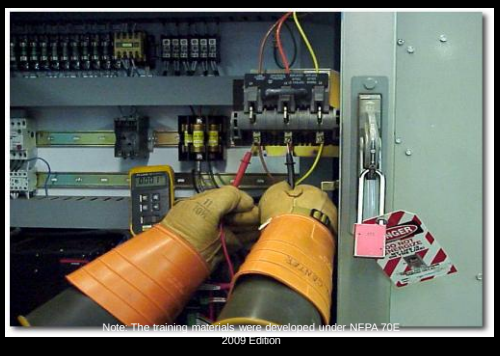
This is what NFPA 70E suggests, and what OSHA expects!

OSHA 1910.335(a)(1)(i)

NFPA 70E Table 3-3.9.1 / 3-3.9.2

eveloped under NFPA 70E
on

This is how it SHOULD be done!!!!!!!!!!



Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- ✓ **Personal and Other Protective Equipment.**
- ✓ Arm and Hand Protection
  - ✓ Employees shall wear rubber insulating gloves where there is a danger of hand and arm injury from electric shock due to contact with live parts.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- ✓ Foot and Leg Protection
  - ✓ Where insulated footwear is used as protection against step and touch potential, dielectric overshoes shall be required.
  - ✓ **Insulated soles shall not be used a primary electrical protection.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- ✓ **130.7 Personal and Other Protective Equipment.**
- ✓ (C) Personal Protective Equipment.
- ✓ (8) Standards for Personal Protective Equipment. Personal protective equipment shall conform to the standards given in Table 130.7(C)(8).

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- ✓ **130.7 Personal and Other Protective Equipment.**
- ✓ (C) Personal Protective Equipment.
- ✓ (9) Selection of personal protective Equipment. When selected in lieu of the flash hazard analysis of 130.3(A), Table 130.7(C)(9)(a) shall be used to determine the hazard/risk category for a task. For tasks not listed a flash hazard analysis is required.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- **130.7 Personal and Other Protective Equipment.**
- (C) Personal Protective Equipment.
- (10) Protective Clothing and Personal Protective Equipment Matrix. Once the Hazard/Risk Category has been identified, Table 130.7(C)(10) shall be used to determine the required personal protective equipment (PPE) for the task.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- **130.7 Personal and Other Protective Equipment.**
- (C) Personal Protective Equipment.
- (11) Protective Clothing Characteristics. Table 130.7(C)(11).

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- Factors in Selection of Protective Clothing:
  - Clothing and equipment that provide worker protection from shock and arc flash hazards shall be utilized.
  - Clothing and equipment required for the degree of exposure shall be permitted to be worn alone or integrated with flammable, non-melting apparel.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- Factors in Selection of Protective Clothing cont'd. :
  - If FR clothing is required, it shall cover associated parts of the body as well as all flammable apparel
  - Allow movement and visibility.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- Layering:
  - Non-melting, flammable fiber garments shall be permitted to be used as under layers in conjunction with FR garments in a layered system for added protection.
  - If non-melting, flammable fiber garments are used as under layers, the system arc rating shall be sufficient to prevent break open of the innermost FR layer at the expected arc exposure incident energy level to prevent ignition of flammable under layers.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- Outer Layers must meet the following criteria:
  - Garments worn as outer layers over FR clothing, such as jackets or rainwear, shall also be made from FR material.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- Underlayers must meet the following:
  - Meltable fibers such acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric under layers (underwear) next to the skin.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- Coverage:
  - Clothing shall cover potentially exposed areas as completely as possible. Shire sleeves shall be fastened at the wrists, and shirts and jackets shall be closed at the neck.
- Fit:
  - Tight-fitting clothing shall be avoided. Loose-fitting clothing provides additional thermal insulation because of air spaces. FR apparel shall fit properly such that it does not interfere with the work task.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- Interference:
  - The garment selected shall result in the least interference with the task but still provided the necessary protection.
  - The work method, location, and task could influence the protective equipment selected.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- Flash Suits must meet the following requirements:
  - Flash suit design shall permit easy and rapid removal by the wearer. The entire suit, including the hood's face shield, shall have an arc rating that is suitable for the arc flash exposure.
  - Where exterior air is supplied into the hood, the air hoses and pump housing shall be either covered b FR materials or constructed of non-melting and nonflammable materials.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

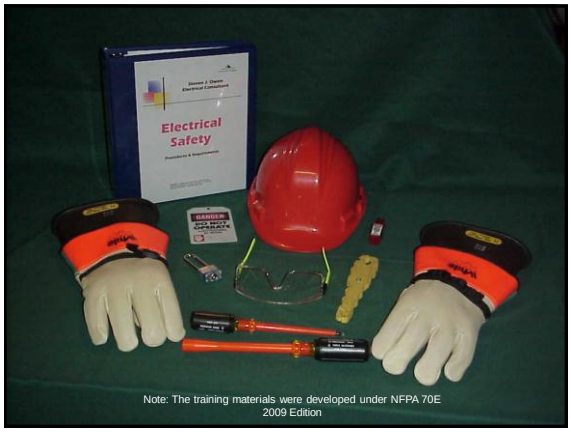
- Face Protection must meet the following requirements:
  - Face shield shall have an arc rating suitable for the arc flash exposure.
  - **Face shields without an arc rating shall not be used.**
  - Eye protection (safety glasses or goggles) shall always be worn under face shield or hoods.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- Hand Protection must consist of:
  - Leather or FR gloves shall be worn where required for arc flash protection.
  - **Where insulating rubber gloves are used for shock protection, leather protectors shall be worn over rubber gloves.**

Note: The training materials were developed under NFPA 70E 2009 Edition



Note: The training materials were developed under NFPA 70E 2009 Edition

PPE-OSHA, 1910.132(a)

- Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.

Note: The training materials were developed under NFPA 70E 2009 Edition

PPE-Employee Owned

- Employee-owned equipment. Where employees provide their own protective equipment, the employer shall be responsible to assure its adequacy, including proper maintenance, and sanitation of such equipment.

Note: The training materials were developed under NFPA 70E 2009 Edition

Why do you need a FR Clothing Program?

- Why do you need to pay attention to NFPA 70E and OSHA requirements for employee protection?
- Check out the cost comparison.
- Examples from Steel Grip

Note: The training materials were developed under NFPA 70E 2009 Edition

Why do you need a FR Clothing Program? Ex 1

- Accident cost before FR program
- Medical $ 812,677.00
- Indemnity 773,613.00
- Vocational 9,948.00
- Expenses 931.00
- TOTAL $ 1,597,229.00

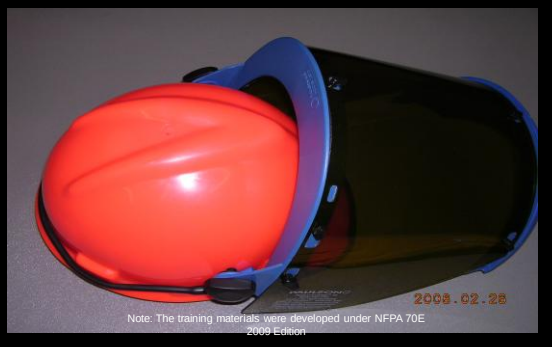
Note: The training materials were developed under NFPA 70E 2009 Edition

Why do you need to Wear FR Clothing?

- Accident cost AFTER implementing FR program
- Medical $ 9,213.00
- Indemnity 1,890.00
- Vocational 1,195.00
- Expenses 10.00
- TOTAL $ 12,308.00

Note: The training materials were developed under NFPA 70E 2009 Edition

Arc Flash Rated Face Shield



Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials [illegible] NFPA 70E [illegible]

Balaclava Sock Hood

Note: The training [illegible] developed under NFPA 70E [illegible]

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

How to Perform Work on or Near Energized Parts

Note: The training materials were developed under NFPA 70E 2009 Edition

Safe Work Practices
Voltage Testing

Note: The training materials were developed under NFPA 70E 2009 Edition

Safe Work Practices
Amperage Testing

Note: The training materials were developed under NFPA 70E 2009 Edition

Applies to both breakers and disconnects.

The Left Hand Rule

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E -2009

- ✓Article 120 Establishing an Electrically Safe Work Condition

Note: The training materials were developed under NFPA 70E 2009 Edition

- ✓ An electrically safe work condition shall be achieved when performed in accordance with the procedures of 120.2 and verified by the following process:
  - ✓ 1. Determine all of possible sources of electrical supply to the equipment (check drawings, diagrams, and identification tag).
  - ✓ 2. After ***properly interrupting load current,*** open disconnecting device(s) for each source.

Note: The training materials were developed under NFPA 70E 2009 Edition

120.1 cont'd

- ✓ 3 Wherever possible, verify blades are fully open or …
- ✓ 4 Apply lockout tagout devices (doc. policy).
- ✓ 5. Use adequate voltage detector. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground.
- ✓ 6. Where it could be reasonably anticipated that the conductors or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, apply ground connecting devices rated for the available fault duty.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 120 Establishing an Electrically Safe Work Condition

- ✓ Each employer shall identify, document, and implement lockout/tagout procedures conforming to 120.3 to safeguard employees from exposure to electrical hazards.
- ✓ The lockout/tagout procedure shall be appropriate for the experience and training of the employees and conditions as they exist in the workplace.

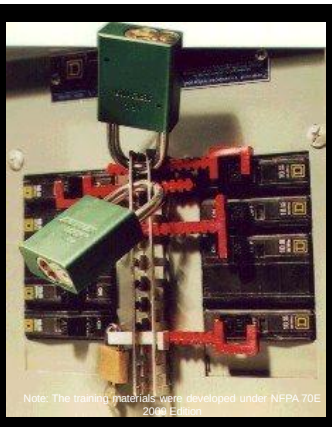
Note: The training materials were developed under NFPA 70E 2009 Edition

Article 120 Establishing an Electrically Safe Work Condition

- ✓ (A) General. All electrical circuit conductors and circuit parts shall be considered energized until the source(s) of energy is (are) removed, at which time they shall be considered deenergized.
  - ✓ Not considered to be in electrical safe work condition until all of the applicable requirements of 120 have to be met before it is considered de-energized.

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition



Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 120 Establishing an Electrically Safe Work Condition

- ✓ 120.2 (B) Principles of Lockout/Tagout Execution.
- ✓ (1) Employee Involvement.
- ✓ (2) Training.
- ✓ (3) Plan.
- ✓ (4) Control of Energy.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 120 Establishing an Electrically Safe Work Condition

- ✓ **120.2 (C) Responsibility.**
- ✓ (1) Procedures.
- ✓ (2) Form of Control.
- ✓ (3) Audit Procedures.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009

- ✓ 120.2(D)(2) Simple Lockout/Tag-out Procedure.
- ✓ Simple:
  - ✓ Involves only a qualified person(s) de-energizing one set of conductors or circuit part source for the sole purpose of performing work with in the Limited Approach Boundary electrical equipment shall be considered to be a simple lockout/tagout.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70 E

- ✓ Complex Lockout/Tagout Procedure:
  - ✓ Requires written plan of execution.
  - ✓ Authorized employee for a set number of employees working under the protection of a group lockout/tagout device(such as an operation lock).

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009

- Each authorized employee shall affix a personal lockout or tagout device to the group lockout device, group lockbox, or comparable mechanism when he or she begins work, and shall remove those devices when he or she stops working on the machine or equipment being serviced or maintained.
  - Tag must be used with lock out device with a statement prohibiting the removal of device or operation of the equipment

Note: The training materials were developed under NFPA 70E 2009 Edition

Lockout/Tagout
1910.147

- ***OSHA HAS DETERMINED THAT LOCKOUT IS, BY FAR, THE MOST EFFECTIVE MEANS OF PROVIDING EMPLOYEE PROTECTION, AND IS PREFERRED OVER TAGOUT.***
- ***OSHA has not accepted the argument that a qualified employee can work on energized circuits as safely as he or she can work on de-energized circuits.***

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130
Working On or Near Live Parts

- 130.1 Justification for Work
- 130.2 Approach Boundaries to Live Parts
- 130.3 Flash Hazard Analysis
- 130.4 Test Instruments and Equipment Use
- 130.5 Work On or Near Uninsulated Overhead Lines
- 130.6 Other Precautions for Personnel Activities
- 130.7 Personal and Other Protective Equipment

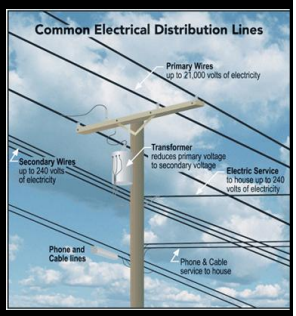
Note: The training materials were developed under NFPA 70E 2009 Edition

Selection and Use of Work Practices - 1910.333

- Intent of 1910.333 continued…
  - 1) De-energize the equipment involved and lockout its disconnecting means, or
  - 2) De-energize the equipment and tag the disconnecting means if the employer can demonstrate that tagging as safe as locking, or
  - 3) Work the equipment energized if the employer can demonstrate that it is not feasible to de-energize it.

Note: The training materials were developed under NFPA 70E 2009 Edition

- **Usually not insulated**
- **Examples of equipment that can contact power lines:**
  - **Crane**
  - **Ladder**
  - **Scaffold**
  - **Backhoe**
  - **Scissors lift**
  - **Raised dump truck bed**
  - **Aluminum paint roller**



Note: The training materials were developed under NFPA 70E 2009 Edition

Overhead Lines

- Lines must be de-energized and grounded before work is begun.
  - If protective measures are used, these shall include:
    - Guarding
    - Isolating
    - Insulating

Note: The training materials were developed under NFPA 70E 2009 Edition

Vehicular & Mechanical Equipment

- Any vehicle (except construction cranes at least 20 feet) that is capable of contacting overhead lines must be operated so that at no time it comes closer than 10 ft. to the overhead lines.

Note: The training materials were developed under NFPA 70E 2009 Edition

Unqualified Persons

- When unqualified persons are working near overhead lines, in an elevated position, such as from an aerial device, the person and the longest conductive object that he or she may be able to contact the line with must not be able to come within the following distances:
  - For voltage to ground 50Kv or below 10 ft
  - For voltage to ground over 50Kv - 10 ft. + 4 in for every 10Kv over 50Kv.

Note: The training materials were developed under NFPA 70E 2009 Edition

Qualified Persons

- When qualified persons are working in the vicinity of overhead lines, whether in an elevated position or from the ground, the qualified persons may not approach or take any conductive object closer to the exposed lines than specified in the appropriate OSHA Table: K-1 or Table S-1for 600 volts or less; and NFPA 70E Table 2-1.3.4.

Note: The training materials were developed under NFPA 70E 2009 Edition

Confined or Enclosed Work Spaces

1910.333 (c)(5)

- With installations in confined spaces OSHA requires that precautions be taken to assure that accidental contact does not occur.
  - Examples:
    - Protective blankets to shield live parts
    - Doors and panels required to be secured if they could knock into employees and cause them to contact exposed energized parts.
- There is also similar language in 70E.

Note: The training materials were developed under NFPA 70E 2009 Edition

Article 130 Working On or Near Live Parts

- Confined or Enclosed Work Spaces (additional 70E requirements)
  - Doors, hinged panels, and the like shall be secured to prevent their swinging into an employee and causing the employee to contact exposed energized electrical conductors or circuit parts operating at 50 volts or more or where an electrical hazard exists.

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Temporary Grounding for Personnel

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E – Temporary Protective Grounding Equipment

- 120.3 (A) Placement. Temporary protective grounds shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to hazardous differences in electrical potential.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E – Temporary Protective Grounding Equipment

- 120.3 (B) Capacity. Temporary protective grounds shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E – Temporary Protective Grounding Equipment

- 120.3 (C) Equipment Approval. Temporary protective grounding equipment shall meet the requirements of ASTM F855, *Standard Specification for Temporary Protective Grounds to be Used on De-energized Electric Power Lines and Equipment.*

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E – Temporary Protective Grounding Equipment

- 120.3 (D) Impedance. Temporary protective grounds shall have an impedance low enough to cause immediate operation of protective devices in case of accidental energizing of the electric conductors or circuit parts.

Note: The training materials were developed under NFPA 70E 2009 Edition

Temporary Protective Grounding

- OSHA Requirements

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

also known as Personal Protective Grounding

- … applies to the grounding of transmission and distribution lines and equipment for the purpose of protecting employees. Paragraph (n)(4) of this section also applies to the protective grounding of other equipment as required elsewhere in this section.

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

- For the employee to work lines or equipment as deenergized, the lines or equipment shall be deenergized under the provisions of paragraph (m) of this section and shall be grounded as specified in paragraphs (n)(3) through (n)(9) of this section.

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

- … if the employer can demonstrate that installation of a ground is impracticable or that the conditions resulting from the installation of a ground would present greater hazards than working without grounds, the lines and equipment may be treated as deenergized provided all of the following conditions are met:

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

(i) the lines and equipment have been deenergized under the provisions of paragraph (m) of this section.

(ii) There is no possibility of contact with another energized source.

(iii) The hazard of induced voltage is not present.

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

- Equipotential zone.

  Temporary protective grounds shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to hazardous difference in electrical potential.

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

- Protective grounding equipment
  - (i) No. 2 AWG copper, minimum. It shall be capable of carrying maximum fault current at point of grounding for time necessary to clear fault.
  - (ii) Low impedance. Low enough to cause immediate operation of protective device.
  - Guidelines found in ASTM F855-2009.

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

- **Testing**

Before any ground is installed. Lines and equipment shall be tested and found absent of nominal voltage, unless previously installed ground is present.

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

- **Order of connection.**

… the ground-end connection shall be attached FIRST, and then the other end shall be attached by means of a live-line tool.

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

- **Order of removal.**

… the grounding device shall be removed from the line or equipment using a live-line tool before the ground-end connection is removed.

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

- **Additional precautions**

When work is performed on a cable at a location remote from the cable terminal, the cable may not be grounded at the cable terminal if there is a possibility of hazardous transfer of potential should a fault occur.

Note: The training materials were developed under NFPA 70E 2009 Edition

1910.269(n) Grounding for the Protection of Employees

- **Removal of grounds**

Grounds may be removed temporarily during tests. During the test procedure, the employer shall ensure that each employee uses insulating equipment and is isolated from any hazards involved, and the employer shall institute any additional measures as may be necessary to protect each exposed employee in case the previously grounded lines and equipment become energized.

Note: The training materials were developed under NFPA 70E 2009 Edition

Meter Safety - How To Safely Measure Current/Voltage

Note: The training materials were developed under NFPA 70E 2009 Edition

Meter Safety

This is EXACTLY the WRONG way to do it!

Note: The training materials were developed under NFPA 70E 2009 Edition

Meter Safety

This is EXACTLY the WRONG way to do it!

Note: The training materials were developed under NFPA 70E 2009 Edition

Handheld test tool safety

Note: The training materials were developed under NFPA 70E 2009 Edition

Handheld test tool safety

Note: The training materials were developed under NFPA 70E 2009 Edition

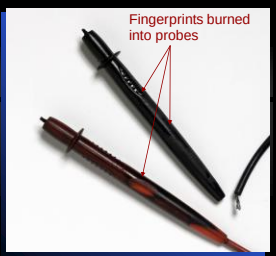
Handheld test tool safety

The wrong meter to use on a power circuit.

Note: The training materials were developed under NFPA 70E 2009 Edition

Handheld test tool safety

The electrician suffered severe burn injuries on his hand and arm.



Note: The training materials were developed under NFPA 70E 2009 Edition

Handheld test tool safety

Typical work environment

Note: The training materials were developed under NFPA 70E 2009 Edition

Handheld test tool safety

Aftermath of an accident

Note: The training materials were developed under NFPA 70E 2009 Edition

Handheld test tool safety

If it melts metal, what does it do to people?

Note: The training materials were developed under NFPA 70E 2009 Edition

Safety inspection

Test leads and probes

Check test lead resistance:

Step 1: Insert leads in V/ Ω and COM inputs.

Step 2: Select Ω , touch probe tips. Good leads are 0.1 - 0.3 Ω.

How do you check a *single* test lead?

Visually check for:

- CAT III-1000 V/CAT IV-600 V rating
- Double insulation
- Shrouded connectors, finger guards
- Insulation not melted, cut, cracked, etc.
- Connectors not damaged: no insulation pulled away from end connectors
- Probe tips: not loose or broken off

Note: The training materials were developed under NFPA 70E 2009 Edition

Safety inspection

Checking meter fuses on most meters

Step 1: Plug test lead in V/ Ω input. Select Ω .

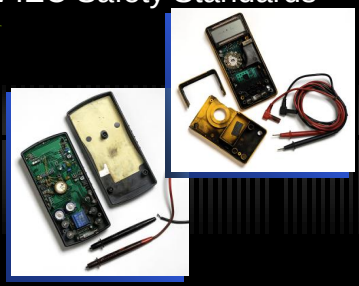
Step 2: Insert probe tip into mA input. Read value.

Step 3: Insert probe tip into A input. Read value.

Is the fuse okay? What would an open fuse read?

Note: The training materials were developed under NFPA 70E 2009 Edition

New IEC Safety Standards



Note: The training materials were developed under NFPA 70E 2009 Edition

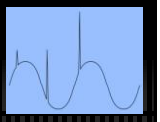
International Electrotechnical Commission

- IEC 61010 is the new standard for low voltage "test, measurement and control equipment".
- IEC 61010 provides much improved protection against "overvoltage impulse transients" - voltage spikes.
- IEC 61010 is the basis for:
  - ANSI/ISA-S82.01-94 (US)
  - CAN C22.2 No. 1010.1-92 (CAN)
  - EN61010-1:1993 (EUR)

Note: The training materials were developed under NFPA 70E 2009 Edition

IEC 61010 key concepts

Protection against overvoltage transients



- CATEGORIES: CAT I to CAT IV
  - The greatest danger from transients is in the high categories, because they could trigger an arc blast.
- IMPULSE TESTING: No failure allowed
  - Meters must be tested by being hit with a specified number of transients, with specified peak voltages.
- INTERNAL SPACING: increased
  - Clearance (distance through the air) and
  - Creepage (surface distance) are increased.

Note: The training materials were developed under NFPA 70E 2009 Edition

Overvoltage category

- The level and energy of voltage impulses is dependent on the location. The closer the location is to the power source, the higher the available fault current, the higher the category

Note: The training materials were developed under NFPA 70E 2009 Edition

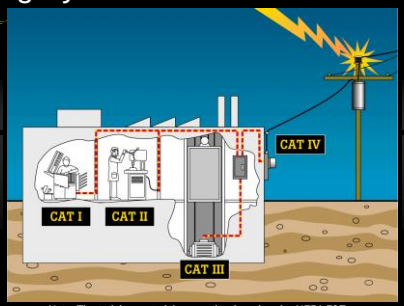
Overvoltage category

- IEC 61010 defines four locations or categories:

CAT IV	"Origin of installation" Utility level and any outside cable run
CAT III	Distribution wiring, including "mains" bus, feeders and branch circuits; permanently installed loads.
CAT II	Receptacle outlet circuit; plug-in loads.
CAT I	Protected electronic circuits

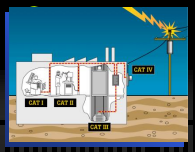
Note: The training materials were developed under NFPA 70E 2009 Edition

Category locations



Note: The training materials were developed under NFPA 70E 2009 Edition

CAT IV

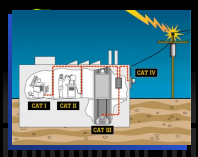


Equipment of overvoltage category IV is for use at the origin of the installation (utility service).

- Outside and service entrance
- Service drop from pole to building
- Run between meter and panel
- Overhead line to detached building
- Underground line to well pump22

Note: The training materials were developed under NFPA 70E 2009 Edition

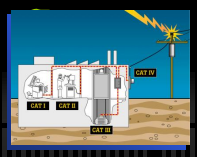
CAT III



- Premises wiring: "mains"circuits, i.e., bus and feeders and distribution panels
- Permanently installed loads: motors, lighting systems, drives, load centers
- Typically separated from utility service by at least a single level of transformer isolation
- Does *not* include receptacle plug-in loads, except in the case of heavy appliance outlets with "short" connections to service entrance

Note: The training materials were developed under NFPA 70E 2009 Edition

CAT II

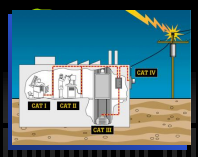


Loads that plug in at receptacle outlet

- Examples of such equipment are appliances, portable tools and other household and similar loads
- All outlets at more than 10 m (30 ft) from Category III
- All outlets at more than 20 m (60 ft) from Category IV

Note: The training materials were developed under NFPA 70E 2009 Edition

CAT I



Equipment in which measures are taken to limit transient overvoltages to an appropriately low level

Examples are protected electronic circuits. A copier that has an internal step-up transformer and 1000 Vdc is still a CAT I-1000 V machine, because the current levels are so low

Note: The training materials were developed under NFPA 70E 2009 Edition

First the CAT, then the voltage

- ✓ Voltage rating by itself can be misleading.
  - ✓ CAT III-1000 V (8 kV transient) is safer than CAT III-600 V (6k V transient)
  - ✓ But CAT III-600 V is safer than CAT II-1000 V
- ✓ First know the category you are working in, then choose the appropriate voltage rating.
- ✓ If you ever measure power circuits, you should use a CAT III-600 V or CAT IV 600 V/CAT III-1000 V meter.
  - ✓ And CAT IV 600 V/CAT III-1000 V test leads and probes.

Note: The training materials were developed under NFPA 70E 2009 Edition

Look for CAT III or CAT IV markings

Note: The training materials were developed under NFPA 70E 2009 Edition

Levels of CAT III protection

CAT	Transient with 2 Ω Source	Fuse and overload Rating	Clearance (air)	Creepage (surface)
III-1000 V IV-600 V	8000 V	1000 V	16.0 mm	16.0 mm
III-600 V II-1000 V	6000 V	1000 V	11.5 mm	14.0 mm
II-600 V	6000 V	600 V	11.5 mm	11.5 mm

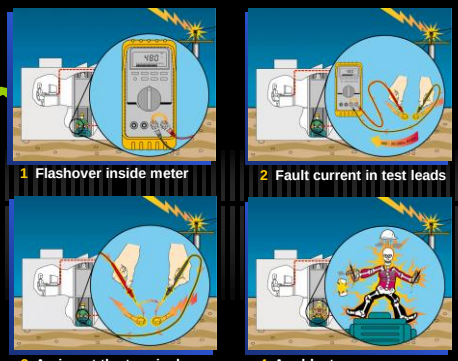
Note: The training materials were developed under NFPA 70E 2009 Edition

"Designed to IEC 1010-1"

But can the product pass testing...

	Brand A	Brand B	Brand C
Markings **Tested @**	CAT II – **750 V** CAT II – 1000 V	CAT III 1000 V Input Cat III – 1000 V	D of C to IEC 1010-1 CAT III – 1000 V
Creepage clearance	3.7 mm **Doesn't comply** with 5.7 mm	2.5 mm **Doesn't comply** with 16 mm	7.5 mm **Doesn't comply** with 16 mm
Transient tests	Input protection components opened	Display window breakdown under high voltage	Input protection components opened @ CAT II level

Note: The training materials were developed under NFPA 70E 2009 Edition



1 Flashover inside meter

2 Fault current in test leads

3 Arcing at the terminals

4 Arc blast

Note: The training materials were developed under NFPA 70E 2009 Edition

What's the bottom line?

- ✓ If you work on power circuits, you need a CAT III-600 V or CAT IV-600 V/ CAT III 1000 V meter.
- ✓ Look for the CAT rating and voltage rating marked near the input jacks.
  - ✓ CAT or voltage rating alone can be misleading
- ✓ Look for independent certification. UL 3111

CAT IV-600 V
CAT III-1000 V

Note: The training materials were developed under NFPA 70E 2009 Edition

What's the bottom line?

- ✓ If you use a scope on power circuits, you need a CAT III-600 V scope and scope probes.
- ✓ Look for the CAT rating and voltage rating marked near the input jacks.

CAT III-600 V

Note: The training materials were developed under NFPA 70E 2009 Edition

What's the bottom line?

Safety must be built-in

- ✓ An industrial grade meter devotes 10 % - 15 % of components exclusively to protection.
- ✓ Built-in protection against the most common safety hazards:
  - ✓ High voltage transients and danger of arc-over
  - ✓ Voltage contact while in continuity or resistance mode
    - ✓ High integrity components
  - ✓ Voltage measurement while test leads are plugged into amps jacks
    - ✓ High energy fuses

Overload protection on all functions

1000V high energy fuses

CAT IV-600 V
CAT III-1000 V

Note: The training materials were developed under NFPA 70E 2009 Edition

What about my old meter?

Unless a meter was specifically designed to meet CAT III-600 V or higher, it is not safe to use on power circuits. Most meters produced before 1997 do not meet the standard.

Original
Fluke 70 Series
NOT RATED

***Older* Fluke 70 Series-III**
CAT II-600 V
UNDER RATED

***New* 170 Series**
CAT IV-600 V
CAT III-1000 V

Newer meters also have additional features and capabilities

- Larger displays
- Back light
- 1000 Vac capability
- Capacitance
- Frequency
- Magnetic hangers
- Temperature
- 3X dc accuracy
- 2X ac accuracy
- Min / Max Record
- Probe holders
- Battery door

Note: The training materials were developed under NFPA 70E 2009 Edition

Meter safety checklist

Insist on these safety features:

- ✓ Fused current inputs (high energy fuses).
- ✓ Overload protection on the ohms function.
- ✓ Test leads that have shrouded connectors and finger guards.
- ✓ Recessed input jacks.
- ✓ Meet the latest safety standards (CAT III-600 V or CAT IV 600 V/CAT III 1000 V) and are independently certified.

Note: The training materials were developed under NFPA 70E 2009 Edition

Meter safety checklist

Watch for:

- ✓ Cracked or oily case
- ✓ Broken input jacks

No meter is safe when improperly used.

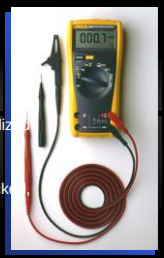
- ✓ Use meters within their rating.
- ✓ Use meters designed for measurements on power circuits.
- ✓ Use replacement fuses approved by the manufacturer.

Note: The training materials were developed under NFPA 70E 2009 Edition

Test lead safety checklist

Don't let test leads be a weak point

- ✓ CAT III-1000 V or CAT IV 600 V/ CAT III 1000 V rating
- ✓ Double insulation
- ✓ Shrouded connectors
- ✓ Arc Flash Hazard consideration using specializ probes and PPE materials
- ✓ Finger guards
- ✓ Insulation not damaged: not melted, cut, crack stretched
- ✓ Connectors: no insulation pulled away from end connectors
- ✓ Probe tips: not loose or broken off (too short)



Note: The training materials were developed under NFPA 70E 2009 Edition

Safety first

Safe practices include but are not limited to:

- ✓ Whenever possible, work on de-energized circuits. Follow proper lock-out/tag-out procedures.
- ✓ Use well maintained tools and appropriate safety gear
  - ✓ Safety glasses, insulated tools, insulating gloves, flash suits, insulating mats, etc.
- ✓ Don't work alone.
- ✓ Practice safe measurement techniques.
  - ✓ Always connect the grounded lead first, hot second.
  - ✓ Disconnect the hot lead first, grounded lead second.
- ✓ Use the three-point test method.
  - ✓ Test known circuit, measure target circuit, then re-test known circuit.

Note: The training materials were developed under NFPA 70E 2009 Edition

"Electrically Safe Work Condition"

- **Approach equipment wearing appropriate Personal Protective Equipment**
- **Stand to the side of equipment and look away**
- **Disconnect equipment**
- **Lockout/Tagout and then open door**
- **Test for absence of voltage**
- **Look around for potential hazards**
- **Use grounding straps if needed**

Note: The training materials were developed under NFPA 70E 2009 Edition

General Electrical Safety Precautions

- **Consider all electrical circuits energized until placed in a "Safe Work Condition"**
- **Never intentionally expose yourself to an electrical hazard**
- **Attend electrical Safety Training meetings including CPR classes**
- **Remove all metal jewelry**
- **Wear the proper protective based on the potential hazard present**

Note: The training materials were developed under NFPA 70E 2009 Edition

General Electrical Safety Precautions

- **All electrical systems are potential Killers, and ALL personnel should be aware of their dangers**
- **Most fatal electric shocks do not happen to the uninitiated, they happen to people who know better.**
- **No job is so important, or task so urgent, that we can not take the time to perform our work safely and in a professional manner**

Note: The training materials were developed under NFPA 70E 2009 Edition

Qualification & Training

Note: The training materials were developed under NFPA 70E 2009 Edition

ELECTRICAL SAFETY

Article 110 of NFPA 70E - 2009

- ✓ Safety-Related Work Practices
- ✓ 29 CFR 1910.331-335
- ✓ NFPA 70E Article 110 General Requirements for Electrical Safety-Related Work Practices

Note: The training materials were developed under NFPA 70E 2009 Edition

ELECTRICAL SAFETY
1910.331-335 OSHA

- ✓ **Scope - 1910.331-335**
  - ✓ Covers qualified persons and unqualified persons.
  - ✓ Rules:
    - ✓ Premises Wiring Installations of electrical conductors and equipment within or on buildings or other structures.
    - ✓ Wiring for Connection to Supply Installations of conductors that connect supply of electricity.
    - ✓ Other Wiring Installations of other outside conductors on the premises.
    - ✓ Optical Fiber Cable Installations of optical fiber cable where such installations are made along with electric conductors.

Note: The training materials were developed under NFPA 70E 2009 Edition

ELECTRICAL SAFETY
Article 110 of NFPA 70E

- ✓ **SAFETY-RELATED WORK PRACTICES**
  - ✓ **110.3 Responsibility**
  - ✓ **The safety-related practices contained in Part II shall be implemented by employees. The employer shall provide the safety-related work practices and shall train the employee who shall implement them.**
  - ✓ ***"CONTRIBUTORY NEGLIGENCE"***

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E – 2009
Host Employer Responsibilities

- ✓ The host employer shall inform contact employers of:
  - ✓ A. Known hazards
  - ✓ B. Information about installation
  - ✓ C. Observed contract-employer-related violations of this standard to the contract employer.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E – 2009
Contract Employer Responsibilities

- Contract employer has to:
  - communicate hazards to employees
  - Ensure that employees follows the work practices required by this standard and safety-related work rules required by the host employer.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009
Contract Employer Responsibilities

- The contract employer shall advise the host employer of:
  - a) Any unique hazards presented by the contract employer's work.
  - b) Any unanticipated hazards found during the contract employer's work that the host employer did not mention, and
  - c) Measures taken by contract and prevention of recurrent hazards

Note: The training materials were developed under NFPA 70E 2009 Edition

ELECTRICAL SAFETY
Article 110 of NFPA 70E/OSHA 1910.332

- **SAFETY-RELATED WORK PRACTICES**
  - **Training Requirements**
  - **The training requirements contained in this section shall apply to employees who face a risk of electrical hazard that is not reduced to a safe level by the electrical installations requirements .**

Note: The training materials were developed under NFPA 70E 2009 Edition

Training 1910.332 / 110.6

- NFPA 70E, **Safety Training:**
  - **Such employees shall be trained to understand the specific hazards associated with electrical energy.**
  - **They shall be trained in safety-related work practices and procedural requirements as necessary to provide protection from the electrical hazards associated with their respective job or task assignments.**
  - **Employees shall be trained to identify and understand the relationship between electrical hazard and possible injury.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Training 1910.332 / 110.6

- **The training required by this section shall be:**
  - **classroom or**
  - **on-the-job type, or**
  - **a combination of the two.**
- **The degree of training provided shall be determined by the risk to the employee.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Training, NFPA 70E

- **Employees working on or near exposed energized electrical conductors or circuit parts shall be trained in:**
  - **Methods of release of victims from contact with exposed energized conductors or circuit parts.**
  - **They shall be regularly instructed in methods of first aid procedures, such as approved methods of resuscitation, if their duties warrant such training.**
  - Training of employees in approved methods of resuscitation, including cardiopulmonary resuscitation, shall be certified by the employer annually.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009

- Qualified Employee Training.
  - Tasks that are performed less often than once per year shall require retraining before the performance of the work practices involved.
  - Training of employees in approved methods of resuscitation, including cardiopulmonary resuscitation, shall be certified by the employer annually.

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009

- Employee Training
- Unqualified Persons also need training to extent of hazards
- An employee shall receive additional training (or retraining) under any of the following conditions:
  - (a) Non compliance with the safety-related work practices.
  - (b) Changes or new technologies that require different work practices
  - (C) Employment of work practices not normally used

Note: The training materials were developed under NFPA 70E 2009 Edition

NFPA 70E - 2009

- The employer shall document that each employee has received the training.
- This documentation shall be made when the employee demonstrates proficiency in the work practices involved and shall be maintained for the duration of the employee's employment.
- Documents shall contain name and date of training.

Note: The training materials were developed under NFPA 70E 2009 Edition

Records of Training

Note: The training materials were developed under NFPA 70E 2009 Edition

Training 110.6(D) NFPA 70E, Qualified Person

- **Qualified Person**
- **Same as the 1999 NEC definition**
- **OSHA Definition: "one who is familiar with the construction and operation of the equipment and the hazards involved".**

Note: The training materials were developed under NFPA 70E 2009 Edition

2002 NEC

Qualified Person:

One who has the skills and knowledge related to the construction and operation of the equipment and has received *safety training* on the hazards involved.

Note: The training materials were developed under NFPA 70E 2009 Edition

Revised

Qualified Person:

This definition is used more than 90 times in the 2002 NEC. **It is also an essential definition in NFPA 70E, NFPA 70B, 79, and in OSHA 1910 and 1926 Standards.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Who or What Determines Who is a Qualified Person:

1. **The employer will determine who is qualified!**
2. **An electrical license issued by a city or state does not make a person qualified! **ND**
3. **not the AHJ.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Training: NFPA 70E 110.6(D)(1) Qualified Person.

- ✓ QUALIFIED PERSON: A qualified person shall be trained and knowledgeable of the construction and operation of equipment or a specific work method, and shall be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method.
- ✓ (a) Such persons shall also be familiar with the proper use of special precautionary techniques, personal protective equipment, ***including arc-flash,*** insulating and shielding materials, and insulated tools and test equipment.

Note: The training materials were developed under NFPA 70E 2009 Edition

Training: NFPA 70E 1-5.4.1

- ✓ QUALIFIED PERSON: Continued …
- ✓ A person can be considered ***qualified*** with respect to certain equipment and methods but still be unqualified for others.
- ✓ (b) An employee who is undergoing on-the-job training and who in the course of such training has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a qualified person shall be considered to be a qualified person for the performance of those duties.

Note: The training materials were developed under NFPA 70E 2009 Edition

Training: NFPA 70E 110.6(D)

- ✓ QUALIFIED PERSON: Continued …
- ✓ (c) Such persons shall be permitted to work within the Limited Approach Boundary of exposed live parts operating at 50 volts or more shall, at minimum, be additionally trained in all of the following:

Note: The training materials were developed under NFPA 70E 2009 Edition

Training:

Section 110.6(D) of NFPA
29 CFR 70E/1910.332

- ✓ The training requirements are almost the same:
  - ✓ (1) **The skills and techniques necessary to distinguish exposed live parts from other parts of electrical equipment.**
  - ✓ (2) **The skills and techniques necessary to determine the *nominal voltage* of exposed live parts.**
  - ✓ (3) **70E only: The approach distances specified in Table 130.2 (C) and the corresponding voltages to which the qualified person will be exposed.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Training:
Section 110.6(D) of NFPA 70E
29 CFR 1910.332

- ✓ OSHA table for approach distance is not the same.
- ✓ Not included in the OSHA standards
  - ✓ (4) **The decision-making process necessary to determine the degree and extent of the hazard and the personal protective equipment and job planning necessary to perform the task safety.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Training:
Section 110.6(D) of NFPA 70E

- ✓ **110.6 (D) Employee Training.**
- ✓ **1. Qualified Persons.**
- ✓ **d) Tasks that are performed less often than once per year shall require retraining before the performance of the work practices involved.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Training:
Section 110.6(D) of NFPA 70E

- ✓ 110.6(D)(2) Unqualified Persons.
  - ✓ **(2) Unqualified Persons.**
  - ✓ **Unqualified persons shall be trained in and be familiar with any of the electrical safety-related practices that might not be addressed specifically by Chapter 1, but are necessary for their safety.**

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Note: The training materials were developed under NFPA 70E 2009 Edition

Training: OSHA 1910.332

- ✓ Employees must be trained in, and familiar with, the safety-related work practices required by 1910.331-335 that pertain to their respective job assignments.
- ✓ **Unqualified employees must also be trained in, and familiar with, any electrically related safety practices not specifically addressed by 1910.331-335 but which are necessary for their safety.**

Note: The training materials were developed under NFPA 70E 2009 Edition

ELECTRICAL SAFETY PRINCIPLES

It's Just 40 Little Words

Plan Every Job
Anticipate Unexpected Events
Identify the Hazard
Minimize the Hazard
Use Procedures as Tools
Use the Correct Tools for the Job Task
Use Personal Protective Equipment
Isolate the Equipment
Assess People's Abilities
Protect the Person
Audit these Principles

Note: The training materials were developed under NFPA 70E 2009 Edition

CONCLUSIONS

- ✓ •***Anticipate the unexpected***
- ✓ A plan is needed to reduce risks of injury
- ✓ There are many elements to consider for the plan
- ✓ Document the elements into an Electrical Safety Program

Note: The training materials were developed under NFPA 70E 2009 Edition

Georgia Tech Research Institute

Electrical Safety, Arc Flash/Blast Injury Prevention for Management

Note: The training materials were developed under NFPA 70E 2009 Edition

This training course was produced under grant number SH-19442-09-06-F13 from OSHA, USDOL.