VOL.13

INDUSTRY UPDATE

Secondary Flame-Resistant Apparel

Bulwark FR

Bulwark® FR

www.bulwark.com

THE LEADER IN SECONDARY FLAME-RESISTANT APPAREL

Bulwark® is the leading producer of secondary flame-resistant apparel in North America. Bulwark garments provide superior flame-resistant protection, comfort, and durability to thousands of workers in electrical utilities and the chemical, oil, gas, mining and petrochemical industries. Bulwark has a 39-year heritage of technical innovation and industry leadership, always remembering that wearer safety is the primary concern. The Bulwark brand makes up the industry's most comprehensive flame-resistant product line in the broadest range of proven thermal protective fabrics.

For Further Information Contact:

In the U.S. and International:
Denise Statham (615) 565-5000

In Canada:
Tim LeMessurier 1-800-667-0700

» INDUSTRY UPDATE

Bulwark® closely follows the continually evolving development of both domestic and foreign resources of flame-resistant and thermally protective fibers and fabrics.

» OBJECTIVES

- Educate specifiers in the need for and function of flame-resistant protective apparel.
- Provide independent evaluations of available flame-resistant fabrics.
- Update developments in the areas of fibers, fabrics, and garments.
- Advise changes in standards and regulatory requirements.

» FAST FACTS

FOR QUICK REFERENCE, USE » FAST FACTS

LOCATED AT BOTTOM OF PAGE

» CONTENTS

» INTRODUCTION TO FR APPAREL AND STANDARDS

The flame-resistant garment business is standards and specifications driven. A basic understanding of how flame resistance is defined and measured is very important. Included is an overall listing of common industry standards, as well as a discussion of the requirements of standards related to specific activities, such as power generation and distribution or petroleum refining.

DO EVERYDAY WEARING APPAREL AND NORMAL WORK CLOTHES HAVE THE SAME FLAMMABILITY CHARACTERISTICS?

All are required to meet the same federal flammability standard:

16 CFR PART 1610.

The standard, administered by the Consumer Products Safety Commission, was originally adopted in 1954 as CS 191-53, the Flammable Fabrics Act. The purpose of the standard is to reduce the danger of injury and loss of life by providing, on a national basis, standard methods of testing and rating the flammability of textiles for clothing use. The standard measures two fabric attributes: ease of ignition and speed of flame spread. A specimen mounted at a 45° angle is exposed to a one second ignition.

If the specimen ignites, the flame spread time is recorded. The Act establishes three classes of flammability based on ease of ignition and flame spread time.

WHAT ARE THE THREE CLASSES OF FABRIC FLAMMABILITY?

	CLASS	FLAME SPREAD TIME
CLASS 1	Normal Flammability	4 seconds or more. May or may not ignite when exposed to the standard 1 second ignition source.
CLASS 2	Intermediate Flammability	4 to 7 seconds and the base fabric ignites. (Applies to fabrics having a raised fiber surface/nap.)
CLASS 3	Rapid, Intense Burning	Less than 4 seconds. Dangerously flammable. Unsuitable for clothing.

WHAT CLASS MUST GARMENTS MANUFACTURED OR SOLD IN THE U.S. MEET?

All wearing apparel sold in the U.S. must be made of fabric from Class 1 or 2.

No wearing apparel can be made of fabric rated Class 3.

Everyday wearing apparel will ignite and continue to burn if exposed to an ignition source. Normal work apparel is made from a range of fabrics similar to those offered as everyday wearing apparel. Just like everyday apparel, normal work apparel will ignite and continue to burn if exposed to an ignition source.

» FAST FACTS

- All manufactured garments are required to meet U.S. flammability standards.
- The standard 16 CFR Part 1610 measures ease of ignition and flame spread time. All non-FR fabrics fit into one of three classes:

  CLASS 1: Normal flammability
  CLASS 2: Intermediate flammability
  CLASS 3: Rapid/Intense burning

- All wearing apparel sold in the U.S. must meet Class 1 or Class 2 category requirements.
- Everyday wearing apparel will ignite and continue to burn if exposed to an ignition source.

IS THERE A NEED FOR FLAME-RESISTANT PROTECTIVE GARMENTS?

All fabrics made of untreated natural fibers and most synthetic fibers are combustible. It is normal and expected that they will ignite and continue to burn when exposed to an ignition source such as flame or electric arc. Because clothing constructed from these normal fabrics meets flammability requirements established by 16 CFR Part 1610, it is generally accepted as having no unusual burning characteristics.

Resistance to ignition and burning is an abnormal condition of wearing apparel. When work environments or occupations pose a risk of garment ignition and burning, flame-resistant apparel should be considered and selected.

HOW DO NORMAL FABRICS REACT TO IGNITION?

Normal fabrics and garments will burn away from the point of ignition with an increasing rate of flame spread and continue to burn after removal of the ignition source. Normal fabrics will continue to burn until they are extinguished or all flammable material is consumed.

HOW DO FR FABRICS REACT TO IGNITION?

Flame-resistant (FR) fabrics and garments are intended to resist ignition, prevent the spread of flames away from the immediate area of high heat impingement, and to self-extinguish almost immediately upon removal of the ignition source.

DO FR GARMENTS PREVENT BURN INJURY?

FR garments will not provide significant protection from burn injury in the immediate area of contact with the ignition source. However, flame-resistant garments do provide protection against clothing ignition and sustained flame spread.

WHAT TYPE UNDERGARMENTS SHOULD BE WORN?

National Fire Protection Association (NFPA) 70E Standard for Electrical Safety in the Workplace, states that non-melting, flammable fiber undergarments may be used in conjunction with FR garments. Flame-resistant t-shirts, henleys and base layer garments can provide additional wearer protection.

ARE FR GARMENTS STILL EFFECTIVE IF CONTAMINATED WITH FLAMMABLE SUBSTANCES?

Flammable substances on FR garments will ignite and continue to burn on the surface of the FR garment. Flame-resistant garments should be immediately removed and replaced with clean FR apparel if they become fouled with flammable material. If laundering or dry cleaning cannot remove flammable contaminants, the contaminated garments should be removed from service.

IS 100% COTTON FABRIC "FLAME-RESISTANT"?

There is a common perception that untreated 100% cotton fabric is somehow "flame-resistant". This is simply not true. While heavyweight untreated 100% cotton fabrics may be more difficult to ignite, they can and will ignite and continue to burn if exposed to an ignition source.

» FAST FACTS

- Flame-resistant fabrics and garments provide protection against clothing ignition and sustained flame spread.
- FR fabrics and garments self-extinguish almost immediately upon removal of ignition source.
- Always wear cotton or natural fiber undergarments. FR undergarments provide additional wearer protection.
- Remove FR garments at once if contaminated with flammable materials.
- Regardless of their weight, untreated 100% cotton fabrics are not flame-resistant.

WHAT ARE SOME COMMON CAUSES OF IGNITION AND BURNING OF WORK APPAREL?

1. Ignition of flammable liquids and/or other flammable soils on the garment.
2. Contact with, or close proximity to, molten metals.
3. Contact with sparks and slag from flame cutting or welding.
4. Contact with open flames.
5. High energy electrical discharges or other electric arc events.
6. Explosion of vapors from volatile liquids or from flammable gases.
7. Ignition of combustible dusts.

Where any risk of ignition exists in the workplace, there is a need for flame-resistant garments.

WHAT IS THE EMPLOYER'S RESPONSIBILITY?

Under paragraph 5a1, the General Duty clause of the federal OSHA Act, it is the employer's responsibility to identify risks and hazards in the workplace and seek out appropriate protective garments and equipment for the protection of workers.

In making this hazard assessment, the employer must consider the risks present and the most appropriate means of addressing those risks. Where ignition risks are present, flame-resistant protective apparel can become a prudent part of an action plan to address these concerns.

HOW DO I CHOOSE THE CORRECT FLAME-RESISTANT GARMENTS?

Any flame and thermal protective fabric must provide the wearer with the expected degree of protection for the useful life of the garment. Garments are specified based on the employer's evaluation of workplace hazards. Protective garments, which function as wearing apparel for normal work activities, must be comfortable and durable while achieving appearance that is acceptable to both the employer and the wearer. In addition to these general considerations, there may be other hazards present such as chemical or molten substance exposure. Finally, these multi-use garments must be able to withstand laundering to remove soils and flammable contaminants and be returned to service without excessive color loss, fuzzing/pilling (surface appearance change) or excessive shrinkage.

» FAST FACTS

- Common causes of ignition of work apparel:
  - Flammable liquids and gases
  - Combustible dusts
  - Slag from flame cutting
  - Electric arc events
  - High energy electrical discharges
  - Flammable soils
  - Molten metals
  - Open flames
  - Welding
  - Sparks
- It is the employer's responsibility to identify risks and hazards in the workplace and to protect employees. When choosing flame-resistant garments, evaluate the workplace, wearer comfort requirements, durability, appearance, and availability of laundry options.

FLAME-RESISTANT
The characteristic of a fabric to resist ignition and to self-extinguish if ignited.

FLAME RETARDANT
A chemical substance used to impart flame resistance.

PRIMARY PROTECTIVE CLOTHING*
Clothing designed for activities where significant exposure to molten substance splash, radiant heat, or flame is likely to occur. Secondary protective garments, like Bulwark's® FR protective work apparel, would be worn under primary garments.

SECONDARY PROTECTIVE CLOTHING*
Clothing designed for continuous wear in areas where intermittent exposure to molten substance splash, radiant heat, and/or flame is possible. FR work apparel, since it is designed for continuous wear, is considered to be secondary protection. The protection afforded by any secondary protective FR garment can be negated by an overwhelming exposure.

CHEMICAL RESISTANCE
As used in this Update, "Chemical Resistance" relates only to the ability of fabrics to withstand exposure to various chemicals without affecting their physical properties or flame resistance.

With the exception of Bulwark® disposable/limited use garments and rainwear, none of the fabrics discussed offer personal protection from chemical exposure. These fabrics will either become wet and transfer chemicals to the wearer, or they are porous enough to allow chemicals to pass through. Chemically protective barrier garments are specialized kinds of primary protective clothing.

REUSABLE PROTECTIVE CLOTHING
Garments which are capable of withstanding a maintenance procedure to remove soil and other contaminants, yet retain the garment's protective characteristic.

FR DISPOSABLE/LIMITED USE PROTECTIVE CLOTHING
FR garments which generally cannot be cleaned; usually provided for supplemental protection from a specific hazard, or to prevent soiling expensive reusable garments. Note: limited use FR disposables will burn in the presence of an ignition source, but will self-extinguish when the ignition source is removed. They must be worn over suitable FR apparel, and not used alone for FR protection. Non-FR disposable garments should never be worn over FR garments.

STOLL CURVE
A plot of thermal energy and time used to predict a pain sensation, or the occurrence of a second degree burn in human tissue.

ARC RATING
The maximum incident energy resistance of a material expressed in calories per square centimeter prior to breakopen or the onset of a second-degree burn.

ATPV
Arc Thermal Performance Value. The incident energy that results in sufficient energy transmitted through the fabric to cause the onset of a second-degree burn based on the Stoll Curve.

Breakopen Threshold Energy or EBT is reported when the ATPV cannot be determined because the fabric breaks open in response to the thermal energy exposure of the electric arc. The lower value of either Breakopen Energy Threshold or ATPV is reported as the arc rating for the material.

*As defined by the American Society for Testing Materials (ASTM) in Standard F1002

» FAST FACTS

- **Flame-Resistant** - The characteristic of a fabric to resist ignition and to self extinguish if ignited.
- **Flame Retardant** - A chemical substance used to provide flame resistance.
- **Primary Protective Clothing** - For activities where significant exposure to flame or heat is likely.
- **Secondary Protective Clothing** - For continuous wear in designated areas where intermittent exposure to flame or heat is possible.
- **Chemical Resistance** - Relates to the ability of fabrics to withstand exposure to various chemicals.
- **Stoll Curve** - Developed by Alice Stoll in the 1960's, and used in many tests to predict the thermal protective performance of textile materials for FR apparel.
- **Arc Rating** - The maximum incident energy resistance of a material expressed in calories per square centimeter prior to breakopen or the onset of a second-degree burn.
- **ATPV** - Arc Thermal Performance Value. The incident energy that results in sufficient energy transmitted through the fabric to cause the onset of a second-degree burn based on the Stoll Curve.

In order to serve the market for flame-resistant protective garments, there must be a continuing focus on the customer's requirements based on their evaluation of existing hazards in the workplace and applicable regulations and standards.

Important considerations in any flame-resistant protective apparel program are testing and standards requirements. Outside of military specifications, the primary existing and proposed tests and standards for the civilian clothing market in the United States are as follows:

CATEGORY	IDENTIFICATION	CLASS	SPONSORING ORGANIZATION	GOV'T LEVEL MANDATING	COMMENTS
GENERAL WEARING APPAREL	D1230	(Test)	ASTM	None	Clothing and textiles intended for clothing
	16 CFR 1610	(Standard)	CPSC	Federal	Clothing and textiles intended for clothing except hats, gloves, footwear, and interlining fabrics
	16 CFR 1616	(Standard)	CPSC	Federal	Children's sleepwear; 7-14 (FF 5-74)
PROTECTIVE CLOTHING	CSA Z462	(Standard)	Canadian Standards Association	None	Canadian version of NFPA 70E. Initially based on 70E, but to be modified and updated for Canadian requirements
	CSA Z96	(Standard)	Canadian Standards Association	None	Canadian requirements for high-visibility safety apparel.
	D4108-87**	(Test)	ASTM	None	Fabric that is intended for use as clothing for protection against a short exposure to open flames
	D6413	(Test)	ASTM	None	Any textile (Note: ASTM version of FTM 5903.1)
	F1506	(Standard)	ASTM	None	Material for clothing for use by electrical utility workers
	F1891	(Standard)	ASTM	None	Rainwear for employees exposed to the hazard of flames or electric arcs
	F1930	(Test)	ASTM	None	Simulated flash fire exposure test using a mannequin
	F1958	(Test)	ASTM	None	Ignitability of clothing by electric arc exposure using a mannequin
	F1959	(Test)	ASTM	None	Determining Arc Thermal Performance Value (ATPV) of flame-resistant textile materials for clothing by electric arc exposure using instrumental sensor panels
	F2178	(Test)	ASTM	None	Determines Arc Rating of face protective products
	F2302	(Performance Specification)	ASTM	None	Minimum requirements for labeling protective garments as flame and thermal resistant
	F2733	(Standard)	ASTM	None	Rainwear for employees exposed to the hazard of flash fire.
	ISEA/ANSI 107	(Standard)	ISEA/ANSI	Federal	High-visibility safety apparel and headwear. Adopted by Federal Highway Administration for workers on federally aided roads.
	F 2700	(Test)	ASTM	None	Measures non-steady state heat transfer through flame resistant materials by continuous, combined convective and radiant heat exposure
	CGSB 155.20	(Standard)	CGSB	None	Workwear for protection from hydrocarbon flash fire (Canada)
	FTMS 191A; 5903.1	(Test)	GSA	Federal	Any textile. Generally has been replaced by ASTM D6413.
	NFPA 70	Standard	NFPA	None*	National Electrical Safety Code (NESC) sets rules for safeguarding personnel during installation, operation, or maintenance of electric supply and communication lines and associated equipment.

CATEGORY	IDENTIFICATION	CLASS	SPONSORING ORGANIZATION	GOV'T LEVEL MANDATING	COMMENTS
PROTECTIVE CLOTHING (Con't.)	NFPA 70E	(Standard)	NFPA	None*	Clothing for employees working on energized electrical circuit parts
	NFPA 702	(Test)	NFPA	None*	Clothing except hats, gloves, footwear, and interlinings
	NFPA 1971	(Standard)	NFPA	None*	All fabrics used in protective clothing for structural fire fighting
	NFPA 1975	(Standard)	NFPA	None*	All fabrics used in station and work uniforms for fire fighters
	NFPA 1977	(Standard)	NFPA	None*	All fabrics used by fire fighters in combating wildlands fires
	NFPA 2112, 2113	(Standard)	NFPA	None*	Selection, care & use of garments for industrial flash fire protection
	29 CFR 1910.269	(Standard)	OSHA	Federal	Clothing for employees exposed to the hazards of flames or electric arcs
	29 CFR 1910.132	Standard	OSHA	Federal	US general requirement for employers to access hazards in the workplace and provide appropriate PPE
	EN340	Standard	ISO	See Note***	European general requirements for protective clothing
	EN471	Standard	ISO	See Note***	European requirements for high-visibility safety apparel.
	EN ISO 11612 (formerly EN 531)	Standard	ISO	See Note***	European requirements for workers exposed to heat and flame
	IEC 61482-2	Standard	IEC	See Note***	European requirements for workers exposed to electric arcs
	EN1149-5	Standard	ISO	See Note***	European requirements for electrostatic properties of PPE

ASTM = ASTM International
CGSB = Canadian General Standards Board
CPSC = Consumer Products Safety Commission
FTMS = Federal Test Method Standard
IEC = International Electrotechnical Commission
GSA = General Services Administration, Office of Federal Supply Services
ISO = International Standards Organization
NFPA = National Fire Protection Association
OSHA = Occupational Safety and Health Administration, Department of Labor

*** NFPA documents may be cited by any government level and therefore take on the force of law**
**** No longer current**
Note*: Directive 89/686/EEC on personal protective equipment is EU law. Standards are not legislated, but provide technical translation of the essential requirements of the PPE Directive.**

WHAT TEST IS MOST COMMONLY USED TO MEASURE FLAME RESISTANCE?

The most commonly used test for measuring flame-resistant fabrics is Method 5903.1 of Federal Test Standard 191A (Flame Resistance of Cloth: Vertical). The ASTM version of this test is designated D6413.

HOW IS THE TEST "FLAME RESISTANCE OF CLOTH: VERTICAL" CONDUCTED?

In an enclosed cabinet, 12-inch long fabric specimens are vertically suspended in a holder with the fabric restrained on three sides. A controlled flame is impinged on the bottom cut edge of the fabric for 12 seconds.

WHAT RESULTS ARE RECORDED FROM THIS TEST?

The flame is extinguished at the end of 12 seconds and three sets of data are recorded:

Afterflame: The number of seconds (in tenths of seconds) during which there is a visible flame remaining on the fabric.

Afterglow: The number of seconds (in tenths of seconds) during which there is a visible glow remaining on the fabric. (Reported, but not part of most performance standards.)

Char Length: The length of fabric (in tenths of inches) destroyed by the flame that will readily tear by application of a standard weight.

Five specimens cut in each fabric dimension (length and width) are tested. The individual results of the five specimens are averaged and reported as the test result.

DOES THE VERTICAL FLAME RESISTANCE TEST METHOD ESTABLISH A STANDARD FOR PERFORMANCE REQUIREMENTS?

No. Federal Test Method 5903.1 establishes a test method only with no pass/fail criteria.

WHAT PERFORMANCE STANDARDS DO GARMENT MANUFACTURERS USE?

Various specifications and performance requirements have been established based on FTM 5903.1 testing. For example, California OSHA specifies a maximum of 2.0 seconds Afterflame and 6.0 inches Char Length for professional fire fighter's barrack's uniforms. ASTM Performance Specification F2302 applies the same criteria as minimum requirements for all protective clothing labeled as heat and flame-resistant. Both the Canadian General Standards Board (CGSB) and the National Fire Protection Association (NFPA) require a maximum of 2.0 seconds Afterflame and 4.0 inches (100mm) Char Length for protection against hydrocarbon flash fires. In the absence of other specifications, Bulwark® follows ASTM F2302 as a minimum requirement. Other performance requirements may apply to specific garments and will be so indicated on the garment label.

There is a lot of misinformation in the market. Many items are labeled "FR" that actually only meet general wearing apparel standards or standards that are only applicable to upholstery or curtains. ASTM F2302 Standard Performance Specification for Labeling Protective Clothing as Heat and Flame-Resistant is the minimum standard for labeling protective clothing as heat and flame-resistant. This standard requires an Afterflame time of no more than 2.0 seconds and Char Length of less than 6.0 inches when tested in accordance with ASTM Test Method D6413 (vertical flame resistance). No melting or dripping of the specimens is allowed during the test. Also, the fabric may not ignite, melt, drip, separate or shrink more than 10% when exposed in a forced air oven at 500°F (260°C) for 5 minutes.

» FAST FACTS

The Flame Resistance of Cloth: Vertical test records:

- **AFTERFLAME**
  The number of seconds there is a visible flame on the fabric after the ignition source is extinguished.
- **AFTERGLOW**
  The number of seconds there is a visible glow on the fabric after the ignition source is extinguished.
- **CHAR LENGTH**
  The length of fabric destroyed by flame.
- 5903.1 establishes a test method only with no pass/fail requirements.

WHAT STANDARDS ARE USED FOR WORKERS EXPOSED TO FLASH FIRE HAZARDS?

The NFPA 2112 Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire and its companion standard, NFPA 2113 on Selection, Care, Use, and Maintenance of these garments specify design, performance, certification requirements, and test methods for flame-resistant garments for use in areas at risk from flash fires. Third party certification of garments is also required. In addition to the usual fabric performance requirements for flame resistance, heat resistance and thermal shrinkage, this standard introduced some new requirements and revised some old ones.

- Flame resistance of each fabric layer is required to be tested as received and after 100 cycles of washing and drying and/or dry cleaning.
- Thermal Protective Performance (TPP) must be tested both with the fabric specimen in contact with the sensor assembly and separated from the sensor by a ¼-inch spacer. A minimum TPP rating of 6.0 is required for "spaced" and 3.0 for "contact".
- Coveralls made to a standard pattern from candidate fabrics are tested for overall flash fire exposure on an instrumented mannequin in accordance with ASTM Test Method F1930. The exposure heat flux is 84 kW/m² (2.02 cal/cm²/sec) with an exposure time of 3.0 seconds. The average total predicted body burn must not exceed 50%.

NFPA 2113 provides guidance in the selection and specification of flame-resistant garments, including workplace hazard assessment. Other sections cover use and care and maintenance recommendations. There is extensive appendix material that amplifies and explains many of the issues including an explanation of the meaning and application of the testing required in NFPA 2112.

Canadian General Standards Board (CGSB) CAN/CGSB 155.20, Workwear for Protection Against Hydrocarbon Flash Fire is the Canadian flash fire standard.

In addition to flame resistance, heat resistance and thermal shrinkage requirements, this standard also requires that the garment label be in both English & French. For single layer garments, the TPP values for both spaced and contact tests must be reported on the garment label.

WHAT STANDARDS ARE USED FOR STATION/WORK UNIFORMS FOR EMERGENCY SERVICES PERSONNEL?

The National Fire Protection Association (NFPA) standard on Station/Work Uniforms for Fire and Emergency Services – NFPA 1975 – establishes minimum performance and certification requirements for textiles and other materials used in the construction of station/work uniforms for emergency services personnel. The standard specifies requirements for the design, performance, testing and certification of nonprimary protective station work uniforms that will not contribute to burn injury severity. Minimum requirements are established for thermally stable flammable textiles that will not melt or shrink excessively as well as optional requirements for fabrics represented as flame-resistant. There are separate labeling requirements for garments assembled from flame-resistant and non FR fabrics.

» FAST FACTS

NFPA 2112 requires approval by a third party listing organization, such as UL®. Both "spaced" and "contact" TPP requirements. Predicted body burn of less than 50% in mannequin test.

Fire and EMS Station / Work Uniforms
NFPA 1975 Requires

- Approval by a third party listing organization, such as UL®.
- Certified garments must not ignite, melt and drip, or separate in a forced air oven test.
- FR or untreated 100% cotton or wool fabrics are acceptable.
- ISO registration of garment manufacturer is required.

Electrical Hazards
OSHA 1910.269 Requires

- Clothing cannot increase extent of wearer injury.
- Employers determine protection required.
- FR clothing is acceptable.

NESC Requires

- Employer must conduct hazard analysis
- Arc rated clothing required if exposure is greater than 2 cal/cm²
- Arc protection required based on tables in the standard, or a minimum effective rating of 4 cal/cm².

Garments meeting the standard are required to be certified by a third party listing organization and the manufacturer is required to be registered to ISO 9000, Quality Management systems-Requirements. Manufacturers are also required to have a written safety alert system and a written product recall system in the event they decide or are directed to issue a product alert or recall.

The standard sets base requirements for all garments. These include heat and thermal shrinkage resistance, thermal stability, seam strength and label durability. There are also optional flame resistance requirements for FR fabrics. Garments being tested to base level requirements alone are tested after 25 home wash cycles. Garments tested to the optional FR requirements are tested after 100 home wash cycles. When garments are made from FR fabrics, they are required to be constructed with inherently FR sewing thread.

WHAT STANDARDS ARE USED FOR ELECTRIC POWER GENERATION, TRANSMISSION, AND DISTRIBUTION?

OSHA's Final Rule on Electrical Protective Equipment (OSHA 1910.269) prohibits clothing that, when exposed to flames or arcs, could increase the extent of wearer injury. Employers must determine appropriate clothing based on an evaluation of potential hazards in the work environment. Clothing made from flame-resistant materials is acceptable under the Rule; i.e., clothing that meets the requirements of ASTM F1506. Untreated cotton or wool fabrics weighing at least 11.0 oz. are acceptable under limited conditions identified by OSHA. (1.)

The National Electrical Safety Code (NESC®) is published by the IEEE. It sets the ground rules for practical safeguarding of persons during the installation, operation, or maintenance of electric supply and communication lines and associated equipment.

The NESC requires that the employer determine potential exposure to an electric arc for employees who work on or near energized parts or equipment. If the exposure is greater than 2 cal/cm^2, employees are required to wear clothing with an arc rating not less than the anticipated level of arc energy as determined by tables in the standard or by choosing clothing with a minimum effective arc rating of 4 cal/cm^2. Certain meltable fabrics are not allowed.

(1.) Arc conditions in the Duke Power Company videotape, which was the primary basis for OSHA's determination, were an 3800 ampere, 12 inch (approx) electric arc that was approximately 12 inches from the material. The arc lasted for 10 cycles or 0.167 seconds.

WHAT ARE THE ELECTRICAL SAFETY REQUIREMENTS FOR THE WORKPLACE?

National Fire Protection Association (NFPA) Standard 70E, Standard for Electrical Safety in the Workplace, was revised in 2009. This standard addresses electrical safety requirements for activities such as operation, repair or demolition of exposed energized electrical conductors or circuit parts. Virtually all aspects of workplace electrical safety, recognizing hazards associated with the use of electrical energy, and taking precautions so that hazards do not cause injury or death are included.

The 2009 Edition addresses host employer/contract employer responsibilities. Another significant 2009 change is the requirement that total system arc rating of layered ensembles must be determined by a multilayer arc test on the combination of all the layers assembled as they would be worn, rather than adding the arc ratings of the individual layers. The standard allows nonmelting, flammable fiber garments to be used as undergarments for added protection, but if PPE is selected using Tables 130.7(C)(9) and 130.7(C)(10) in the standard, **all layers added to determine the total system arc rating must be flame resistant. In the past companies have tested FR shirting layered over non flame resistant T-shirts to achieve a system arc rating.**

NFPA 70E does not allow adding the arc ratings of garments in a layered system, but each ensemble has to be arc tested with the fabrics layered as they will be worn. This applies whether the garments are from the same manufacturer or from different manufacturers – all ensembles must the arc tested.

Under NFPA 70E employers must document and implement an overall electrical safety program that includes hazard/risk evaluation and job briefing procedures. This program must be audited annually. If energized electrical conductor or circuit parts operating at 50 volts or more are not placed in an electrically safe work condition, written authorization by work permit is required. Employees must be qualified to do the work and trained to understand the specific hazards and potential injury associated with electrical energy. Employees exposed to shock hazards must be retrained annually in cardiopulmonary resuscitation.

Employers must conduct both shock and flash hazard analysis to establish a flash protection boundary. When work will be performed within the arc flash protection boundary, the employer must document the incident energy exposure in calories per square centimeter. Arc rated clothing conforming to the requirements of ASTM F1506 and appropriate PPE must be worn either based on the incident energy determined for the specific task or by using NFPA 70E Table 130(C) (9) to determine the hazard/risk category.

Canadian Standards Association Standard Z462-08, Workplace Electrical Safety is the Canadian standard for electrical workplace safety. Garments meeting the requirements of NFPA 70E also meet the requirements specified in CSA Z462-08, Section 4.3.7. Z462 PPE requirements are currently essentially identical to the 2009 Edition of NFPA 70E. Future plans are to modify Z462 for Canadian requirements.

WHAT ARE THE GARMENT PERFORMANCE REQUIREMENTS FOR WORKERS EXPOSED TO ELECTRIC ARCS?

The ASTM F1506 Specification for Flame-Resistant Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electrical Arc and Related Thermal Hazards covers performance properties of textile materials to be used for wearing apparel by electrical workers exposed to electric arcs. These materials must meet the following performance requirements:

- A general requirement that thread, findings, and closures used in garment construction not contribute to the severity of wearer injuries in the event of an electric arc exposure.
- A set of minimum performance specifications for knit and woven fabrics.
- The fabric must not melt, drip, or have more than 2.0 seconds Afterflame or 6.0 inches Char Length when tested as received and after 25 launderings or dry cleanings. Testing for flame resistance is in accordance with ASTM Test Method D6413.
- The fabric may not have more than 5.0 seconds Afterflame time when tested as received in accordance with ASTM Test Method F1959. The arc rating is reported as either: arc rating ATPV or arc rating E_{BT} (if the ATPV cannot be calculated because of fabric breakopen). The arc rating is reported as guidance on the performance of the fabric in arc exposure testing. There is no minimum required value for arc rating.

Garments conforming to the requirements of F1506 must be labeled with a tracking code, a statement that the garments meets the requirements of F1506, the manufacturer's name, size information, care instructions and fiber content, and the arc rating (ATPV) or (E_{BT}). When garments are made with a different number of fabric layers in different areas; e.g., double layer front panels, the arc rating for each area must be designated. Pockets, trim, closures, seams, etc. are not considered extra layers.

» FAST FACTS

Electrical Safety NFPA 70E Requires

Employees must use safe work practices and personal protective equipment (PPE), which includes arc rated clothing based upon the incident energy associated with the specific task. Total system arc rating of layered ensembles must be determined by a multilayer arc test. If PPE is selected using Tables in the standard, all layers used to determine the total system arc rating must be flame-resistant. Employers must document an overall safety program including hazard/risk assessment and job briefing procedures. This program must be audited annually.

- All layers used to determine total system arc rating must be FR.
- Cannot add arc ratings together. Each ensemble must be tested layered as it will be worn.
- CSA Z462 is the Canadian standard for electrical workplace safety. As currently written, the PPE requirements are virtually identical to NFPA 70E. Future plans are for Canadian modifications.

Workers Exposed to Electric Arcs, ASTM F1506 Requires

- Thread, findings and closures do not contribute to the wearer's injuries in an electric arc exposure.
- Knit or woven fabrics may not melt and drip, or have more than 2.0 seconds Afterflame or 6.0 inches Char Length.
- Fabrics can not have more than 5.0 seconds Afterflame in an electric arc exposure test.
- Arc rating must appear on garment labels.

HOW ARE PROTECTIVE GARMENTS FOR WORKERS EXPOSED TO ELECTRIC ARC TESTED?

Two standards relating to performance of textiles materials intended for use as protective clothing for workers exposed to electric arcs have been issued by ASTM International:

- F1958, Standard Test Method for Determining Ignitability of Non-Flame-Resistant Material for Clothing for Electric Arc Exposure Method Using Mannequins:

This test method exposes a material to heat energy from an electric arc and determines the incident exposure energy that causes ignition. The test also determines the probability that ignition will occur. Material performance is determined by the ignitability of the specimen(s). Materials that meet the flame resistance requirements of Specification F1506 do not require testing by this method unless they meet these requirements by melting to escape from the flame.

Textile materials, either in single or multiple layers, are fabricated as shirts and exposed to an electric arc while mounted on at least two mannequins. The mannequins are arranged in a circle centered on the arc. Results are reported as a probability of ignition at various incident exposure energy levels at a specified amperage and distance. Multiple tests are required to assure statistical significance.

- F1959, Standard Test Method for Determining the Arc Thermal Performance Value for Materials for Clothing:

This test method is used to measure the arc rating of materials intended for use as flame-resistant clothing for workers exposed to electric arcs that can generate heat flux rates from 2 to 600 cal/cm^2/second. It is not intended for non-flame-resistant materials. Arc ratings are expressed in cal/cm^2 and are derived from the Arc Thermal Performance Value (ATPV) or Breakopen Threshold Energy (E_{BT}).

- Textile materials in the form of flat specimens mounted on three two-sensor panels are exposed to an electric arc. The panels are arranged in a circle around the arc spaced at 120°F (49°C). Arc parameters are 8 +/- 1-kA arc current, 12-inch electrode gap, stainless steel electrodes, and 12-inch distance between the arc centerline and the test specimen surface. The incident energy range is achieved by increasing or decreasing the arc duration.
- The amount of heat energy transferred by the textile materials is measured by copper calorimeters mounted in the sensor panels. A series of at least seven tests are run over a range of incident energies. From the heat transfer data, the Arc Thermal Performance Value (ATPV) is calculated as the incident energy that results in a 50% probability of the onset of a second-degree burn. This is determined based on the Stoll Curve, a skin burn injury model produced from data on human tissue tolerance to heat that is used as an overlay for the plot of the sensor responses. The Heat Attenuation Factor (HAF) is the percentage of total energy the fabric has prevented from reaching the panel sensors.
- A minimum of 20 data points is required for data analysis, of which 15% must always exceed the Stoll second degree burn criteria and 15% must never exceed the Stoll criteria. At least 50% of the values must be within +/- 20% of the final ATPV. Some of these values will exceed and some will not exceed the Stoll burn injury criteria. If two or more occurrences of material breakopen are noted at less than 20% above the ATPV determination, a breakopen response is determined as the 50% probability that breakopen will occur. In this case the lower value of either Breakopen Threshold Energy (E_{BT}) or ATPV is reported as the arc rating for the material.

» FAST FACTS

ASTM F1958

- Determines probability of ignition at a range of arc exposures.
- Used to test FR and non-FR materials.
- Fabrics are tested as shirts mounted on mannequins.

ASTM F1959-99

- Determines arc rating of materials based on electric arc exposure.
- Fabrics are mounted on flat panels for testing.
- Ratings are expressed in cal/cm^2.
- E_{BT} determined if material shows breakopen response above the ATPV.

ARE THERE SPECIAL REQUIREMENTS FOR FLAME-RESISTANT RAINWEAR?

There are two standards that address rainwear exposed to the hazards of electric arc and flames. ASTM Standard Specification F1891, Arc and Flame-Resistant Rainwear applies to rainwear for use by workers exposed to thermal hazards of electric arcs and open flames. ASTM Standard Specification F2733, Flame-resistant Rainwear for Protection against Flame Hazards establishes requirements for workers exposed to industrial hydrocarbon fires or other petrochemical fire hazards.

Both standard specifications establish applicable test methods, minimum physical and thermal performance requirements, suggested sizing charts, and suggested purchasing information for rainwear.

These standards establish a requirement that the FR rainwear material must have a trapezoidal tear resistance greater than 6 pounds, withstand 30 PSIG water pressure without leaking, and have seams that demonstrate a hydrostatic resistance of 3 PSIG for 2 minutes. All mechanical fastener closures such as buttons and snaps must be covered by the rainwear outer layer material and a layer of material on the inside of the garment to reduce heat transfer to the skin. For garments meeting F1891, all fabrics, trim and findings used to manufacture rainwear must be electrically non-conductive. Markings and reflective trim must not degrade the protective performance of the rainwear.

The rainwear material must not melt, drip, or have more than 2.0 seconds Afterflame when tested in accordance with ASTM Test Method D 6413. F1891 requires a maximum of 6.0 inches Char Length; F2733 has a more stringent requirement of 4.0 inches Char Length, maximum. Testing is conducted on rainwear material as received and after five cleaning and drying cycles following the manufacturer's care instructions.

Rainwear for protection from electric arcs is tested for thermal resistance to an electric arc by ASTM Test Method F1959 to determine the arc rating and heat attenuation factor (HAF). The arc rating is expressed in calories per square centimeter and is derived from the Arc Thermal Performance Value (ATPV) or Breakopen Threshold Energy (EBT). The arc rating must be equal or greater than 5.0 cal/cm^2. Response characteristics of the rainwear material; Afterflame time, breakopen, charring, electric arc ignition, embrittlement, melting and shrinkage are determined and reported at exposures equal to the arc rating. No dripping of the material is permitted at exposures twice the arc rating.

Rainwear for protection from hydrocarbon fires and related hazards is tested to determine percent body burn following exposure on an instrumented mannequin in accordance with ASTM Test Method F1930. The exposure heat flux is 84 kW/m^2 (2.02 cal/cm^2/sec) with an exposure time of 3.0 seconds. Three coverall specimens made in accordance with the standard garment requirements of F1930, Section 8.3.2, are laundered and dried one time following the manufacturer's care instructions before testing. The average predicted second and third-degree burn areas and total area of burn injury is determined. Both the third-degree burn area and the total area of burn injury are reported. The average predicted burn area must be equal to or less than 40%. Other material responses to the simulated flash fire are also reported including Afterflame time, breakopen, charring, dripping, garment ignition, embrittlement, melting and shrinkage.

Garments meeting the requirements of ASTM F1891 and/or F2733 must be labeled with a statement that the garments conform to the specification, the manufacturer's name, style designation, size information, care instructions and fiber content. Garments for protection from electric arcs must be labeled with the arc rating (ATPV or EBT) of the base material. If the rainwear also meets the requirements of ANSI/ISEA Standard for High-Visibility Safety Apparel and Headwear, it must also be labeled with a statement that the garment meets this standard. Other labeling requirements include the Performance Class and Level and the durability of the garment to appropriate cleaning processes.

» FAST FACTS

ASTM Standard Specifications for Flame and Thermal Protective Rainwear

- Material must withstand 30 PSIG water pressure without leaking.
- Seam hydrostatic resistance requirement 3 PSIG/2 minutes.
- No melt and drip permitted in vertical FR testing. Maximum allowable Char Length is no more than 4.0 inches for F2733 or 6.0 inches for F1891.
- For rainwear for protection from electric arcs, the arc rating (either ATPV or E_{BT}) must be equal to or greater than 5.0 calories per square centimeter. The material response characteristics are evaluated at the arc rating and no dripping is permitted at twice the exposure level of the arc rating.
- Rainwear for protection from hydrocarbon fires and related hazards must have an average predicted total burn area equal to or less than 40% when exposed to a 3 second simulated flash fire.
- Garments meeting the requirements of F1891 and/or F2733 must be labeled with a statement that the garments conform to the specification, the manufacturer's name, style designation, size information, care instructions and fiber content. Garments for protection from electric arcs are required to be labeled with the arc rating (ATPV or EBT) of the base material.

WHAT ARE THE REQUIREMENTS FOR HIGH VISIBILITY SAFETY APPAREL?

ANSI/ISEA 107-2010 American National Standard for High-Visibility Safety Apparel and Headwear establishes design, material, photometric and physical performance requirements, care labeling and marking rules for high visibility garments. Garments compliant to ANSI/ISEA 107-2010 are intended to provide visibility to the user in hazardous situations under any light conditions by day and under illumination by vehicle headlights in the dark.

High-visibility garments marked as flame resistant must comply with the requirements of at least one of the following standards in its entirety: ASTM F1506, ASTM F1891, ASTM F2302, ASTM F2733, or NFPA 2112.

As mandated by the Federal Highway Administration (FHWA), all workers within the rights-of-way of a federally-aided highway who are exposed to either traffic or construction equipment within the work area must wear high-visibility safety apparel. This apparel must meet the Performance Class 2 or 3 requirements of ANSI/ISEA 107-2010. Class 2 garments provide a superior level of visibility for higher risk occupations when work backgrounds are complex and/or weather is inclement, workers' attention is diverted from approaching traffic and vehicle speed is typically greater than 25 mph. Class 3 garments are worn when workers are a high risk due to limited sight distances and/or extreme weather conditions and high speed vehicle traffic. These garments must enable the wearer to be identified as a person.

WHAT IS THE DIFFERENCE BETWEEN INHERENT FLAME RESISTANCE AND TREATMENTS?

Flame and thermal resistant fibers and fabrics can generally be divided into two groups: those that are inherently flame- resistant, and those that achieve flame resistance through special treatments.

Inherently flame-resistant fibers/fabrics – Flame resistance is an essential characteristic of the fiber from which textiles are made.

Treated fibers/fabrics – Have an applied chemical treatment to change the original level of a specific property or properties, in this instance flame resistance.

BE ADVISED

A number of temporary water soluble flame retardant treatments for cotton have been used. Borax and boric acid salt combinations are the most common. These treatments are strongly discouraged by Bulwark® because of the potential lack of control in application or conditions of wear.

HOW LONG HAVE FR GARMENTS BEEN AVAILABLE?

From earliest times, exposure to fire has been a concern. Various combinations of ammonium salts of sulfuric, hydrochloric, or phosphoric acid have been used to impart flame resistance to cotton textiles. THPC (sold as ROXEL® or FR2®) was the original commercially successful flame-resistant treatment for cotton work apparel. These fabrics had many shortcomings and the treatment was not durable for the life of the garment. Today, flame retardant finishes for 100% cotton and cotton blend fabrics are available with varying levels of durability, including finishes guaranteed for the life of the garment.

Synthetic flame-resistant fibers were developed in the 1950's. The first fiber introduced was NOMEX® from DuPont. As with the development of FR cotton, new finishes and additional fibers have been produced to address identified shortcomings. Currently, various blends and finishes are available for a variety of end uses.

WHAT IS THE BEST FR FIBER AND/OR FABRIC?

There is no perfect flame-resistant garment system that meets all needs. Each FR fiber or treated fabric has certain properties that can be either benefits or shortcomings. Blending different fibers attempts to balance these properties for maximum fabric performance. It is important to be aware of these properties so garments may be selected to meet the specific requirements of a given application.

WHAT KEY POINTS SHOULD I CONSIDER WHEN CHOOSING FR GARMENTS?

Your review of fabrics should consider thermal protection, static resistance, comfort, durability, stability, employee acceptance, appearance, ease of laundry maintenance, color availability, and relative cost. You also need to be aware of any special circumstances, such as electric arc, molten substance, or chemical hazards.

On the following pages you will find detailed descriptions of the fibers and fabrics currently used to manufacture work apparel.

» FAST FACTS

- ANSI/ISEA 107-2010 is the hi-vis garment standard.
- Hi-vis garments marked as FR must also comply with a recognized flammability standard.
- FWHA requires Class 2 or 3 garments when working on federally-aided highways.

Inherently Flame-Resistant Fibers
Flame resistance is an essential characteristic of the fiber.

Treated Fabrics
Flame resistance is achieved through special treatments applied to the fiber or fabric. Non-Durable FR Treatments are not recommended.

- Some flame retardant finishes for 100% cotton and cotton blend fabrics are durable for the life of the garment.

Blending
Using two or more fibers in one fabric to balance fiber strengths and weaknesses.

FR Fabric Selection Considerations

Thermal Protection	Static Resistance
Comfort	Durability
Stability	Appearance
Relative Cost	Available Colors
Ease of Laundry Maintenance	

GENERIC NAME	FIBER	MANUFACTURER	MOISTURE REGAIN*	TENACITY G/DEN**	COMMENTS
Aramid (meta)	Nomex® Conex®	Dupont Teijin (Japan)	5.5	4.0-5.3	• Long chain synthetic polyamide fiber • Excellent thermal stability. Will not melt and drip. • Excellent chemical and abrasion resistance • Fair colorfastness to laundering and light exposure
Aramid (para)	KEVLAR® TWARON® TECHNORA®	Dupont Teijin Teijin (Japan)	4.3 4.0	21-27 22.6	• Long chain synthetic polyamide fiber • Blended with Nomex® for fabric integrity in high temperature exposures • Fair abrasion resistance • Sensitive to chlorine bleach, light, and strong mineral acids
Polyamide imide	KERMEL®	KERMEL® (France)	3.4	4.0-4.5	• Long chain synthetic polyamide fiber. Excellent thermal stability. Will not melt and drip. • Excellent chemical and abrasion resistance • Fair colorfastness to laundering and light exposure
Melamine	BASOFIL®	BASOFIL® LLC	5.0	2.0	• A melamine fiber formed when methylol compounds react to form a three dimensional structure of methylene ether and methylene bridges • Resistant to many solvents and alkalis. Moderately resistant to acids. • Will not shrink, melt or drip when exposed to a flame
Modacrylic	Protex®	Kaneka (Japan)	2.5	1.7-2.6	• Long chain synthetic polymer fiber containing acrylonitrile units modified with flame retardants • Excellent chemical resistance • Fair abrasion resistance • High thermal shrinkage
FR Acrylic	Super Valzer®	Kanebo (Japan)	2.5	1.7-2.6	• Long chain synthetic polymer fiber containing acrylonitrile units modified with flame retardants • Excellent chemical resistance • Fair abrasion resistance • High thermal shrinkage
PBI	PBI Gold®	PBI Performance Products Inc.	15.0	2.8	• Polymer is a sulfonated poly (2,2-m-phenylene-5,5 bibenzimidazole). Will not ignite, does not melt. • Excellent chemical resistance • Dyeable in dark shades only
Polyimide	P84®	Inspec Fibres (Austria)	3.0	4.3	• Long chain synthetic polyimide fiber • High thermal shrinkage • Thermal properties inferior to Nomex®
FR Viscose	Lenzing FR®	Lenzing (Austria)	10.0	2.6-3.0	• Man-made cellulosic, properties similar to cotton • Fiber contains flame retardants
FR Cotton	FR Cotton	Natural Fiber	8.0	2.4-2.9	• Flame retardant treated in fabric form. Poor resistance to acids. • Relatively poor abrasion resistance • Relatively poor colorfastness to laundering and light exposure • Wear properties similar to untreated cotton
FR Polyester	AVORA® FR Polyester Trivera CS	INVISTA Trivera (GERMANY)	.4	4.5	• Polyester with proprietary organic phosphorus compound incorporated into the polymer chain • Properties similar to regular polyester except as modified by flame retardants • Melt point 48.2°F (9°C) lower than regular polyester
Carbon/ Oxidized PAN	CarbonX® Carbtex®	Chapman Innovations Ashburn Hill Corp	N/A	3-5	• Oxidized polyacrylonitrile (O-PAN). High limiting oxygen index (LOI). Remains strong on exposure to high temperature. Fiber is black in color.
Polyamide	Nylon	INVISTA Solutia	4.5	6.0-8.0	• Long chain synthetic polyamide in which less than 85% of the aramide linkages are attached • Blended with FR cotton to improve abrasion resistance, wear properties significantly better than untreated cotton
Vinal	VINEX® FR9B®		3.0	3.0	• Fabric blended of 85% Vinal/15% rayon • Fiber composed of vinyl alcohol units with acetal crosslinks • Sheds aluminum splash • Very sensitive to shrinkage from wet and dry heat

* A measure of ability to absorb moisture. (Percent by weight of moisture gained from a bone dry state at 65% relative humidity)
**A measure of strength and durability. (Tenacity is defined as force per unit linear density to break a known unit of fiber)

» TREATED FABRIC

Fabrics that are treated with a flame retardant chemical to make them flame-resistant. The fibers used in these fabrics, such as cotton, are not normally considered protective and become flame-resistant because of the treatment. The durability of the treatment can vary from very limited to life of the garment.

AMPLITUDE® BY MILLIKEN 88% COTTON/12% NYLON

Milliken Amplitude® is made from a blend of cotton and nylon fibers. Amplitude® is differentiated from conventional 88/12 fabrics that are constructed with warp yarns that are a blend of 75% cotton and 25% nylon and 100% cotton filling yarns. Amplitude® is an intimate blend of 88% cotton and 12% nylon. This means that every yarn, warp and filling, consists of 88% cotton and 12% nylon. This fabric is also finished by a patented process without the use of ammonia. Milliken fabrics under the Amplitude® brand are available in a variety of weights, including a 6.0 oz sateen weave version that is rated HRC 2 for NFPA 70E applications and is certified by Underwriters Laboratories to NFPA 2112.

Bulwark Protective Apparel markets garments made from Milliken Amplitude® durable FR cotton blend fabrics under the brand name "Excel-FR® ComforTouch®".

APPLICATIONS

Utilities, petrochemical, chemical, oil and gas. Nearly all areas involving ferrous metals such as foundries, flame cutting, welding, etc.

NOT RECOMMENDED FOR

Use around molten "white metals" such as aluminum, magnesium, or zinc, or for use in critical static control operations. Use of phosphorus containing flame resistant cotton is not recommended in chemical operations where contact with strong oxidizers (e.g., >10% sodium hypochlorite, NaOCl) or reducing agents (e.g., sodium hydrosulfite, $Na_2S_2O_4$) are a consideration.

FLAME RESISTANCE

When laundered by recommended procedures, Milliken Amplitude® fabric is guaranteed to be flame resistant for the life of the garment.

COLORS

Dyeable in a wide range of colors. Colorfastness to laundering is variable and similar to untreated cotton.

EFFECT OF ACIDS AND ALKALIS

Resistant to alkalis and most solvents, but many acids will completely destroy cotton, both FR and non-FR. The fabric does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

Cotton is unaffected by chlorine bleach at correct temperature and pH ranges. However, repeated chlorine bleach launderings will destroy the flame-retardant polymer. **Chlorine bleach must not be used on flame retardant treated durable FR cotton blend fabrics.** Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering, but **industrial laundry detergents containing hydrogen peroxide must not be used.**

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

Cotton has relatively poor resistance to mildew, aging, and sunlight. Abrasion resistance is also relatively poor. Nylon is added to the blend to improve abrasion resistance. Direct exposure to ultraviolet rays in welding can cause actinic degradation resulting in fabric strength and color loss.

THERMAL STABILITY

Milliken Amplitude® has good resistance to dry heat and is a natural insulator. In a thermal exposure, the nylon portion of the 88% cotton/12% nylon blend is completely absorbed by the majority cotton fiber. It does not flow or lead to skin contact. This fabric is acceptable for use in occupations exposed to electric arc hazards.

Phosphorus treated cotton bleands cannot be used around molten white metals such as aluminum, magnesium, or zinc. Because of the low surface tension of these substances in liquid form, they will stick to FR cotton blends. See the sections on VINEX® FR-9B®, Wool/Rayon Blends, and coated aluminum splash fabrics for information on fabrics appropriate for use around white metals.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain of Milliken Amplitude® is excellent which results in low static propensity. The addition of a small amount of nylon and the flame resistant process has only a minor affect on moisture regain. However, since static control depends on ambient relative humidity, the garment should not be considered for applications where critical static control is required without proper wearer grounding. **It is especially important that these garments not be donned or removed in a hazardous area.**

PROCESSING

Durable FR cotton/nylon blend garments made from Milliken Amplitude® fabrics can be laundered by normal procedures used for any 100% cotton garments. Laundry shrinkage of up to 3.5% can be expected, although exposure to excessive dryer temperatures will result in much higher shrinkage. Starches, fabric softeners, and other laundry additives should be avoided. **DO NOT USE CHLORINE BLEACH DO NOT USE INDUSTRIAL LAUNDRY DETERGENTS OR OTHER CHEMICALS CONTAINING HYDROGEN PEROXIDE.** Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering. The fabric can be tunnel finished up to 280°F (138°C) fabric temperature or pressed at normal utility press temperature (300°F / 149°C). See Bulwark Care & Cleaning Information Bulletin RK-78 or www.bulwark.com for more information.

GARMENT COST

Milliken Amplitude® durable FR cotton/nylon blend garments cost about 20% more than equivalent weights of durable FR 100% cotton.

GARMENT LIFE

Garment life under normal wear conditions is about 40-50% more than durable FR 100% cotton fabric, and perhaps 1/2 that of NOMEX®.

COATED COTTON ALUMINUM SPLASH RESISTANT FABRICS

Special fabrics using a system of antimony oxide and bromide compounds bound to the fiber by a special latex binder have been used for aluminum splash protection. FR-8® was a fabric that is no longer available. **Because of continuing questions about FR-8®, this section is being retained in the Update. However, Bulwark® is not aware of any current North American manufacturer of this product.**

Phosphorus containing flame retardant treatments for 100% cotton flame-resistant fabrics are NOT suitable for protection against aluminum splash. NOMEX® is also inappropriate for this end use. Because of the surface tension of molten aluminum, it will stick to these fabrics. Traditionally, garments of heavy weight untreated 100% cotton were worn by workers exposed to the risk of aluminum splash, as the molten aluminum does not stick to untreated cotton fabric. Antimony oxide and bromide coated 100% cotton fabrics were developed to provide some additional flame-resistant protection from aluminum splash. Fabric blends of natural and synthetic fibers have been introduced to this market and have become the standard for aluminum splash protection.

APPLICATIONS

If the fabric is available, very limited use in the market for protection from aluminum splash and in pot room applications. Antimony oxide/bromide coated 100% cotton fabrics are recommended for use where exposure to cryolite (Na_3AlF_6) is a consideration. These fabrics provide limited splash protection and flame resistance against molten zinc.

NOT RECOMMENDED FOR

General FR protection where long term durability of the finish is required.

MOISTURE REGAIN

The finish is bound to the fibers by a latex binder which allows very little moisture absorbency.

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

Durability of the finish is not life of the garment and may only meet reasonable expectations through 10 to 15 heavy soil industrial laundering processes or 15 to 25 home laundering. It should be recognized that the finish, while not reliable over the life of the garment, does afford protection beyond that of untreated cotton garments. After loss of FR properties, the fabric would provide no more protection than untreated cotton. This finish is not durable to dry cleaning.

GARMENT COST

Garments coated with antimony oxide/bromide compounds cost about 10% more than durable FR cotton.

GARMENT LIFE

The finish weakens the fabric and garment life may be only 50% to 75% that of durable FR cotton or untreated cotton garment of comparable weight.

DURABLE FR 100% COTTON

These fabrics are made flame-resistant by application of a flame retardant finish. This finish can be either a phosphonium salt precondensate polymerized with gaseous ammonia (THPOH-NH_3), or a heat-cured dialkylphosphonamide. These processes bind the flame retardant to cotton fiber for FR durability. Either process has only a minor effect on fabric hand and performance. Among fabrics produced by the "ammonia cure" process are AMTEX® by Mount Vernon Mills, Inc., Banox Certified® by ITEX, Inc. and INDURA® by Westex, Inc. Fabrics produced by the heat cure process include Dale AntiFlame® and many of the cotton knit and fleece fabrics.

Bulwark® Protective Apparel markets garments made from durable flame-resistant 100% cotton fabrics under the brand name "EXCEL FR®".

APPLICATIONS

Utilities, petrochemical and chemical plants, oil, gas, military applications, and wildland fire fighting. Nearly all areas involving ferrous metals such as foundries, flame cutting, welding, etc.

NOT RECOMMENDED FOR

Use around molten "white metals" such as aluminum, magnesium, or zinc or for use in critical static control operations. Fabrics treated by the gaseous ammonia process should not be worn in chemical operations where contact with strong oxidizers (e.g., >10% sodium hypochlorite, NaOCl) or reducing agents (e.g., sodium hydrosulfite, $Na_2S_2O_4$) is a consideration.

FLAME RESISTANCE

Durable flame-resistant 100% cotton fabrics are guaranteed to be flame-resistant for the life of the garment.

COLORS

Dyeable in a wide range of colors. Colorfastness to laundering is variable and similar to untreated cotton.

EFFECT OF ACIDS AND ALKALIS

Cotton is resistant to alkalis and most solvents, but many acids will destroy cotton fabric. The fabric does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

Cotton fabric is unaffected by chlorine bleach. However, repeated chlorine bleach launderings will destroy the flame-resistant finish. Chlorine bleach must not be used on durable flame retardant treated cotton fabrics. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering. Industrial laundry detergents containing hydrogen peroxide must not be used.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

Cotton has relatively poor resistance to mildew, aging, and sunlight. Abrasion resistance is also relatively poor. Direct exposure to ultraviolet rays in welding can cause actinic degradation resulting in fabric strength and color loss.

THERMAL STABILITY

Durable FR cotton fabrics have good resistance to dry heat and are a natural insulator. Some molten white metals such as aluminum, magnesium, or zinc have low surface tension. In an accident, the molten metal will stick to these fabrics. Durable FR cotton fabrics cannot be used around these materials. See the sections on VINEX® FR-9B®, Wool/Rayon Blends, and coated aluminum splash fabrics for information on fabrics for use around white metals.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain of durable FR cotton is excellent, resulting in low static propensity. However, without proper wearer grounding these fabrics should not be considered for critical static control applications. **It is especially important that these garments not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water affects cleaning and contains mineral salts that form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and serve as fuel if garments are exposed to an ignition source.

Durable FR 100% cotton garments can be laundered by normal cotton processes. Laundry shrinkage of up to 5% can be expected. Exposure to excessive dryer temperatures will result in higher shrinkage. Avoid use of starches, fabric softeners, and other laundry additives. **DO NOT USE CHLORINE BLEACH. DO NOT USE INDUSTRIAL LAUNDRY DETERGENTS OR OTHER CHEMICALS CONTAINING HYDROGEN PEROXIDE.** Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering. Garments can be tunnel finished up to 280°F (138°C) fabric temperature or pressed at normal utility press temperatures (300°F / 149°C). See Bulwark® Care & Cleaning Information Bulletin RK-78 or www.bulwark.com for more information.

GARMENT COST

Garments of durable FR 100% cotton fabrics cost about twice as much as conventional 65% polyester/35% cotton, or about 1/2 the cost of NOMEX®.

GARMENT LIFE

Garment life under normal wear conditions is the same as regular 100% cotton, about 1/2 to 2/3 that of 65% polyester/35% cotton, and perhaps 1/3 of NOMEX®.

DURABLE FR COTTON BLENDS 88% COTTON/12% NYLON

Blends of cotton and nylon are designed to increase abrasion resistance compared to similar woven and knit fabrics. Woven fabrics may be made from an intimate blend of 88% cotton and 12% nylon. They may also be constructed with a 75% cotton/25% nylon warp and a 100% cotton filling for an overall blend of 88% cotton/12% nylon. Knit fabrics may be made with an intimate blend of cotton and nylon, or by other methods like plating. These fabrics are made flame-resistant by application of a flame retardant. This finish can be either a phosphonium salt precondensate polymerized with gaseous ammonia (THPOH-NH_3), or a heat-cured dialkylphosphonamide. These processes bind the flame retardant to cotton fiber FR for durability. Either process has little effect on fabric hand and performance. Among fabrics produced by the "ammonia cure" process are AMTEX® by Mount Vernon Mills, Inc., Banwear® by ITEX, Inc. and INDURA® Ultra Soft® by Westex Inc. Many knit and fleece fabrics are produced by the heat cure process.

Bulwark® Protective Apparel markets these garments under the brand name "EXCEL FR® ComforTouch®".

APPLICATIONS

For utilities, petrochemical, oil, gas, military, and wildland fire fighting. Nearly all areas involving ferrous metals such as foundries, welding, etc.

NOT RECOMMENDED FOR

Use around molten "white metals" such as aluminum, magnesium or zinc; or for use in critical static control operations. Fabrics treated by the gaseous ammonia process should not be worn in occupations where contact with strong oxidizers (e.g., >10% sodium hypochlorite, NaOCl) or reducing agents (e.g., sodium hydrosulfite, $Na_2S_2O_4$) is possible.

FLAME RESISTANCE

These fabrics are guaranteed to be flame-resistant for the life of the garment.

COLORS

Dyeable in a range of colors. Colorfastness to laundering is similar to untreated cotton.

EFFECT OF ACIDS AND ALKALIS

Cotton and nylon are resistant to alkalis and most solvents, but many acids will destroy cotton fiber. The fabric does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

Cotton fabric is unaffected by chlorine bleach. However, repeated chlorine bleach launderings will destroy the flame-resistant finish. Chlorine bleach must not be used on durable flame retardant treated cotton fabrics. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering. Industrial laundry detergents containing hydrogen peroxide must not be used.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

Cotton has relatively poor resistance to mildew, aging, and sunlight. Nylon in the blend improves abrasion resistance. Direct exposure to ultraviolet rays in welding causes actinic degradation resulting in fabric strength and color loss.

THERMAL STABILITY

These fabrics have good resistance to dry heat and are a natural insulator. In a thermal exposure, the nylon portion of the blend is absorbed by the cotton fiber and does not contact the skin. These fabrics are acceptable for use in occupations exposed to electric arc hazards. Some molten white metals including aluminum, magnesium, and zinc have low surface tension. Treated FR fabrics cannot be used around these metals. In an accident, the molten metal will stick to the fabric. See the sections on VINEX® FR-9B®, Wool/Rayon Blends, and coated aluminum splash fabrics for information on fabrics for use around white metals.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain is excellent, resulting in low static propensity. However, without proper wearer grounding these fabrics should not be considered for critical static control applications. **It is especially important that these garments not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water affects cleaning and contains mineral salts that form insoluble deposits on the fabric. These deposits can negate flame resistance and serve as fuel if garments are exposed to an ignition source.

Durable FR cotton blend garments can be laundered by normal cotton processes. Shrinkage of up to 5% can be expected. Excessive dryer temperatures will result in higher shrinkage. Avoid use of starches, fabric softeners, and other laundry additives. **DO NOT USE CHLORINE BLEACH. DO NOT USE INDUSTRIAL LAUNDRY DETERGENTS OR OTHER CHEMICALS CONTAINING HYDROGEN PEROXIDE.** Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering. Garments can be tunnel finished up to 280°F (138°C) fabric temperature or pressed at normal utility press temperatures (300°F / 149°C). See Bulwark® Care & Cleaning Information Bulletin RK-78 or www.bulwark.com for more information.

GARMENT COST

Durable FR cotton blend garments cost about 20% more than durable FR 100% cotton.

GARMENT LIFE

Garment life under normal wear conditions is about 50-60% more than durable FR 100% cotton, and perhaps 1/2 that of NOMEX®.

FR DISPOSABLES
55% WOODPULP/45% POLYESTER

The Bulwark® line of FR Disposables is made from Precision Fabrics Groups limited use / disposable hydro entangled fabrics which are topically treated with flame retardant chemicals. The FR treatment is a non-durable phosphate based compound with a fluorochemical additive for water and oil repellency. Water repellency allows these garments to withstand minor splashes without saturation. With the Bulwark® Chemical Splash Flame-Resistant Coverall, the substrate fabric is laminated to a clear PVC film with hot melt polyurethane making an impervious laminate with chemical resistant properties. Both of these coveralls will burn in the presence of an ignition source, but will self-extinguish when the ignition source is removed.

APPLICATIONS

The Bulwark® FR Disposable is highly breathable and offers about 80% filtration efficiency against particles in the 2-5 micron range. It is classified as acceptable for use in Class C: Particulate Abatement activities. Garments made of this fabric can extend the life of more expensive thermal protective garments by preventing flammable contaminants from soiling the fabric.

The Bulwark® Chemical Splash Flame-Resistant Coverall is an impervious laminate with chemical resistant properties. Chemical penetration testing of this garment has been conducted in accordance with ASTM F1001, liquid challenges only, using ASTM F903, Procedure C. Please refer to applicable product literature for data related to specific chemical challenges. The Bulwark® Chemical Splash Flame-Resistant Coverall is also classified as acceptable for use in Class C: Particulate Abatement activities.

NOT RECOMMENDED FOR

Not for asbestos removal. Neither of these disposable coveralls is designed as a primary source of thermal protection and must be worn over suitable flame-resistant apparel.

FLAME RESISTANCE

Both of these disposable coveralls meet the flammability requirements of NFPA 701. The Bulwark® Chemical Splash Flame-Resistant Coverall also meets the flammability requirements of CAN/CGSB 4.2-M77.

COLORS

These coveralls are only available in Sky Blue.

EFFECT OF ACIDS AND ALKALIS

The Bulwark® FR Disposable Coverall has very limited chemical resistance. Refer to applicable product literature for the performance characteristics of the Bulwark® Chemical Splash Flame-Resistant Coverall.

EFFECT OF BLEACHES AND SOLVENTS

The Bulwark® FR Disposable Coverall has very limited chemical resistance. Refer to applicable product literature for the performance characteristics of the Bulwark® Chemical Splash Flame-Resistant Coverall.

EFFECT OF MILDEW, AGING, SUNLIGHT, AND ABRASION

As disposable limited use covering garments, exposure in storage to sunlight and/or moist conditions that could result in mildew should be avoided. Neither fabric has significant abrasion resistance.

THERMAL STABILITY

Both of these disposable coveralls will burn in the presence of an ignition source, but will self-extinguish when the ignition source is removed. These limited use disposable garments are not designed as a primary source of thermal protection and **must** be worn over suitable flame-resistant clothing.

PROCESSING

Neither coverall is washable. Always dispose of in a responsible manner when soiled.

GARMENT COST

The Bulwark® FR Disposable Coverall costs about 1/3 as much as a 65% polyester/35% cotton coverall. The Bulwark® Chemical Splash Flame-Resistant Coverall costs about 1/2 as much as a 65% polyester/35% cotton coverall.

GARMENT LIFE

These coveralls are designed to be used as disposable supplemental protection from a specific hazard, or to prevent soiling expensive reusable protective garments. Although a single use of each garment is anticipated, number of possible wearings will depend on work activities during use.

LIMITED DURABILITY FR TREATED 100% COTTON

Fabrics produced with the gaseous ammonia or ammonia cure reaction, but whose finish is not guaranteed for the life of the garment. Cotton is soft and widely viewed as the most comfortable fiber. The ammonia cure flame-resistant process has only a minor effect on either fabric hand or performance characteristics. Limited durability FR treated 100% cotton fabrics include Banox® by ITEX, Inc. and Proban® FR-7A® by Westex, Inc.

APPLICATIONS

Molten metals industry and some welding operations where harsh environmental exposures are destructive to the fabric itself. Because the garments themselves have a relatively short service life, durability of the FR finish to extended laundry processing is not seen as a benefit.

NOT RECOMMENDED FOR

Use around molten white metals such as aluminum, magnesium, or zinc or for use in critical static control operations. Limited durability FR treated 100% cotton fabrics should not be worn in chemical operations where contact with strong oxidizers (e.g., >10% sodium hypochlorite, NaOCl) or reducing agents (e.g., sodium hydrosulfite, $Na_2S_2O_4$) is a consideration.

FLAME RESISTANCE

Durability of these 100% cotton fabrics may vary. Manufacturers certify the flame resistance of these fabrics through 25 industrial washes at 185°F (85°C) or through 50 home washings at 140°F (60°C). See garment manufacturer for more information.

COLORS

Dyeable in a wide range of colors. Colorfastness to laundering is variable and similar to untreated cotton.

EFFECT OF ACIDS AND ALKALIS

Cotton is resistant to alkalis and most solvents, but many acids will completely destroy both FR cotton and non-FR. The fabric does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

Bleach resistance deserves a special comment. Cotton itself is unaffected by chlorine bleach if it is properly used (correct temperature and pH ranges). However, repeated chlorine bleach launderings will destroy the flame retardant polymer in treated cotton fabric. Chlorine bleach must not be used on flame retardant treated cotton fabrics. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering, but industrial laundry detergents containing hydrogen peroxide must not be used.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

Cotton has relatively poor resistance to mildew, aging and sunlight. Abrasion resistance is also relatively poor. Direct exposure to ultraviolet rays in welding can cause actinic degradation resulting in fabric strength and color loss.

THERMAL STABILITY

FR cotton fabric has good resistance to dry heat and is a natural insulator. Phosphorus treated 100% cotton cannot be used around molten white metals such as aluminum, magnesium, or zinc. Because of the low surface tension of these substances in liquid form, they will stick to FR cotton. See the sections on VINEX® FR-9B®, Wool/Rayon Blends, and coated aluminum splash fabrics for information on fabrics appropriate for use around white metals.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain of cotton is excellent, and results in low static propensity. However, since static control depends on ambient relative humidity, without proper wearer grounding, the fabric should not be considered for applications where critical static control is required. **It is especially important that these garments not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

Limited durability FR treated 100% cotton garments can be laundered by normal procedures used for any 100% cotton garments. Laundry shrinkage of up to 5% can be expected, although exposure to excessive dryer temperatures will result in much higher shrinkage. Avoid starches, fabric softeners, and other laundry additives. **DO NOT USE CHLORINE BLEACH. DO NOT USE INDUSTRIAL LAUNDRY DETERGENTS OR OTHER CHEMICALS CONTAINING HYDROGEN PEROXIDE.** Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering. The fabric can be tunnel finished up to 280°F (138°C) fabric temperature or pressed at normal utility press temperatures (300°F / 149°C).

GARMENT COST

Garments made from limited durability FR treated 100% cotton fabrics cost about 10-15% less than equivalent weight garments made of durable FR 100% cotton.

GARMENT LIFE

Garment life under normal wear conditions is the same as untreated 100% cotton garments of the same construction and weight.

» TREATED FIBERS

Fabrics made from synthetic fibers that are extruded with a flame retardant chemical in the fiber-forming process. These fabrics become flame-resistant for the life of the garment because the flame retardant cannot be removed by wear or laundering.

LENZING FR® 100% RAYON

Lenzing FR® is a man-made cellulosic fiber made by Lenzing AG. It is permanently flame retardant treated in the fiber forming process. Lenzing FR® has been extensively used in fabric blends where it provides increased moisture absorption and comfort without compromising protection.

APPLICATIONS

For industrial protective clothing, Lenzing FR® is commonly blended with other fibers such as para and meta aramids, P84®, and PBI. Lenzing FR® can be used in knits, wovens, and non-wovens.

NOT RECOMMENDED FOR

Use in outer shell fabrics, bunker gear, or other applications where abrasion resistance and extreme physical durability are required.

FLAME RESISTANCE

Lenzing FR® is permanently flame-resistant and this property cannot be degraded by laundering. A solid, non-soluble flame retardant is incorporated at the fiber spinning stage.

COLORS

Dyeable in a wide range of colors. Colorfastness to laundering is variable and similar to normal viscose fiber.

EFFECT OF ACIDS AND ALKALIS

Lenzing FR® is stable when exposed to a wide variety of acids and alkalis. Avoid prolonged exposure to high concentrations of sulfuric acid, sodium hydroxide, dimethyl formamide, and dimethyl sulfoxide. The fabric does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

Lenzing FR® is stable when exposed to a wide variety of bleaching agents and organic solvents.

EFFECT OF MILDEW, AGING, SUNLIGHT, AND ABRASION

Lenzing FR® has good UV resistance. Exposure to sunlight (UV rays) does not cause premature aging of the fiber. Resistance to abrasion is fair. Mildew resistance is relatively poor.

THERMAL STABILITY

Lenzing FR® has good resistance to dry heat and is a natural insulator. It will not melt or drip. High tenacity fibers, such as aramids, are commonly blended with Lenzing FR® to enhance physical durability and thermal stability of the fabric.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain is excellent and results in low static propensity. However, since static control depends on ambient relative humidity, without proper wearer grounding fabric containing Lenzing FR® should not be considered for applications where critical static control is required. **It is especially important that garments containing Lenzing FR® not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

Garments made of Lenzing FR®, or blends thereof, can be laundered or dry cleaned by normal procedures. Shrinkage can typically vary up to 5%, and is primarily a function of fabric construction and the fabric finishing process. Since Lenzing FR® is often blended with other fibers, it is recommended that the laundering instructions for these fabrics be followed.

GARMENT COST

As Lenzing FR® is commonly blended with other fibers for industrial applications, garment cost will vary depending on the fabric weight and fiber blend.

GARMENT LIFE

As Lenzing FR® is commonly blended with other fibers for industrial applications, garment life will vary depending on the fabric weight and fiber blend.

BLENDS OF MODACRYLIC AND COTTON

Various blends of Modacrylic and cotton fibers have been introduced in both woven and knit fabric constructions for use in T-shirts, polo shirts, sweatshirts, hoods, shirts, pants, and coveralls. These fabrics are characterized by excellent, cotton-like hand and include Firewear® from Springfield LLC, a 55% Modacrylic/45% cotton blend, Valzon FR®, a 60% Modacrylic/40% cotton blend from Westex Inc., and DRIFIRE®, a 85% Modacrylic/15% cellulosic blend from DRIFIRE Inc.

APPLICATIONS

Utilities, and for fire fighters station/work uniforms.

NOT RECOMMENDED FOR

Use around molten substances or welding operations or in critical static control applications.

FLAME RESISTANCE

The FR acrylic fiber is treated with a flame retardant in the fiber forming polymer. Flame resistant properties are permanent and cannot be degraded by laundering. The cotton is not treated for flame resistance but derives its self-extinguishing characteristic from the presence of the FR acrylic fiber.

COLORS

Dyeable in a wide range of colors with good colorfastness. Fabrics may be overprinted.

EFFECT OF ACIDS AND ALKALIS

Chemical resistance is similar to 100% cotton. These fabrics are resistant to alkalis and most solvents. Many acids will completely destroy the cotton portion of the blend. The fabrics do not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

Laundering with chlorine bleach is not recommended because it will cause the fabric to lose color. However, chlorine has no affect on the flame resistance of the fabric.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

Overall blend has relatively poor resistance to mildew, aging, and sunlight. Abrasion resistance is similar to cotton.

THERMAL STABILITY

Not recommended for use around any molten substance or welding exposure. Thermal stability is excellent and the fabric will not melt.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain of the blend is excellent. Except in very low relative humidity, these fabrics should have little static propensity. However, it should not be considered for use in critical static control applications without proper wearer grounding. **It is especially important that these garments not be donned or removed in a hazardous area.**

PROCESSING

Modacrylic/cotton blend fabrics should be laundered in soft water (<4.0 grains) without chlorine bleach. Hard water can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

Best appearance and garment life results are achieved with low temperature (120°F / 49°C) laundering using surfactant chemistry detergents. Wash temperatures higher than 120°F (49°C) may cause fabric to shrink excessively. May be conditioned and tunnel finished at up to 230°F (110°C) fabric temperature. In home laundering, use the Permanent Press settings on the washer and dryer. See www.bulwark.com for more information.

GARMENT COST

Garments made from blends of Modacrylic and cotton cost about the same as comparable garments made from durable FR 100% cotton.

GARMENT LIFE

Garment life under normal wear conditions is about 1 1/2 times that of durable FR 100% cotton.

WOOL AND RAYON BLENDS ALUMINUM INDUSTRY PROTECTIVE FABRICS

Several fabrics are available for use by the molten metals industry in general and the aluminum smelting and casting industry in particular. These fabrics are primarily blends of wool and rayon or Lenzing FR® and include PR-97® from Melba Industries and TenCate OASIS® from TenCate™ SouthernMills™. These fabrics are designed to shed both molten aluminum and cryolite or "bath" (Na_3AlF_6), a catalyst used in smelters to extract aluminum metal from ore. These fabrics are available in both shirt and pant weights. See section on VINEX FR-9B for alternative aluminum splash protective fabric.

Bulwark® Protective Apparel markets TenCate™ SouthernMills™ TenCate OASIS® under the category Molten Metal Protection.

APPLICATIONS

The molten metals industries, including red metals and aluminum smelting and casting.

NOT RECOMMENDED FOR

Use in critical static control applications.

FLAME RESISTANCE

Lenzing FR® and other FR rayon products are treated in the fiber forming process and laundering cannot degrade this property. The wool portion of the blend may or may not be FR treated. See information provided by the fabric or garment manufacturer.

COLORS

Dyeable in a wide range of colors.

EFFECT OF ACIDS AND ALKALIS

Wool is resistant to attack by acids, but is extremely vulnerable to attach by weak alkalis, even at low dilutions.

EFFECT OF BLEACHES AND SOLVENTS

Wool is irreversibly damaged by dilute oxidizing bleaches such as hypochlorite. Reducing agents cause wool to dissolve. Wool is generally very resistant to solvents except those capable of breaking the disulfide crosslinks in the fiber.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

Wool is attacked by short ultraviolet wavelengths in sunlight. Resistance to abrasion is fair to good, but resistance to mildew is poor.

THERMAL STABILITY

Wool burns very slowly even in contact with a flame. FR treatment can enhance this characteristic. Rayon has good resistance to dry heat and is a natural insulator.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain of wool is high – 13 to 18% under standard conditions. Due to its affinity for water, wool does not build up significant static charges. Since static control depends on ambient relative humidity, without the proper wearer grounding the fabric should not be considered for applications where critical static control is required. **It is especially important that these garments not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

Follow garment manufacturer's recommendations. Molten splash protective wool and rayon blend garments should be washed separately in buffered surfactant chemistry detergents at a maximum temperature of 120°F (49°C). **Neither chlorine bleach nor perborate may be used because they will destroy the wool fiber.** Maximum dryer temperature must not exceed 150°F (65.5°C) and garments must be removed from the dryer with 35% moisture content or excessive shrinkage will result. Fabrics may be pressed at a low temperature for wool. For home laundering use the delicate or gentle cycle and rinse in cold water. Use the minimum temperature setting available and remove clothes when still damp to minimize shrinkage. Press with hand iron on wool setting. See Bulwark® Care & Cleaning Information Bulletin RK-80 or www.bulwark.com for more information.

GARMENT COST

Garments made of wool and rayon blend fabrics cost about 10% more than garments made from 6.0 oz NOMEX®.

GARMENT LIFE

Under normal wear conditions, garment life is expected to fall between FR cotton and 65% polyester/35% cotton, or between 2 and 3 years.

» BLENDS OF TREATED & INHERENTLY FR FIBERS

Fabrics that are made from a mixture of inherently flame-resistant fibers, such as NOMEX®, with fibers that are treated in the fiber-forming process, such as Lenzing FR®. These fabrics become flame-resistant for the life of the garment because the flame retardant cannot be removed by wear or laundering.

NOMEX®/FR RAYON BLENDS

NOMEX® has been blended with Lenzing FR® which produces a durable fabric with higher moisture regain than 100% aramid. These blends include NOMEX® AP, a PGI DIFCO blend of 65% NOMEX® and 35% Lenzing FR®.

APPLICATIONS

Petrochemicals, utilities, and for fire fighter station wear.

NOT RECOMMENDED FOR

Use around molten substances or welding operations, or in critical static control applications.

FLAME RESISTANCE

Fabrics made from blends of NOMEX®/FR Rayon are mixtures of inherently flame-resistant aramid fibers with permanently FR treated Lenzing FR® which means that this property cannot be removed by wear or laundering.

COLORS

The aramid fiber may be solution dyed, which means the fiber is dyed in the fiber forming process, or piece dyed, depending on the color. Similarly, the Lenzing FR® fiber may be piece dyed, or undyed, depending on the color.

EFFECT OF ACIDS AND ALKALIS

The aramid fiber is unaffected by most acids, and has generally good resistance to alkalis. The chemical resistance of the viscose portion of the blend is similar to cotton in that it is destroyed by strong acids.

EFFECT OF BLEACHES AND SOLVENTS

These garments are unaffected by most bleaches and solvents. However, the fabric does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

The aramid portion of the blend has excellent resistance to mildew, aging, and abrasion. Natural aramid fiber will yellow with exposure to sunlight.

Lenzing FR® has good resistance to sunlight and aging, fair resistance to abrasion, and poor resistance to mildew.

THERMAL STABILITY

Aramid fiber has good thermal stability and does not melt. Lenzing FR® has good resistance to dry heat and is a natural insulator. Fabrics made from blends of NOMEX®/FR Rayon are inappropriate and not recommended for use around molten substances or welding operations.

MOISTURE REGAIN/STATIC CONTROL

The high ambient moisture regain properties of Lenzing FR® exceed that of cotton. Except in very low relative humidity, these garments should have little static propensity. However, without proper wearer grounding they should not be considered for use in critical static control applications. **It is especially important that these garments not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

Garments made from blends of NOMEX®/FR Rayon fabric should be washed separately in low alkalinity, surfactant based detergents at 140°F (60°C) maximum. pH values in laundering should not exceed 10.0. Color loss, excessive shrinkage, and reduced garment life may result from repeated exposure to excessive temperature and pH in laundering.

These garments should be dried at 140°F (60°C) to 160°F (71°C) maximum stack temperature so that the temperature in the dryer basket does not exceed 280°F (138°C). Exceeding these temperatures will accelerate color loss. **DO NOT USE CHLORINE BLEACH**. These garments can be dry cleaned in perchloroethylene solvent. Garments may be pressed or tunnel finished if desired. Garment temperature should not exceed 280°F (138°C). See Bulwark® Care & Cleaning Information Bulletin RK-63 or www.bulwark.com for more information.

GARMENT COST

Garments made from blends of NOMEX®/FR Rayon cost about 10% less than NOMEX®IIIA and 2 times as much as durable FR 100% cotton.

GARMENT LIFE

Under normal wear conditions, garment life should be about 80% to 90% that of NOMEX® and 2-3 times the life of durable FR 100% cotton.

VINEX® FR-9B® 85% VINAL/ 15% FR RAYON

VINEX® FR-9B® is a blend of 85% vinal (a synthetic fiber composed of vinyl alcohol units with acetal crosslinks) and 15% FRR rayon. The primary use of VINEX® is in resisting molten aluminum splash. VINEX® is a trademark of Westex, Inc.

APPLICATIONS

Almost exclusively in the aluminum casting industry for its unique ability to shed molten aluminum.

NOT RECOMMENDED FOR

Use in critical static control applications. Of limited use in aluminum smelters or pot rooms because cryolite (Na_3AlF_6), the catalyst used to extract aluminum from ore, will stick to VINEX®. Not recommended for use where exposure to molten zinc is possible.

FLAME RESISTANCE

VINEX® (also known as FR-9B®) is inherently flame-resistant, and this property cannot be degraded by laundering.

COLORS

Dyed in fabric form and available in a range of colors. Colorfastness in the navy and medium blue shades is excellent.

EFFECT OF ACIDS AND ALKALIS

VINEX® is highly resistant to a wide variety of most common acids and alkalis with no observed loss of fabric strength. However, concentrated nitric acid will degrade the fabric. VINEX® does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

VINEX® is resistant to most organic solvents. Chlorine bleach will not damage the fiber, but will result in discoloration of the shade.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

VINEX® has relatively poor resistance to mildew, aging and sunlight. Abrasion resistance is fair.

THERMAL STABILITY

VINEX® will not continue to burn if ignited and will not melt. The fabric sheds molten aluminum. The fiber has relatively poor thermal stability and will shrink excessively in the presence of moist heat above 140°F (60°C).

MOISTURE REGAIN/STATIC CONTROL

Moisture regain and stiffness/ hand of VINEX® are similar to cotton. With relatively high moisture regain, the fabric should be expected to have little static propensity. However, without proper wearer grounding it should not be considered for use in critical static control applications. **It is especially important that VINEX® garments not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

VINEX® is very sensitive to moist heat and should not be laundered above 140°F (60°C) or excessive shrinkage will occur. Home drying should be conducted on the permanent press cycle. Completely dry fabric can be ironed or pressed **without steam** at 260°-270°F (127°-132°C). Garments may be dry cleaned by any method, but this may remove softeners resulting in reduced comfort.

GARMENT COST

Garments of VINEX® cost about 6-7 times as much as 65% polyester/35% cotton blends and about 2 times more than durable FR 100% cotton.

GARMENT LIFE

Under normal wear conditions, garment life should be slightly less than similar weight conventional 65% polyester/35% cotton.

» INHERENTLY FR FIBERS

Fabrics made from synthetic fibers whose flame resistance is an essential characteristic of the fiber chemistry, such as NOMEX®. The flame-resistant property of these fabrics cannot be removed by wear or laundering.

COOL TOUCH® 2

COOL TOUCH® 2 garments are made from Tecasafe Plus fabric manufactured by TenCate. COOL TOUCH® 2 is available in two blends: 48% modacrylic/ 37% lyocell/ 15% para-aramid and 45% modacrylic/ 35% lyocell/ 15% polyamide imide/ 5% para-aramid. The fabric is durable with higher moisture regain than 100% aramid fabrics and is designed to achieve NFPA 70E HRC 2 and NFPA 2112 compliance.

Bulwark® Protective Apparel markets TenCate Tecasafe™ Plus fabric under the brand name "COOL TOUCH® 2".

APPLICATIONS

Petrochemicals, electrical workers, and for fire fighter station wear.

NOT RECOMMENDED FOR

Use around molten substances or welding operations or in critical static control applications.

FLAME RESISTANCE

COOL TOUCH® 2 garments are made from a blend of fibers that are inherently flame-resistant which means that this property cannot be removed by wear or laundering. The Lyocell fiber is not treated for flame resistance, but derives its self-extinguishing characteristic from the presence of the other fibers.

COLORS

Dyeable in a range of colors with good colorfastness.

EFFECT OF ACIDS AND ALKALIS

The fabric is resistant to alkalis and most solvents, but does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

Flame-resistant properties of COOL TOUCH® 2 garments are unaffected by most bleaches and solvents. Laundering with chlorine bleach is not recommended. This will weaken the fabric and accelerate color loss. Use of oxygen bleach is acceptable where necessary.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

The fabric has excellent resistance to mildew, aging, and abrasion. Colorfastness to sunlight is superior to aramid fabrics.

THERMAL STABILITY

COOL TOUCH® 2 fabric has excellent thermal stability and does not melt. COOL TOUCH® 2 is inappropriate and not recommended for use around molten substances or welding operations.

MOISTURE REGAIN/STATIC CONTROL

The high ambient moisture regain properties of Lyocell exceed that of cotton. Except in very low relative humidity, COOL TOUCH® 2 garments should have little static propensity. However, they should not be considered for use in critical static control applications without proper wearer grounding. **It is especially important that COOL TOUCH® 2 garments not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

For good colorfastness, COOL TOUCH® 2 garments should be washed separately in low alkalinity, surfactant based detergent at laundry temperatures up to 140°F (60°C). Processing in hotter formulas may be required to remove soils but could affect color and shrinkage.

COOL TOUCH® 2 garments should be dried at 140°-160°F (60°-71°C) maximum stack temperature so that the temperature in the dryer basket does not exceed 280°F (138°C). Exceeding these temperatures will accelerate color loss. In home laundering, use the permanent press setting on the washer and dryer. Remove promptly from the dryer.

DO NOT USE CHLORINE BLEACH. COOL TOUCH® 2 garments can be dry cleaned in perchloroethylene solvent. Garments may be pressed or tunnel finished if desired. Garment temperature should not exceed 280°F (138°C). See Bulwark® Care & Cleaning Information Bulletin RK-81 or www.bulwark.com for more information.

GARMENT COST

Garments made from COOL TOUCH® 2 cost about 30% less than 6.0 oz NOMEX®IIIA and 1 1/2 times as much as durable FR 100% cotton.

GARMENT LIFE

Under normal wear conditions, garment life should be comparable to NOMEX® and 2-3 times the life of durable FR 100% cotton.

GLENGUARD® FR

GlenGuard® FR is a trademark of Glen Raven Technical Fabrics, LLC for their proprietary blend of Kermel® with modacrylic and antistatic fibers. The fabric is available in woven and knit constructions. Solution dyed for improved colorfastness, the fabrics offer excellent strength and durability with soft hand and inherent flame-resistant and electric arc protection. Arc ratings are superior to similar weight FR fabrics.

APPLICATIONS

Utilities, petrochemical oil and gas services, transportation workers and professional fire fighters.

NOT RECOMMENDED FOR

Use in critical static control applications or exposure to molten metal substances or welding operations.

FLAME RESISTANCE

GlenGuard® FR is a blend of inherently flame-resistant fibers and this property cannot be degraded by laundering.

COLORS

Solution dyed, which means that it is dyed in the fiber forming process. This limits color selection, but provides improved colorfastness. Custom colors are available with minimum order requirements.

EFFECT OF ACIDS AND ALKALIS

GlenGuard® FR is highly resistant to most acids and to low concentrations of cold alkalis. GlenGuard® FR does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

The Kermel® fiber resists alkalis, bleaches, solvents and low acid concentrations. The blended GlenGuard® FR fabric is resistant to most solvents (except phenols and solvents that are very polar) and chlorine bleach. However, chlorine bleach should not be used in laundering GlenGuard® FR.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

GlenGuard® FR has excellent resistance to mildew, abrasion, aging and sunlight. Resistance to sunlight is superior to aramid fiber fabrics.

THERMAL STABILITY

GlenGuard® FR has excellent thermal stability and will not melt. GlenGuard® FR is not recommended for use around any molten substances or welding operations.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain and stiffness/hand of GlenGuard® FR are similar to cotton. A static dissipative fiber is added as part of the blend to combat nuisance static. However, without proper wearer grounding the fabric should not be considered for use in critical static control applications. **It is especially important that GlenGuard® FR garments not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

In accordance with recommendations published by Glen Raven Technical fabrics, LLC, GlenGuard® FR may be laundered at 140°F (60°C) using the alkaline wash formula found in NFPA 2113 *Standard on Selection, Care, Use and Maintenance of flame-resistant Garments for Protection of Industrial Personnel Against Flash Fire.* Recommended drying procedure is a medium/permanent press setting at a maximum stack temperature of 155°F (68°C).

GARMENT COST

Garments of GlenGuard® FR cost slightly more than equivalent weights of NOMEX®.

GARMENT LIFE

Under normal wear conditions, garment life is expected to be 3-5 years, or roughly equivalent to the wear life of NOMEX® garments of equivalent fabric weight.

KERMEL® SYNTHETIC POLYAMIDE IMIDE ARAMID FIBER

KERMEL® is a synthetic polyamide imide aramid fiber manufactured in France by Kermel. KERMEL® fiber is only offered in fabrics blended with other fibers. KERMEL® is blended with wool for dress uniforms, sweaters and underwear, and with high tenacity aramid for bunker gear and gloves. In the professional fire fighter and work wear areas, KERMEL® is offered in both knit and woven constructions in a 50/50 blend with FR viscose rayon.

For the purposes of this review, KERMEL® will refer to the 50/50 blend with FR rayon.

APPLICATIONS

Petrochemical, utilities and professional fire fighters.

NOT RECOMMENDED FOR

Use around any molten substances or welding operations, or in critical static control operations.

FLAME RESISTANCE

KERMEL® is inherently flame-resistant and this property cannot be degraded by laundering.

COLORS

The fiber is solution dyed, which means it is dyed in the fiber forming process. This limits the color selection, but provides improved colorfastness.

EFFECT OF ACIDS AND ALKALIS

KERMEL® is highly resistant to most acids and to low concentrations of cold alkali.

EFFECT OF BLEACHES AND SOLVENTS

KERMEL® is resistant to most solvents (except phenols and solvents that are very polar), and chlorine bleach. KERMEL® fabric resists alkalis, bleaches, and solvents, but is subject to damage by acids. **KERMEL® must not be laundered with chlorine bleach.**

The fabric is available with a water repellent finish to help protect against chemical splashes and help provide acid resistance for the FR rayon. However, the fabric does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

KERMEL® has excellent resistance to mildew, aging, sunlight and abrasion.

THERMAL STABILITY

KERMEL® has excellent thermal stability and does not melt. KERMEL® blended with FR rayon is not recommended for use around any molten substances or welding operations. KERMEL® will stick to hot molten contact and form holes. Blends of KERMEL® and wool are recommended for use near molten processes.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain is comparable to cotton and has a soft hand. Except in low relative humidity, KERMEL® would have little static propensity. However, without proper wearer grounding it should not be considered for use in critical static control applications. **It is especially important that garments containing KERMEL® fibers not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

KERMEL® garments should be washed separately in low alkaline, surfactant based detergents at 140°F (60°C), maximum. They should be dried at 140°F (60°C) stack temperature so that fabric temperature measured in the basket does not exceed 280°F (138°C). Exceeding these recommendations can result in significant shrinkage and/or loss of physical properties and durability. **KERMEL® must not be laundered with chlorine bleach.**

GARMENT COST

Garments of KERMEL® cost about 6 times more than conventional 65% polyester/35% cotton, and about 2 1/2 times more than durable FR 100% cotton. Prices are equal to, or slightly more than, 6.0 oz NOMEX®.

GARMENT LIFE

Under normal wear conditions, garment life should be equal to conventional 65% polyester/35% cotton garments or about 1/2 that of NOMEX®.

NOMEX®

NOMEX® is a meta aramid fiber manufactured by DuPont. For clothing applications, it is offered as NOMEX® IIIA, a blend of 93% NOMEX®, 5% KEVLAR®, and 2% static dissipative fiber.

APPLICATIONS

Petrochemicals, utilities, military applications, auto racing, volunteer and professional fire fighters.

NOT RECOMMENDED FOR

Use around any molten substances, welding operations, or in a critical static control application.

FLAME RESISTANCE

NOMEX® is inherently flame-resistant and this property cannot be degraded by laundering.

COLORS

NOMEX® is dyeable in a wide range of colors. Colorfastness to laundering varies depending on the shade. The fiber is also available in a solution dyed form where it is dyed in the fiber forming process. This limits color selection, but provides improved color fastness at increased cost.

EFFECT OF ACIDS AND ALKALIS

NOMEX® is unaffected by most acids, except for some strength loss after long exposure to hydrochloric, nitric, and sulfuric acid. It has generally good resistance to alkalis.

EFFECT OF BLEACHES AND SOLVENTS

The fiber is unaffected by most bleaches and solvents, except for slight strength loss from exposure to sodium hypochlorite bleach. However, the fabric does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

NOMEX® has excellent resistance to mildew, aging and abrasion. Natural (undyed) NOMEX® fiber is not white and will yellow with exposure to sunlight. Accordingly, some lighter dyed shades will discolor rapidly. These lighter shades are available in solution dyed form.

THERMAL STABILITY

NOMEX® has good thermal stability and does not melt. The fiber decomposes between 700°-800°F (371°-427°C). NOMEX® is not recommended for use around any molten substances or welding operations. Hot molten contact will stick to the fiber, forming holes.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain is moderate compared to other synthetic flame-resistant fibers, but only about 70% of cotton.

Because of the presence of static dissipative fiber, antistatic performance of NOMEX® IIIA is not dependent on ambient relative humidity. It is important to recognize that NOMEX® IIIA is designed to combat nuisance static only and, like 100% cotton, without proper wearer grounding it should not be considered for use in critical static control applications. **It is especially important that NOMEX® garments not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

For best color retention, laundry processing should be carried out at 140°F (60°C) or less in buffered, nonionic detergents. However, higher temperature/harsher detergent laundering will only affect the color, not the FR performance of the fabric. NOMEX® garments may be dry cleaned in either perchloroethylene or petroleum solvents. They may be conditioned or tunnel finished at up to 280°F (138°C) fabric temperature. See Bulwark® Care and Cleaning Information Bulletin RK-63 or www.bulwark.com for more information.

GARMENT COST

Garments of NOMEX® IIIA cost about five times as much as garments made from conventional 65% polyester/35% fabrics, and about 2 times more than garments made from durable FR 100% cotton fabrics.

GARMENT LIFE

Under normal wear conditions, NOMEX® garments can last as long as 3-5 years, or 2-3 times the life of conventional 65% polyester/35% cotton, and 3-5 times the life of durable FR 100% cotton.

Garments made of NOMEX® IIIA are extremely durable and can be expected to perform well for many years in applications where longevity can be utilized.

P84® SYNTHETIC LONG CHAIN POLYIMIDE FIBER

P84® is made by Inspec Fibres in Austria. Inferior in properties to NOMEX®, it is used in minority amounts in blended fabrics for specialty end uses.

Both TenCate™ SouthernMills™, Inc. and Springfield LLC offered fabrics for fire fighter turnout gear, but these fabrics are no longer available. Because of continuing questions about P84®, this section is being retained in the Update. However, Bulwark® is not aware of any current North American manufacturer of products made from this fiber.

APPLICATIONS

Specialty end uses.

NOT RECOMMENDED FOR

Use around white or red metals, other molten substances, or in a static control application.

FLAME RESISTANCE

P84® is inherently flame-resistant and this property cannot be degraded by laundering.

COLORS

The fiber is solution dyed, which means the fiber is dyed in the fiber forming process. This limits color selection, but provides improved colorfastness.

EFFECT OF ACIDS AND ALKALIS

P84® is resistant to all common organic solvents and acids. Extended exposure to alkalis will cause degradation.

EFFECT OF BLEACHES AND SOLVENTS

P84® is unaffected by bleach and the blended fabric may be dry cleaned. Fabrics containing P84® fiber do not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

P84® has excellent resistance to mildew, aging and abrasion, but poor resistance to sunlight.

THERMAL STABILITY

Thermal stability of P84® alone is poor and blending with other fibers is done to try to overcome this weakness. P84® is not recommended for use around white or red metals, or other molten substances. White metals, such as aluminum, will stick to P84®, and other molten substances will quickly form holes due to thermal shrinkage of the fiber.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain of P84® is poor and average stiffness is high resulting in poor drape and hand. Static propensity should be high. **It is especially important that garments containing P84®fibers not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

P84® blends are expected to be home laundered. The blended fabrics can be dry cleaned.

PBI

PBI is a synthetic polybenzimidazole fiber made by PBI Performance Products Inc., which may be used alone or in blends. PBI Gold® is a 60% KEVLAR® aramid/40% PBI blend fabric offered by PGI DIFCO and TenCate™ SouthernMills™ for career apparel applications. PBI TriGuard™ is a blend of 20% PBI, 30% LENZING FR® and 50% Micro Twaron®.

Although there has been some market interest in PBI TriGuard™, this review will focus on PBI Gold®.

APPLICATIONS

PBI Gold® is used in turnout gear for professional fire fighters and other career apparel.

NOT RECOMMENDED FOR

Critical static control applications.

FLAME RESISTANCE

PBI Gold® is inherently flame-resistant and this property cannot be degraded by laundering.

COLORS

PBI Gold® is gold in color. It is dyeable in dark shades only.

EFFECT OF ACIDS AND ALKALIS

PBI fiber has excellent resistance to most acids and alkalis.

EFFECT OF BLEACHES AND SOLVENTS

PBI has excellent resistance to solvents. PBI Gold® loses strength when exposed to chlorine bleach. PBI Gold® does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

PBI has good resistance to mildew and aging. Prolonged exposure to sunlight will cause darkening and loss of tensile strength. PBI fiber has fair abrasion resistance, but the PBI Gold® blend has very good abrasion resistance.

THERMAL STABILITY

PBI Gold® will not ignite and does not melt. PBI has excellent thermal stability and retains fiber integrity and suppleness after flame exposure. Molten substance contact with PBI Gold® will cause pinholing in the fabric.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain of PBI fiber is excellent and actually exceeds that of cotton and rayon. Moisture regain of PBI Gold® is about equal to NOMEX® and other synthetic fabrics. Average stiffness is very low, yielding a good hand and drape. PBI is by far the most natural feeling synthetic fabric. Without proper wearer grounding, PBI Gold® should not be considered for use in critical static control applications. **It is especially important that garments containing PBI® fibers not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

Garments made from PBI Gold® fabric should be washed separately in low alkaline, surfactant based detergents at 140°F (60°C), maximum. Wash pH should be 10.0 or lower. Chlorine bleach weakens the fabric. Do not over dry. Fabric temperature in the dryer basket should not exceed 210°F (99°C). Exceeding these recommendations can result in significant garment shrinkage. Garments of PBI Gold® can be tunnel finished, but fabric temperatures should not exceed 210°F (99°C). See Bulwark® Care & Cleaning Information Bulletin RK-73 or www.bulwark.com for more information.

GARMENT COST

Garments made from PBI Gold® fabrics cost about 2 times more than NOMEX® and about 3-4 times as much as durable FR 100% cotton.

GARMENT LIFE

Under normal wear conditions, PBI Gold® garments can be expected to last about 1/2 to 3/4 as long as comparable weights of NOMEX® and 1 1/2 times as long as durable FR 100% cotton garments.

PROTERA™

Protera™ is a DuPont trademark for garments made from 65% Modacrylic/23% Nomex®/10% Kevlar®/2% static dissipative fiber. Available in both shirt and pant weights, these fabrics are durable and designed to achieve NFPA 70E HRC 2 and NFPA 2112 compliance.

APPLICATIONS

Petrochemicals, electrical workers, and for fire fighter station wear.

NOT RECOMMENDED FOR

Use around molten substances or welding operations or in critical static control applications.

FLAME RESISTANCE

Protera™ garments are made from a blend of fibers that are inherently flame-resistant which means that this property cannot be removed by wear or laundering.

COLORS

Dyeable in a range of colors with good colorfastness.

EFFECT OF ACIDS AND ALKALIS

The fabric is resistant to alkalis and most solvents, but does not provide personal chemical protection to the wearer. Where chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

Flame-resistant properties of Protera™ garments are unaffected by most bleaches and solvents. Laundering with chlorine bleach is not recommended. This will weaken the fabric and accelerate color loss.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

The fabric has excellent resistance to mildew, aging, and abrasion and fair resistance to sunlight. Garments are not to be line dried or stored in sunlight.

THERMAL STABILITY

Protera™ fabric has good thermal stability and does not melt. Protera™ is inappropriate and not recommended for use around molten substances or welding operations.

MOISTURE REGAIN/STATIC CONTROL

Moisture regain is moderate and comparable to other synthetic flame-resistant fibers, but less than cotton. Because of the presence of static dissipative fiber, anti-static performance of Protera™ is not dependent on ambient relative humidity. It is important to recognize that Protera™ is designed to combat nuisance static only and without proper wearer grounding should not be considered for use in critical static control applications. **It is especially important that Protera™ garments not be donned or removed in a hazardous area.**

PROCESSING

Flame-resistant apparel should be washed using soft water (<4.0 grains). Hard water can affect cleaning and contains mineral salts that can form insoluble deposits on the fabric. These deposits can negate the flame-resistant characteristics of the garment, and may serve as fuel if garments are exposed to an ignition source.

For best color retention, Protera™ garments should be washed before wearing and separately by color after each subsequent wearing in low alkalinity, surfactant based detergent at laundry temperatures up to 140°F (60°C). Processing in hotter formulas may be required to remove soils but could affect color and shrinkage, not the FR performance of the garments. Avoid use of chlorine bleach.

Protera™ garments should be dried at 140°-160°F (60°-71°C) maximum stack temperature so that the temperature in the dryer basket does not exceed 280°F (138°C). Exceeding these temperatures will accelerate color loss. In home laundering, use the permanent press setting on the washer and dryer. Remove promptly from the dryer. Do not line dry or store in sunlight.

Protera™ garments can be dry cleaned in perchloroethylene solvent. Garments may be pressed or tunnel finished if desired. Garment temperature should not exceed 280°F (138°C).

GARMENT COST

Protera™ garments cost about 20% less than 6.0 oz NOMEX®IIIA and 2 times as much as durable FR 100% cotton.

GARMENT LIFE

Under normal wear conditions, garment life should be comparable to NOMEX® and 2-3 times the life of durable FR 100% cotton.

QUILTED LINING SYSTEMS

Quilted garment linings must provide varying levels of protection from the climate, be compatible with the outer shell fabric, and serve as part of the flame-resistant protection package in case of garment ignition – all while helping control the overall cost of the finished garment. The components of the quilted lining package must also work together. For example, the face cloth must prevent fiber migration and shifting of the insulation, while being durable to extended laundering.

Quilted linings may be constructed of flame-resistant treated fabrics, inherently flame-resistant fabrics, or a combination of both. However, for maximum protection, each component of a multi-layer assembly should be flame-resistant. The use of non-FR materials, such as polyester fiberfill, may contribute to wearer injury in case the flame-resistant body fabric breaks open following a flame or thermal exposure.

FABRIC NAME/ (MANUFACTURER)	DESCRIPTION (WEIGHTS)	COMPONENTS	
Q/9® (TenCate™ SouthernMills™)	Composite quilted liner (9.3 oz.)	Backing Face Stitching	100% aramid needled 6.0 batt 3.3 oz. Plain Weave face Aramid Thread / "Chicken Wire" Pattern
Q/10® (TenCate™ SouthernMills™)	Composite quilted liner (8.8 oz.)	Backing Face Stitching	75% Modacrylic /25% Aramid needled 5.0 oz. batt 3.3 oz. Plain Weave and Light (0.5 oz.) PE/PET scrim Aramid Thread / Diamond Pattern
Q/12® (TenCate™ SouthernMills™)	Composite quilted liner (12.8 oz.)	Backing Face Stitching	75% Modacrylic /25% Aramid needled 9.0 oz. batt 3.3 oz. Plain Weave and Light (0.5 oz.) PE/PET scrim Aramid Thread / "Big Onion" Pattern
Q/15® (TenCate™ SouthernMills™)	Composite quilted liner (14.2 oz.) Wind barrier protection	Backing Face Stitching	100% Aramid needled batt 3.3 oz. Plain Weave and Light (0.5 oz.) PE/PET scrim Aramid Thread / "Big Onion" Pattern
Therma-120 (PGI DIFCO	Composite quilted lining (8.0 oz)	Backing Face Stitching	Thinsulate™ insulation blend of Modacrylic/Aramid/Polyester Plain Weave Nomex and two layers of lightweight Remay® scrim Aramid Thread/Diamond Pattern
Therma-150 (PGI DIFCO	Composite quilted lining (9.0 oz)	Backing Face Stitching	Thinsulate™ insulation blend of Modacrylic/Aramid/Polyester Plain Weave Nomex and two layers of lightweight Remay® scrim Aramid Thread/Diamond Pattern
Therma-200 (PGI DIFCO)	Composite quilted lining (10.0 oz)	Backing Face Stitching	Thinsulate™ insulation blend of Modacrylic/Aramid/Polyester Plain Weave Nomex and two layers of lightweight Remay® scrim Aramid Thread/Diamond Pattern
THERMATEX® 6B (PGI DIFCO)	Composite quilted liner (10.1 oz.)	Backing Face Stitching	6.0 oz. lofted batt of loose virgin Aramid fiber 3.2 oz. (Plain Weave or Rip-Stop) and two layers of lightweight Reemay® scrim Aramid Thread / Diamond Pattern
THERMATEX® 7B (PGI DIFCO)	Composite quilted liner (11.1 oz.)	Backing Face Stitching	7.0 oz. lofted batt of loose virgin Aramid fiber 3.2 oz. (Plain Weave or Rip-Stop) and two layers of lightweight Reemay® scrim Aramid Thread / Diamond Pattern
THERMATEX® 6B/VAPRO® (PGI DIFCO)	Composite quilted liner (12.4 oz.) Wind/rain protection and breathability	Backing Face Stitching	6.0 oz. lofted batt of loose virgin Aramid fiber Micro-porous FR membrane laminated to batt 3.2 oz. (Plain Weave or Rip-Stop) and two layers of lightweight Reemay® scrim Aramid Thread / Diamond Pattern
THERMATEX® 9B/VAPRO® (PGI DIFCO)	Composite quilted liner (13.4 oz.) Wind/rain protection and breathability	Backing Face Stitching	9.0 oz. lofted batt of loose virgin Aramid fiber Micro-porous FR membrane laminated to batt 3.2 oz. (Plain Weave or Rip-Stop) and two layers of lightweight Reemay® scrim Aramid Thread / Diamond Pattern
MODA-QUILT® (Westex, Inc.)	Composite quilted liner (10.25 oz. and 13.50 oz.)	Backing Face Stitching	Fiber fill of inherently flame-resistant Modacrylic fiber Plain Weave FR cotton Aramid Thread/Diamond Pattern
FLAME-QUILT® (Westex, Inc.)	Composite non-woven quilted FR thermal barrier line (10.75 oz.)	Backing Face Stitching	Fiber fill of 50% BASOFIL® and 50% FR Rayon Plain Weave FR cotton Aramid Thread/Diamond Pattern

RAINWEAR

Flame-resistant rainwear forms an effective barrier against rain and wind. Additionally, it must not melt, drip, or burn when exposed to the thermal energy generated in a flash fire or electric arc. FR rainwear is available that meets the high visibility requirements of the American National Standards Institute (ANSI) Standard 107.

Flame-resistant rainwear is available in both breathable and non-breathable body fabrics. However, the most generally available suits are made with non-breathable fabrics.

NON-BREATHABLE FABRICS

Are made by single or double coating a NOMEX® substrate with flame-resistant polychloroprene, PVC, or other waterproof, non-breathable substance. Please note that some products labeled as "FR" use a nylon substrate. This material is inferior to coated NOMEX® fabrics.

BREATHABLE FABRICS

Are made by laminating a NOMEX® woven outer shell fabric to a breathable polyurethane liner in a two or three layer system or laminating the shell fabric to NOMEX® knit or non-woven lining with a breathable PTFE membrane in a trilaminant system.

APPLICATIONS

Electric utilities, oil and gas operations, and other work activities where a risk of thermal exposure exists in a wide range of climatic conditions.

NOT RECOMMENDED FOR

Use around any molten substances, welding operations, or in critical static control applications.

FLAME RESISTANCE

The NOMEX® fabric used in both breathable and non-breathable rainwear is inherently flame-resistant and this property cannot be degraded by laundering. The waterproof coating on non-breathable rainwear is flame-resistant

COLORS

Rainwear is usually specified in bright yellow/green or orange to meet high visibility requirements. If the rainwear also meets the requirements of ANSI/ISEA Standard for High-Visibility Safety Apparel and Headwear it must also be labeled with a statement that the garment meets this standard. Other labeling requirements include the Performance Class and Level and the durability of the garment to appropriate cleaning processes.

EFFECTS OF ACIDS AND ALKALIS

Rainwear is resistant to most acids and will provide wearers some low-level chemical splash protection. Please see manufacturer's product literature for specific recommendations. However, flame-resistant rainwear is primarily intended to protect from rain. Where major chemical exposure is a hazard, appropriate specialized barrier garments should be selected.

EFFECT OF BLEACHES AND SOLVENTS

Do not use chlorine bleach. Do not dry clean.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

Non-breathable rainwear has excellent resistance to mildew, aging, sunlight, and abrasion.

THERMAL STABILITY

Fabrics used for FR rainwear will not ignite and do not melt. They have extreme thermal stability. Molten substance contact with flame-resistant rainwear will cause burn through and pinholing.

MOISTURE REGAIN/STATIC CONTROL

Not applicable.

PROCESSING

Rainwear should be wiped clean with a mild detergent/water solution and rinsed, or machine-washed, warm, using mild detergent. Hang to dry. Do not use solvents or abrasive cleaners. Do not dry clean.

GARMENT COST

Non-breathable rainwear will cost about 3 times more than a NOMEX® coverall.

GARMENT LIFE

Expected garment life under normal wear conditions should approach NOMEX® and be 3-5 times more than durable FR 100% cotton garments. However, abrasion from hard use under adverse conditions, such as climbing poles, could result in shorter service life.

» IN CONCLUSION...

The Bulwark® brand makes up the most comprehensive flame-resistant product line in the broadest range of proven thermal protective fabrics. While always leading in innovation, Bulwark® provides industry-leading technical support and advice to our customers.

WHAT DEVELOPMENTS ARE ON THE HORIZON IN FR FABRICS AND GARMENTS?

New fibers and fabrics based on them are constantly being developed in response to changing needs of the market. The ultimate success of these developments will depend on market requirements as well as the cost effectiveness of the materials.

On 7 February 2008, a sugar refinery explosion, possibly caused by static electricity igniting fine sugar dust, killed 14 people and injured over 40. OSHA had been criticized in a 2006 US Chemical Safety Board report for lack of preparation for such explosions and a safety program which "inadequately addresses dust explosion hazards". This has lead to increased emphasis on prevention of combustible dust explosions and providing PPE for workers exposed to this hazard.

On March 19, 2010 OSHA issued an interpretation of the flash fire standard NFPA 2112 as it related to policy for citing the general industry standard for PPE, 29 CFR 1910.132(a) for failure to provide and use FR clothing in oil and gas well drilling, servicing and production related operations. OSHA stated that use of FRC is inconsistent among operators and contractors in areas with clear potential for flash fires.

This interpretation has become known simply as the OSHA Memo. Combined with several drilling platform accidents that resulted in loss of life, and the Gulf of Mexico accident and spill, the result has been a renewed emphasis on NFPA 2112 and market demand for garments certified to this performance standard.

In the electric arc flash protection market, NFPA 70E Hazard Risk Category 2 (4.0-25 cal/cm^2) has become the most recognized requirement for industrial applications. OSHA has stepped up enforcement activities in the area of workplace electrical safety using 70E as evidence of hazard recognition in evaluating General Duty Clause violations under the OSHA Act.

These developments have lead to demands for multi-purpose or "dual hazard" PPE that has an arc rating of HRC 2 and is certified to NFPA 2112. These garments are also expected to be lightweight and comfortable to wear by providing moisture absorption and wicking characteristics along with improved durability and appearance retention – at competitive prices.

HOW DOES BULWARK® FR APPAREL SATISFY THE SAFETY AND PERSONNEL NEEDS OF MY COMPANY?

Bulwark® garments are designed to (1) be comfortable, (2) fit well, (3) not shrink excessively, (4) not lose color when laundered, (5) retain their shape and surface appearance, and (6) reflect the image the specifier wishes to present, in terms of color and style. In other words, Bulwark® flame-resistant protective apparel must serve all of the expected functions of conventional wearing apparel, yet retain flame-resistant properties for the useful life of the garments.

WHAT FR FABRICS DOES BULWARK® USE FOR ITS FR WORK APPAREL?

Bulwark® stocks the following flame-resistant protective garments:

EXCEL FR® Durable FR 100% Cotton

EXCEL FR® ComforTouch® Durable FR 88% Cotton / 12% Nylon

Particle and chemical resistant FR Disposable non woven garments

NOMEX® IIIA

COOL TOUCH® 2 45% modacrylic / 35% lyocell / 15% polyamide imide 5% para-aramid

COOL TOUCH® 2 48% modacrylic / 37% lyocell / 15% para-aramid

FireWear®

PBI Gold®

Tencate Oasis®

PVC/Kevlar®/NOMEX® rainwear

Additional fabrics have been approved for use in Bulwark® garments and are available upon request as a make to order.

» FAST FACTS

- Flash fire emphasis from combustible dust and petro-chem markets based on garment certification to NFPA 2112.
- NFPA 70E HRC 2 category dominates industrial applications.
- Demand for dual-purpose garments with performance characteristics

WHAT IS THE BEST WAY TO REPAIR FR GARMENTS?

Minor repairs that do not affect the integrity of the garment should be made with like materials by sewing on patches or darning small holes. To provide continued flame resistance, garments must be repaired with materials that have at least the same FR performance characteristics as the original fabric and sewing threads.

HOW IMPORTANT IS THE CLEANING OF FR GARMENTS?

Proper cleaning and maintenance of any flame-resistant garment is essential to remove potentially hazardous soils and avoid a build up of materials that could mask performance. This includes flammable soils and gasses as well as other contaminants such as build up of hard water ions that can coat fibers with flammable material. ASTM has two standard guides that provide good general references for care and cleaning of flame-resistant and thermal protective clothing; ASTM Standard F1449 Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing and F2757, Guide for Industrial Laundering of Flame, Thermal and Arc Resistant Clothing.

Always follow garment manufacturer's care label recommendations and other published instructions or recommendations.

CAN EMBLEMS AND EMBROIDERY BE ADDED TO FR GARMENTS?

The question of garment identification and personalization is always difficult to answer. The only comment of the consensus standards writing organizations, such as NFPA and ASTM International, is that nothing on an article of clothing may increase the extent of wearer injury in case of garment ignition. No OSHA or military standards address this area. SFI, the race car driver's association, has not addressed this issue.

Bulwark® does not recommend the use of non-flame-resistant embroidery or emblem attachment to flame-resistant garments. However, wearer identification is a safety issue in itself. In the final analysis, the end user must weigh the benefits of identification and personalization against the potential risk from using non-FR materials.

WHAT IF LOCAL CONDITIONS REQUIRE CLEANING PROCEDURES DIFFERENT FROM THE MANUFACTURER'S RECOMMENDATION?

To ensure continued flame-resistant performance, it is necessary to follow the manufacturer's recommendations for textile maintenance processing of each type of flame-resistant garment. Whenever deviations from manufacturer's recommendations are necessitated by local conditions, testing must be conducted to ensure that the protective properties are maintained through the expected service life of the garment.

IS THERE ADDITIONAL INFORMATION ON LAUNDERING FR GARMENTS? IF SO, HOW CAN I GET IT?

Bulwark® Care and Cleaning Information Bulletins provide laundry instructions for our flame-resistant protective apparel. You can access the latest information at our website, www.bulwark.com. The Care and Cleaning Information Bulletins are also available from VF Imagewear Technical Services at 545 Marriott Drive, Nashville, TN 37214.

IS STATIC ELECTRICITY A CONCERN FOR FR GARMENTS?

The generation of static electricity on clothing depends on a number of factors: the relative humidity, the fabrics involved, the use of grounding devices, and the task being performed. Synthetic fabrics such as polyester absorb less moisture and retain more static than natural fiber fabrics. Synthetic FR fabrics such as NOMEX IIIA contain 2% static dissipative fiber to control nuisance static. Garments made from NOMEX IIIA fiber do not require moisture in the atmosphere to conduct static electricity. However, these garments alone without other engineering controls will not address the hazards associated with static.

Natural fabrics made from cotton and synthetic cellulosic fibers like Lyocell® have little static build-up in high humidity conditions because the fiber absorbs water from the atmosphere. The water conducts and helps distribute the static charge. Cellulosic fiber fabrics are ineffective at dissipating static charges at low relative humidity (<20% RH).

Donning or removing garments can generate static charge through triboelectric generation by friction and cause charge separation between the layers of clothing. Testing of a Bulwark vest showed a 5X increase in static charge when the vest was removed.

In the final analysis, no garment alone will provide protection from hazardous static charges. A static control program, of which the garments are only a part, is required for protection of personnel in hazardous environments.

WHAT IS THE "LIFE OF A BULWARK GARMENT"?

Bulwark guarantees that our reusable garments will retain their flame resistant properties for the life of the garment as long as our recommended laundering guidelines are followed. The life of a Bulwark garment is not defined by the age of the garment, the number of times it has been worn or the number of times it has been laundered.

A Bulwark garment is removed from service for the same reasons as everyday clothing: it no longer fits comfortably; it is contaminated with a flammable substance that cannot be completely removed; there are stubborn, unsightly stains; it has become threadbare. Finally, if a garment has rips, tears or holes which cannot be repaired it must be removed from service.