Electric Utility PPE Considerations

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Electric Utility PPE Considerations

Webinar Overview

- Arc Flash Understanding
- Applicable Utility Standards
  - Applicable Standards
  - Test Methods
- Importance of Wearer Protection
  - Arc Rated PPE
  - Burn Injuries
- PPE Considerations
  - Comfort
  - Life Cycle
  - Care and Maintenance
- Actual Fabric Comparisons
- Summary
Electric Utility PPE Considerations

Introduction
Electric Utility PPE Considerations

Introduction

Utility Line Work is Commonly Quoted as One of the Ten Most Dangerous Jobs in the U.S.

OHSA Estimates:

74 fatalities and 444 serious injuries occur annually for those workers involved in electrical utility work. *

Protection from the Unexpected – Hidden Dangers for Electric Utility Workers

Unexpected exposure to an arc flash event can cause serious burn injuries resulting in death. While these events may not be commonplace, the potential injuries can be very serious and life altering.


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A survey was conducted of 40 patients treated for electrical work injuries. Most patients had neurological (92.5%), psychological (90.0%), and musculoskeletal (72.5%) symptoms, which were documented on average 303.7 days after injury. 23 patients (57.5%, 14 electrical contact and 9 electrical flash) attempted to return to work on average 107.7 days after injury, but only 13 patients (32.5%, six electrical contact and seven electrical flash) successfully returned to work 59.38 days after injury.

**Sources:**
Arc Flash Overview
Physical arc is created when electricity conducts unpredictably between exposed phases or to a ground.

Arc flash can occur in low voltage (LV) and high voltage (HV) electrical systems.

Arc flash events can be caused by:
- Human error or improper training
- Poorly maintained equipment
- Equipment failure
- Poorly designed electrical systems

- Can Ignite / Melt Typical Work Clothing
- Burn Unprotected Skin
An Arc Event Presents Many Types of Hazards

- Intense Radiant and Convective Energy > 1.5 cal/cm²
  - 2nd & 3rd Degree Burns for Unprotected Skin
  - Ignition of Non-FR Clothing
- Typically Short Duration Events
- Molten Metal / Hot Gases / Smoke
- Secondary Fire (Area Equipment, Transformer Oils ..)
- Battery Acids
- Potential Concussive Forces / Projectiles
- Damaging Sound Pressure Level

Potential Temperature Exposures:* 

- Metal terminal temperatures ~ 35,000°F
- Intermediate plasma of arc ~ 22,000°F

Surface temperature of the sun ~ 10,000°F

Severe Burn Injuries Can Result with Exposures at Significant Distances from Conductors

Standards and Test Methods
Overview – Industry Standards

**OHSA 29 CFR 1910.269**

- Revised in 2014
- Covers the operation and maintenance of electric power generation, control, transformation, transmission, and distribution lines and equipment.
- Covers employer required training of utility workers and assurance of adherence to safety procedures
- Establishment of safe work practices, job briefings, and energy control procedures
- Requires hazard assessments and specifications for head to toe PPE
- Requirements for employers to establish minimum approach distances

**Hazard Assessment Tools**

- OHSA 29 CFR 1910.269 – Appendix E
- IEEE Std. 1584 - Guide for Arc Flash Hazard Calculations
- NESC - National Electrical Safety Code®
- NFPA 70E
Electric Utility PPE Considerations

Overview – Industry Standards

**NESC: National Electrical Safety Code**

Section 1 – 010. Purpose: *...practical safeguarding of persons, utility facilities, and affected property during the installation, operation, and maintenance of electric supply and communication facilities; under specified conditions*

- Code covers basic provisions for safeguarding workers engaged in the installation, operation, and maintenance of electric supply and communication facilities
- Standard of safe practices for adoption by public/private utilities and commissions
- NESC is a voluntary standard – State by State adoption decisions (part or full)
- Assists in complying with OSHA 29 CFR 1910.269
- Establishes work and safety rules for installation, operation, and maintenance
- Establishes guard zones and clearance distances
- Incident energy analysis tools
- Appropriate PPE selection – Clothing and Equipment

*This Code is not intended as a design specification or an operational manual*

THE NESC IS A SAFETY CODE
Overview – Industry Standards

NESC: National Electrical Safety Code®

Utility Worker Side of the Meter

Line Side

Load Side

Electric Supply

Premises Wiring

Industrial Electrician Side of the Meter

NFPA 70E: Standard For Electrical Safety In the Workplace
Overview – Industry Standards


- Provides Min Requirements for FR Arc Materials
  - Sewing Thread, Findings, Closures
  - Physical Characteristics (e.g., Fabric Strength)
  - Laundering Colorfastness & Shrinkage
  - Vertical Flammability (New and 25x Cleaning Cycles)
  - Labeling Specifics (Arc Rating, Fiber Content, etc.)

- Primarily for Manufacturers
  - Testing Reports Available to Garment Purchasers

- Manufacturer Self-Certification
Determine Arc Rating (cal/cm$^2$) of FR System

- The Energy Level predicting a 2nd Degree Burn Occurring. Referred to as Arc Thermal Performance Value (ATPV) or the Energy Level to Break-open The Fabric(s) (Ebt)

Specimens Tested On Flat Panels

Simulated Open Arc

Minimum 20 Panels Test

Sensors Measure Heat from Arc
  - Incident Energy of Arc
  - Energy Transmitted Through Specimen

**ARC rating (cal/cm$^2$):** The Energy Level With 50% Probability of 2$^{nd}$ Degree Burn Occurring *(Referred to as Arc Thermal Performance Value (ATPV)) or The Energy Level to Break-open The Fabric(s) (Ebt)*
**ARC rating (cal/cm²):** The Energy Level With 50% Probability of 2nd Degree Burn Occurring *(Referred to as Arc Thermal Performance Value (ATPV)) or The Energy Level to Break-open The Fabric(s) (EBT)*

**Arc Thermal Performance Value (ATPV):**
incident energy with a 50% probability of sufficient heat transfer through the fabric to predict onset of a second-degree burn*

**Energy Breakopen Threshold (EBT):**
incident energy with a 50% probability of fabric breakopen. Breakopen is an open area at least 1.6 cm² (0.5 in.²)**

**ARC rating (cal/cm²)** for a fabric is reported as the lesser of ATPV or EBT for the fabric tested

* Based on the Stoll Curve, cal/cm²
** Test sensor may not record sufficient energy to predict the onset of a second degree burn
Wearer Protection – Arc Flash
Wearer Protection – Arc Flash

Complacent:

...without awareness of some potential danger or defect.

Personal Risk Assessment

- Human nature to assess risk based upon personal experiences
- Experiences can provide great learning opportunities
- Challenge – risk decisions based on experience alone
- Workers may lack experience and ability to imagine consequences
- Low Frequency/High Consequence Severity

Each time you take a risk and do not suffer a bad consequence, the belief the task was safe is reinforced or the risk of injury and negative consequence is perceived as so low, it is not worth concern.

Success Breeds Complacency

REMEMBER

Performing a task previously without injury, does not suggest you are safe from harm or the risk of injury is low enough it's not worth concern.
Safety & Health Program

1. Culture
   - Attitudes, Beliefs, Understanding

2. Engineering
   - Technical solutions to make equipment safer

3. Work Practices
   - Proper Tools
   - Proper Procedures

4. PPE

PPE - Last Line of Defense

- Clothing
- Eye Protection
- Foot Protection
- Head Protection
- Hand Protection
- Hearing Protection
- Respiratory Protection

Wearer Protection – Arc Flash

- Leadership & Expectations
- Accountability & Consequences
- Right Metrics
- Right Organization & Structure

- Thermal Hazards &
- Flame Resistant Apparel
Wearer Protection – Arc Flash

Flame Resistant and Arc Rated PPE

- Does Not Ignite & Burn
- Does Not Melt & Drip
- Maintains A Barrier
- Insulates Wearer from Heat
- Resists Breaking Open

Reduces Burn Injury & Increases Chances of Survival

Burn Injuries Can Still Occur Using FR Clothing
Non-FR Fabrics Can Ignite and Burn and Melt When Exposed to An Electric Arc

Non-FR Cotton

Before Electric Arc Flash

During Electric Arc Flash

After Electric Arc Flash

The Untreated Cotton Garment Did Ignite and Continued to Burn.
Electric Utility PPE Considerations

Wearer Protection – Arc Flash

Arc Rated Garments Will Resist Ignition and Offer Increased Protection

Arc Rated PPE

Before Electric Arc Flash

During Electric Arc Flash

After Electric Arc Flash

Arc Rated Garment Did Not Ignite nor Break-Open
Arc rated PPE is designed to reduce potential burn injury as a result of exposure to a arc flash event.

**NESC – 2012, 410.A.3:** potential exposures greater than 2 cal/cm² requires arc rated clothing not less than anticipated arc energy.

**NESC** allows use of non-FR under layers to be worn with a flame resistant outer layer.

- All clothing systems should be arc tested to ensure adequate protection
- All under layers should be no-melt, no-drip
- Recommend flame resistant and/or arc rated under layers
- Layering of arc rated garments can provide greater protection

**PPE or Work Wear Should be Arc Rated, Not Just “FR”**
Electric Utility PPE Considerations

Wearer Protection – Arc Flash

OSHA Accident Report Investigation Detail

Accident: 200535078 - Three Employees Were Burned In Flash Arc Fire

Report ID: 0751910 -- Event Date: 06/06/2012
Inspection: 316574011

- At approximately 9:00 a.m. on June 6, 2012, Employee #1 an electrical engineer, Employee #2 and Employee #3, electrical workers
- Employee #2 wearing a long sleeve arc rated (ATPV 7.7) shirt and non-flame resistant denim jeans, work boots, hard hat and safety glasses
- A fault occurred, 4160 volts, and caused an arc flash. Employee #1 and #2 approximately 10 feet from the arc flash
- Employee #2 jeans ignited. Employee #1 attempted to roll #2 and pat out the flames
- Emergency Response Team (ERT) was alerted by another employee in the area at the time of the event
- ERT members, responded immediately with a fire extinguisher. Employee #2 was extinguished with a fire extinguisher.
- A polyester blanket was placed over Employee #2 to cover and prevent shock. The blanket caught fire from still smoldering jeans.
- Fire extinguisher was used a second time to extinguish Employee #2’s jeans.
- One responder reported that a fire appeared to be coming from under Employee #2, so they rolled him and patted the fire down again
- Employee #1 was burned on his hands while trying to extinguish Employee #2. Employee #1 had flash burns to his face, with blisters in some areas. Employee #1 was taken by ambulance and kept overnight in the hospital.
- Employee #2 was not as seriously burned on his head and neck as he was on the lower portions of his body. Employee #2’s pants were consumed in the fire, Employee #2 was flown via medical helicopter to a hospital burn unit, with burns on 55% of his body

Non-FR jeans ignited and continued to burn despite immediate efforts of emergency response personnel to extinguish the flames. Employee suffered burns on 55% of his body, mostly on the lower portions where the non-FR clothing was worn.
Burn injuries of 40% - 60% body burn*

- Average hospital stay duration
  - 54 Days (survivor)
  - 21 days (fatality)

- Average cost of hospital stay
  - $780,000 (survivor)

- Additional Costs: lawsuits, productivity losses, OSHA fines, insurance claims

A well designed and executed PPE program can potentially cost significantly less than a single burn injury claim

*Source: American Burn Association
National Burn Repository® 2013
Chances of surviving a fire decrease…

- Burn Injury
- Age

Source: American Burn Association 2011 study
Wearer Protection – Arc Flash

**Hospital Costs** – Depending on the % total body burn, hospital costs can be upwards of $1MM.

*Survivor Hospital Cost*

On Average:

1 day spent in the hospital for every 1% body burn

Source: 2014 National Burn Registry Annual Report
Hospital Costs – Even fatal burn injuries can carry high hospitalization costs.

Fatality - Hospital Cost

Source: 2014 National Burn Registry Annual Report
PPE Considerations
Electric Utility PPE Considerations

3 Pillars of Comfort

- Thermal Comfort
- Moisture Management

- Fabric Hand

- Garment Fit Design

Balance of Properties
Light Weight
- Fabric weight has significant impact on thermal comfort and heat stress

Breathability
- Air flow improves evaporative and convective cooling
- Lower likelihood of heat stress

Fabrics Which Absorb and Repel Moisture
- Aids with evaporative cooling. Push-Pull effect

Moisture Dissipates Across Fabric Surface
- Can enable faster drying. Key factor in feeling cool and dry

How to Measure?

Fabric Weight (Actual)

Air Permeability

Drying Rate Moisture Regain Sweating Manikin

Vertical Wicking
Data can provide comfort guidance, but always conduct a wear trial

The Key: All Factors Must Be In Balance!
Ease of Care and Durability

Ease of Laundering
- Soil Release Properties
- Contaminate Removal vs. Redistribution

Special Laundering Procedures
- Bleach
- Hard Water
- Others

Effect of Laundering on Garment Properties
- Wear Durability
- Replacement and Repairs
Value:

...the material or monetary worth of something...the worth of something compared to the price paid or asked for it.

Conditioned to Look at Initial Procurement Cost

Pressure to save money on the front end decision for short term gains
The cheaper alternative is not always the least expensive to own.

Must Consider

Quality
Cost Effectiveness
Total Life Cycle Costs
Long Term Performance
Wearer Safety

Identify key fabric considerations to choose a FR PPE program with the best long term value; save more money over time than is possible through initial purchase price considerations alone.

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PPE Considerations

Cost Effectiveness can be gauged by Garment Life Cycle

Attribute Measurements
- Field Trials and Actual Use
- Fabric/Garment Testing

Key Considerations
- Durability
  - FR Protection Durability
  - Fabric and Garment Wear Durability
  - Repair/Replacement Frequency
- Launderability
  - Soil Release Properties
  - Ease of Care
- Appearance

Garment Life Cycle is a Result of the Fabric Long Term Care Characteristics

Repair and Replacement Costs Are Significant
Fabric Comparisons
### DuPont Nomex® MHP 7.0oz
- Actual Weight 7.0 oz/sqyd
- Multiple Hazard Protection
- ATPV 8.4
- Inherent Nomex® and Kevlar® Based engineered Blend
- Flame resistant properties not affected by laundering
- Tested to 200 industrial launderings

### FR Treated Cotton 88/12 7.0 oz
- Typical Actual Weight 8.0 oz/sqyd
- Multiple Hazard Protection
- ATPV 8.7
- 88% Cotton, 12% Nylon
- Flammable cotton fabric treated to retard ignition
- Flame retardant properties can be affected by laundering

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**When Considering PPE Choices, The Fabric Determines Many of the Desirable Garment Characteristics**
IFTH Comfort Study Results

Nomex® MHP is the overall winner on key comfort criteria while keeping the Nomex® and Kevlar® strength.

Best Scores For

- **Softness:** Pleasant sensation to the touch
- **Smooth:** Low perception of harshness
- **Thinnest:** Low height of the samples perceived between fingers
- **Most drape:** Evaluates the falling of the material under its own weight
- **Most Supple:** Capacity of the fabric to slid between fingers without resistance
- **Least voluminous:** Perceived quantity of residual material after squeezing it on the hand
- **Crease recovery:** Capacity of the fabric to recover its initial shape
- **Least Noisy:** Hearing perception resulting from the friction of the material with itself.
**Moisture Regain %**

Measures how much moisture is absorbed by a fabric from its surroundings.

- Fabrics which absorb moisture easier can be prone to slowly releasing *(more water to dry)*.
- Goal is to find optimized fabrics which transport **and** also effectively release moisture.

**Drying Rate**

<table>
<thead>
<tr>
<th></th>
<th>Residual Water (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nomex® MHP</td>
<td>80</td>
</tr>
<tr>
<td>88/12 FR Treated Cotton</td>
<td>40</td>
</tr>
</tbody>
</table>

**Encourages Wearer Acceptance**

Helps with Heat Stress
High Aramid Content

Strength, Durability, Appearance

Nomex® MHP can provide better durability

60% Higher break strength after laundering compared to FRTC 88/12

Break strength + Abrasion Resistance = Predicted Durability

Fabric Comparison

Electric Utility PPE Considerations

Nomex® MHP

100X IL

FRTC 88/12

200X IL

Lbs.

Break Strength (Warp + Fill)

100X IL

200X IL

133

185

115

Nomex® MHP

FRTC 88/12

Cycles

Abrasional Resistance

100X IL

200X IL

862

430

625

351

Nomex® MHP

FRTC 88/12

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Electric Utility PPE Considerations

Fabric Comparison

**Superior Fit Retention and Professional Appearance**

**Low Shrinkage = Better Fit Retention**

- 50+% less shrinkage
- 25 washes (FRTC 88/12)
- 37% less shrinkage
- 100 washes (FRTC 88/12)
- 48% less shrinkage
- 200 washes (FRTC 88/12)

**Color Fastness = Appearance Retention**

- 20% less color loss
- 25 washes (FRTC 88/12)
- 160% less color loss
- 200 washes (FRTC 88/12)

**Graphs**

- Laundry shrinkage (%)
  - 25x IL: 3.44, 8.39
  - 100x IL: 5, 7.89
  - 200x IL: 5.67, 10.9

- Delta E
  - Industrial laundry color fastness (25xIL): 2.026
  - 200xIL: 4.2
  - FRTC 88/12: 2.428

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DuPont Nomex® MHP Can Provide a Lower Life Cycle Cost

- Low shrinkage
- Better durability
- Excellent appearance retention

Saves Money Over Time

Fabric Comparison

TOTAL COST OF OWNERSHIP COMPARISON

- FRTC 88/12
- Initial Cost $65

- Nomex® MHP
- Initial Cost $85

$17,500 |

Replacement Costs Can Be Significant

* Assumptions: 200 wearer program, 6 year model, 4 sets of PPE per employee

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Summary
Conclusions and Summary

- Arc flash exposure can cause serious injury and death
- A single burn injury can cost millions and impose human suffering
- Proper PPE matching the assessed hazard is essential to worker safety
- Choose Fabric First - Fabric properties dictate desirable garment Properties
- Greater comfort encourages worker acceptance and can reduce potential heat stress
- Greater durability leads to a longer garment life cycle
- Do not accept substitutions or “just as good” choices

One Small Mistake Can Lead to a Lifetime of Consequences
For additional questions – please feel free to reach out to Dennis directly at:

Dennis.L.Mater@dupont.com

In addition – you can ask our team questions *live* at the upcoming NSC show – *booth # 1439*
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