Launderability and Impact on Protection

Webinar September 16, 2015

Dennis L. Mater
dennis.l.mater@dupont.com
FR Apparel Sales Technical Leader – North America
Webinar Overview

Introduction

How Does Flame Resistant Protection Work?
- Flame Resistant Garment Fabric Types
- FR Performance Assurance

Proper FR PPE Care
- ASTM Standards
- Manufacturer’s Recommendations
- Home Laundering Vs. Industrial Laundering Considerations

Critical Laundering Considerations
- Cleaning and Residual Contamination
- Specific Laundering Procedures
- Laundering Effects on Garment Properties

Impact on Protection Summary
Introduction
FR PPE Garments Require Regular and Proper Maintenance to Ensure Reliable FR Performance and a Long Life Cycle

Reason for wearing FR PPE is to minimize burn injuries from ignited clothing

- How can laundering affect FR protection?
- Can the flame resistant protection be compromised?

Learn How Laundering Can Impact FR Protection and Worker Safety Not Just the Garment Itself

OHSA 29CFR 1910.132 (f)(1)(v) requires the employer to provide training to each employee required to wear PPE - Proper care, maintenance, useful life and disposal of the PPE.

Must Consider

- Flame Resistant Technology
- Laundering Procedures
- Garment Fitness for Use
- Consistency of Care
How Does FR Protection Work?
The Benefit of Wearing FR Clothing

Minimize Burn Injury & Increase the Chances of Survival

- Does not ignite, melt, drip, nor continue to burn
- Maintains a barrier from flames, and insulates the wearer from heat (to various extents)
- Resists Breaking Open

FR PPE Provides Valuable Escape Time, Can Reduce Burn Injury, and Increase Chances of Survival
**How Does FR PPE Protection Work**

### Flame Resistant Fabric Types

**Inherent (e.g. Nomex®, Kevlar®, PBI®, Kermel®, etc)**
- Dyed fabric does not require chemical treatments
- FR properties are present in the fiber chemistry at time of production
- Fiber molecular structure does not support combustion

**Blended Inherent (e.g. Nomex® MHP, Tecasafe® Plus, etc)**
- Dyed fabric typically requires no post chemical treatments.
- Synergistic effects - achieve flame resistance & other properties

**Chemically FR Treated (e.g. Ultrasoft®, Proban®, Dale Antiflame®, etc.**
- Flammable dyed fabrics are post treated w/ flame retardant chemicals
- Flame retardant chemicals interferes w/ combustion process
How Does FR PPE Protection Work

FR Performance Assurance

Before Purchase

Degree of Assurance Can Be Dependent on Technology Choice

- Inherent Fabrics
  - Flame resistance properties exist from fiber creation
- Blended Inherent Fabrics
  - Requires no post chemical treatments
- FR Treated or Post Treated Fabrics
  - Flame retardant properties dependent on quality of post-treatment application to finished fabric
  - Potential variation of FR treatment level or uniformity

Garment Certification*

- NFPA 2112 Certification* for minimum performance
  - ASTM F1930 – Thermal Manikin
  - Vertical Flame Testing
- NFPA 70E Arc Flash Rating

*Certification process only considers a representative sample

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Proper FR PPE Garment Care
Proper FR PPE Garment Care

Laundering Process

Laundering Can Be a Critical Part of the Protection Assurance

- Type of Contaminates
- Time
- Temperature
- Cycle Settings
- Machine Settings - Mechanical Action
- Chemicals
- Local environment - water hardness

Many Variables Must Be Considered
Proper FR PPE Garment Care

Instructions for Proper Care

**ASTM F-2757**
Standard Guide for *Home Laundering* Care and Maintenance of Flame, Thermal and Arc Resistant Clothing
- End User Care and Maintenance
- Company or Individual Responsibility

**ASTM F-1449**
Standard Guide for *Industrial Laundering* of Flame, Thermal, and Arc Resistant Clothing
- Expertise
- Service

**Manufacturer’s Recommendations**
- Care Label Instructions
- Contact Manufacturer

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Proper FR PPE Garment Care – Home Laundering

ASTM F-2757

Standard Guide for Home Laundering Care and Maintenance of Flame, Thermal and Arc Resistant Clothing

This guide is intended for use by employees of the end user, such as safety personnel or program administrators, who have chosen to implement a home laundered flame, thermal or arc resistant clothing program.

- Describes the key components involved in the home care and maintenance of flame, thermal, and arc resistant clothing.
- Decision to home launder flame, thermal and arc resistant clothing is part of an overall hazard analysis.
- Provides the end user assistance to develop laundering methods that will clean the garment and maintain the flame, thermal, and arc resistant characteristics of the clothing during its useful service life.
- Provides suggestions for increasing the wear life, appearance and function of the clothing; and suggestions as to when flame, thermal, and arc resistant garments should be removed from service.
Proper FR PPE Garment Care – Home Laundering

ASTM F-2757 Standard Guide for *Home Laundering* Care and Maintenance of Flame, Thermal and Arc Resistant Clothing

### Key Highlights

1.3 It is important that potentially flammable contaminants are removed from garments during the wash process. **If flammable contaminants are not removed, the flame resistance of the garment may be compromised.**

1.3.1 To reduce the potential of employees wearing garments contaminated with flammable substances, **the end user should analyze the soil conditions to which a worker may be exposed**, along with the effectiveness of the wash procedure. **In the event home laundering is deemed ineffective, alternative solutions should be pursued** (dry cleaning, industrial laundering, disposable FR overalls, etc.).

5.2 The **decision to home launder flame, thermal and arc resistant clothing is part of an overall hazard analysis.** It should include the nature of the hazard, the soils and any chemicals present in the workplace.

6.4 **Removal from Service**— For most practical purposes, **garments may be temporarily or permanently removed from service for reasons as determined by inspection based on subjective evaluation.** Ultimately, determination of when flame, thermal and arc resistant clothing should be removed from service is the **responsibility of the end user.**
Proper FR PPE Garment Care – Industrial Laundering

ASTM F-1449

Standard Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing

This guide provides guidelines for use by suppliers of the flame, thermal, and arc resistant clothing (including the fabric and fibers used in its construction), processors, and end users to effectively care for and maintain flame, thermal, and arc resistant clothing.

- Identifies the responsibilities of the fiber, fabric, and clothing manufacturers, as well as the processor, the processor’s chemical supplier and the end user.
- Describes the key components involved in a program for the care and maintenance of flame, thermal, and arc resistant clothing.
- Provides a processor assistance to develop a processing system that maintains the flame, thermal, and arc resistant characteristics of the clothing during its useful service life.
- Provides suggestions as to when flame, thermal, and arc resistant garments should be removed from service.
1.3 It is important that potentially flammable contaminants are removed from garments during the wash process. If flammable contaminants are not removed, the flame resistance of the garment will be compromised.

1.5 It is the responsibility of the end user to determine if their laundering method is the appropriate care and maintenance procedure for their application. (See Appendix XI and XLI.)

5.3 The guidelines in this standard will provide a processor assistance to develop a processing system that maintains the flame, thermal, and arc resistant characteristics of the clothing during its useful service life.

5.3.1 The development of published formulas for each fabric and level of soiling is difficult at any given point in time due to ongoing continuous improvement of flame, thermal and arc resistant clothing, including new fibers, fabrics, and laundering equipment and procedures.

NOTE - The National Institute for Occupational Safety and Health (NIOSH) recommends leaving clothing soiled with hazardous chemicals at work to be laundered by the employer.
6.3.1 **Laundry wash formulas** should be developed by the processor and wash chemical supplier in collaboration with the clothing and fabric manufacturers based on the following criteria:

**Washing Machine Type and Volume**
- Machine Loading Factor
- Mechanical Action
- Extraction
- Cycle Times

**Product Classifications and Material Construction**
- Soil types and soil level

**Sorting**

**Wash Room Chemistry**
- Water Temperature
- Water Hardness
- Detergent Make-up
- Additives

**Finishing Process**
- Type Finishing-Drying, Pressing, Tunneling
- Moisture Retention
- Finishing Temperature
- Finishing Time

**Special Instructions prohibiting laundering** (for example, "Dry Clean Only" or "Do Not Wash").
Proper FR PPE Garment Care – All Laundering

Manufacturer’s Recommendations

- Care label instructions
- Garment manufacturer expertise
- Garment component (fabric, fiber, etc.)
- Suppliers
- All garments and fabrics are not the same
Launderability – Impact on Protection

Industrial Laundering Services

“...decision to home launder flame, thermal and arc resistant clothing is part of an overall hazard analysis.” ASTM F 2757

“It is the responsibility of the end user to determine if their laundering method is the appropriate care and maintenance procedure for their application.” ASTM F 1449

Proper Laundering

- Appropriate cycles, mechanical action, water temperatures, water softness and chemical formulas.

Service

- Delivery, size changes, inventory, tracking/reporting, initial outfitting, training.

Weekly Inspection and Repair

- Searching garments for holes, missing buttons and broken zippers and repairing with FR materials.

Proactive Replacement

- Retiring garments from service.

Experience with standards and industry best practices regarding the proper laundering, repair and replacement of flame resistant clothing.
Critical Laundering Considerations

Protection Performance Assurance
Launderability – Impact on Protection

Critical Laundering Considerations

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

Special Laundering Procedures
- Bleach
- Hard Water
- Launder Similar Fabrics Together
- Others

Effect of Laundering on Garment Properties
- Wear Durability
- Flame Resistant Properties
- Replacement and Repairs
Critical Laundering Considerations

Ease of Laundering
Upstream oil and gas exploration is a great example of problematic contaminants. Care should be taken not to use FR PPE with residual stains or contaminants that could be flammable. Even small amount of residual contaminants could be problematic. Contaminates need to be removed from wash to guard against re-deposition on the garment.

Ease of Cleaning Can Provide Greater Protection Assurance
1) The independent study was conducted by the Department of Human Ecology, University of Alberta.


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Launderability – Impact on Protection

Ease of Laundering

Hydrocarbon Soiled FR PPE Coverall

Thermal Manikin before and during the ASTM F1930 exposure

*Total 6 cal/cm² - 2 cal/cm²/s heat flux @ 3 seconds*

*NFPA 2112 minimum requirement*
Contaminates on the garment burned for another 8 seconds after the burner flames were extinguished.

How Clean are Your Garments?
Critical Laundering Considerations

Special Laundering Procedures

FR Treated Fabrics

Inherent Fabrics

All FR Fabrics
Lost or Compromised Flame Retardant Properties Due to:

- Sensitivity to Chlorine-Containing Bleaches*
- Premature Failure of Flame Resistant Finish (Mechanical)
- Ion-Exchange Effects in Hard Water (+ Peroxide Effects)
- Static Control - Flammable Fabric Softeners
- Incompatibility with Working Environment (Chemical Exposure)

Fabric weight variation & FR treatment uniformity can effect rate of loss

* Potential thermal hazard reaction w/ concentrated bleach
Special Laundering Procedures

NFPA 2112
Vertical Flame Requirement
< 4inches

Impact of Chlorine Bleach on Flame Resistance

- Vertical flame measured using ASTM D6413 test method
- Laundering using sodium hypochlorite at bleach manufacturer’s recommended concentration

Note: Bleach is not recommended for most flame resistant fabrics. For best results follow manufacturer’s laundering guide.
Special Laundering Procedures – Strong Oxidizers

SAFETY ADVISORY

Cotton Flame Resistant Garments

Products of Reaction

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<tr>
<th>Products of Reaction</th>
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<tbody>
<tr>
<td>Cotton FRG</td>
</tr>
<tr>
<td>- +155 °F when exposed to 11% NaOCl solution</td>
</tr>
<tr>
<td>- +92 °F when exposed to 6% NaOCl (household bleach)</td>
</tr>
<tr>
<td>- Chloroform</td>
</tr>
<tr>
<td>- Carbon tetrachloride</td>
</tr>
<tr>
<td>- Phosgene</td>
</tr>
<tr>
<td>Nomex</td>
</tr>
<tr>
<td>- +10 °F when exposed to NaOCl solution</td>
</tr>
<tr>
<td>- No gas generation</td>
</tr>
</tbody>
</table>

The Channelview facility recently experienced a recordable injury when a contract employee accidently dislodged a line containing NaOCl (bleach or sodium hypochlorite) and was sprayed. He experienced burns that were greater in magnitude than would have been expected from exposure to a 13% solution.

The contractor was wearing a cotton flame resistant garment (FRG). According to testing done by the Newtown Square Research Center and the clothing manufacturer, these fabrics can exothermically react with bleach solutions to produce enough heat to burn skin and give off toxic gases (see box above). Nomex flame resistant garments do not react similarly.

The manufacturer of the cotton FRG in this incident, Westex, cautions against the use of Bleach and Hydrogen Peroxide in their laundry guide but they do not communicate the potential for heat generation when these products are used.

What can you do to prevent a similar occurrence at your site?

- Share this information with all of your employees and contractors.
- Discontinue the use of cotton flame resistant garments in areas where bleach and other strong oxidizers are present or require chemical resistant clothing over cotton FRG.
- Ensure that employees are aware of manufacturer guidelines and laundering requirements for all PPE.
- Review the technical literature for all PPE for similar limitations and reactions.

FR-Treated Fabrics
Can the Original FR Properties of Inherent Fabrics Made with Fibers Like Nomex® IIIA be Compromised?

Using Nomex® Branded Fabrics as an example:

- FR Properties are not affected by the use of chlorine bleach
- No ION Exchange effect
- No post-treated, FR chemical finish to wear off
- Fabric softeners (because Nomex® is anti-static, fabric softeners are not needed for static control)
Special Laundering Procedures

Key Considerations for All FR Fabrics

- Wash separately or with other like FR garments
- Hard water may combine with soap film to deposit flammable contaminants on the fabric
- Fabric softeners or other additives (such as starch) may coat fibers and affect FR performance
- Heavy soil and contaminates, especially if greasy or petroleum based, can reduce the FR performance

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Laundering Considerations

Effect of Laundering on Garment Properties
When considering wear, it is important to have a strong fabric in the garment that retains a high percentage of original performance after multiple launderings.

Thin spots, rips, tears, and holes can compromise the protection factor of a FR garment.
Launderability – Impact on Protection

Effect of Laundering on Durability Inherent vs. Fr Treated Fabrics

Nomex® Coveralls after 10 washes

FRT Cotton Coveralls after 10 washes

Launderability – Impact on Protection

Effect of Laundering on Durability Inherent vs. Fr Treated Fabrics

Nomex® Coveralls after 100 washes

FRT Cotton Coveralls after 100 washes

<table>
<thead>
<tr>
<th>Laundry Shrinkage (%) after 100X Wash</th>
<th>NOMEX®</th>
<th>FRT COTTON</th>
</tr>
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<tbody>
<tr>
<td>3-4 %</td>
<td>14%</td>
<td></td>
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</table>
Launderability – Impact on Protection

How do you know FR Protection is still there?

FR Performance Assurance

After Wear and Cleaning

**Degree of Assurance Can Be Dependent on Technology Choice**

- **Inherent and Blended Inherent Fabrics**
  - Flame resistant properties of the fabric itself unaffected by laundering
  - Improper laundering can increase burn injury – Contaminates, additives, etc.

- **FR Treated Fabrics**
  - Flame resistant properties of the fabric itself can be changed by laundering
  - Laundry history must be known
  - Improper laundering can increase burn injury – Contaminates, additives, etc.

**FR Assurance Testing**

- **All FR Fabrics**
  - Non-destructive tests not available – Garment destruction discerning FR protection
The following items, identifiable by visual examination, may diminish the effectiveness of the flame, thermal, and arc resistant clothing.

- **Worn Out**—Thin spots, holes, excessive wear or abrasion – Elbow or knee areas
- **Mechanical Damage**—Evidence of cuts, rips, tears, open seams, and nonfunctional closures.
- **Modifications**—Alteration(s) to a garment that differs significantly from the original design.
- **Fit**—The flame, thermal, and arc resistant clothing no longer fits the wearer.
- **Flammable Substances**—Garments soiled by substances that represent a flammability risk solvents, solids, oils, and other petroleum based contaminates that cannot be properly removed by cleaning.

**NOTE:** The presence of a petroleum or chemical odor can be evidence of a flammable substance.
Standard **Primarily for End-Users**

- OSHA Recognized Tool for 29 CFR 1910.132
- Perform Fire / Exposure Hazard Analysis
- Protective Clothing Selection
  - Meet Minimum NFPA 2112 Specifications
  - Meet Required Protection Identified in Hazard Analysis
  - Based on Specific Work Tasks
- Wearing / Training Information
- Care & Maintenance Information

**NFPA 2113:** Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures From Fire.
Summary
Conclusions and Summary

- FR PPE Wearer Safety and Long Life Cycle require proper maintenance
- Follow ASTM Guidelines and Manufacturer’s Care Instructions
- Home or Industrial Laundering – Consistency of Care and Oversight
- Launderability Is a Key Consideration for Garment Choice
- Improperly Maintained FR Garments – Increased Risk of Injury
- Laundering Is a Critical Part of Protection Assurance

When You Purchase FR PPE, You Are Buying Protection Assurance & Peace of Mind
Thank You
Disclaimer

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