Arc Flash Hazard: OSHA Guidance Document & NFPA 70E Emphasis on Electrical Maintenance Impacts PPE Selection - Take Note!

Scott Francis, Technical Sales Manager | April 2026

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Agenda

- Arc Flash Basics
- OSHA Arc Flash Guidance Document
- Review NFPA 70E Risk Assessment Procedure - Condition of Equipment!
- Protection - Condition of FR/AR PPE Program? Human Error!
- Comfort - Innovative FR/AR Fabric Blends
- Trust - PPE Selection - Best Practices

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Arc Flash Basics

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NFPA 70E PPE Cat 2 Arc Flash Scenario

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Arc Flash Hazard

- A dangerous release of energy created by an electrical fault
- Release will contain:
  - Thermal energy
  - Acoustical energy
  - Pressure wave
  - Debris

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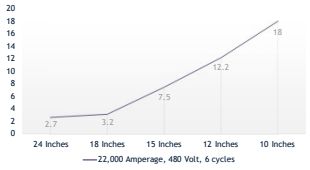
Intensity of an Arc Flash

Variables that effect the incident energy of an electrical arc flash:

- Amperage
- Voltage
- Arc gap
- Cycle time
- Distance away from arc
- 3 phase vs. single phase
- Confined space

Example:
22,000 Amp, 480 Volt, 6 cycles



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Arc Energy Basics

+ Incident energy expressed in cal/cm^2
+ Arc rating of clothing/PPE expressed in cal/cm^2
+ Approx. 1 cal/cm^2 = hottest part of lighter in 1 sec
+ An exposure of only 1.2 calories/cm2 will cause second-degree burn on human skin
+ Typical non-FR workwear can ignite @ 4-5 cals

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OSHA Arc Flash Guidance Document

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OSHA Arc Flash Guidance Document

+ Guidance - Not a standard or regulation and creates no new legal obligations. Provides further emphasis - it's a known and recognized hazard!!
+ Misconception – De-Energized Work, LOTO, ESWC
+ Justified Energized Work – Infeasible or Inconvenient? Greater Hazard
+ OSHA Guidance Points to NFPA 70E – Standard for Electrical Safety in the Workplace
+ Implores electrical workers to not "Wear Fuel!"

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Review NFPA 70E Risk Assessment Procedure – Condition of Equipment!

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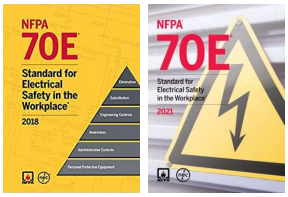
Risk Assessment Review

When?

+ Data reviewed every 5 years or when changes occur to the system. Equipment label updated, if needed.

Impacts

1. Incident energy or PPE category
2. Arc flash boundary
3. PPE selection
4. OSHA compliance – CFR 1910.132
5. Electrical safety program



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Equipment Labels – PPE Category or Incident Energy

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Article 130.5 Arc Flash Risk Assessment - Review

130.5 (A) General

01 ▸ 02 ▸ 03

01 Identify arc flash hazards

02 Estimate the likelihood of occurrence and potential severity of injury

03 Determine if additional protective measures are required, including the use of PPE

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Estimate of Likelihood and Severity

- Consider design of electrical equipment – overcurrent protective device and operating time
- Consider electrical equipment operating condition and maintenance condition, assess the preventative maintenance program (Informative Annex S – Assessing the Condition of Maintenance)
- Use of Table 130.5 (C) can be used to estimate likelihood of arc flash occurrence

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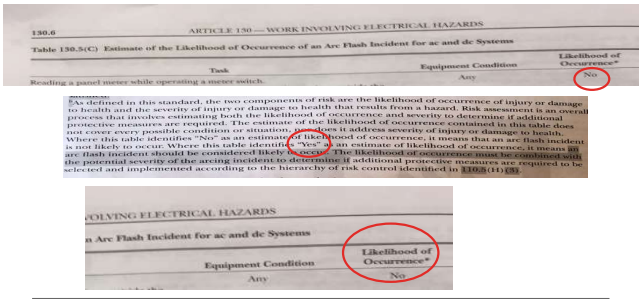
Likelihood of Occurrence of an Arc Flash – Task, Condition



130.6 ARTICLE 130 — WORK INVOLVING ELECTRICAL HAZARDS

Table 130.5(C) Estimate of the Likelihood of Occurrence of an Arc Flash Incident for ac and dc Systems

Task	Equipment Condition	Likelihood of Occurrence*
Reading a panel meter while operating a meter switch.	Any	No

*As defined in this standard, the two components of risk are the likelihood of occurrence of injury or damage to health and the severity of injury or damage to health that results from a hazard. Risk assessment is an overall process that involves estimating both the likelihood of occurrence and severity to determine if additional protective measures are required. The estimate of the likelihood of occurrence contained in this table does not cover every possible condition or situation, nor does it address severity of injury or damage to health. Where this table identifies "No" as an estimate of likelihood of occurrence, it means that an arc flash incident is not likely to occur. Where this table identifies "Yes" as an estimate of likelihood of occurrence, it means an arc flash incident should be considered likely to occur. The likelihood of occurrence must be combined with the potential severity of the arcing incident to determine if additional protective measures are required to be selected and implemented according to the hierarchy of risk control identified in 110.1 (H) (1).

OLVING ELECTRICAL HAZARDS

n Arc Flash Incident for ac and dc Systems

Equipment Condition	Likelihood of Occurrence*
Any	No

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Task Condition

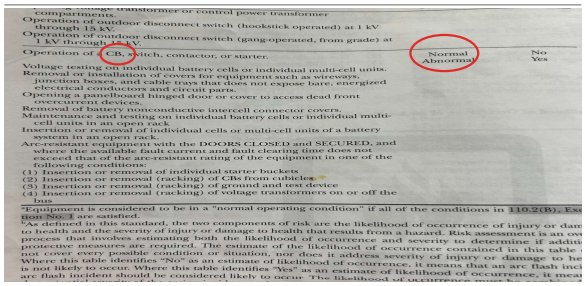

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Table 130.5 (C) Likelihood of Occurrence of an Arc Flash

- Yes/No answer for likelihood of occurrence
  - Yes means arc flash is likely to occur, so additional protective measures like PPE are required
- Use arc flash PPE category and PPE tables
  - Tables 130.7 (C) (15) a, b, and c, if using PPE category method
  - OR use incident energy analysis method

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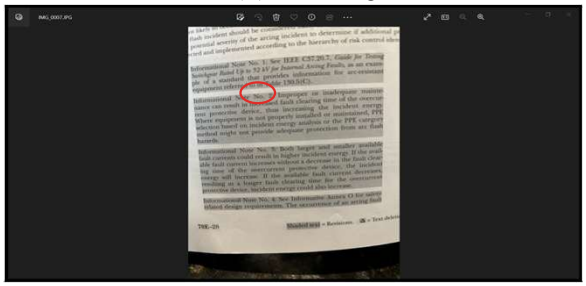
70E Notes Table 130.5 (C) – Assessing Maintenance



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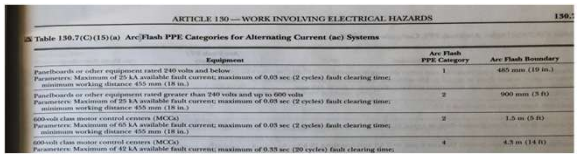
Arc Flash PPE Category Method/NFPA 70E Tables Method

- Changes: Do the electrical changes/additions impact the equipment parameters such as available fault current and clearing time? Do the changes still meet the parameter criteria listed for that equipment type in the PPE category table? If parameter criteria are not met, use the incident energy analysis method.



ARTICLE 130 — WORK INVOLVING ELECTRICAL HAZARDS 130.7

Table 130.7(C)(15)(a) Arc Flash PPE Categories for Alternating Current (ac) Systems

Equipment	Arc Flash PPE Category	Arc Flash Boundary
Panelboards or other equipment rated 240 volts and below Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	1	485 mm (19 in.)
Panelboards or other equipment rated greater than 240 volts and up to 600 volts Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	900 mm (3 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 42 kA available fault current; maximum of 0.33 sec (20 cycles) fault clearing time;	4	4.5 m (14 ft)

- Every 5 years: The data supporting the information on the electrical equipment label (regardless of method) must be reviewed for accuracy at intervals not exceeding 5 years

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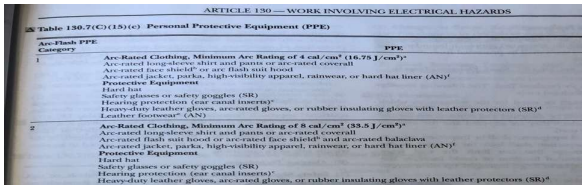
PPE Selection via 2 Methods

- OR via incident energy analysis method – simply select arc-rated clothing with an arc rating equal to or greater than the estimated incident energy determined by methods in Annex D



ARTICLE 130 — WORK INVOLVING ELECTRICAL HAZARDS

Table 130.7(C)(15)(c) Personal Protective Equipment (PPE)

Arc-Flash PPE Category	PPE
1	Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm² (16.75 J/cm²)[a] Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated face shield[b] or arc flash suit hood Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c] Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)[c] Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[d] Leather footwear[e] (AN)
2	Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm² (33.5 J/cm²)[a] Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield[b] and arc-rated balaclava Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)[c] Protective Equipment Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts)[c] Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[d]

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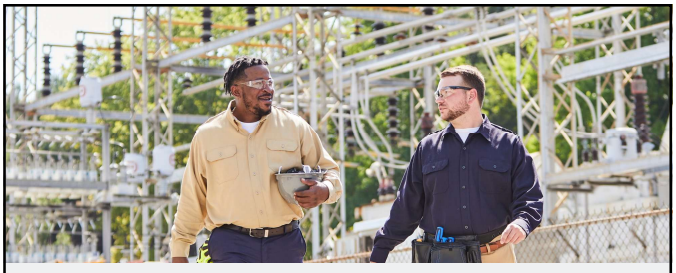

Protection – Condition of FR/AR PPE Program?

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Condition of FR/AR Clothing-PPE Program?

TASK-BASED

- Proper FR/AR clothing is put on to perform a specific task.

DAILY WEAR

- Proper AR/FR clothing is worn at all times during work hours.

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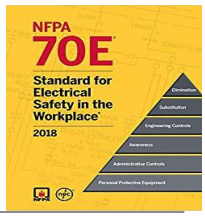
Additional Protective Measures – PPE (Protective Measure)

Hierarchy of Risk Control Methods

The risk assessment procedure shall require that preventative and protective risk control methods be implemented in accordance with the following hierarchy:

1. Elimination
2. Substitution
3. Engineering controls
4. Awareness
5. Administrative controls
6. PPE



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Human Error

- "The risk assessment procedure shall address the potential for human error and its negative consequences on people, processes, the work environment, and equipment."
- "Informational Note: the potential for human error varies with factors such as tasks and the work environment. See information Annex Q."

  Annex Q – Human Performance and Electrical Safety

- Hierarchy of Risk Controls: No risk control infallible. All of the controls are subject to errors in human performance!

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Human Error – NFPA 70E Informational Annex Q

Human Performance and Workplace Electrical Safety

- Human Performance: Aspect of Risk Management that addresses human performance as factors that either lead to or prevent errors.
- Human performance addresses human error as a unique control that is complementary to the hierarchy of risk controls.

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Human Error – NFPA 70E Annex Q – Error Precursors

- Error precursors are situations when the demands of the task environment exceed the capabilities of the worker or the limitations of human nature.
- Also, precursors can be unfavorable conditions that increase the probability for error during a specific work task.
- Precursors are grouped in four broad categories.

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Informative Annex Q, Table Q.5

	Error Precursors	Optimal Tool(s)	Human Performance Tool(s)
Task Demands	Time Pressure (In a Hurry) Lack of Clarity		Pre-Job Briefing
Work Environment	Distractions / Interruptions Unexpected Conditions		Self-Check with Verbalization (STAR)
Individual Capabilities	Lack of Knowledge (Faulty Mental Model) Lack of Experience		Stop When Unsure
Human Nature	Complacency / Overconfidence Stress		Job Site Review

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PPE Culture: Top Reasons Employees Fail to Wear PPE

+ Forgetfulness: “I just forgot”
+ Misunderstanding: “I didn’t know”
+ Fearlessness, Overconfidence, Complacency: ”I won’t get in an accident,” “I’ve gone my entire career without an accident,” “That only happens to other people”
+ Time Constraints: “I didn’t have the time” or “It takes too much time”
+ Discomfort: “It doesn’t fit right” or “It’s not comfortable”

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Dangers of Non-FR Clothing – FUEL!

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FR/AR Clothing: Self Extinguish Westex® UltraSoft®

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Two Key FR/AR PPE Roles

Self Extinguish
+ FR Mechanisms - No Fuel, Free Radical Scavengers

Insulate
+ Arc Flash - Arc Rating

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FR/AR Clothing

20 cal/cm²

8 cal/cm²

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Layered Arc Ratings (ATPV)

+ UltraSoft 8.7 cal/cm² over 8.7 cal/cm² = 26.8 cal/cm²
+ UltraSoft 8.7 cal/cm² over 8.9 cal/cm² knit = 29 cal/cm²
+ DH Air 9.1 cal/cm² over 6 cal/cm² base layer = 18 cal/cm²
+ UltraSoft 8.7 cal/cm² over 8.2 cal/cm² iQ knit = 27 cal/cm²
+ Layered arc ratings are usually more than additive, need to be determined experimentally

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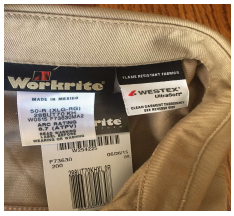
Garment Labels



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Garment Labels

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Comfort – Innovative FR/AR Fabrics

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PPE Culture: Top Reasons Employees Fail to Wear PPE

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Comfort

3 Key Factors That Influence Comfort

1) Thermal Comfort & Moisture Management
   - *Ability to transport heat and moisture away from the body*
2) Tactile (Hand) Properties
   - *Perception of fabric touch and feel*
3) Garment Fit / Design
   - *Closeness, tightness, and compression of garment*

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Comfort Basics: **4 primary ways our bodies release and regulate heat**

Radiation (Dry Heat Transfer)
Heat and energy from a warmer body “radiates” into a cooler atmosphere

Convection (Dry Heat Transfer)
Lose heat through the movement of air around our body

Conduction (Dry Heat Transfer)
Heat flows from your body through direct contact with a cooler object

Evaporation (Wet Heat transfer or Evaporative Heat transfer)
As the amount of heat being removed from the body decreases, sweat is created.
As the sweat evaporates into the atmosphere, heat is removed and the body cools

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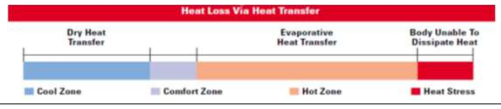
Comfort

The Difference in the Cooling Mechanisms

Heat stress occurs when the body can no longer cool itself

- Dry Heat Transfer - Cooler Environments
  - In cooler environments heat loss through radiation, convection, and conduction are more prominent
- Wet Heat Transfer - Hot Environments
  - In hot environments when the temperature is greater than that of your body (~90 to 95°F), the primary method of cooling is wet heat transfer or evaporation



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Heat Stress

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

Examples of heat illness causes:

- Poor hydration
- Lack of rest breaks
- Lack of shade
- Poor health

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Comfort – Moisture Management

Fiber's Role in Moisture Management and Evaporate Heat Transfer

- Fibers with high moisture absorbency - hydrophilic (PULL)
  - Increased ability to absorb moisture and sweat
  - Saturated fibers swell, decreasing the fabric's ability to breathe
  - Can take longer to dry and can feel wet and heavy
  - Cellulosic (i.e. Lyocell)/ "natural" fibers (i.e. cotton, wool, silk)
- Fibers with lower moisture absorbency - hydrophobic (PUSH)
  - Absorbs less moisture than hydrophilic fibers
  - Dries faster due to lower moisture content
  - Synthetic fibers (i.e. polyester, modacrylic, aramid - Nomex®)
- Innovative fabric blends now can have both fiber types
  - Engineered fabric blends, like Westex® DH Air™ incorporate both fiber types to optimize moisture management

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Why FR/AR Blends? Comfort = Protection

The market was asking for solutions in protective apparel that addressed the following criteria:

Comfort	Excellent breathability for comfort in hot environments, moisture management and soft feel
Protection	Cat 2 arc protection, NFPA 2112 certified with low body burn % and minimal thermal shrinkage
Value	Provides lifelong protection, cost effectiveness and shrinkage control
Appearance	Wash and wear ability, improved appearance after laundering with stylish look
Confidence	Lifelong protection

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Comfort – Innovative FR/AR Fabrics

The latest FR/AR fabrics are blends and are deemed more comfortable.

Why? Lighter weight, air permeability and moisture management.

Fabric brands:

+ Westex® DH and DH Air™
+ Knit FR fabrics
+ Glenguard
+ Tencate Tecasafe One
+ Arvind – Carhartt FR Force

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FR, Arc Rated Fabric Blends

Westex® DH Air™ is comprised of a patent-pending fiber blend of 47% TENCEL™ Lyocell, 38% Modacrylic and 15% Aramid.

47% TENCEL™ Lyocell

+ Cellulosic fiber – provides comfort and performance similar to cotton, but stronger
+ Fabric performance – moisture wicking and breathable fiber, wide range of dyeing options, comfortable

38% Modacrylic

+ FR protection – provides protection to the fabric structure
+ Fabric performance – abrasion resistance, ability to dye into solid colors

15% Aramid

+ FR protection – provides thermal stability, improved arc flash
+ Fabric performance- enhances fabric strength and durability

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FR/AR Fabric Blend Landscape

Product	Published Weight (oz/yd²)	Composition	FR Durability	ATPV / NFPA 70E Category	NFPA 2112
Westex® DH Air™	5.5	47% TENCEL™ Lyocell 38% Modacrylic 15% Aramid	Inherently FR	9.1 cal/cm² Category 2	Yes
Arvind/Carhartt FR Force	4.7	50% Lenzing FR 38% Aramid 10% Polyamide 2% Antistat	Inherently FR	8.6 cal/cm² Category 2	Yes
Tecasafe One	5.5	51% Lyocell 39% Modacrylic 10% Aramid	Inherently FR	8.2 cal/cm² Category 2	Yes
Glenguard	5.5	74% Kermel 20% Modacrylic 5% Twaron 1% Antistat	Inherently FR	9.5 cal/cm² Category 2	Yes

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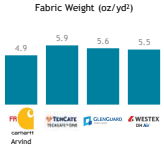
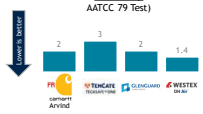
Blended Fabrics Attributes - Comfort

Fabric Weight (oz/yd²)

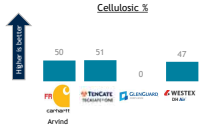


Low fabric weight is not the only indication for comfort.

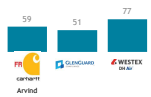
Water Drop
AATCC 79 Test)



Cellulosic %



Air Permeability
ASTM D737)



Note: Water drop testing is performed as received.

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Comfort is Inherently Subjective

- Not linked to weight across fiber types
- Not linked to weight within type until >30% delta
- Wear tests are the best way to judge
- Wear tests will help develop consensus on FR/AR clothing options
- Employee engagement opportunity

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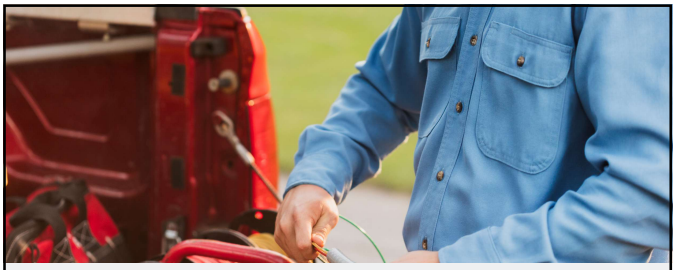

Trust: PPE Best Practices

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Types of AR/FR Clothing and PPE Programs

TASK-BASED

+ Proper FR/AR clothing is put on to perform a specific task.

DAILY WEAR

+ Proper AR/FR clothing is worn at all times during work hours.

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Risk Assessment/Risk Management

+ **Risk:** Hazard(s), consequences, likelihood of consequences
+ **Risk Management:** Reduce risk to "ALARP" (as low as reasonably practicable)

Likelihood of Consequences:

1. Qualified person
2. Human error - NFPA 70E - "state" of qualified person - human performance
3. History and current status of equipment? Current status of PPE program?

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Routine Tasks and Complacency

A significant amount of arc flash incidents occur involving either brand-new employees or the more-experienced employees.

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Cultural Risk with Task Based PPE Programs

+ Routine tasks – PPE category 1 and 2 type tasks: Will workers consistently don PPE at the appropriate time? Complacency!
+ Normalization of deviance: the gradual process through which unacceptable practices and standards become acceptable. As the deviant behavior is repeated without catastrophic results, it becomes the social norm of the organization.

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Cultural Risk with Task Based PPE Programs (Cont.)

+ Complacency is usually one of the root causes of electrical incidents at 480V
+ Although it is considered low voltage, 480V equipment is a leading killer in the electrical industry
+ FR/AR daily wear clothing is a SEAT BELT

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Costs of Daily Wear vs. Task Based PPE (10 wearers for 5 years)

FR/AR Daily Wear (10 wearers) – Initial Investment $1,000/wearer for 5 sets of FR/AR clothing
$1,000/wearer X 10 wearers = $10,000 for year 1
Replacement/Maintenance costs for 4 years; $500/wearer X 10 wearers = $5,000/year
$5,000/year X 4 years = $20,000 Daily Wear: $10,000 + $20,000 = $30,000 over 5 years

FR/AR Task based Coveralls (10 wearers): Initial investment $150/coverall X 10 wearers = $1,500
(good for 5 years) Why good for 5 years? Not likely wearing them consistently – not worn out!!

Hidden Productivity Costs in Time for Task Based PPE:
10 work stops/day/wearer X 10 min./work stop = 100 min./day/wearer X 10 wearers=1,000 min./day
1,000 minutes/day X 20 days/month = 20,000 minutes/month X 1 hour/60 minutes = 333 hours/month
333 hours/month X $40/hour = $13,320/month; $13,320/month X 12 months/year = $159,840/year
Task Based: $159,840/year X 5 years = $799,200 over 5 years

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Potential Task-Based Scenario—Bank Arc Flash

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Real Life Arc Flash Caught on Surveillance Camera: Daily Wear—Westex UltraSoft®

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Thank you.
Questions?
scott.francis@milliken.com
(708) 302-3905
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