OSHA, 70E & PPE

North Texas AIHA/ASSE
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Topics

- OSHA & NFPA 70E Standards
- Qualified vs. Unqualified Employees
- Safety-Related Work Practices
- Arc Flash
- Hierarchy of Control
- NFPA 70E PPE Selection
- Examples of PPE
Terminology

- **Flame Retardant**
  - Chemical added to resist burning

- **Flame Resistant**
  - Combustion is prevented, terminated or inhibited
  - With or without removal of ignition source
  - Not tested for exposure to electric arc

- **Arc Rated**
  - FR clothing tested for exposure to electric arc
  - Replaces “flame resistant” in NFPA 70E-2012
When working on or near electricity or electrical equipment employees must be trained in & use Electrical Safety-Related Work Practices

NFPA 70E 2012

29 CFR 1910
OSHA’s Electrical Safety-Related Work Practices in General Industry

- 29 CFR 1910.331 - .335
  - .331 Scope
  - .332 Training
  - .333 LOTO - MAD’s - Safe work practices
  - .334 Use of equipment
    - Portable
    - Fixed
    - Test
  - .335 PPE & Warning

- Based in part on NFPA 70E
  - Standard for Electrical Safety in the Workplace
OSHA and NFPA 70E

- OSHA standards are the “SHALL”
- NFPA 70E is the “HOW”
These Standards apply to both Qualified Employees & Unqualified Employees Performing Electrical Work
Who is a Qualified Employee?
Qualified Employee is Competent in the Following:

- Safety-related work practices
- Safety procedures
- OSHA requirements
- Distinguishing live parts from others
- Determining nominal voltage
- Minimum approach distances (MADs)

Proper use of:

- Precautionary procedures
- PPE
- Insulating & shielding materials
- Insulated tools
Who is an **Unqualified** Employee?

EVERYONE WHO IS NOT A QUALIFIED EMPLOYEE!
Unqualified Employees

Are normally protected by the installation requirements by OSHA’s Electrical Standards

• General Industry - Subpart S (1910.301-.399)

Which requires

• No exposed live parts
• Live parts to be covered/protected

However

If their work exposes them to electrical hazards which would otherwise be protected -- they must be trained to recognize and avoid hazards they encounter or are likely to encounter while working
What electrical hazard is responsible for nearly 80% of the accidents, incidents and fatalities among Unqualified employees?

**Electrocution**

Usually associated with a lack of equipment grounding!
Qualified Employees

Are normally protected by the installation requirements in OSHA’s Electrical Standards

- General Industry - Subpart S (1910.301-.399)

Which requires

- No exposed live parts
- Live parts to be covered/protected

However

If their work exposes them to electrical hazards which would otherwise be protected -- they must be protected against ALL the electrical hazards:
Shocks - Electrocution - Arc Blast - Burns - Explosion
Safety-Related Work Practices

- Live parts must be deenergized unless
  - Create additional or increased hazards
  - Infeasible due to
    - Equipment design
    - Operational Limitations
  - <50 Volts, if no increased exposure to:
    - Electrical burns
    - Explosion due to electric arcs

NFPA 70E 130.2(A) page 22
Additional or Increased Hazards

- May not be able to interrupt
  - Life support equipment
  - Emergency alarm system
  - Ventilation of hazardous locations
  - Lighting

NFPA 70E 130.2(A) Information Note 1 page 22
Infeasible

- Diagnostics and testing of electrical circuits which must be performed “hot”
  - Startup or Troubleshooting

- Work on an integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment
  - Consider the implications for the operation of a refinery or chemical plant

NFPA 70E 130(A) Information Note 2 page 22
Working “Hot”

- **Qualified** employees may work on live parts that meet any of the 3 exceptions IF:
  - Electrical Work Permit (EWP)
    - Description of circuit/equipment & location
    - Justification why must work hot
    - Description of safe work practices to be used
    - Results of Shock Hazard Analysis
    - Results of Arc Flash Hazard Analysis
    - How unqualified restricted from area
    - Documentation of job briefing
    - Signature of authorizing person

NFPA 70E 130.2(B) pages 22-23
What electrical hazard is responsible for nearly 80% of the accidents, incidents and fatalities among Qualified employees?

Arc Blast / Arc Flash
Arc Flash Event

A dangerous release of energy created by an electrical fault

- Release will contain:
  - Thermal energy
  - Acoustical energy
  - Pressure wave
  - Debris
Arc Flash Events

- Can reach 35,000° F
- Fatal burns >10 feet
- Majority of hospital admissions are arc flash burns, not shock
- 30,000 arcs and 7000 burn injuries per year
- Over 2000 people admitted to burn centers yearly with severe arc flash burns
Variables that effect the size and energy of an electric arc flash:

- Amperage
- Voltage
- Arc Gap
- Closure time
- Distance away from arc
- 3-phase vs single phase
- Confined space
Arc Energy Basics

- Exposure energy (incident energy) expressed in cal/cm²
- \( \frac{1}{2} \) to 1 cal/cm² = hottest part of lighter in 1 sec
- 1.2 calorie exposure will cause second degree burn on human skin
- Typical non-AR (Arc Resistant) workwear can ignite @ 4-5cals
- Arcs typically release 5-30 cals - energies of 30-60 cals are not uncommon
Energy goes up dramatically as distance from arc drops:

**EXAMPLE:** 22,000A, 480V, 6 cycles:

<table>
<thead>
<tr>
<th>24”</th>
<th>18”</th>
<th>15”</th>
<th>12”</th>
<th>10”</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7 cal.</td>
<td>3.2 cal.</td>
<td>7.5 cal.</td>
<td>12.2 cal.</td>
<td>18 cal.</td>
</tr>
</tbody>
</table>

How close are **you** to the arc?
Appendix B (Hazard Assessment & PPE Selection)

**Engineering Solutions:**
- Guards
- Barriers
- Design Features

**Administrative Solutions:**
- Employee Training
- Standard Operating Procedures
- Hot Work Permit

**Personal Protective Equipment:**
- FR Clothing
- Hard Hat
- Safety Glasses

**Remember** – PPE is a last line of defense!
Other examples to protect employees from electrical hazards:

**Alerting Techniques**

- Safety signs and tags
- Barricades
- Attendants
Flash Protection Labeling

Arc Flash Hazard labeling must be posted which identifies:

- At least one of the following:
  - Available incident energy and working distance
  - Minimum arc rating of clothing
  - Required level of PPE
  - Highest HRC
  - Nominal system voltage
  - Arc flash boundary

NFPA 70E 130.5(C) 26
PPE Selection
PPE Requirements
1910.335(a)(1)(i)

The Note to this paragraph refs to Subpart I which requires:

Employers

- Must determine what is needed (Job Hazard Assessment)
- Must train employees on proper use of PPE
- Must enforce use of PPE

Employees must use the PPE!
How do I perform a JHA for PPE for Energized Work?

1. Perform a Shock Hazard Analysis

NFPA 70E 130.4(A) page 23
Determine the Shock Protection Boundaries

NFPA 70E 130.4(B) page 24
A number of “approach boundaries” exist and both qualified and non-qualified persons must understand these definitions.

“FLRPE”

See NFPA 70E, Annex C, Limits of Approach 61
Limited Approach Boundary

For SHOCK protection only!

- Energized part
- Prohibited
- Restricted
- Limited Approach Space
- Limited Approach Boundary

480v = 3 feet 6 inches

The closest distance an "unqualified" person can approach, unless escorted by a "qualified" person.

EFCOG-Energy Facilitation Contractors Group-DOE
Restricted Approach Boundary

For SHOCK protection only!

Energized part

Prohibited

Restricted Approach Space

Restricted Approach Boundary

The closest distance to exposed live parts a “qualified” person can approach without proper PPE and tools.

480v = 12 inches

To cross this boundary, the qualified person must wear PPE and have proper tools.

EFCOG-Energy Facilitation Contractors Group-DOE
Prohibited Approach Boundary

For SHOCK protection only!

Crossed **ONLY** by a “qualified” person, which when crossed by body part or object, requires the same protection as if direct contact was made with the live part.

EFCOG-Energy Facilitation Contractors Group-DOE
Approach Boundary Distances for SHOCK Hazard

- **NFPA 70E**
- **Alternating Current**
  - Table 130.4(C)(a) page 25
- **Direct Current**
  - Table 130.4(C)(b) page 26
- **Using Nominal System Voltage**
  - Limited Approach Boundary
    - Exposed Movable Conductor
    - Exposed Fixed Circuit Part
  - Restricted Approach Boundary
  - Prohibited Approach Boundary
How do I perform a JHA for PPE for Electrical Work?

2. Perform an Arc Flash Hazard Analysis

NFPA 70E 130.5 page 26
Arc Flash Hazard Analysis

- Considering overcurrent protection
  - Design
  - Opening time
  - Condition (i.e. maintenance)

- Determine:
  - Arc Flash Boundary
  - Incident energy at the working distance
  - PPE required within the flash boundary

NFPA 70E 130.5 page 26
How do I Determine the Incident Energy and Arc Flash Boundary?
Arc Flash Boundary & Incident Energy

- For 50 volts and up, arc flash boundary:
  - Distance at which a person is likely to receive a second degree burn
    - Incident energy = 1.2 cal/cm²

- See Annex D for calculation
  - Incident Energy
  - Arc Flash Boundary

NFPA 70E 130.5(A) page 26 and Annex D
Flash Protection Boundary

• The distance from exposed live parts within which a person could, at a minimum, receive a second degree burn if an arc flash were to occur.
• Arc flash PPE is required within this boundary.
• Note: Distance may be less than or greater than the shock protection boundaries.

EFCOG-Energy Facilitation Contractors Group-DOE
General PPE Requirements

- PPE that is designed and constructed for:
  - Body part to be protected
  - Work to be performed

  NFPA 70E 130.7(A) page 28

- Working within:
  - Restricted approach boundary
    - Use PPE per NFPA 70E 130.4
  - Arc flash boundary
    - Use PPE per NFPA 70E 130.5
General PPE Requirements

- Arc rated PPE must cover all ignitable clothing
- Nonconductive
  - Head protection
  - Face, neck, chin protection
- Hair or beard nets must be arc rated
- Eye protection
- Hearing protection within arc flash boundary
Selecting PPE based on Hazard/Risk Category (HRC) of Specific Tasks

NFPA 70E
130.7(C)(15)(a) and (b) and
130.7(C)(16)
NFPA 70E Hazard/Risk Categories

- **HRC 0** = Minimal risk
- **HRC 1** = Risk of 2\textsuperscript{nd} degree burn
- **HRC 2** = High risk of 2\textsuperscript{nd} degree burns and arc blast effects
- **HRC 3** = High risk of 2\textsuperscript{nd} and 3\textsuperscript{rd} degree burns and arc blast effects
- **HRC 4** = Greatest risk of 2\textsuperscript{nd} and 3\textsuperscript{rd} degree burns and arc blast effects
Table 130.7(C)(15)(a) – HRC Classifications and Use of Rubber Insulating Gloves and Insulated and Insulating Hand Tools (Alternating Current Equipment) – Formerly Table 130.7(C)(9) 33

Table 130.7(C)(15)(b) – HRC Classifications and Use of Rubber Insulating Gloves and Insulated and Insulating Hand Tools (Direct Current Equipment) 38

Table 130.7(C)(16) - Protective Clothing & PPE Equipment 39

**Pro:** Easiest and quickest method

**Con:** Provides the least amount of accuracy. Limited tasks are covered in tables
WARNING!

NFPA 70E 130.7 PPE Requirements

- Protect against:
  - Shock
  - Thermal effects of arc flash

- Do not protect against:
  - Physical trauma from arc blast
    - Debris
    - Pressure wave
    - Acoustical energy
Confused by Selection Process?

- Annex H
- Table H-2
  - Simplified
  - Two-category
  - Arc-rated clothing system
- Provides minimal arc-rated PPE for facilities with large and diverse electrical systems
- Other PPE for electrical hazards may be necessary
Table H-2

- HRC 1 and 2
  - Everyday Work Clothing
    - Arc-rated (minimum 8)
    - Long-sleeve shirt with pants, or
    - Coveralls

- HRC 3 and 4
  - Arc Flash Suit
    - Arc-rated (minimum 40)
    - Long-sleeve shirt with pants, and/or
    - Coveralls, and/or
    - Arc flash coat and pants
PPE
Hazard Assessment for PPE
1910.132(d)

• Employer must evaluate the workplace to determine if hazards are present which necessitate the use of PPE.

• If hazards are present, employer must select appropriate PPE, train employees on proper use, and require its use.

• Employer must certify completion of hazard assessment for PPE.

Certification must include:

• workplace evaluated
• person certifying completion
• date of the hazard assessment
• id of the document as certification of hazard assessment
When PPE is required, the employer must cover the following areas:

- When PPE is necessary
- What PPE is necessary
- How to properly don and doff PPE
- How to adjust and wear PPE
- The limitations of the PPE
- The proper care, maintenance, useful life and disposal of the PPE
Why is FR Needed?

- Most severe burn energies and fatalities are caused by non-flame resistant clothing igniting and continuing to burn.

- Flame resistant clothing will self-extinguish, thus limiting the injury.

- Body area under non-FR clothing is often burned more severely than exposed skin.
What is Flame Resistant Clothing?

- Clothing made from fabrics that self-extinguish
- Fabrics may be natural or synthetic
- Designed to limit (not eliminate) burn injury
- Survival, extent of injury, recovery time and quality of life are all dependent on FRC performance
Engineered Flame Resistant Fabrics

• Natural fibers
• Synthetic fibers
• Natural / synthetic blends

NOTE: Flame resistance must be durable to launderings, wear, the environment, etc. for the service life of the garment

Look for proven products!
Proper Use

• FRC should be appropriate to hazard
• Always the outermost layer
• Worn correctly; zipped, buttoned, etc
• All natural, non-melting undergarments
• Clean, no flammable contaminants
• Repaired correctly and removed from service when needed

• To comply with NFPA 70E-2012: MUST BE ARC-RATED
Insulating gloves come in two “type’s”:

**Type I**
-Pro: Greater flexibility and “feel”
-Con: Not ozone-resistant, will crack if exposed to ozone or UV over time.

**Type II**
-Pro: Ozone-resistant.
-Con: Not as comfortable to wear (less flexible)
**Insulating Gloves: Class**

<table>
<thead>
<tr>
<th>Tag Color</th>
<th>Class</th>
<th>Proof Test Voltage AC / DC</th>
<th>Max. Usage Voltage AC / DC</th>
<th>Glove Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beige</td>
<td>00</td>
<td>2,500 / 10,000</td>
<td>500 / 750</td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>0</td>
<td>5,000 / 20,000</td>
<td>1,000 / 1,500</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>1</td>
<td>10,000 / 40,000</td>
<td>7,500 / 11,250</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>2</td>
<td>20,000 / 50,000</td>
<td>17,000 / 25,500</td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>3</td>
<td>30,000 / 60,000</td>
<td>26,500 / 39,750</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>4</td>
<td>40,000 / 70,000</td>
<td>36,000 / 54,000</td>
<td></td>
</tr>
</tbody>
</table>

**FAST FACT**: Remember, it’s not the color of the glove that’s important – it’s the color of the tag!
Class & Type designations are found on the cuff portion of the glove.
Protector gloves need not be used with Class 0 gloves, under limited-use conditions, where small equipment and parts manipulation necessitate unusually high finger dexterity.

NFPA 70E-2012 130.7(C)(7)(a) Exception Note:
When protector gloves are not worn, ASTM F 496, Standard Specifications for In-Service Care of Insulating Gloves and Sleeves, must be followed.

Extra care is needed in the visual examination of the glove and in the avoidance of handling sharp objects.

**FAST FACT**: Do not use leather protectors alone for protection against electric shock. Serious injury or death could result. Always use proper rubber insulating gloves.
1910.335(a)(1)(ii) Protective equipment shall be maintained in a safe, reliable condition and shall be periodically inspected or tested, as required by 1910.137.

1910.335(a)(1)(iii) If the insulating capability of protective equipment may be subject to damage during use, the insulating material shall be protected. (For example, an outer covering of leather is sometimes used for the protection of rubber insulating material.)
# Protective Equipment Testing Schedule

<table>
<thead>
<tr>
<th>Equipment</th>
<th>When to Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gloves</td>
<td>Before first issue and every six months after that.*</td>
</tr>
<tr>
<td>Blankets / Sleeves</td>
<td>Before first issue and every 12 months after that.</td>
</tr>
<tr>
<td>Line Hose / Covers</td>
<td>Upon indication that insulating value is devalued.</td>
</tr>
</tbody>
</table>

* If the protective equipment has been electrically tested, but not issued for use it may not be placed in service unless it has been electrically tested within the previous 12 months.
Eye and face PPE shall be distinctly marked to identify the manufacturer.

Comply with ANSI Z87.1 Editions 1989, 1989(revised 1998), or 2003 or be at least as protective
Eye protection is required whenever there is danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion.

**Remember:** If using face shield for arc flash protection be sure to check the Minimum arc thermal protection value (ATPV) rating (in cal/cm²).
Comply with
ANSI Z89.1 Editions 1986, 1997, or 2003
or be at least as protective
ANSI Z89.1-1986 separates protective helmets into **two** different types and **three** different classes.

**Type 1** helmets incorporate a full brim (brim fully encircles the dome of the hat)

**Type 2** helmets have no encircling brim, but may include a short bill on the front
Regarding electrical performance, ANSI Z89.1-1986 recognizes three classes:

**Class A Helmets** reduce the force of impact of falling objects and also reduce the danger of contact with exposed low-voltage electrical conductors. Helmet shells are proof-tested at 2,200 volts of electrical charge.

**Class B Helmets** reduce the force of impact of falling objects and also reduce the danger of contact with exposed high-voltage electrical conductors. Helmet shells are proof-tested at 20,000 volts.

**Class C Helmets** reduce the force of impact of falling objects, but offer no electrical protection.
ANSI Z89.1-2003 no longer uses Type 1 and Type 2 to describe the brim characteristics of a protective helmet. The new Type designation is as follows:

**Type I** helmets offer protection from blows to the top of the head

**Type II** helmets offer protection from blows to both the top and sides of the head
Class G (General) Helmets - This is equivalent to the old Class A. Class G helmets are proof tested at 2,200 volts.

Class E (Electrical) Helmets - This is equivalent to the old Class B. Class E helmets are proof tested at 20,000 volts.

Class C (Conductive) Helmets - This class provides no electrical insulation; the class designation did not change from the old standard.
The following information must be marked inside the helmet

- Manufacturer's name
- The “ANSI Z89.1-YEAR” designation
- Class designation (G, E or C)
- Date of manufacture
Employees must use protective footwear when employee’s feet are exposed to:

- falling or rolling objects,
- objects piercing the sole,
- electrical hazards.

Comply with ANSI Z41 Editions 1991, 1999, or 2005 or be at least as protective.
Indicates ANSI standard met
PT indicates “protective toe” portion of standard

Indicates Male or Female
Impact resistance
Compression resistance

(Cd) conductive properties
(Mt) metatarsal resistance rating
(EH) electrical hazard
(PR) puncture resistance
(SD) static dissipative properties.
Electrical shock resistant (EH) footwear is manufactured with non-conductive electrical shock resistant soles and heels.

It must be capable of withstanding the application of 14,000 volts at 60 hertz for one minute with no current flow or leakage current in excess of 3.0 milliamperes, under dry conditions.
Insulating blankets, matting, covers, line hose, gloves, and sleeves made of rubber shall meet the following requirements:

- Manufacture and marking
- Blankets, gloves, and sleeves shall be produced by a seamless process.
- Each item shall be marked with its classification (i.e. Class 0 – Class 4)

**REMEMBER:**
- Non-ozone-resistant will be marked “Type I”
- Ozone-resistant will be marked “Type II”
If an employee provides their own protective equipment, the employer shall be responsible to assure its adequacy, including proper maintenance, and sanitation of such equipment.
When working near exposed conductors the employee must use insulated tools or handling equipment.