The Electric Arc Flash Hazard and the Last Line of Defense

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70E PPE 2 Arc Flash (480v)

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 Intensity

• Variables that effect the size and energy of an electric arc flash are:
  • Amperage
  • Voltage
  • Arc Gap
  • Cycle time
  • Distance away from arc
  • 3 phase v single phase
  • Confined space

Arc Energy Basics

• Exposure energy expressed in cal/cm²
• ½ to 1 cal/cm² = hottest part of lighter in 1 sec
• An exposure of only 1-2 calories will cause second degree burn on human skin
• Typical non-FR workwear can ignite @4-5cals
• Arcs typically release 5-30 cals, and energies of 30-60 cals are not uncommon
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, **7000** burn injuries per year

*Over **2000** people admitted to burn centers yearly with severe arc flash burns*

Why is FR, AR Needed?

- Most severe burn injuries 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/Arc Rated 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
Introduced as “INDURA Ultra Soft” in 1999, Now Ultra Soft

- Guaranteed Flame Resistant for the Life of the Garment
- Improved much Softer Feel
- 12% High Tenacity Nylon Focused on the Face of the Fabric
- Substantially Improves Abrasion Resistance
- Extends Garment Wear Life by Over 75%
- Enhanced Flash Fire and Electric Arc Protection

TECHNOLOGY

The INDURA® technology combines

- Special Preparation Process
- Custom Engineered Equipment
- Advanced Process Controls
- Several Additional Proprietary Processing Steps
- Computer Monitoring Equipment to Measure Consistency and Quality of the FR Technology
New World of AR/FR Clothing

• FRC used to be perceived as ugly, uncomfortable, expensive, scratchy, hot and not breathable
• Major shift last 3-5 years to lighter, softer more breathable fabrics and to styles virtually identical to “street clothing”
• Examples include Nomex blends, FRMC, UltraSoft®, knits, fleeces, denims.

Engineered Flame Resistant Fabrics

• Natural fibers
• Synthetic fibers
• Natural / synthetic blends

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

  • Look for proven products!
Bottom Line: ALL FR Fabrics are “Engineered” to be Flame Resistant

• “Inherent” & “Treated” are Marketing Term

• Key- The flame resistance must be durable to launderings, wear etc. for the service life of the garment
• Key- Whether Synthetic, Natural or Blends; LOOK FOR MARKET PROVEN PRODUCTS!

FR Cotton/ Cotton Blend Fabrics

• A.R.C. & Sparkguard by Magid Glove
• Benchmark FR
• Walls FR (Itex China)
• Banox/ Banwear by Itex
• Dale Antiflame
• Firewall by Marv Holland
• StormMaster
• Beslin
What Is a Burn?

• A chemical process which progressively injures skin; severity relates to depth

• 1st: redness, pain – not permanent

• 2nd: blistering – skin will regenerate

• 3rd: total skin depth destroyed. Will not regenerate – requires grafting

What Is Important?

• Three factors: extent, severity, location

• Extent expressed as % body surface reaching 2nd and 3rd degree. Closely linked to survivability

• Severity, location linked to quality of life
Survival

• Burn percentage, more than severity, predicts survival because skin is infection barrier
• 2nd and 3rd degree break skin, providing an infection pathway
• Most hospital deaths 2-4 weeks post-exposure are infection (gram-neg staph)

Survival Factors

• Odds of survival fall with total % burn
• Odds of survival fall precipitously above 50% burn
• Odds of survival fall as age increases
The Bottom Line

- Accidents happen
- “Street Clothing” can and does worsen injury
- you can’t do anything about your age

- But -
you can do something about your clothing

70E HRC 2 Arc Flash (480v)
Arc Flash Incident –

Man working at school dies of injuries from fire

April 18, 2004 — A Elmhurst man is dead six days after being burned in a fire at Chicago’s Wright Elementary School. Pivodz Djokovic, 34, was doing electrical work at the school on North Harding Avenue.

According to the Cook County medical examiner, the man he was working on sparked setting his clothing on fire. He died at Stroger Hospital yesterday afternoon.

Wright will remain closed for repairs for the rest of the school year.
Identifying Appropriate FR: 70E

- *Standard for Electrical Safety in the Workplace*
- Covers industrial personnel
  - Electricians
  - Maintenance workers
  - Operators
What’s Significant about 70E

CHANGE!
• Focused on injury reduction, 1) self extinguish and 2) insulate from burn
• Quantification of hazard
• Correlation of fabric performance to specific hazard
• 2015 version latest Edition

How Do I Find My Hazard Level

• Engineering Firm
  • Lewellyn
• NFPA 70E HRC Tables.....Now PPE Category
• NFPA Annex H
  • Simplified Method
### NFPA 70E Task/Condition tables

<table>
<thead>
<tr>
<th>Task</th>
<th>Equipment Condition</th>
<th>Arc Flash PPE Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading a panel meter while operating a motor switch</td>
<td>Any</td>
<td>No</td>
</tr>
</tbody>
</table>

#### Notes:
- Normal operation of a circuit breaker (CB), switch, contactor, or motor.

### NFPA 70E Task / PPE Category and Boundary

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Arc Flash PPE Category</th>
<th>Arc Flash Boundaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 V other equipment rated 240 V and below</td>
<td>1</td>
<td>400, 1,500</td>
</tr>
<tr>
<td>Permanently installed device rated 240 V and below</td>
<td>1</td>
<td>400, 1,500</td>
</tr>
<tr>
<td>Permanently installed device rated 240 V and above</td>
<td>1</td>
<td>400, 1,500</td>
</tr>
<tr>
<td>240 V other equipment rated 480 V and below</td>
<td>2</td>
<td>300, 1,000</td>
</tr>
<tr>
<td>240 V other equipment rated 480 V and above</td>
<td>2</td>
<td>300, 1,000</td>
</tr>
<tr>
<td>480 V other equipment rated 600 V and below</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>480 V other equipment rated 600 V and above</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>600 V other equipment rated 600 V and below</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>600 V other equipment rated 600 V and above</td>
<td>4</td>
<td>50</td>
</tr>
</tbody>
</table>

#### Notes:
- Required for all exposed live parts of exposed live parts of exposed live parts.
Identify Minimum ATPV and System based on PPE Category From Table 130.7(C)(11)

<table>
<thead>
<tr>
<th>PPE Category</th>
<th>Clothing Description</th>
<th>Minimum ATPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Arc Rated (AR) Shirt and AR Pant or AR Coverall</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Arc Rated Shirt and AR Pant or AR Coverall</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Arc Rated AR Shirt and AR Pant or AR Coverall, and arc flash suit system to meet minimum</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>Arc rated Shirt, FR Pant or coverall and arc flash suit system to meet minimum</td>
<td>40</td>
</tr>
</tbody>
</table>
The 70E Solution

- National trend is **single layer PPE 2 daily wear** and PPE 4 flash gear (Annex H)
  - Don’t delay critical steps
Informative Annex H

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

<table>
<thead>
<tr>
<th>Clothing*</th>
<th>Applicable Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Everyday Work Clothing</strong></td>
<td>All arc flash PPE category 1 and arc flash PPE category 2 tasks listed in Table 130.7(C)(15)(A)(a) and Table 130.7(C)(15)(A)(b), and task 130.7(C)(15)(B)</td>
</tr>
<tr>
<td>Arc-rated long-sleeve shirt with arcm-rated pants (minimum arc rating of 8)</td>
<td>or</td>
</tr>
<tr>
<td>Arc-rated coveralls (minimum arc rating of 8)</td>
<td></td>
</tr>
</tbody>
</table>

*Arc Flash Suit
A total clothing system consisting of arc-rated shirt and pants and/or arcm-rated coveralls and/or arc flash protective clothing. The minimum arc rating of the system depends on the minimum arc rating of the components and protective clothing.

*Note that other PPE listed in Table 130.7(C)(16), which include arcm-rated face shields or arc flash suit hoods, arcm-rated hard hat liners, safety glasses or safety goggles, head bands, hearing protectors, rubber gloves, rubber insulating gloves, and leather protective footwear are required. The arc rating for a garment is based on the rating of the garment as a whole.

*The estimated available short-circuit current capacities and flash clearing times or arc ratings are listed in the text of Table 130.7(C)(15)(A)(a) and Table 130.7(C)(15)(B). Various tasks are listed in Table 130.7(C)(15)(A)(a) and Table 130.7(C)(15)(B). For tasks not listed or for power systems with power greater than the estimated available short-circuit capacity or with longer durations, an arc flash hazard analysis is required in accordance with 130.5.
Arc Rating

- ASTM F1959 Test Method Defines Fabric Performance in Electrical Arc Flash

- ATPV – Incident energy (cal/cm²) that results in 50% likelihood of onset of 2nd degree burn under fabric

ASTM F1959 Testing

- Fabric panels are subjected to electric arcs
- Calorimeters measure heat transfer through fabric
- Voltage, amperage, gap and distance are held constant
- Duration (cycles) are varied to achieve higher and lower energies
Layered Arc Ratings (20 cal)

- UltraSoft- 8.7 over 8.7 = 26.8 cal/cm²
- UltraSoft 8.7 over 8.9 knit= 29 cal/cm²
- UltraSoft 12.4 over 8.7 = 32.2 cal/cm²
- UltraSoft 12.4 over 8.9 knit = 31 cal/cm²
- UltraSoft- 8.7 over 8.2 iQ knit =27 cal
ASTM F1506

• Standard Specification for Flame Resistant Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards

• Describes minimum performance requirements
• Consensus standard
• Requires Arc Rating in label of garment

Comfort – The Bottom Line

• Never make comfort decisions from graphs, data, office samples or appearance

• There is simply no substitute for a wear test
Comfort & Heat Stress

- Comfort is inherently subjective
  - Not linked to weight across fiber types
  - Not linked to weight within fiber type until >30% delta
  - Wear tests are the only way to judge
  - Account for shrinkage over time

Heat Stress

- No single layer, breathable woven/knit fabric (FR or not) causes heat illness

- Heat illness causes:
  - Poor hydration
  - Lack of rest breaks
  - Lack of shade
  - Poor health
Keys to Choosing a Successful Program

- What hazard(s) are present?
- What performance standards are available for the hazard?
- What product options are available that protect to the level of our hazard(s)?
- What is the maximum level of protection that our personnel will voluntarily wear?
- What choices can we allow?

Proper Use

- FRC should be appropriate to hazard (s) Dust??
- 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