Bulwark®
PROTECTION

VOL 18

INDUSTRY UPDATE

SECONDARY FLAME-RESISTANT APPAREL

THE LEADER IN SECONDARY FLAME-RESISTANT APPAREL

Bulwark® is the leading provider of secondary flame-resistant apparel in the world. Bulwark garments offer 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 44-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.

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OBJECTIVES

1. Educate specifiers and safety professionals in the need for and function of flame resistant protective apparel.
2. Advise changes in performance standards and regulatory requirements.
3. Provide independent summary of available flame resistant fabrics.
4. Update developments in the areas of fiber, fabric, and garments.

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.

INTRODUCTION

Industry Update is written and produced by Bulwark Protection®, the leading provider of secondary flame resistant apparel in the world. Bulwark Protection designs, manufactures, and sells garments offering superior flame resistant protection, comfort, and durability to thousands of workers in electrical utilities, chemical, oil, gas, mining, and petrochemical industries across the world. Bulwark Protection® follows the continually evolving development of both domestic and world-wide standards for the FR industry. They work closely with manufacturers of flame resistant and thermally protective fibers and fabrics. Bulwark Protection, with a heritage of technical innovation and industry leadership, focuses on wearer safety as a primary concern.

The flame resistant garment business is standards and specifications driven. This Industry Update offers a basic understanding of how flame-resistance is defined and measured. Included is a listing of common FR industry standards, a discussion of the performance requirements of standards related to specific activities such as power generation and distribution or petroleum refining, and a review of the fibers and fabrics used in the flame resistant industry. In conclusion, the Industry Update offers answers to commonly asked questions from wearers of FR protective clothing.

EVERYDAY FABRIC FLAMMABILITY RATINGS

Normal work apparel and everyday wearing apparel are made from fabrics similar in weight, fiber content, and flammability characteristics. All clothing made from these fabrics are not flame resistant and will ignite and continue to burn if exposed to an ignition source. 16 CFR 1610, administered by the Consumer Products Safety Commission, was developed 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 everyday clothing use. It was originally adopted in 1954 as The Flammable Fabrics Act, CS 191-53. 16 CFR 1610 does not apply to children's sleepwear or flame resistant protective clothing.

16 CFR 1610 measures two attributes of everyday fabrics: 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. All wearing apparel and normal work clothing sold in the U.S. must be made of fabric rated Class 1, Normal Flammability.

CLASS 1

Normal Flammability
3.5 seconds or more to ignite. May or may not ignite when exposed to the standard 1 second ignition source.

CLASS 2

Intermediate Flammability
Does not apply to plain surface textile fabrics.

CLASS 3

Rapid, Intense Burning
Less than 3.5 seconds to ignite. Dangerously flammable. Not suitable for everyday clothing.

Years of testing have demonstrated some fabrics always yield passing flammability data. As a result, certain fabrics have earned an exemption from testing. Exempted fabrics are plain surface fabric, regardless of fiber content, weighing at least 2.6 oz/yd² and all fabrics, plain surface, or raised-fiber surface regardless of weight, made entirely from or entirely from a combination of acrylic, modacrylic, nylon, olefin, polyester, and wool.

THE NEED FOR FR GARMENTS

All fabrics made of untreated natural fibers and most synthetic fibers are combustible. 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, they are 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.

Flame resistant garments provide protection against clothing ignition and sustained flame spread thereby minimizing the extent of burn injury. FR garments may not provide significant protection from burn injury in the immediate area of contact with the ignition source.

FR WORK CLOTHING

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. Tetrakis (hydroxymethyl) phosphonium chloride (THPC) was the original, commercially successful, flame resistant treatment for cotton work apparel. These fabrics had many limitations,

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 that guarantee flame-resistance 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.

The best reason to invest in a flame resistant (FR) clothing program is simple: FR clothing saves lives. For those working in industries where employees are at risk of clothing ignition, FR workwear is a critical component in protection. The key to FR workwear is that it self-extinguishes or does not ignite. The most serious burns in an industrial setting usually aren't caused by the actual fire or explosion. The most serious burns are caused by regular workwear (non-FR cotton, nylon, or polyester) igniting and continuing to burn after the heat source has been removed. The use of FR clothing which self-extinguishes or does not ignite dramatically reduces the severity of burn injuries and increases the chances of survival.

COMMON CAUSES OF IGNITION AND BURNING OF WORK APPAREL

- Ignition of flammable liquids or other flammable soils on the garment
- Explosion of vapors from volatile liquids or from flammable gases
- High energy electrical discharges or other electric arc events
- Contact with, or proximity to, molten metals
- Contact with sparks and slag from flame cutting or welding
- Contact with open flames
- Ignition of combustible dusts

PURPOSE OF FR GARMENTS

- FR fabric does not ignite or continue to burn
- FR garments provide a degree of protection against short-duration thermal exposures such as a flash fire or electric arc flash
- FR garments help minimize burn injury from an exposure
- FR garments increase the chances of survival

LIMITATIONS OF FR GARMENTS

FR garments should only be used for protection against continuous thermal exposures, molten metal splash, hot liquids, steam, or chemicals if the FR fabric and garment are specifically designed for such applications. They should not be worn alone for structural or other fire fighting activities.

EMPLOYEE AND EMPLOYER RESPONSIBILITIES

The user is responsible for determining the level of hazards and proper personal protective equipment (PPE) needed. Only persons properly trained, who understand the performance requirements for use and care of the garment, are qualified to wear them. If unsure about the protection level required at a worksite, please consult the employer.

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 to 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 is an essential element of an action plan to address these concerns.

In North America, consensus standards exist for many industries. In the EU, protective clothing, in general, must meet ISO 13688. EN ISO 13688, Protective Clothing – General Requirements, specifies performance requirements to protect against one or more hazards including heat & flame, moving parts, weather, chemicals, or cuts and stabs. It is always cited in combination with another standard which addresses more specific performance requirements for the identified hazard. Performance requirements covered by ISO 13688 include the following.

» Basic health and ergonomic requirements (innocuousness, design and comfort) to guarantee the clothing will not adversely affect the health or hygiene of the user. Some requirements address concerns associated with exposure to nickel in metal components of the garment, pH of the fabric, colorfastness to perspiration, and the presence of restricted dyestuffs.

» Ageing requirements measure properties of the protective clothing which might change over time. For example, performance thresholds are established for colorfastness to light and to laundry shrinkage. Woven textile materials should not shrink or extend more than 3% in either length or width (5% for knitted textiles).

» Size designations including body dimensions are marked and correspond with the garment size.

» Product labelling includes proper CE marking, applicable pictograms, and care instructions. All labels are required to be printed legibly and durably in appropriate languages.

» Extensive user information including details about the manufacturer, material content, instructions for use, and an explanation of pictograms must be included.

FAST FACTS

All manufactured garments are required to meet U.S. flammability standards.

» 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 made from plain surface textile fabric and sold in the U.S. must be made of fabric rated Class 1.

» Everyday wearing apparel will ignite and continue to burn if exposed to an ignition source.

» When work environments or occupations pose a risk of garment ignition and burning, flame resistant apparel should be considered and selected.

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

» When choosing flame resistant garments, evaluate the workplace, wearer comfort requirements, durability, appearance, and availability of laundry options.

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

» Regardless of their weight, untreated 100% cotton fabrics are not flame resistant.

INDUSTRY TERMS

Arc Rating - A means of describing the ability of a material to protect against the thermal energy generated by an electric arc expressed in calories per square centimeter (cal/cm^2) stated as either an Arc Thermal Performance Value (ATPV), or Breakopen Threshold Energy (E_{BT}). The lower of either the ATPV or E_{BT} is reported as the arc rating.

Arc Thermal Performance Value or ATPV - the incident energy expressed in cal/cm^2 for a material or a multi-layer system of materials resulting in a 50% probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a 2nd degree burn injury based on the Stoll curve.

Breakopen Threshold Energy or E_{BT} – the incident energy on a material or material system that results in a 50% probability of breakopen. 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.

CAT Rating – a range of arc ratings as defined in NFPA 70E, Standard for Electrical Safety in the Workplace.
CAT 1 or Category 1 – 4.0 to 7.9 cal/cm^2
CAT 2 or Category 2 – 8.0 to 24.9 cal/cm^2
CAT 3 or Category 3 – 25 to 39.9 cal/cm^2
CAT 4 or Category 4 – 40 cal/cm^2 or higher

Chemical Protection - as used in this Industry Update, relates to the ability of fabrics to repel small amounts of inadvertent liquid chemical splash of specific groups of chemicals (Acids, Corrosives, Polar Organic Solvents).

Chemical Resistance – as used in this Industry Update, relates only to the ability of fabrics to withstand exposure to various chemicals without affecting the physical properties or flame-resistance.

Disposable FR Protective Clothing - FR garments which generally cannot be cleaned; usually provided for supplemental protection against a specific hazard or to prevent soiling expensive reusable garments.

Flame resistant - the characteristic of a fiber, fabric, or garment to resist ignition or to self-extinguish if ignited.

Flame Retardant - a chemical substance used to impart flame-resistance.

Inherent FR Fibers and Fabrics – synthetic fibers and fabrics having flame resistance as an intrinsic property. No additional treatment is needed to make an inherently FR fiber or fabric flame resistant.

FR Disposable/Limited Use Protective Clothing – FR garments which, generally, cannot be cleaned and are provided for supplemental protection from a specific hazard or to prevent soiling expensive reusable garments.

Percent Predicted Body Burn – the sum of areas represented by the sensors that calculate at least a second degree burn injury during manikin testing of flame resistant clothing per ASTM F1930, Standard Test Method for Evaluation of flame resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin.

Primary Protective Clothing – ASTM F1002, Standard Performance Specification for Protective Clothing and Materials for use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards, defines primary protective clothing as clothing designed to be worn for work activities where significant exposure to molten substance splash, radiant heat, or flame is likely to occur. Secondary protective clothing, like Bulwark's FR protective work apparel, would be worn under primary protective clothing.

Reusable Protective Clothing - garments which are capable of withstanding laundering to remove soil and other contaminants yet retain the garment's protective characteristic.

Secondary Protective Clothing - ASTM F1002 defines secondary protective clothing as clothing designed for continuous wear for work activities in designated locations in which intermittent exposure to molten substance splash, radiant heat, or flames is possible. FR work apparel, designed for continuous wear, is considered secondary protection. The protection afforded by secondary protective FR garments may be negated by an overwhelming exposure.

Stoll Curve - a plot of thermal energy vs. time, used to predict a pain sensation or the occurrence of a second degree burn in human tissue.

Treated FR Fabric – fabric requiring a flame retardant chemical finish to render flame resistant properties. FR treatments can vary in durability; not all deliver flame resistance that lasts for the life of the garment.

WORKPLACE HAZARDS AND PERFORMANCE STANDARDS

Numerous workplace hazards have the potential to cause clothing ignition and burn injuries to the wearer. The most common are flash fires, electric arc flash, and welding, cutting, or grinding accidents. Other hazards, such as chemical splash, are a concern and require special protective garments. Workers at risk of encountering these hazards should be wearing flame resistant clothing.

Measuring Flame Resistance
The most common test for measuring the flame-resistance of fabrics is ASTM D6413, Standard Test Method for Flame Resistance of Textiles (Vertical Method). Twelve-inch 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. The flame is extinguished at the end of 12 seconds and three sets of data are recorded:

After-flame: 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.

ASTM D6413 establishes a test method only. Relevant industry performance standards define the pass/fail requirement for flammability and other appropriate tests.

Relevant Performance Standards Used by Garment Manufacturers
Most industry performance standards for FR clothing require ASTM D6413 testing. Minimum performance requirements typically allow no more than 2.0 seconds after-flame and char length ranging from 4 inches to 6 inches depending on the hazard.

Not all workplace hazards have consensus standards written around them. In the absence of a consensus industry standard, Bulwark Protection® sites ASTM F2302, Standard Performance Specification for Labeling Protective Clothing Which Provides Resistance to Incidental Exposures to Heat or Open Flame, as a minimum requirement.

ASTM F2302 is the minimum standard for labeling protective clothing as heat and flame resistant. This standard requires an after-flame time of no more than 2.0 seconds and char length of less than 6.0 inches (150 mm) when tested in accordance with ASTM Test Method D6413 (Vertical Flame Resistance). No melting or dripping of the specimens is allowed during the test. The fabric may not ignite, melt, drip, separate or shrink more than 20% when exposed in a forced air oven at 500°F (260°C) for 5 minutes in accordance with ASTM F2894.".

Other performance requirements may apply to specific garments and will be so indicated on the garment label. Be aware of misinformation in the market. Many items labeled "FR" only meet general wearing apparel standards or standards applicable to upholstery or curtains.

FAST FACTS

» ASTM D6413 Flame-Resistance of Textiles Vertical test records:
» After flame - the number of seconds there is a visible flame on the fabric after the ignition source is extinguished.
» After glow - 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.
» ASTM D6413 - establishes a test method only, with no pass/fail requirements. 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.

FLASH FIRE FUELED BY FLAMMABLE VAPOR OR GAS

A vapor or gas flash fire is a short duration burst of flames occurring when flammable gases or vapors are released into the air and ignited. Clothing suitable for protection against flash fire is governed by NFPA 2112 and its companion standard NFPA® 2113.

Facts

- Flash fire is a potential hazard when working around flammable vapors & gases.
- A vapor or gas flash fire occurs when flammable vapors or gases ignite.
- A flash fire requires fuel, oxygen, and an ignition source.
- A vapor or gas flash fire typically lasts less than 5 seconds.

Standards and Test Methods

The flash fire companion standards are NFPA® 2112, Standard on Flame Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire, and NFPA® 2113, Standard on Selection, Care, Use, and Maintenance of Flame Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire.

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

If the need for flame resistant clothing is determined by the hazard assessment, workers should be issued clothing designed and certified to meet NFPA 2112, Standard on Flame resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire.

NFPA® 2112 specifies 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 required.

NFPA® 2112 now includes shrouds, balaclavas, and hoods in the list of protective clothing, along with a set of performance requirements for fabrics used in their construction. Like other 2112-certified elements, fabrics and findings used in shrouds, balaclavas, and hoods must be subjected to a battery of tests to demonstrate flame and heat-resistant properties. Unlike other fabrics used to make 2112-certified garments materials used in shrouds, balaclavas, and hoods are not subjected to a simulated flash fire. There are no test or design requirements for the hoods themselves. They should carry the same label mandated on all other NFPA® 2112 certified garments.

NFPA® 2112 includes performance requirements for FR emblems and annex material offering more specific language surrounding the use of non-FR emblems. Although not mandatory, the standard suggests the size of an individual non-FR emblem be limited to 16 in^2 and the total coverage of all non-FR emblems on a single garment be no more than 40 in^2.

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.

Heat Transfer Performance (HTP) 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 HTP rating of 6.0 cal/cm^2 is required for “spaced” and 3.0 cal/cm^2 for “contact”.

Coveralls made to a standard pattern from candidate fabrics are tested for overall flash fire exposure on an instrumented manikin in accordance with ASTM Test Method F1930. The exposure heat flux is 84 kW/m^2 (2.0 $cal/cm^2/sec$) with an exposure time of 3.0 seconds. The average total predicted body burn must not exceed 50%.

Canadian General Standards Board (CGSB) CAN/CGSB 155.20, Workwear for Protection Against Hydrocarbon Flash Fire and Optionally Steam & Hot Fluids, is the Canadian flash fire standard. Like NFPA® 2112, the most recent edition of CGSB 155.20 retains performance requirements for flame and heat resistance, thermal protective performance, and thermal shrinkage. Garment labels must be printed in English and French.

Additionally, instrumented thermal manikin testing must result in a maximum of 40% predicted total burn injury. New language was added to allow for the option of small or full-scale testing to evaluate the protective capabilities against steam or hot fluid.

EN ISO 11612:2015, Protective Clothing – Clothing to protect against heat and flame is a European standard. ISO 11612 is intended to protect workers against contact with heat and flame. This clothing is suitable for a wide range of working environments where there is a need for clothing with limited flame spread properties in combination with protection against heat transmission (radiant, convective, or contact heat and molten metal splashes). Minimum performance consists of flame spread (surface and/or edge ignition, respectively Code A1 and A2) in combination with one heat transmission code. “0” means no protection offered.

Heat Transmission Codes:
A: Limited flame spread
(A1 = surface ignition, A2 = edge ignition)
B: Convective heat (B1-B3)
C: Radiant heat (C1-C4)
D: Molten Aluminum splash (D1-D3)
E: Molten Iron splash (E1-E3)
F: Contact heat (F1-F3)

Protective Clothing Requirements

Flame resistant daily wear is an important addition to workplace PPE programs as they help reduce the severity of injuries due to a thermal event which may cause significant burn injuries to those not wearing flame resistant garments. When a daily wear program is implemented, employees are issued and required to wear flame resistant uniforms which provide them with consistent and dependable thermal protection in case of a flash fire. With daily wear FR PPE, the risk of having employees unprotected is greatly reduced. A daily wear FR PPE program ensures employees have FR protection throughout the day.

FR clothing is most effective against thermal hazards when properly worn. Garments should fit properly and be worn with sleeves rolled down, collars properly fastened, and shirt tails tucked. Garments should be kept clean, as contaminants may reduce the FR properties of a garment, and always washed according to the manufacturer’s instructions. Employees should undergo training to fully understand how to care for and properly wear their FR PPE.

FAST FACTS

- Flash fire protective clothing must be third party certified to the NFPA® 2112 standard.
- The fabric must demonstrate less than 50% predicted body burn injury when fabric is tested to ASTM F1930.
- The fabric must have a minimum Heat Transfer Performance (HTP) not less than 6 cal/cm^2 (spaced) and 3 cal/cm^2 (contact).
- Fabrics meeting NFPA 2112 must have minimal Heat & Thermal Shrinkage Resistance – no melt, drip, separation, or ignition, and maximum 10% thermal shrinkage.

FLASH FIRE FUELED BY COMBUSTIBLE DUST

A combustible dust flash fire occurs when a cloud of fine particulate from industrial operations ignites. Clothing suitable for protection against flash fire is governed by NFPA® 2112 and its companion standard NFPA® 2113.

Facts

Combustible dust, as defined by the 2020 edition of NFPA® 654, Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids,
is "a finely divided combustible particulate solid that presents a flash-fire hazard or explosion hazard when suspended in air or the process-specific oxidizing medium over a range of concentrations."

Less formal definitions strictly relate particle size to the assessment of when a dust may be deemed combustible. Less than 420 microns is usually the threshold in size.

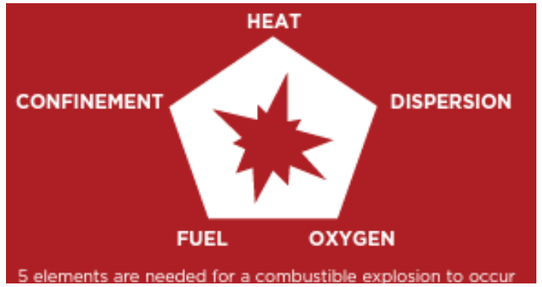
Most combustible dust is often generated as a by-product of activities such as grinding, pulverizing, sifting, etc. Left unnoticed or unattended, dust may accumulate to dangerous levels in plain sight or in areas completely unseen such as on overhead beams, on light fixtures, or above tiles of a suspended ceiling. Obscure locations pose a significant threat since they may never be addressed in routine housekeeping protocol and may house years of particulate accumulation with the potential to fuel a combustible dust fire.

3 elements are needed for a fire to start and continue to burn

The mere presence of dust does not create a hazard. The potential for a combustible dust explosion only exists when five factors occur simultaneously, a rare but potentially devastating phenomenon. In this respect, it differs substantially from the normal three factors required for a regular fire.

The "fire triangle" visually describes the three elements necessary for a regular fire to start and continue to burn. Fuel, oxygen, and heat are essential to initiate and sustain combustion.

When dust is fueling a fire, two additional factors must be present. The dust must become airborne in a confined space and a specific concentration of dust is needed. If one of the five elements is not present, a combustible dust explosion cannot occur. In an industrial environment, the source of ignition starting the fire may be an open flame, mechanical sparks, welding slag, or any variety of thermal energy. The illustration for the required constituents of a combustible dust explosion is known as the "combustible dust pentagon".



5 elements are needed for a combustible explosion to occur

The question of how much dust creates a hazard has been heavily debated. NFPA® 654 provides formulas for measuring dust in a variety of environments. Less formal means of gauging a potential hazard is to notice if visible footprints are left behind when walking across a surface covered with dust or if the color of the covered surface cannot be discerned.

Combustible dust accidents are usually characterized by a series of explosions. The initial explosion sends shock waves through nearby areas which dislodge overhead accumulations of latent dust. This new source of dust becomes suspended in the air and has potential to charge a subsequent explosion in an adjacent area of the plant. The ensuing events often cause damage and loss of life.

Standards and Test Methods

NFPA® 652, Standard on the Fundamentals of Combustible Dust, is the first source of information about managing combustible dust in the workplace. As the title suggests, this document contains the most basic requirements on combustible dust regardless of industry. In the introductory paragraphs of the 2019 version, the document states

"This new standard establishes the relationship and hierarchy between it and any of the industry- or commodity-specific standards, ensuring that fundamental requirements are addressed consistently across industries, processes, and dust types."

The most fundamental requirement of NFPA® 652 is a mandate for the owner/operator of the facility producing or handling dust to conduct a Dust Hazards Analysis, or DHA. Prior to the DHA, it must first be determined if the particulate dust is explosive or combustible. The standard provides detailed instruction on how to make that determination. If a dust is deemed combustible or explosive, a DHA must be conducted to determine whether existing workplace conditions could cause the dust to ignite and burn or explode. Responsibility for the Dust Hazards Analysis is placed on the owner/operator. This requirement is applied retroactively, which means for existing facilities, as well as new ones, a Dust Hazards Analysis must be conducted by September 7, 2020, and must cover material evaluation, process systems, and building or building compartments.

NFPA® 654, Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids, requires facilities where combustible dust exists to conduct a hazard assessment in accordance with NFPA® 2113, Standard on Selection, Care, Use, and Maintenance of Flame Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire, to determine the need for flame resistant clothing.

Industries with the largest number of explosions include the food, wood, chemical, metal, rubber, plastics, utility, and paper segments. In response to heavily publicized combustible dust accidents and explosions, OSHA initiated a National Emphasis Program (NEP) which sought to train OSHA compliance officers on the recognition of combustible dust hazards. To date, OSHA has held stake-holder meetings but has not yet issued a federal regulation on combustible dust.

The flash fire companion standards are NFPA® 2112, Standard on Flame Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire, and NFPA® 2113, Standard on Selection, Care, Use, and Maintenance of Flame Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire.

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

If the need for flame resistant clothing is determined, workers should be issued clothing designed and certified to meet NFPA 2112, Standard on Flame resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire.

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NFPA® 2112 now includes shrouds, balaclavas, and hoods in the list of protective clothing, along with a set of performance requirements for fabrics used in their construction. Like other 2112-certified elements, fabrics and findings used in shrouds, balaclavas, and hoods must be subjected to a battery of tests to demonstrate flame and heat-resistant properties. Unlike other fabrics used to make 2112-certified garments materials used in shrouds, balaclavas, and hoods are not subjected to a simulated flash fire. There are no test or design requirements for the hoods themselves. They should carry the same label mandated on all other NFPA® 2112 certified garments.

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Coveralls made to a standard pattern from candidate fabrics are tested for overall flash fire exposure on an instrumented manikin in accordance with ASTM Test Method F1930. The exposure heat flux is 84 kW/m² (2.0 cal/cm²/sec) with an exposure time of 3.0 seconds. The average total predicted body burn must not exceed 50%.

EN ISO 11612:2015, Protective Clothing – Clothing to protect against heat and flame is a European standard. ISO 11612 is intended to protect workers against contact with heat and flame. This clothing is suitable for a wide range of working environments where there is a need for clothing with limited flame spread properties in combination with protection against heat transmission (radiant, convective, or contact heat and molten metal splashes). Minimum performance consists of flame spread (surface and/or edge ignition, respectively Code A1 and A2) in combination with one heat transmission code. "0" means no protection offered.

Heat Transmission Codes:
A: Limited flame spread
(A1 = surface ignition, A2 = edge ignition)
B: Convective heat (B1-B3)
C: Radiant heat (C1-C4)
D: Molten Aluminum splash (D1-D3)
E: Molten Iron splash (E1-E3)
F: Contact heat (F1-F3)

Protective Clothing Requirements

Flame resistant daily wear is an important addition to workplace PPE programs as they help reduce the severity of injuries due to a thermal event which may cause significant burn injuries to those not wearing flame resistant garments. When a daily wear program is implemented, employees are issued and required to wear flame resistant uniforms which provide them with consistent and dependable thermal protection in case of a flash fire. With daily wear FR PPE, the risk of having employees unprotected is greatly reduced. A daily wear FR PPE program ensures employees have FR protection FR protection throughout the day.

FR clothing is most effective against thermal hazards when properly worn. Garments should fit properly and be worn with sleeves rolled down, collars properly fastened, and shirt tails tucked. Garments should be kept clean, as contaminants may reduce the FR properties of a garment, and always washed according to the manufacturer's instructions. Employees should undergo training to fully understand how to care for and properly wear their FR PPE.

FAST FACTS

- Flash fire protective clothing must be third party certified to the NFPA® 2112 standard.
- The fabric must demonstrate less than 50% predicted body burn injury when fabric is tested to ASTM F1930.
- The fabric must have a minimum Heat Transfer Performance (HTP) not less than 6 cal/cm² (spaced) and 3 cal/cm² (contact).
- Fabrics meeting NFPA 2112 must have minimal Heat & Thermal Shrinkage Resistance – no melt, drip, separation, or ignition, and maximum 10% thermal shrinkage.

» NFPA® 652, Standard on the Fundamentals of Combustible Dust, is considered the general industry standard when combustible dust presents a hazard.

» Combustible dust is a finely divided particulate solid that presents a fire or deflagration hazard when suspended in air or some oxidizing medium.

» Combustible dust explosions can occur only when five factors are present: heat, confinement, dispersion, fuel, and oxygen.

» OSHA has not yet issued a federal regulation on combustible dust.

ELECTRIC ARC FLASH

An electric arc flash is an electrical discharge through the air from a high voltage source to a conductor or to the ground. It can generate very high temperatures which melt nearby metals and plastics and damage electric circuits. It produces extremely high radiant energy capable of igniting clothing and causing 2nd and 3rd degree burns to the skin.

Facts

- Electric arc flash is a hazard when working on and around energized conductors or equipment.
- Electric arc flash occurs when electricity is released and finds a path to ground.
- An electric arc flash lasts a fraction of a second, creates heat, flames, a pressure wave, and a loud noise.
- The amount of thermal energy produced by an electric arc flash depends on the current, duration of the flash, and distance traveled.

Standards and Test Methods

The Federal regulation covering safe work practices for workers in the electric power industry is OSHA Final Rule 1910.269, Electric Power Generation, Transmission, and Distribution. The latest edition of the regulation became law July 10, 2014, with a compliance deadline of April 1, 2015.

1910.269 requires employers to provide and pay for flame resistant protective clothing and equipment covering the entire body. The PPE must have an arc rating equal to or greater than the estimated potential electric arc flash heat energy when exceeding 2.0 cal/cm². Additionally, employers must make a reasonable effort to conduct an arc flash hazard analysis on all systems operating between 50 and 240 volts to establish the required arc rating of the protective clothing and equipment.

Appendix E of 1910.269 provides tables listing incident energies for common exposures found in electric power transmission and distribution work. Employers may use these tables to estimate incident energy under the exposure conditions covered by the tables. In addition, Appendix E provides guidance on assessing the workplace for flame and electric-arc hazards, selecting a reasonable incident-energy calculation method under various conditions, and selecting reasonable parameters for use in calculating incident heat energy. Appendix E also provides guidance on selection of appropriate protective clothing and arc rated head and face protection.

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

The NESC requires the employer to determine potential exposure to an electric arc for employees who work on or near energized parts or equipment operating at 50 volts or greater. If the exposure is greater than 2 cal/cm², employees are required to wear clothing with an arc rating not less than the anticipated level of arc energy. The level is determined by completing a detailed arc hazard analysis or by using tabulated values found in Table 410-1.

Table 410-1 outlines equipment types, nominal voltage ranges, and the arc thermal performance value (ATPV) in cal/cm² for clothing or clothing systems for employees working on or near energized lines, parts, or equipment. Depending on the voltage, effective arc ratings can range from 4 calories to as much as 60 calories/cm². The NESC also contains requirements that risk factors, such as equipment condition and work methods, must be considered in implementation of an arc flash program. A job briefing must be conducted by a first-level supervisor or person in charge. Certain meltable fabrics are not allowed. National Fire Protection Association (NFPA) Standard 70E, Standard for Electrical Safety in the Workplace, is designed to provide a practical safe working area for employees relative to the hazards arising from the use of electricity. The standard addresses electrical safety-related work practices for activities such as installation, removal, inspection, operation, repair, maintenance or demolition of electric conductors, electric equipment, signaling and communications conductors and equipment, and raceways. It includes safe work practices for employees performing other work activities which may expose them to electrical hazards such as installation of conductors and equipment or in installations used by the electrical utility that are not an integral part of a generating plant, substation, or control center.

NFPA® 70E focuses on the importance of a thorough and complete risk assessment and includes acknowledgement that human error may negatively affect the workplace environment and, potentially, the safety of employees. The risk assessment procedure is required to include a

process for employees to identify hazards, assess the associated risks and apply the hierarchy of risk controls which ranks elimination of the risk as the highest priority.

One noteworthy update to the standard in 2018 was the removal of all mandatory references. This change effectively moves all citations of performance standards and other referenced documents into informational notes. For example, PPE is now required to "conform to applicable local, state or federal codes and standards". The table which lists examples of such standards is "informational" in nature and, therefore, no longer a requirement of the document. In addition, manufacturers of PPE are now required to demonstrate conformity to the chosen performance standard by one of three specific methods defined by increasing levels of external oversight.

Table 130.5(C) of NFPA 70E is used first to determine if an arc flash hazard exists. If a hazard does exist, tables 130.7(C) (15)(a) or (b) (one each for ac and dc systems) would be used to determine the arc flash boundary inside which appropriate PPE and clothing are required to be worn and must protect all parts of the body. Once the need for arc flash PPE is established, proper selection of appropriate PPE can be accomplished by conducting an incident energy analysis or using the arc flash PPE category method which references tables to determine the proper PPE category of clothing. Arc rated clothing conforming to the requirements of an applicable performance standard such as ASTM F1506 must be worn by any employee working within the arc flash boundary.

Under NFPA® 70E employers must document and implement an overall electrical safety program which includes a 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.

NFPA 70E TABLE 130.7(C)(15)(C) PERSONAL PROTECTIVE EQUIPMENT (PPE)

ARC-FLASH PPE CATEGORY	PPE	MINIMUM ARC RATING
1	• Arc-rated long-sleeve shirt and pants or arc-rated coverall • Arc-rated face shield or arc flash suit hood • Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner • Hard hat, safety glasses or safety goggles, hearing protection • Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors • Leather footwear	4 CAL/CM²
2	• Arc-rated long-sleeve shirt and pants or arc-rated coverall • Arc-rated flash suit hood or arc-rated face shield and arc-rated balaclava • Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner • Hard hat, safety glasses or safety goggles, hearing protection • Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors • Leather footwear	8 CAL/CM²
3	• Arc-rated long-sleeve shirt, arc-rated pants, arc-rated coverall, arc-rated arc flash suit jacket, arc-rated arc flash suit pants, arc-rated arc flash suit hood • Arc-rated gloves or rubber insulating gloves with leather protectors • Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner. • Hard hat, safety glasses or safety goggles, hearing protection • Leather footwear	25 CAL/CM²
4	• Arc-rated long-sleeve shirt, arc-rated pants, arc-rated coverall, arc-rated arc flash suit jacket, arc-rated arc flash suit pants, arc-rated arc flash suit hood • Arc-rated gloves or rubber insulating gloves with leather protectors • Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner • Hard hat, safety glasses or safety goggles, hearing protection • Leather footwear	40 CAL/CM²

Canadian Standards Association Z462, Workplace Electrical Safety, is the Canadian standard for electrical workplace safety and remains highly harmonized with NFPA® 70E with two significant exceptions. Z462 retains all mandatory references and, as a result, continues to require that arc-rated clothing meets the performance requirements of ASTM F1506. The new edition of Z462 introduces the concept of conformity assessment but only as non-mandatory language residing in the appendix of the document. For the first time, arc-rated clothing meeting the performance requirements of NFPA® 70E may not meet the requirements of CSA Z462 and vice versa. To fully comply with both standards, an arc-rated garment must meet the performance requirements of ASTM F1506.

ASTM F1506, 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. Thread, findings, and closures used in garment construction should not contribute to the severity of wearer injuries in the event of an electric arc exposure. Fabric must meet a set of minimum performance specifications for knit and woven fabrics. The fabric must not melt, drip, or have more than a 2.0 second after-flame or 6.0 inch char length when tested according to ASTM D6413 as received and after 25 launderings or dry cleanings. The fabric may not have more than 5.0 seconds after-flame time when tested as received in accordance with ASTM Test Method F1959, Standard Test Method for Determining the Arc Rating of Materials for Clothing. As of 2020, findings and fabrics 3rd party certified to NFPA 2112 are qualified for use in ASTM F1506 garments.

Garments conforming to the performance requirements of ASTM F1506 must be labeled with a tracking code, a statement that the garments meet the requirements of ASTM F1506, the manufacturer's name, size information, care instructions, fiber content, and the arc rating. The arc rating is reported as either arc rating ATPV or arc rating E_{BT}. Manufacturers are given up to 12 months to update labels after the standard is revised or updated.

One primary measurement of performance of textile materials intended for use as protective clothing for workers exposed to electric arcs is issued by ASTM International - ASTM F1959, Standard Test Method for Determining the Arc Rating of 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/cm²/second. It is not intended for non-flame resistant materials. Arc ratings are expressed in cal/cm² 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 equally spaced in a circle around the arc. 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 is 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.

IEC 61482-2: 2020 Live working – Protective clothing against the thermal hazards of an electric arc – Part 2: Requirements is a European standard. IEC 61482-2 guarantees the consequences of exposure to an electric arc will not be aggravated by the clothing itself. It addresses both the design of the garment and the materials used in manufacture. Minimum performance requirements for garment materials include limited flame spread properties, mechanical properties as well as arc thermal resistance properties.

Protective Clothing Requirements

- In North America, electric arc flash protective clothing most commonly meets ASTM F1506.
- The clothing must be flame resistant (FR).
- The clothing must be arc rated – either Arc Thermal Performance Value (ATPV) or Energy Breakopen Threshold (E_{BT}).
- Electric arc flash protective clothing should state NFPA® 70E PPE category ratings of CAT 1, CAT 2, CAT 3 or CAT 4 when applicable.
- 70E allows an incidental amount of elastic in underwear and socks.

FAST FACTS

OSHA 1910.269 on electrical hazards requires:

» The use of FR/arc rated clothing be worn by all electrical workers who could be exposed to an electric arc while on the job.

» Employees must be properly clothed in FR/arc rated garments having arc ratings equal to or greater than the estimated incident energies.

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.

NFPA 70E on electrical safety 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.

Employers must document an overall safety program including hazard/risk assessment and job briefing procedures. This program must be audited annually.

» Arc rated clothing required for all electrical work, but with exceptions for "normally operating" equipment.

» PPE tables split. The first table is used to determine if an arc flash hazard exists; the second is used to determine the arc flash category of the PPE.

» All layers used to determine total system arc rating must be FR. Arc ratings cannot be added together, each ensemble must be tested layered as it will be worn.

» CSA Z462 is the Canadian standard for electrical workplace safety. It retains mandatory references to performance standards and introduces the concept of conformity assessment using non-mandatory language in the appendix only. There are also changes to Lockout requirements, references to Canadian Standards and additional Canadian annexes not found in 70E.

ASTM F1506,
Workers Exposed to Electric Arcs, 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 After-flame or 6.0 inches Char Length.

» Fabrics cannot have more than 5.0 seconds After-flame in an electric arc exposure test.

» Arc rating must appear on garment labels.

ASTM F1959

» Determines arc rating of materials based on electric arc exposure.

» Fabrics are mounted on flat panels for testing.

» Arc ratings are expressed as the lower of either the ATPV or E_{BT} and are expressed in cal/cm².

WELDING, CUTTING, GRINDING

A welding, cutting, or grinding hazard occurs when hot metal sparks or spatter sprays into the surrounding area and lands on the worker.

Facts

- Hazard potential when performing various welding, cutting, or grinding operations.
- Hot metal sparks and/or spatter may be ejected causing skin burns to unprotected areas.
- Non-flame resistant clothing may melt or ignite and burn if sparks or welding slag becomes trapped on the garment.
- The potential for sparks and/or spatter depends on the type of welding being performed (Arc, TIG, MIG, Flux core, Plasma, etc.).

Standards and Test Methods

There is no widely adopted standard for the protection of welders in North America. ANSI Z49, Safety in Welding, Cutting, and Allied Processes provides guidance for educators, operators, managers, and supervisors in the safe setup and use of welding and cutting equipment and the safe performance of welding and cutting operations, but no specifics are given for the design of protective clothing.

The international/European standard ISO 11611:2015, Protective clothing for use in welding and allied processes, specifies minimum basic safety requirements and test methods for protective clothing worn during welding and allied processes. Information for hoods, aprons, sleeves, and gaiters is included. This type of protective clothing is intended to protect the wearer against spatter (small splashes of molten metal), short contact time with flame, and radiant heat from an electric arc used for welding and allied processes. Wearing this type of clothing minimizes the possibility of electric shock by short-term, accidental contact with live electrical conductors at voltages up to approximately 100 V d. c. in normal conditions of welding. For adequate overall protection against the risks welders are likely exposed, personal protective equipment (PPE) covered by other standards should be worn to protect the head, face, hands, and feet. Guidance for selection of the type of welders clothing for different welding activities is detailed in Annex A of this International Standard.

ISO 11611 specifies design features of the garment for protection of the wearer including pocket flaps wider than the pockets they cover and neck coverage. Seams are stitched and topstitched in a way to help molten metal splash roll off the garment and not get caught in the seams. Seam strength per ISO 13935, Textiles – Seam tensile properties of fabrics and made-up textile articles Part 2: Determination of maximum force to seam rupture using the grab method, fabric tear strength per ISO 13937, Textiles – Tear properties of fabrics Part 2: Determination of tear force of trouser-shaped test specimens (single tear method), and flame spread per ISO 15025, Protective clothing – Protection against heat and flame – method of test for limited flame spread are among the tests required by the standard.

Protective Clothing Requirements

- ANSI Z49, Safety in Welding, Cutting, and Allied Processes, only requires heavy fabrics. If cotton, the fabric should be FR treated to reduce combustibility.
- Clothing should minimize the potential for ignition, burning, or trapping hot sparks.
- Clothing materials which may melt should not be used.

VISIBILITY

A visibility hazard is a condition where a worker's ability to be seen by those operating vehicles or other moving equipment is necessary to avoid being struck. The need to be seen is recognized as a critical issue for workers safety. Low visibility is a serious issue for workers who must perform tasks near moving vehicles and equipment. There are a host of work environments that could require High Visibility Safety Apparel (HVSA) including, anyone working on or around roadways, oil and gas, mining, warehouses, shipyards, and other manufacturing facilities and environments where vehicles, equipment, or machinery could strike workers. In fact, the Federal Highway Administration published a regulation to establish a policy for the use of high-visibility safety apparel for workers within the Federal-aid highway rights-of-ways.

Facts

- Visibility becomes a hazard when working in low light conditions either in daytime or nighttime.
- Conspicuity is enhanced by high contrast between the garment and the ambient background against which it is seen.
- The degree of visibility enhancement may be based on things like the degree of risk,

the light level, complexity of the work background, and the speed of the vehicle or equipment.

Standards and Test Methods

ANSI/ISEA 107, American National Standard for High-Visibility Safety Apparel, establishes design, material, photometric and physical performance requirements, care labeling, and marking rules for high visibility garments. Garments compliant to ANSI/ISEA 107 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 performance requirements of at least one of the following standards in its entirety: ASTM F1506, ASTM F1891, ASTM F2302, ASTM F2733, NFPA® 1977, 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. The apparel must meet Performance Class 2 or 3 requirements of ANSI/ISEA 107.

The 2015 edition of ANSI/ISEA 107 consolidated the previously separate ANSI 107 and ANSI 207 (high visibility apparel for public safety workers) standards. Although these standards addressed different work groups, they had much in common and the committee found that revising two very similar standards on separate timetables was inefficient. With consolidation, the committee was able to streamline the revision process and better manage product overlap and testing.

The standard introduced three garment "types" which are based on the work environment of the wearer. Type O garments are intended for "off-road" workers, Type R garments are meant for employees working along a "roadway", and Type P garments meet the unique needs of "public safety" workers. Other significant changes include a provision for small-sized Type R garments to be compliant with less background fabric and a requirement for garments to be labeled "non-FR" if they are not flame resistant.

The 2020 edition of ANSI/ISEA 107 added the option of testing for overall luminance of HVSA. Benefits and an explanation of the optional testing are described in Appendix H. ASTM E 1501-99 (2004) describes a method which may be used for taking measurements. The test is to mount a garment on a manikin which is rotated and measured with a goniometer in 15° increments. The resulting data illustrates the 360° retroreflective performance of the garment.

CSA Z96, High-visibility Safety Apparel, is the Canadian counterpart to ANSI/ISEA 107. The standards differ in that the ANSI standard defines square inch measurements for the high visibility background material while the CSA standard states sections of the body which must be covered with fluorescent or bright colored fabric. Z96 also requires a harness shape of retroreflective trim cover the upper torso including around the waist, front suspenders, and a back "X". Specific rules are defined for flame resistant garments. The designation Class 1, Level FR is given to these garments.

Protective Clothing Requirements

Fluorescent colors are difficult to achieve on some fabrics. For this reason, few options are available in 100% cotton garments meeting high visibility standards. Most fabrics will include synthetic fibers which are more easily dyed to a high visibility shade that meets the standard.

It is important to follow laundering instructions for high visibility garments. The fluorescent color of the background material may fade, and the performance of the retroreflective striping may be diminished with harsh laundry processes reducing the garments' ability to protect the wearer.

- ANSI/ISEA 107 garments specify a garment type on the label. The types are Type O (Off-road and Non-Roadway Use), Type R (Roadway and Temporary Traffic Control Zones), Type P (Emergency and Incident Responders and law Enforcement Personnel), and Supplemental Items (Pants, Overalls, Shorts, Rain Pants, and Gaiters.
- ANSI/ISEA 107 garments specify a performance class on the label. The classes are Class 1 (minimum materials, slower vehicle speeds), Class 2 (additional materials, minimum for roadway applications), Class 3 (greatest visibility in complex backgrounds and maximum materials, required placement on moving parts), and Class E for Supplemental Items.
- The standard defines minimum amounts of background material for the different Types and Classes.
- The standard defines minimum retroreflective striping coverage for the different Types and Classes.
- The standard defines compliant garment design and striping configurations.
- HVSA garments are required to be labeled as either FR or Non-FR. If designated as FR, a garment label must indicate which of the approved FR standards is met.

WEATHER – RAIN AND COLD

Often, workers wearing FR clothing work outdoors exposed to inclement weather. To maintain protection, all elements of PPE should meet industry FR standards. This includes insulation within garments.

Facts

For rain and storms, FR rainwear is designed to provide protection from wind and rain for personnel who must work outdoors in all types of weather conditions. It must also provide protection from other hazards existing in the workplace such as flame exposures, electric arcs, or flash fires. In addition, most FR rainwear is expected to provide high visibility protection so the worker may be seen under adverse conditions of limited visibility compounded by weather.

For cold weather, 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. 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 fibers, inherently flame resistant fibers, or a combination of both. For maximum protection, the face cloth and batting layers of the assembly should be flame resistant. The use of non-FR materials, such as polyester fiberfill, may contribute to wearer injury if the flame resistant outer shell fabric breaks open from a flame or thermal exposure.

Standards and Test Methods

Rainwear - There are two standards which address rainwear exposed to the hazards of electric arc and flames – ASTM F1891 and ASTM F2733. In general, all FR rainwear material must have a trapezoidal tear-resistance greater than 6 pounds, withstand 30 PSIG water pressure without leaking, and must demonstrate a hydrostatic resistance to the seams 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. Both standards establish applicable test methods, minimum physical and thermal performance requirements, suggested sizing charts, and suggested purchasing information for rainwear.

ASTM F1891, Standard Specification for Arc and Flame resistant Rainwear, applies to rainwear for use by workers exposed to thermal hazards of electric arcs and open flames. All fabrics, trim, and findings used to manufacture F1891 rainwear must be electrically non-conductive. Markings and retroreflective trim must not degrade the protective performance of the rainwear. The rainwear material must not melt, drip, or have more than 2.0 seconds after-flame when tested in accordance with ASTM Test Method D 6413. F1891 requires a maximum of 6.0 inches char length

ASTM F1891 rainwear 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 (E_{BT}). The arc rating must be equal or greater than 5.0 cal/cm^2. Response characteristics of the rainwear material; after-flame 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.

Garments for protection from electric arcs must be labeled with the arc rating (ATPV or E_{BT}) of the base material. Other labeling requirements include the performance loss and the durability of the garment to appropriate cleaning processes.

ASTM F2733, Standard Specification for Flame resistant Rainwear for Protection against Flame Hazards, establishes performance requirements for clothing on workers exposed to industrial vapor and gas fires or other petrochemical fire hazards. 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 vapor and gas fires and related hazards is tested to determine percent predicted body burn following exposure on an instrumented mannequin in accordance with ASTM Test Method F1930. The exposure heat flux is 84 kW/m^2 (2.0 cal/cm^2/sec) with an

exposure time of 3.0 seconds. Three coverall specimens made in accordance with the standard garment sizing 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 after-flame time, break-open, charring, dripping, garment ignition, embrittlement, melting and shrinkage.

Most rainwear meeting the performance requirements of F2733 may also provide some protection against hot liquid splash hazards. Although it has been withdrawn in recent years, ASTM F2701, Test Method for Evaluating Heat Transfer through Materials for Protective Clothing upon Contact with Hot Liquid Splash, may have been used to evaluate protection form this hazard.

Garments meeting the performance 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. Certain rain suits are tested and rated to both arc and flash fire hazards.

Most arc-rated and/or flash fire-rated rainwear meets the high visibility requirements conforming to the American National Standards Institute ANSI/ISEA 107, *Standard for High-Visibility Safety Apparel*. As with arc and flash fire protection, the end user must ensure the rainwear is labeled as meeting the requirements of this standard.

Arc-rated and/or flash fire-rated rainwear is available in both breathable and non-breathable body fabrics; however, most generally available rain suits are made from non-breathable materials.

Some rainwear labeled as "FR" may be made from synthetic fabrics that will melt if exposed to an ignition source or thermal hazard. This type of rainwear may only be tested to a general wearing apparel standard or even a standard intended for upholstery and table linen. Rainwear tested and certified by its manufacturer to ASTM requirements must not melt, drip, or ignite when exposed to the thermal energy generated in a flash fire or electric arc.

Insulated Outerwear

NFPA® 2112, Standard on Flame resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire, addresses outerwear. Deemed critical to the safety of end users, performance requirements for lined or insulated outerwear were added to the standard in the summer of 2013 and were retained in the 2018 edition without any changes. The addition specifically addresses the unique features of cold weather gear which is sometimes designed with a removable lining. In the instance where the shell and lining may be worn separately, each stand-alone piece must be independently certified. In the case where the insulation layer is permanently attached to the certified outer shell, the performance requirements of the insulation layer are adjusted to account for the added protection afforded by the outer shell.

FAST FACTS

ASTM F2733 and F1891 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 or 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 EBT) must be equal to or greater than 5.0 cal/cm2. 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 vapor and gas 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.

» Rainwear meeting the performance requirements of F1891 and/or F2733 must be labeled stating the rainwear conforms to the specification, the manufacturer's name, style designation, size information, care instructions and fiber content. Rainwear for protection from electric arcs are required to be labeled with both the ATPV and EBT of the base material.

CHEMICAL SPLASH

There are work environments with potential for inadvertent liquid chemical splash where chemical skin burn injuries are possible. This hazard may exist in laboratories which have an abundance of chemicals present or in industrial facilities where chemical equipment operators, tenders, and workers mix, blend, package, or fill liquid chemicals into containers.

As discussed in this document, fabrics with chemical repellent properties refers to fabrics which repel small amounts of liquid chemicals inadvertently splashed onto them at atmospheric pressure. This includes acids, corrosives, and polar organic solvents. Not discussed in this document are specialized fabrics for other applications such as HazMat spills, chemical vapor permeation, blood borne pathogen exposure, and exposure to steam or liquid under pressure.

Potential for liquid chemical splash may be addressed with non-permeable lab coats, aprons, or vests which may be uncomfortable, hot, and restrictive to movement. Protection may also require a secondary protective layer requiring the wearer to decide when to wear it. This requirement adds a decision point in the PPE process which leaves room for error.

Facts

- Liquid chemical splash is a hazard when working with or around acids, corrosives, strong oxidizers, and polar organic solvents.
- Occurs when a small amount of liquid chemical is inadvertently splashed onto the wearer's clothing at atmospheric pressure.
- Is common in many laboratories and industrial facilities.
- May wick very quickly through standard work clothing or lab coats.
- Is characterized by a relatively small volume of liquid at atmospheric pressure.
- May require non-permeable clothing, like a barrier suit, which is not addressed in this guide.

Standards and Test Methods

OSHA 1910.1450, Occupational Exposure to Hazardous Chemicals in Laboratories, is the federal rule applying to all employees engaged in laboratories using hazardous chemicals. It requires employers to train employees to protect themselves from exposure to hazardous chemicals. It includes training topics such as appropriate work practices, emergency procedures, and personal protective equipment (PPE).

The appendix of OSHA 1910.1450 provides guidance in the use of PPE in labs and explains basic principles, responsibilities, and plans for PPE use.

Appendix Section A – General Principles: Perform risk assessments for hazardous chemicals and procedures prior to laboratory work, select appropriate controls including PPE to minimize risk, and wear lab coats and gloves when working with hazardous materials.
Appendix Section B - Responsibilities: Laboratory personnel use PPE as appropriate for each procedure involving hazardous chemicals.

Appendix Section D – Chemical Hygiene Plan (CHP): Implement a plan which sets forth PPE, engineering controls, apparel, and chemical handling, where trained laboratory workers should ensure proper engineering controls and PPE are in place.

Appendix Section E – General Procedures for Working with Chemicals: Wear appropriate PPE at all times.

OSHA regulation 1910.132, Personal Protective Equipment, requires employers to ensure personal protective equipment is "provided, used, and maintained in a sanitary and reliable condition whenever it is necessary..." to prevent injury. This includes protection of any part of the body from hazards through absorption, inhalation, or physical contact.

NFPA® 45, Fire Protection for Laboratories Using Chemicals, establishes basic requirements for protection of life and property through prevention for employees involved in the use of chemicals in laboratory-scale operations. The standard is designed to control hazards and protect personnel from the harmful effects of chemical fire or explosion. These excerpts from Section 6.6, Flame resistant Clothing, mandates the following performance requirements.

6.6.2 Flame resistant lab coats shall be worn where pyrophoric reagents are used outside the inert atmosphere of a glove box.

6.6.3 Flame resistant gloves shall be worn whenever possible where pyrophoric reagents are used outside the inert atmosphere of a glovebox.

6.6.5 Flame resistant clothing shall meet the requirements of NFPA® 2112.

Protective Clothing Requirements

- OSHA 1910.132 – employer shall provide appropriate PPE for the hazard.
- Garments which protect from intermittent

chemical splash should have the ability to shed small amounts of liquid chemicals as described above.

- Garments which protect from intermittent chemical splash should prevent or reduce the ability of certain liquid chemicals to wick through the garment fabric.

- Garments which protect from liquid chemical splash should be comfortable and breathable for wearing all day, rather than for use on an as needed basis.

FAST FACTS

Laboratory Thermal and Chemical Splash

» Flammable lab coats and regular clothing can — and will — make a dangerous situation far worse if they catch fire.

» A variety of classes of flammable and combustible liquids are common in labs, as well as the use of open flames and pyrophoric chemicals.

» Inadvertent chemical-splash accidents are a common occurrence in many labs, and traditional, woven lab coats generally don't provide adequate protection.

» Garments designed to specifically protect against small chemical-splash hazards may not be FR.

» Second-layer aprons or vests that are both chemical splash protective and FR are typically uncomfortable in that they don't breathe well and restrict a wearer's range of motion, and therefore are not always worn when needed.

» While eliminating the cause of accidents and/or instituting engineering controls and safety procedures can play critical roles, having the proper PPE as a line of defense is equally important.

INSECTS

Stinging or biting insects include bees, wasps, hornets, ticks, and fire ants. The health effects of being stung or bitten range from mild discomfort or pain to a lethal reaction for those workers allergic to the insect's venom.

Facts

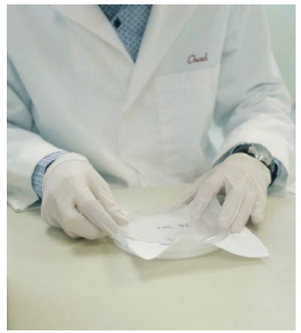
DEET is the active ingredient used in many insect repellent products used to repel biting insects. DEET can be highly flammable in concentrated forms. If used, it should be sprayed on the skin, only, and never sprayed onto garments, especially FR garments.

Using insect repellent clothing is one of the most effective steps to keep bugs, mosquitoes, and ticks away when outdoors. Garments may be treated with insect repellent to provide protection from a variety of insects. Permethrin has been successfully used in the United States as an Environmental Protection Agency (EPA) registered product since 1977, with an excellent safety record. Acceptable processes for treating garments with permethrin should render protection that is durable to multiple launderings.

Due to potential flammability, FR garments treated with insect repellent should be tested to FR standards such as NFPA 2112 after the fabrics are treated.

Standards and Test Methods

Permethrin is a substance that, in small doses, disrupts the nervous systems of nearby insects causing them to become incapacitated. In heavier doses, it may kill some insects.



Knockdown (KD) testing is a widely accepted methodology for determining the efficacy of insect repellent-treated textile products. A repellent-treated textile sample is placed in an enclosed space and insects are introduced. Once a specified time has elapsed, the insects' reactions are observed. Insects incapable of coordinated flight are deemed to be "knocked down".

Permethrin is effective against ticks, mosquitos, ants, flies, chiggers, and midges (no see-ums). Insect repellent apparel may be EPA registered. The EPA registration process is designed to evaluate a product to ensure it will not have adverse effects on people or the environment. Approved products have been rigorously evaluated on multiple levels: the chemistry, the application process, and the final consumer product. Many species and varieties of insects may be tested, including many that can carry dangerous diseases such as mosquitoes, ticks, ants, flies, chiggers, and midges (no-see-ums).

The insect repellent treatment does not affect the flame resistant characteristics or arc rating of the fabric.

Protective Clothing Requirements

There are several brands offering insect repellent clothing. As a result, people who want to protect themselves against mosquitos, ticks, and other annoying insects can choose from a wide array of clothes.

FR garments treated with the permethrin process may be washed using a normal home laundering process when following the garment laundry instructions. They should not be industrially laundered or dry-cleaned.

A small item of insect repellent clothing provides less repellency compared to a larger one. Adjustment in the type or number of garments worn may be needed depending on the number of biting insects present. Topical repellent may be used for exposed skin and is especially recommended for heavily infested locations.

Bulwark Protection offers insect repellent garments which are first treated and then UL certified to NFPA 2112.

ELECTROSTATIC DISCHARGE - ESD

Electrostatic discharge (ESD) is a quick, momentary flow of electric current between two electrically charged objects caused by contact. ESD may damage or destroy sensitive electronic components, erase, or alter magnetic media, or set off explosions or fires in flammable environments.

Facts

The generation of static electricity on clothing depends on several factors: relative humidity, the fiber content of selected garments, use of grounding devices, and the task being performed.

Fabrics containing cellulosic fibers like cotton or Lyocell® have little static build-up in high humidity environments 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).

Synthetic fabrics, such as polyester and nylon, absorb less moisture and retain more static compared to fabrics containing natural fibers. Some 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 fully address hazards associated with static.

Standards and Test Methods

EN 1149-5:2018, Protective Clothing – Electrostatic properties - Part 5: Material performance and design requirements is a European standard. EN 1149 is a series of standards for test methods and performance requirements on electrostatic properties of materials and garments. Protective clothing complying with Part 5 of this European Standard is intended to prevent the occurrence of electrostatic discharges which may cause ignition of an explosive atmosphere. This type of dissipative clothing is always used as part of a grounded system (footwear, dissipative flooring, etc.) EN 1149-5 specifies design and material requirements. The electrostatic behavior of fabric used in protective clothing may be assessed by measuring the surface resistivity as described in EN 1149-1:2006 (requirement: 2.5 x 109 Ω, max) or the charge decay according to the test method outlined in EN 1149-3:2004 (requirement: shielding factor higher than 0.2 sec and/or half decay time less than 4 sec).

Protective Clothing Requirements

Donning or removing garments may generate static charge through tribo-electric generation by friction and cause charge separation between the layers of clothing. 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.

FIRE FIGHTING

Emergency services, including fire fighting, are public organizations whose job is to take quick action to deal with emergencies.

Facts

Along with fighting fires, firefighters respond to non-fire related calls and technical rescue incidents including roadway incidents, vehicle extrication, medical emergencies, hazmat, urban search and rescue, high/low angle rescue, swift water rescue, and flood rescue. The threat of accidental thermal exposure may still exist making FR station wear a critical layer of protection for firefighter safety.

Standards and Test Methods

Situations may occur resulting in clothing

underneath turn out gear being exposed to heat and flame. The value of wearing flame resistant station wear is significant enough that NFPA® created a standard, NFPA® 1975, to address the issue. While compliance is voluntary, wearing protection maximizes the firefighter's chances of survival.

NFPA® 1975, Standard on Emergency Services Work Apparel, establishes minimum performance and certification requirements for textiles and other materials used in the construction of work uniforms for emergency services personnel. The standard specifies requirements for the design, performance, testing and certification of non-primary, protective station work uniforms that will not contribute to the severity of burn injury.

Minimum requirements are established for thermally stable, non-flame resistant textiles that will not melt or shrink excessively as well as optional requirements for fabrics represented as flame resistant, water-resistant, and/or insect repellent. There are separate labeling requirements for garments assembled from flame resistant and non-FR fabrics.

The standard sets base performance requirements for garments including heat and thermal shrinkage resistance, thermal stability, seam strength, and label legibility. There are also optional flame-resistance requirements for FR fabrics. Garments being tested to base level performance requirements alone are tested after 25 home wash cycles. Garments tested to the optional FR requirements are tested after 100 home wash cycles. They are required to be constructed with inherently FR sewing thread. 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 9001, Quality Management Systems-Requirements.

NFPA® 1951, Standard on Protective Ensembles for Technical Rescue Incidents, establishes minimum performance and certification requirements for textiles and other materials used in the construction of protective ensembles for technical rescue incidents. The standard specifies requirements for the design, performance, testing, and certification of garments worn by fire and emergency services personnel.

Minimum fabric and garment performance requirements are established for flammability, heat resistance, thermal shrinkage, evaporative heat transfer, tear and breaking strength, laundry shrinkage, and seam strength along with other requirements for various garment components. Garments meeting this standard are required to be constructed with inherently FR sewing thread and are also required to meet sizing requirements. Garments meeting the standard are required to be certified by a third-party listing organization.

Protective Clothing Requirements

For many industries, flame resistant clothing has been widely adopted as a means of protecting employees from burn injury or death; however, it is estimated only a quarter of fire departments specify FR station wear. FR station wear can be considered an integral part of every firefighter's personal protective equipment designed to be worn continuously in designated locations where exposure to heat and flame is possible.

100% non-FR cotton, although acceptable under NFPA® 1975, is a fuel and can ignite if exposed to an ignition source and ultimately contribute to firefighter burn injury. Although synthetic or synthetic blend fabrics are not compliant with NFPA® 1975, for many fire departments, uniforms made from synthetic fabrics are still the station wear fabrics of choice. Unlike FR fabrics, synthetics easily melt, drip, and can unnecessarily add to firefighter injury. Flame resistant clothing is engineered to self-extinguish upon removal of the ignition source. It's designed to limit burn injury and provide an additional layer of protection when incorporated with primary PPE.

FAST FACTS

NFPA 1975 on emergency services work apparel requires:

» Approval by a third-party listing organization such as UL®.

» Component recognized fabric must not melt, ignite or stick to glass plates in a forced air oven test

» FR or untreated 100% cotton or wool fabrics are acceptable.

» ISO 9001 Registration of the garment manufacturer is required.

WILDLAND FIRES

A wildland fire is an unplanned, uncontrolled fire in an area of combustible vegetation in a rural or urban area. In the right place, at the right time, wildland fire can create environmental benefits improving wildlife habitat. In the wrong place at the wrong time, wildfires can wreak havoc, threaten lives, homes, communities, and natural resources.

Facts

The people managing wildland fires are highly trained and equipped with well-designed tools and high performing clothing and equipment to keep them safe while they do their work.

Standards and Test Methods

The National Fire Protection Association (NFPA) Standard on Protective Clothing and Equipment for Wildland Fire Fighting and Urban Interface Fire Fighting – NFPA® 1977 – establishes minimum performance and certification requirements for textiles and other materials used in the construction of protective clothing for wildland fire fighting. The standard specifies requirements for the design, performance, testing and certification of garments worn by wildlands fire fighters.

Minimum fabric and garment performance requirements are established for flammability, radiant heat, thermal shrinkage, evaporative heat transfer, tear/burst strength, laundry shrinkage, and seam strength, along with other requirements for various garment components. Garments meeting this standard are required to be constructed with inherently FR sewing thread and are also required to meet specific sizing requirements.

Garments meeting NFPA® 1977 are required to be certified by a third-party listing organization and the manufacturer is required to be registered to ISO 9001, Quality Management Systems-Requirements.

Protective Clothing Requirements

Wildland firefighters encounter numerous challenges while on the job, from blazing flames to rugged terrain. To deal with the tough elements and harsh conditions, it's important to use personal protective equipment.

Invest in top-quality, flame resistant brush shirts, pants, and overalls. Choose clothing certified to meet or exceed NFPA 1977 standards. Use durable, flame resistant materials because synthetic materials may melt and result in severe burns and other injuries. Clothing accessories should include flame resistant shrouds and masks to help keep smoke out of the lungs and provide a layer of protection for the neck, face, and head from heat and particulate matter.

PERFORMANCE STANDARDS AND TEST METHODS

IDENTIFIER	TITLE	CLASS	MANDATE	COMMENTS
ANSI/ISEA 107	American National Standard for High-Visibility Safety Apparel	Standard	Federal	Adopted by Federal Highway Administration for workers on federally funded roads
ANSI/ISEA Z49.1	Safety in Welding,Cutting, and Allied Processes	Standard	None	
ASTM D1230	Standard Test Method for Flammability of Apparel Textiles	Test Method	None	
ASTM D6413	Standard Test Method for Flame Resistance of Textiles (Vertical Test)	Test Method	None	
ASTM F1506	Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs	Standard	None	
ASTM F1891	Standard Specification for Arc and Flame Resistant Rainwear	Standard	None	
ASTM F1930	Standard Test Method for Evaluation of Flame-Resistant Clothing for Protection against Fire Simulations Using an Instrumented Manikin	Test Method	None	A simulated flash fire exposure test
ASTM F1959	Standard Test Method for Determining the Arc Rating of Materials for Clothing	Test Method	None	Determines the arc thermal performance value (ATPV) or break-open threshold energy (EBT) of textiles using electric arc exposure
ASTM F2178	Standard Specification for Arc Rated Eye or Face Protective Products	Test Method	None	
ASTM F2302	Standard Performance Specification for Labeling Protective Clothing Which Provides Resistance to Incidental Exposures to Heat or Open Flame	Standard	None	
ASTM F2621	Standard Practice for Determining Response Characteristics and Design Integrity of Arc Rated Finished Products and Evaluating Other Products in an Electric Arc Exposure	Standard	None	
ASTM F2700	Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame-Resistand Materials for Clothing with Continuous Heating	Test Method	None	Used to determine TPP and HTP
ASTM F2733	Standard Specification for Flame-Resistant Rainwear for Protection Against Flame Hazards	Standard	None	For evaluation of rainwear for workers who are at risk for exposure to flash fire
CAN/CGSB 155.20	Workwear for Protection Against Flash Fire and Optionally Steam and Hot Fluids	Standard	None	Canadian counterpart to NFPA 2112
CPSC 16 CFR 1610	"Code of Federal Regulations Title 16 - Commercial Practices Chapter II - Consumer Product Safety Commission Subchapter D - Flammable Fabrics Act Regulations Part 1610 - Standard for the Flammability of Clothing Textiles"	Standard	Federal	
CPSC 16 CFR 1616	"Code of Federal Regulations Title 16 - Commercial Practices Chapter II - Consumer Product Safety Commission Subchapter D - Flammable Fabrics Act Regulations Part 1616 - Standard for the Flammability of Children's Sleepwear: Sizes 7 - 14 (FF 5 - 74)"	Standard	Federal	
CSA Z462	Workplace Electrical Safety	Standard	None	Canadian counterpart to NFPA 70E
CSA Z96	High-Visibility Safety Apparel	Standard	None	Canadian counterpart to ANSI/ISEA 107
EN 1149-5	Protective clothing - Electrostatic properties - Part 5: Material performance and design requirements	Standard	EU Law	European Standard
EN 61482-2	Live working - Protective clothing against the thermal hazards of an electric arc - Part 2: Requirements	Standard	EU Law	European Standard
ISO 11611	Protective clothing for use in welding and allied processes	Standard	EU Law	European Standard
ISO 11612	Protective clothing - Clothing to protect against heat and flame - Minimum performance requirements	Standard	EU Law	European Standard
ISO 13688	Protective clothing - General requirements	Standard	EU Law	European Standard
ISO 20471	High visibility clothing - Test methods and requirements	Standard	EU Law	European Standard

PERFORMANCE STANDARDS AND TEST METHODS (CONTINUED)

IDENTIFIER	TITLE	CLASS	MANDATE	COMMENTS
NFPA 1951	Standard on Protective Ensembles for Technical Rescue Incidents	Standard	None	Contains performance requirements for fabrics and garments used for protection in technical rescue incidents.
NFPA 1971	Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting	Standard	None	Contains performance requirements for fabrics and garments used for protection in structural fire fighting.
NFPA 1975	Standard on Emergency Services Work Apparel	Standard	None	Performance requirements for fabrics and garments used in firefighter's station uniforms.
NFPA 1977	Standard on Protective Clothing and Equipment for Wildland Fire Fighting and Urban Interface Fire Fighting	Standard	None	Performance requirements for fabrics and garments used for protection in wildlands firefighting.
NFPA 2112	Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire	Standard	None	
NFPA 2113	Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire	Standard	None	
NFPA 45	Standard on Fire Protection for Laboratories Using Chemicals	Standard	None	
NFPA 652	Standard on the Fundamentals of Combustible Dust	Standard	None	
NFPA 654	Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids	Standard	None	
NFPA 70	National Electric Code	Standard	None	The benchmark for safe electrical design, installation, and inspection to protect people and property from electrical hazards
NFPA 70E	Standard for Electrical Safety in the Workplace	Standard	None	Contains descriptions of clothing for employees working on energized electrical circuit parts
OSHA 29 CFR 1910.132	"Code of Federal Regulations Title 29 - Labor Part 1910 - Occupational Safety and Health Standards Subpart I - Personal Protective Equipment Section 132 - General Requirements Subtitle B - Regulations Relating to Labor Chapter XVII - Occupational Safety and Health Administration, Department of Labor"	Regulation	Federal	For employers in general industry to assess hazards in the workplace and provide appropriate PPE
OSHA 29 CFR 1910.269	"Code of Federal Regulations Title 29 - Labor Part 1910 - Occupational Safety and Health Standards Subpart R - Special Industries Section 269 - Electric power generation, transmission, and distribution. Subtitle B - Regulations Relating to Labor chapter XVII - Occupational Safety and Health Administration, Depart of Labor"	Regulation	Federal	Contains protective clothing descriptions for employees exposed to the hazards of flames or electric arcs
OSHA 5(a)(1) General Duty Clause	OSH Act of 1970	Regulation	Federal	The employer is responsible for evaluating the workplace for potential hazards and for supplying proper PPE to their employees.

FLAME RESISTANT FIBERS AND FABRICS

Fiber to Yarn to Fabric

A basic understanding of how fabrics are made is helpful when presenting information about flame resistant fibers and fabrics. Woven and knit fabrics are made from fibers which have been spun into yarns. Fibers may be natural or synthetic.

The natural fibers are cotton, linen, wool, and silk. Cotton and linen come from plants. Cotton fiber is pulled directly from the cotton plant in the field. Linen is made from the stalks of the flax plant. Wool is the fur from animals such as sheep or alpacas. Silk comes from silkworm's cocoons which are unwound to create a yarn.

Synthetic fibers are made by mixing and reacting chemicals in a vessel. Some fibers, such as rayon and bamboo, begin with plant matter, such as tree trunks, ground into a pulp with chemicals added. Others, such as polyester, are petroleum based. The resulting solution is extruded through a fixture, called a spinnerette.

Short, staple-length fibers are first subjected to a process that separates the fibers, aligns them in parallel fashion and creates a rope-like bundle called sliver. Multiple slivers are combined to go through a series of processes that draft the rope-like bundle into a smaller and smaller strand while simultaneously imparting twist for strength. These single yarns are often plied and twisted before being converted into fabric.

The resulting yarns are formed into fabric by weaving or knitting machines.

Flame resistant fibers and fabrics may be divided into two general groups: inherently flame resistant and treated for flame-resistance. Both offer flame-resistance for the life of the garment. For inherently flame resistant fibers and fabrics, flame-resistance is an essential characteristic of the solution from which the synthetic textiles are made. Treated fibers and fabrics have an applied chemical treatment creating the flame-resistance.

Be Advised: Temporary water-soluble flame-retardant treatments for cotton may be used. Borax and boric acid salt combinations are the most common. These treatments are strongly discouraged by Bulwark Protection® because of the potential lack of control in application or conditions of wear.

Bulwark.com contains information about laundering fabrics made from a variety of fibers and finishes. Information for industrial laundry may be obtained by contacting Technical Services at Bulwark Protection.

FIBERS USED IN FLAME-RESISTANT FABRICS

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
PBO	Zylon	Toyobo (Japan)	2.0% moisture regain	5.8 g/den	• High-performance, heat-resistant fiber with a benzene-fused oxazole ring structure. - Almost twice as strong as aramid fibers (Kevlar, Nomex) and about 10 times stronger than steel.
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 fiber derived from wood • Comfort properties similar to cotton • Made inherently FR by incorporating a phosphorus compound in the fiber-forming process
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)	0.4	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® Tecgen	Chapman Innovations Carbtex Technology Invista	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)

100% FR COTTON

100% FR cotton fabrics are made flame resistant by undergoing a treatment process to impart a flame-retardant chemical into the fabric. In North America, this process is typically a phosphonium salt precondensate polymerized with gaseous ammonia (THPOH-NH3) referred to as an ammonia-cured process. A heat-cured process using diakylphosphonamide is also used. Both processes bind the flame-retardant to the cotton fiber for FR durability. Both processes have a minor effect on the original fabric hand and physical characteristics of the resulting flame resistant fabric.

Bulwark® PROTECTION

DURABLE 100% FR COTTON

Two different processes are typically used to treat cotton to retain FR properties – the ammonia-cured process and the heat-cured process. Among the fabrics produced by the ammonia cure process are Amtex by Mount Vernon Mills, Banox by Itex, Inc., and Indura by Westex by Milliken. Fabrics produced by the heat cured process include Dale Antiflame®. These fabrics can meet NFPA® 70E CAT 1 or CAT 2 and NFPA® 2112 compliance.

Bulwark Protection manufactures garments made from Durable 100% FR Cotton fabrics under the brand name Excel FR.

APPLICATIONS

Used by:

- utility and other electrical workers
- petrochemical and chemical plants
- oil and gas drilling locations
- military installations
- wildland fire fighting sites
- ferrous metal foundries
- cutting, grinding, and welding processes

NOT RECOMMENDED FOR

Do not use around "white metals" such as aluminum, magnesium, or zinc as these metals may stick to the fabric. Not for use where strong oxidizer (>10% sodium hypochlorite, NaOCl), or reducing agents (sodium hydrosulfite, Na2S2O4) are present as contact with these chemicals may result in chemical burns to the wearer. Not for use in critical static control applications.

FLAME RESISTANCE

Guaranteed flame resistant for the life of the garment when laundry instructions are followed.

COLORS

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

EFFECT OF ACIDS AND ALKALIS

Resistant to many alkalis and most solvents. Many acids will destroy cotton fibers. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS

Repeated laundering with chlorine bleach will destroy the flame resistant finish. Chlorine bleach and laundry detergents containing hydrogen peroxide must not be used.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

Relatively poor resistance to mildew, aging, sunlight, and abrasion. Direct exposure to UV rays in welding may result in fabric strength and color loss.

THERMAL STABILITY

Good resistance to dry heat and a natural insulator. White metals may stick to cotton and transfer heat to the wearer. Acceptable for use in occupations where workers could be exposed to electric arc.

MOISTURE REGAIN/STATIC CONTROL

Excellent moisture regain resulting in low static propensity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING

Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Durable FR cotton garments may be laundered by normal cotton processes. Wash in low alkalinity, surfactant-based detergent. Generally, if woven they may be industrial laundered. If knit, home laundering is recommended. Use a maximum wash temperature between 120°-160°F (49°-70°C) depending on the specific fabric. Home laundry at all temperatures is acceptable

Garments may be tunnel finished up to 280°F (138°C) fabric temperature or pressed at a normal utility press temperature of 300°F (149°C). Shrinkage of up to 5% may be expected. Excessive dryer temperatures will result in higher shrinkage.

For best results, follow garment label laundry instructions.

LIMITED DURABILITY 100% FR COTTON

Fabrics produced with the ammonia cure process with a finish not guaranteed for the life of the garment are considered to have limited durability. Limited durability FR treated 100% cotton fabrics include Banox by Itex, Inc.

APPLICATIONS
Used in the molten metal industry and some welding operations where harsh environmental exposures are destructive to the fabric itself and, therefore, durability of the FR finish is not seen as beneficial.

NOT RECOMMENDED FOR
Do not use around “white metals” such as aluminum, magnesium, or zinc, as these metals may stick to the fabric. Not for use where strong oxidizer (>10% sodium hypochlorite, NaOCl), or reducing agents (sodium hydrosulfite, Na2S2O4) are present, as contact with these chemicals may result in chemical burns to the wearer. Not for use in critical static control applications.

FLAME RESISTANCE
Flame resistance is typically certified to 25 industrial and 50 home launderings. See manufacturer for details.

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

EFFECT OF ACIDS AND ALKALIS
Resistant to many alkalis and most solvents. Many acids will destroy cotton fibers. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Repeated laundering with chlorine bleach will destroy the flame resistant finish. Chlorine bleach and laundering detergents containing hydrogen peroxide must not be used.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Relatively poor resistance to mildew, aging, sunlight, and abrasion. Direct exposure to UV rays in welding may result in fabric strength and color loss.

THERMAL STABILITY
Good resistance to dry heat and a natural insulator. White metals may stick to cotton and transfer heat to the wearer. Acceptable for use in occupations where workers could be exposed to electric arc.

MOISTURE REGAIN/STATIC CONTROL
Excellent moisture regain resulting in low static propensity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Limited Durability FR cotton garments may be laundered by normal cotton processes, but the FR finish is not guaranteed for an unlimited number of launderings.

Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent. Generally, if woven, garments may be industrial laundered with special processing. Home laundry at all temperatures is acceptable. If knit, home laundering is recommended with a maximum wash temperature between 120°-140° F (49°-60° C) depending on the specific fabric.

Garments may be tunnel finished up to 280°F (138°C) fabric temperature or pressed at a normal utility press temperature of 300°F (149°C). Shrinkage of up to 5% may be expected. Excessive dryer temperatures will result in higher shrinkage.

For best results, follow garment label laundry instructions.

100% FR COTTON DENIM

Common 100% FR denim fabrics include Amtex by Mount Vernon Mills and Indura by Westex by Milliken treated with the ammonia-cured process and Dale Antiflame Denim created with the heat-cured process. The fabrics come in a variety of fabric weights and finishes. They are designed to achieve NFPA® 70E CAT 2 and NFPA® 2112 compliance.

Bulwark Protection offers a variety of cotton denim jeans from straight fit to relaxed fit for men and women.

APPLICATIONS

Used by utility and other electrical workers in:

- petrochemical and chemical plants
- oil and gas drilling locations
- military installations
- wildland fire fighting sites
- ferrous metal foundries
- cutting, grinding, and welding processes

NOT RECOMMENDED FOR
Do not use around “white metals” such as aluminum, magnesium, or zinc, as these metals may stick to the fabric. Not for use where strong oxidizer (>10% sodium hypochlorite, NaOCl), or reducing agents (sodium hydrosulfite, Na2S2O4) are present, as contact with these chemicals may result in chemical burns to the wearer. Also, not for use in critical static control applications.

FLAME RESISTANCE
Guaranteed flame resistant for the life of the garment when laundry instructions are followed.

COLORS
Dyeable in a range of colors but are typically a shade of indigo. Colorfastness to laundering is variable and similar compared to untreated cotton denim.

EFFECT OF ACIDS AND ALKALIS
Resistant to many alkalis and most solvents. Many acids will destroy cotton fibers. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Repeated laundering with chlorine bleach will destroy the flame resistant finish. Chlorine bleach and laundry detergents containing hydrogen peroxide must not be used. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Relatively poor resistance to mildew, aging, sunlight, and abrasion. Direct exposure to UV rays in welding may result in fabric strength and color loss.

THERMAL STABILITY
Good resistance to dry heat and a natural insulator. White metals may stick to cotton and transfer heat to the wearer. Acceptable for use in occupations where workers could be exposed to electric arc.

MOISTURE REGAIN/STATIC CONTROL
Excellent moisture regain resulting in low static propensity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent. FR cotton denim garments may be laundered by normal cotton processes. Home laundering at all temperatures is acceptable. Garments may be industrial laundered with a maximum wash temperature between 120°-160°F (49°-70°C) depending on the specific fabric.

Garments may be tunnel finished up to 280°F (138°C) fabric temperature or pressed at a normal utility press temperature of 300°F (149°C). Shrinkage of up to 5% may be expected. Excessive dryer temperatures will result in higher shrinkage.

For best results, follow garment label laundry instructions.

100% FR COTTON KNITS

The process to treat cotton knits to retain FR properties is ammonia curing. Among the fabrics produced by the ammonia cure process are Westex TrueComfort® by Westex by Milliken and PyroSafe® by Antex. At 7 oz. weight they can normally achieve NFPA® 70E CAT 2 and NFPA® 2112 compliance.

Bulwark Protection manufactures garments made from durable 100% FR cotton knit fabrics under the brand name Excel FR. These include t-shirts and Henleys.

APPLICATIONS

Used by utility and other electrical workers in:

- petrochemical and chemical plants
- oil and gas drilling locations
- military installations
- wildland fire fighting sites
- ferrous metal foundries
- cutting, grinding, and welding processes

Often used as a base layer**.**

NOT RECOMMENDED FOR
Do not use around "white metals" such as aluminum, magnesium, or zinc, as these metals may stick to the fabric. Not for use where strong oxidizer (>10% sodium hypochlorite, NaOCl), or reducing agents (sodium hydrosulfite, $Na_2S_2O_4$) are present, as contact with these chemicals may result in chemical burns to the wearer. Also, not for use in critical static control applications.

FLAME RESISTANCE
Guaranteed flame resistant for the life of the garment when laundry instructions are followed.

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

EFFECT OF ACIDS AND ALKALIS
Resistant to many alkalis and most solvents. Many acids will destroy cotton fibers. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Repeated laundering with chlorine bleach will destroy the flame resistant finish. Chlorine bleach and laundry detergents containing hydrogen peroxide must not be used.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Relatively poor resistance to mildew, aging, sunlight, and abrasion. Direct exposure to UV rays in welding may result in fabric strength and color loss.

THERMAL STABILITY
Good resistance to dry heat and a natural insulator. White metals may stick to cotton and transfer heat to the wearer. Acceptable for use in occupations where workers could be exposed to electric arc.

MOISTURE REGAIN/STATIC CONTROL
Excellent moisture regain resulting in low static propensity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent. FR cotton garments may be laundered by normal cotton processes. For knits, home laundering is recommended. Use a maximum wash temperature between 95°-160°F (35°-70°C) depending on the specific fabric.

Garments may be industrial tunnel finished up to 280°F (138°C) fabric temperature or pressed at a normal utility press temperature of 300°F (149°C). Shrinkage of up to 5% should be expected. Excessive dryer temperatures will result in higher shrinkage.

For best results, follow garment label laundry instructions.

FR COTTON RICH BLENDS

Blending cotton with synthetics imparts durability or comfort to the garments not found in 100% cotton garments. Nylon or polyester may be added for durability while Spandex or other stretch fibers may be added for movement.

Cotton rich blends are made flame resistant with the same methods used on 100% cotton fabric. This process is typically a phosphonium salt precondensate polymerized with gaseous ammonia (THPOH-NH3) or a heat-cured diakylphosphonamide.

FR cotton rich blends may also be made flame resistant with the Westex G2 technology. Westex G2 fabrics incorporate dual elemental chemistry which is a tailored combination of phosphorus acting as an insulator and a nitrogen source. These fabrics come in a variety of woven and knit blends and are offered by Bulwark in the iQ Series garments.

Bulwark®
PROTECTION

FR COTTON/NYLON BLENDS

Blends of cotton and nylon are designed to increase abrasion resistance compared to 100% FR cotton fabrics. The nylon also gives wrinkle resistance to button-down shirts. Fabrics may be made from an intimate blend of 88% cotton and 12% nylon yarns. They may also be constructed with 75% cotton/25% nylon warp yarns and 100% cotton filling yarns for an overall blend of 88% cotton/12% nylon. The FR treatment process is typically the same as that used for creating 100% FR cotton – either ammonia cured or heat-cured. These fabrics are designed to achieve NFPA® 70E CAT 2 and NFPA® 2112 compliance.

Among the fabrics produced by the ammonia cure process are Amtex by Mount Vernon Mills, Banwear by Itex, Inc., and UltraSoft by Westex by Milliken.

Westex by Milliken G2 technology is also used for 88% cotton/12% nylon fabrics. These fabrics incorporate dual elemental chemistry which is a tailored combination of phosphorus acting as an insulator and a nitrogen source.

Bulwark Protection markets garments made from durable flame resistant 88% cotton/12% nylon fabrics under the brand name Excel FR ComforTouch. IQ Comfort Woven garments are made with Westex by Milliken's G2 technology fabrics.

APPLICATIONS
Used by utility and other electrical workers, in petrochemical and chemical plants as well as oil & gas drilling.

NOT RECOMMENDED FOR
Do not use around "white metals" such as aluminum, magnesium, or zinc, as these metals may stick to the fabric. Not for use where strong oxidizer (>10% sodium hypochlorite, NaOCl), or reducing agents (sodium hydrosulfite, Na2S2O4) are present, as contact with these chemicals may result in chemical burns to the wearer. Also, not for use in critical static control applications.

FLAME RESISTANCE
Guaranteed flame resistant for the life of the garment when laundry instructions are followed.

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

EFFECT OF ACIDS AND ALKALIS
Resistant to many alkalis and most solvents. Many acids will destroy cotton fibers. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Repeated laundering with chlorine bleach will destroy the flame resistant finish. Chlorine bleach must not be used. 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
Relatively poor resistance to mildew, aging, sunlight, and abrasion. Direct exposure to UV rays in welding may result 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. These FR fabrics should not be used around aluminum, magnesium, or zinc. In an accident, the molten metal will stick to the fabric.

MOISTURE REGAIN/STATIC CONTROL
Excellent moisture regain resulting in low static propensity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent. Woven treated cotton/nylon blend garments may be laundered by normal cotton processes. Home laundering at all temperatures is acceptable. Maximum industrial wash temperature between 120°-160° F (49°-70° C) depending on the specific fabric.

Garments may be tunnel finished up to 280°F (138°C) fabric temperature or pressed at a normal utility press temperature of 300°F (149°C). Excessive temperatures in the washer and dryer cycles may have negative impact on shrinkage and color retention.

For best results, follow garment label laundry instructions.

FR COTTON/POLYESTER BLENDS

Blends of cotton and polyester are designed to add wrinkle resistance and to increase abrasion resistance compared to 100% FR cotton fabrics. Fabrics made from 65% cotton/35% polyester yarns were developed by Westex by Milliken using G2 technology which incorporates dual elemental chemistry, a tailored combination of phosphorus acting as an insulator and a nitrogen source. These fabrics are designed to achieve NFPA® 70E CAT 2 and NFPA® 2112 compliance.

Bulwark Protection markets garments made from Westex by Milliken's G2 technology 65% cotton/35% polyester under the brand name iQ Series Endurance. This includes a ripstop twill blend used in shirts and coveralls and a duck weave used in pants.

APPLICATIONS
Used by utility and other electrical workers in petrochemical and chemical plants as well as oil and gas drilling.

NOT RECOMMENDED FOR
Do not use around "white metals" such as aluminum, magnesium, or zinc, as these metals may stick to the fabric. Not for use where strong oxidizer (>10% sodium hypochlorite, NaOCl), or reducing agents (sodium hydrosulfite, Na2S2O4) are present, as contact with these chemicals may result in chemical burns to the wearer. Not for use in critical static control applications.

FLAME RESISTANCE
Guaranteed flame resistant for the life of the garment when laundry instructions are followed.

COLORS
Dyeable in a wide range of colors. Colorfastness to home and industrial laundering has been found to be good in standard testing. Colorfastness to light is excellent.

EFFECT OF ACIDS AND ALKALIS
Resistant to alkalis and most solvents, but many acids will destroy both FR and non-FR cellulosic-like cotton. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Cotton and polyester fibers are unaffected by chlorine bleach at correct temperature and pH ranges. However, Repeated laundering with chlorine bleach will destroy the flame-resistant finish. Chlorine bleach and laundering 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. Polyester 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
iQ Endurance woven fabric has good resistance to dry heat and is a natural insulator. In a thermal exposure, the polyester portion of the blend is protected by the flame resistant polymer structure and the cellulosic fibers which prevent sticking, melt flow, dripping and provide excellent protection to the body. This fabric is acceptable for use in occupations where workers could be exposed to electric arc.

MOISTURE REGAIN/STATIC CONTROL
Moisture regain of iQ Endurance woven fabric is excellent which results in low static propensity. The addition of synthetic fibers and the flame resistant process has only a minor effect 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent. Garments made from FR cotton and polyester blends in woven fabric have been tested for both home and industrial laundering. Home laundering at all temperatures is acceptable. Garments performed well for color fastness, strength retention and appearance. Maximum industrial wash temperature between 120°-160° F (49°-70° C) depending on the specific fabric.

Excessive temperatures in the washer and dryer cycles may have negative impact on shrinkage and color retention.

For best results, follow garment label laundry instructions.

FR COTTON RICH DENIM BLENDS

FR Cotton may be blended with other fibers to increase characteristics like abrasion resistance, stretch, and durability. There are denims constructed with a blend of 70% FR cotton and 30% Tencel providing a better drape or 94% cotton/5% polyester, and 1% Spandex providing stretch. These fabrics are designed to achieve NFPA® 70E CAT 2 and NFPA® 2112 compliance.

APPLICATIONS

Used by utility and other electrical workers in

- petrochemical and chemical plants
- oil and gas drilling locations
- military installations
- wildland fire fighting sites
- ferrous metal foundries
- cutting, grinding, and welding processes

NOT RECOMMENDED FOR

Do not use around “white metals” such as aluminum, magnesium, or zinc as these metals may stick to the fabric. Not for use where strong oxidizer (>10% sodium hypochlorite, NaOCl) or reducing agents (sodium hydrosulfite, Na2S2O4) are present as contact with these chemicals may result in chemical burns to the wearer. Also, not for use in critical static control applications.

FLAME RESISTANCE

Guaranteed flame resistant for the life of the garment when laundry instructions are followed.

COLORS

Dyeable in a range of colors but are typically a shade of indigo. Colorfastness to laundering is variable and similar compared to untreated cotton denim.

EFFECT OF ACIDS AND ALKALIS

Resistant to many alkalis and most solvents. Many acids will destroy cotton fibers. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS

Repeated laundering with chlorine bleach will destroy the flame resistant finish. Chlorine bleach and laundry detergents containing hydrogen peroxide must not be used.

Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

Relatively poor resistance to mildew, aging, sunlight, and abrasion. Direct exposure to UV rays in welding may result in fabric strength and color loss.

THERMAL STABILITY

Good resistance to dry heat and a natural insulator. White metals may stick to cotton and transfer heat to the wearer. Acceptable for use in occupations where workers could be exposed to electric arc.

MOISTURE REGAIN/STATIC CONTROL

Excellent moisture regain resulting in low static propensity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING

Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent. FR cotton blend denim garments may be laundered by normal cotton processes. Home laundering at all temperatures is acceptable. Garments may be industrial laundered with a maximum wash temperature between 120°-160°F (49°-70°C) depending on the specific fabric.

FR cotton denim blend garments may be tunnel finished up to 280°F (138°C) fabric temperature or pressed at a normal utility press temperature of 300°F (149°C). Shrinkage of up to 5% can be expected. Excessive dryer temperatures will result in higher shrinkage.

For best results, follow garment label laundry instructions.

FR COTTON RICH KNIT BLENDS

FR Cotton and synthetics may be blended to create lightweight, comfortable, flame resistant knit fabrics for shirts and base layers. These fabrics are designed to achieve NFPA® 70E CAT 2 and NFPA® 2112 compliance.

FR cotton and Spandex blended knits have the look and feel of regular t-shirts, polos, and button-down Henleys with a great amount of stretch provided by the Spandex as well as the knit construction. Antex Knits makes popular blends used by both Bulwark Protection and Carhartt.

Westex by Milliken has used their G2 technology to create innovative FR knits for workers. As with other G2 fabrics, the fabrics incorporate dual elemental chemistry which is a tailored combination of phosphorus acting as an insulator and a nitrogen source. The fabrics are made from a blend of high-performance fibers. The fabrics are a two-layered construction providing increased moisture management. Designed to be worn against the skin, the inner layer moves moisture away from the body and into the outer fabric structure where it spreads and evaporates quickly. They help keep the wearer dry and comfortable.

Bulwark Protection markets FR cotton rich knit blends from Antex in the Flex Knit line of garments which incorporates Spandex for comfort. The Westex by Milliken fabrics are marketed in the iQ Series Comfort Knits and Comfort Plus Knits. The Comfort Knits are made from 69% cotton/25% polyester/6% polyoxadiazole. The Comfort Plus knits are 70% cotton/30% polyester.

APPLICATIONS
Used by utility and other electrical workers, in petrochemical and chemical plants as well as oil & gas drilling.

NOT RECOMMENDED FOR
Do not use around “white metals” such as aluminum, magnesium, or zinc as these metals may stick to the fabric. Not for use where strong oxidizer (>10% sodium hypochlorite, NaOCl) or reducing agents (sodium hydrosulfite, Na2S2O4) are present as contact with these chemicals may result in chemical burns to the wearer. Also, not for use in critical static control applications.

FLAME RESISTANCE
Guaranteed flame resistant for the life of the garment when laundry instructions are followed.

COLORS
Dyeable in a wide range of colors. Colorfastness to home laundering has been found to be good in standard testing. Colorfastness to light is excellent.

EFFECT OF ACIDS AND ALKALIS
Resistant to alkalis and most solvents. Many acids will destroy both FR and non-FR cellulosics comparable to cotton. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Cotton, POD, and polyester fibers are unaffected by chlorine bleach at correct temperature and pH ranges; however, repeated chlorine bleach launderings could destroy the flame resistant polymer. Chlorine bleach must not be used on flame resistant, treated, durable Westex G2™ blended 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
Resistant to mildew, aging, and sunlight. This fabric incorporates micro-denier polyester and POD performance fibers that have excellent abrasion resistance. Direct exposure to ultraviolet rays in welding may cause actinic degradation resulting in fabric strength and color loss.

THERMAL STABILITY
Good resistance to dry heat and a natural insulator. In a thermal exposure the polyester is protected by the FR polymer structure and the cellulosic fibers which prevent sticking, melt flow, and dripping. Acceptable for use in occupations where workers could be exposed to electric arc.

MOISTURE REGAIN/STATIC CONTROL
Excellent moisture regain resulting in low static propensity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Starches, fabric softeners and other laundry additives should not be used in processing.

Wash in low alkalinity, surfactant-based detergent. Westex G2™ Comfort Knit fabrics have been tested for home laundering. It has performed well for color fastness, strength retention, and appearance. Shrinkage results will vary depending upon the temperature and cycle used to launder the garment.

Recommended dryer temperatures are between 140-160° F (60-70° C). Excessive temperatures in the washer and dryer cycles may have negative impact on shrinkage and color retention.

For best results, follow garment label laundry instructions.

ARAMID AND ARAMID RICH BLENDS

Aramid fibers are a family of long chain synthetic polymers developed for strength and high temperature thermal stability. They will not ignite, melt, or drip. The flame resistant property is an essential characteristic of the fiber chemistry and cannot be removed by wear or laundering.

Bulwark® PROTECTION

NOMEX® IIIA

Nomex and Kevlar are manufactured by DuPont for apparel and other applications. They are blended with carbon, a static dissipative fiber, to create DuPont's Nomex IIIA, also known as Nomex Essential. Available in several weights including 4.5oz, 6oz, and 7.5oz, it is used for making shirts, pants, and coveralls. These fabrics typically achieve NFPA® 70E CAT 1 and NFPA® 2112 compliance.

Advances in Nomex IIIA technology have produced fabrics with a better hand and with chemical splash resistance. Bulwark Protection's iQ Series Nomex Comfort garments are made with Nomex IIA fabric having improved visual appearance and hand. ShieldCXP is Nomex IIIA with a finish delivering chemical splash resistance.

APPLICATIONS

Used by:

- petrochemical and chemical plants
- oil and gas drilling
- military applications
- auto racing
- volunteer and paid fire fighting

NOT RECOMMENDED FOR
Do not use around any molten substances, welding operations, or in a critical static control application.

FLAME RESISTANCE
Guaranteed flame resistant for the life of the garment when laundry instructions are followed. Nomex is inherently flame resistant. 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
Unaffected by most acids, except for some strength loss after long exposure to hydrochloric, nitric, and sulfuric acid. Good resistance to alkalis. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Unaffected by most bleaches and solvents. Slight strength loss from exposure to sodium hypochlorite bleach. Laundering with chlorine bleach is not recommended as it will weaken the fabric and accelerate color loss.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Excellent resistance to mildew, aging, and abrasion. Natural Nomex will yellow with exposure to sunlight. Some lighter dyed shades will discolor rapidly. Lighter shades are available in solution dyed form.

THERMAL STABILITY
Excellent thermal stability and does not melt. Fiber decomposes between 700-800° F (371-427°C). Nomex is not recommended for use around molten substances or welding operations. Hot molten substances will stick to the fiber and burn through the fabric.

MOISTURE REGAIN/STATIC CONTROL
Moderate moisture regain compared to other synthetics. The antistatic fiber is designed to only combat nuisance static. Without proper grounding these fabrics should not be used in critical static control applications. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Wash separately using soft water (<1.5 grains (25 ppm)) and for best color retention use buffered, nonionic detergents at industrial laundry temperatures up to 140°F (60°C). Processing at hotter temperatures could affect color and shrinkage but not the FR performance. Home laundering at all temperatures is acceptable.

Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent.

Garments should be dried at 140°-160°F (60°-71°C) maximum stack temperature so the temperature in the dryer basket does not exceed 280°F (138°C). In home laundering, use the permanent press setting on the washer and dryer. Remove promptly from the dryer. Nomex® garments may be dry cleaned in either perchloroethylene or petroleum solvents.

For best results, follow garment label laundry instructions.

NOMEX® COMFORT

Nomex is an aramid fiber blend manufactured by DuPont. For clothing applications, it is offered as Nomex IIIA, Nomex Essential, or Nomex Comfort. They all use the same fiber blend ratio of 93% Nomex meta-aramid fiber, 5% Kevlar para-aramid fiber, and 2% static dissipative fiber. Nomex Comfort fabrics are processed to improve tactile properties, performance, and visual appearance. Nomex Comfort provides the same level of protection as Nomex Essential but has a more comfortable feel against the skin. These fabrics typically achieve NFPA® 70E CAT 1 and NFPA® 2112 compliance.

Bulwark Protection offers a collection of shirts, pants, and coveralls made from Nomex Comfort.

APPLICATIONS

Used by:

- petrochemical and chemical plants
- oil and gas drilling
- military applications
- auto racing
- volunteer and paid fire fighting

NOT RECOMMENDED FOR
Do not use around any molten substances, welding operations, or in a critical static control application.

FLAME RESISTANCE
Guaranteed flame resistant for the life of the garment when laundry instructions are followed. Nomex is inherently flame resistant. 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
Unaffected by most acids, except for some strength loss after long exposure to hydrochloric, nitric, and sulfuric acid. Good resistance to alkalis. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Unaffected by most bleaches and solvents. Slight strength loss from exposure to sodium hypochlorite bleach. Laundering with chlorine bleach is not recommended as it will weaken the fabric and accelerate color loss.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Excellent resistance to mildew, aging, and abrasion. Natural Nomex will yellow with exposure to sunlight. Some lighter dyed shades will discolor rapidly. Lighter shades are available in solution dyed form.

THERMAL STABILITY
Excellent thermal stability and does not melt. Fiber decomposes between 700-800° F (371-427°C). Nomex is not recommended for use around molten substances or welding operations. Hot molten substances will stick to the fiber and burn through the fabric.

MOISTURE REGAIN/STATIC CONTROL
Moderate moisture regain compared to other synthetics. The antistatic fiber is designed to only combat nuisance static. Without proper grounding these fabrics should not be used in critical static control applications. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Wash separately using soft water (<1.5 grains (25 ppm)) and for best color retention use buffered, nonionic detergents at laundry temperatures up to 140°F (60°C). Processing at hotter temperatures could affect color and shrinkage but not the FR performance. Home laundering at all temperatures is acceptable.

Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent.

Garments should be dried at 140°-160°F (60°-71°C) maximum stack temperature so the temperature in the dryer basket does not exceed 280°F (138°C). In home laundering, use the permanent press setting on the washer and dryer. Remove promptly from the dryer. Nomex® garments may be dry cleaned in either perchloroethylene or petroleum solvents.

For best results, follow garment label laundry instructions.

NOMEX® SHIELDCXP®

Westex ShieldCXP uses a base fabric of Nomex IIIA with a proprietary finish creating liquid chemical repellency properties. Garments made from ShieldCXP provide chemical splash protection. These fabrics typically achieve NFPA® 70E CAT 1 and NFPA® 2112 compliance.

Lab coats made from ShieldCXP by Bulwark Protection are used in laboratories across the U.S. Coveralls are also available.

APPLICATIONS

Used in:

- academic and commercial research laboratories
- chemical processing plants
- industries when flash fire and inadvertent liquid chemical splash are potential hazards

NOT RECOMMENDED FOR

Do not use around any molten substances and welding. Large volume splash hazards, splash hazards under pressure, non-polar organic liquid chemicals. Note: see the list of chemicals that have been tested. Be sure chemicals applicable to the lab have been tested.

FLAME RESISTANCE

ShieldCXP is inherently flame resistant. This property cannot be degraded by laundering.

COLORS

Available in Royal blue and Navy blue. Colorfastness to laundering varies depending on the shade.

CHEMICAL REPELLENCY

Effective in repelling liquid chemicals having medium to high surface tension and medium to high polarity at atmospheric pressure. Examples include Sulfuric Acid, Hydrochloric Acid, Hydrofluoric Acid, Nitric Acid, Hydrogen Peroxide, Acetonitrile, Methanol, Ethanol, i-Propanol and more.

EFFECT OF MILDEW, AGING, SUNLIGHT, AND ABRASION

ShieldCXP has excellent resistance to mildew, aging and abrasion. Natural (undyed) Nomex fiber is not white and will yellow with exposure to sunlight.

THERMAL STABILITY

Excellent thermal stability and does not melt. The fiber decomposes between 700° - 800°F (371°-427°C). ShieldCXP is not recommended for use around molten substances or welding operations. Hot molten substances will stick to the fiber and burn through the fabric.

MOISTURE REGAIN/STATIC CONTROL

Moderate moisture regain compared to other synthetics. The antistatic fiber is designed to only combat nuisance static. Without proper grounding these fabrics should not be used in critical static control applications. **Do not don or remove these garments in a hazardous area.**

LAUNDERING

Wash separately using soft water (<1.5 grains (25 ppm)) in low alkalinity, surfactant-based detergent at laundry temperatures up to 140°F (60°C).

Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

ShieldCXP will maintain its chemical splash resistance up to 50 industrial launderings when laundered according to recommended guidelines. Home laundering at all temperatures is acceptable.

Note: Higher wash temperatures and higher alkalinity may negatively impact the life of the repellency properties. Wash in low alkalinity, surfactant-based detergent.

For best results, follow garment label laundry instructions.

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 Comfort Blend, a 65/35 blend of Nomex and Lenzing FR, and Comfort MP, a 50/40/10 blend of Nomex, Lenzing FR and Tencel. Both Comfort Blend and Comfort MP are manufactured by Tencate™. These fabrics typically achieve NFPA® 70E CAT 1 and NFPA® 2112 compliance.

APPLICATIONS
Used by:

- utilities
- petrochemical and chemical plants
- oil and gas drilling
- firefighter station/work uniforms

NOT RECOMMENDED FOR
Do not use around molten substances or welding operations, or in critical static control applications.

FLAME RESISTANCE
Guaranteed flame resistant for the life of the garment when laundry instructions are followed. Nomex is inherently flame resistant. This property cannot be degraded by 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
Aramid fiber is unaffected by most acids and has generally good resistance to alkalis. Lenzing and Tencel chemical resistance is comparable to cotton (destroyed by strong acids). The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Physical and FR properties are unaffected by most bleaches and solvent. Laundering with chlorine bleach is not recommended as it will weaken the fabric and accelerate color loss.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Aramid fibers have excellent resistance to mildew, aging, and abrasion. Sunlight may change the color. 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.

MOISTURE REGAIN/STATIC CONTROL
Excellent moisture regain resulting in low static propensity except in very low relative humidity. Without proper grounding these fabrics should not be used in critical static control applications. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Wash separately using soft water (<1.5 grains (25 ppm)) in low alkalinity, surfactant-based detergent at laundry temperatures up to 140°F (60°C).

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. Processing at hotter temperatures could affect color and shrinkage, but not the FR performance. Home laundering at all temperatures is acceptable. Wash in low alkalinity, surfactant-based detergent.

Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Garments should be dried at 140°-160°F (60°-71°C) maximum stack temperature so the temperature in the dryer basket does not exceed 280°F (138°C). Exceeding these temperatures will accelerate color loss. For in home laundering, use the permanent press setting on the washer and dryer. Remove promptly from the dryer. Garments may be dry cleaned in perchloroethylene solvent.

For best results, follow garment label laundry instructions.

KERMEL/MODACRYLIC BLENDS

Kermel is a synthetic polyamide imide aramid fiber manufactured in France by Kermel. It is blended with wool for dress uniforms, and with high tenacity aramid for fire fighter bunker gear, as well as FR rayon. Another common Kermel blend fabric is GlenGuard, a blend of Kermel, modacrylic, and antistatic fibers available in several weights for use in shirts, pants, and coveralls.

This review will refer to Kermel blends.

APPLICATIONS

Used in

- utilities
- petrochemical and chemical plants
- oil and gas drilling
- firefighter station/work uniforms

NOT RECOMMENDED FOR
Do not use around any molten substances or welding operations, or in critical static control operations.

FLAME RESISTANCE
Guaranteed flame resistant for the life of the garment when laundry instructions are followed.

COLORS
The Kermel 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. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Resistant to most solvents (except phenols and solvents that are very polar), and chlorine bleach. Resists alkalis, bleaches, and solvents, but subject to damage by acids. Must not be laundered with chlorine bleach.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
KERMEL® has excellent resistance to mildew, aging, sunlight, and abrasion.

THERMAL STABILITY
Good thermal stability and does not melt. Hot molten contact will stick to the fiber, forming holes.

MOISTURE REGAIN/STATIC CONTROL
Kermel/modacrylic blends have moderate moisture regain compared to other synthetics. Except in low relative humidity, Kermel would have little static propensity. The anti-static fiber is designed to only combat nuisance static; therefore, without proper grounding, these fabrics should not be used in critical static control applications.
Do not don or remove these garments in a hazardous area.

LAUNDERING
Wash separately using soft water (<1.5 grains (25 ppm)) in low alkaline, surfactant-based detergents at 140°F (60°C), maximum. Home laundering at all temperatures is acceptable. Wash in low alkalinity, surfactant-based detergent.

Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Garments should be dried at 140°F (60°C) stack temperature so fabric temperature measured in the basket does not exceed 280°F (138°C). Exceeding these recommendations may result in significant shrinkage and/or loss of physical properties and durability.

For best results, follow garment label laundry instructions.

ARAMID/PBI BLENDS

PBI is a synthetic polybenzimidazole fiber made by PBI Performance Products Inc. which is used in blends with other fibers. PBI Gold is a 60% Kevlar aramid/40% PBI blend fabric. PBI is also branded as TriGuard which is a blend of 50% Twaron, 30% Lenzing FR and 20% PBI.

This review will focus on PBI Gold®.

APPLICATIONS

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

NOT RECOMMENDED FOR
Critical static control applications.

FLAME RESISTANCE
Guaranteed flame resistant for the life of the garment when laundry instructions are followed.

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

EFFECT OF ACIDS AND ALKALIS
Excellent resistance to most acids and alkalis. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Excellent resistance to solvents. PBI Gold loses strength when exposed to chlorine bleach. Where chemical exposure is a hazard, specialized garments should be used.

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 PBI Gold has very good abrasion resistance.

THERMAL STABILITY
PBI has excellent thermal stability and retains fiber integrity and suppleness after flame exposure. Does not ignite or melt. Molten substance contact will cause pin-holing in the fabric.

MOISTURE REGAIN/STATIC CONTROL
Excellent moisture regain resulting in low static propensity except in very low relative humidity. Without proper grounding these fabrics should not be used in critical static control applications. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash 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. Home laundering at all temperatures is acceptable.

Fabric temperature in the dryer basket should not exceed 210°F (99°C). Exceeding these recommendations may result in significant garment shrinkage. Garments of PBI Gold® may be tunnel finished, but fabric temperatures should not exceed 210°F (99°C). Remove promptly from the dryer.

Garments may be dry cleaned in perchloroethylene solvent.

For firefighters turn-out gear, follow garment label laundry instructions for best results.

OTHER ARAMID BLENDS

TenCate developed Evolv, a unique blend of fibers to provide FR protection and durability in a lightweight fabric. It takes advantage of the strength of an aramid, the moisture wicking of a cellulosic and the feel of a modacrylic. These fabrics are designed to achieve NFPA® 70E CAT2 and NFPA® 2112 compliance.

Bulwark Protection's iQ Series Comfort Wovens are made with Evolv. The product line includes shirts and mobility coveralls.

APPLICATIONS

Used by

- utility and other electrical workers
- petrochemical and chemical plants
- oil & gas drilling

NOT RECOMMENDED FOR
Do not use around molten substances or welding operations, as these substances may stick to the fabric. Also, not for use in critical static control applications.

FLAME RESISTANCE
A blend of fibers that are inherently flame resistant which means the FR property cannot be removed by wear or laundering. The Lyocell and cellulosic fibers are not FR treated but derive their 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
Resistant to many alkalis and most solvents. Many acids will destroy cellulosic fibers like Lyocell. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
FR properties are unaffected by most bleaches and solvents. Laundering with chlorine bleach is not recommended as it will weaken the fabric and accelerate color loss.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Excellent resistance to mildew, aging, and abrasion. Colorfastness to sunlight is superior to higher aramid content fabrics.

THERMAL STABILITY
Excellent thermal stability and does not melt. Not recommended for use around molten substances.

MOISTURE REGAIN/STATIC CONTROL
Good moisture regain resulting in low static propensity except in very low relative humidity. Without proper grounding these fabrics should not be used in critical static control applications. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent at temperatures up to 140°F (60°C). Garments should be dried at 140°-160°F (60°-71°C) maximum stack temperature so 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.

For best results, follow garment label laundry instructions.

MODACRYLIC RICH BLENDS

Modacrylic fibers are extruded with a flame-retardant chemical in the fiber forming process. This makes these fibers flame resistant for the life of the garment because the flame retardant cannot be removed by wear or laundering. For use in garments, they are typically blended with other fibers like Lyocell, aramid, cotton, or Tencel to provide other beneficial characteristics like moisture wicking and strength.

Bulwark® PROTECTION

MODACRYLIC/LYOCELL/ARAMID BLENDS

Various blends of modacrylic, lyocell, and aramid fibers have been introduced in woven fabric constructions for use in shirts, pants, and coveralls. These fabrics are characterized by excellent, cotton-like hand, moisture wicking and durability.

Various blends are manufactured by Tencate ™ under the name of Tecasafe™ Plus. These fabrics are designed to achieve NFPA® 70E CAT1 or CAT2 and NFPA® 2112 compliance.

Bulwark Protection makes and sells a variety of styles including shirts and coveralls made with Tecasafe Plus fabrics under the CoolTouch 2 or CT2 collection

APPLICATIONS

Used by

- utility and other electrical workers
- petrochemical and chemical plants
- oil & gas drilling
- firefighter station/work uniforms

NOT RECOMMENDED FOR
Do not use around molten substances or welding operations, as these substances may stick to the fabric. Also, not for use in critical static control applications.

FLAME RESISTANCE
A blend of fibers that are inherently flame resistant which means the FR property cannot be removed by wear or laundering. The Lyocell fiber is not FR treated 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
Resistant to many alkalis and most solvents. Many acids will destroy cellulosic fibers like Lyocell. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
FR properties are unaffected by most bleaches and solvents. Laundering with chlorine bleach is not recommended as it will weaken the fabric and accelerate color loss.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Excellent resistance to mildew, aging, and abrasion. Colorfastness to sunlight is superior to higher aramid content fabrics.

THERMAL STABILITY
Good thermal stability and does not melt. Not recommended for use around molten substances.

MOISTURE REGAIN/STATIC CONTROL
Good moisture regain resulting in low static propensity except in very low relative humidity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent at temperatures up to 140°F (60°C). In home laundering, use the permanent press setting on the washer.

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 dryer.

For best results, follow garment label laundry instructions.

MODACRYLIC/COTTON OR CELLULOSE BLENDS

Various blends of modacrylic and cotton/cellulosic 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. Fabrics with 65% or more modacrylic probably won't meet NFPA 2112 compliance testing.

THE VARIOUS BLENDS INCLUDE

- Firewear 55% modacrylic/45% cotton
- Valzon FR 60% modacrylic/40% cotton
- 67% modacrylic /29% cotton/4% polyester
- 70% modacrylic/30% Tencel
- 85% modacrylic/15% cellulosic

APPLICATIONS
Used by utilities and for fire fighters station/ work uniforms.

NOT RECOMMENDED FOR
Do not use around molten substances or welding operations, as these substances may stick to the fabric.

FLAME RESISTANCE
The Modacrylic fiber polymer provides the fabric with self-extinguishing properties guaranteed flame resistant for the life of the garment when laundry instructions are followed. The other fibers derive their self-extinguishing characteristics from the presence of the modacrylic fibers.

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

EFFECT OF ACIDS AND ALKALIS
Resistant to many alkalis and most solvents. Many acids will destroy cotton fibers. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Chlorine bleach is not recommended as it will cause the fabric to lose color. Chlorine has no effect on the flame resistance of the fabric.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Relatively poor resistance to mildew, aging, and sunlight. Abrasion resistance is similar compared to cotton.

THERMAL STABILITY
Good thermal stability. It will not melt or drip.

MOISTURE REGAIN/STATIC CONTROL
Excellent moisture regain resulting in low static propensity except in low relative humidity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent at temperatures up to 140°F (60°C). 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.

For best results, follow garment label laundry instructions.

MODACRYLIC/ARAMID BLENDS

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 CAT2 and NFPA® 2112 compliance.

This section discusses Protera.

APPLICATIONS

Used by

- utility and other electrical workers
- petrochemical and chemical plants
- oil & gas drilling
- firefighter station/work uniforms

NOT RECOMMENDED FOR
Do not use around molten substances or welding operations, as these substances may stick to the fabric. Also, not for use in critical static control applications.

FLAME RESISTANCE
A blend of fibers that are inherently flame resistant which means the FR 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. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Flame resistant properties 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
Good thermal stability and does not melt. 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 Protera™ is designed to combat nuisance static only and without proper wearer grounding should not be considered for use in critical static control applications.
Do not don or remove these garments in a hazardous area.

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent at laundry temperatures up to 140°F (60°C). 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. Garments may be pressed or tunnel finished, if desired. Garment temperature should not exceed 280°F (138°C).

Do not line dry or store in sunlight.

Protera™ garments may be dry cleaned in perchloroethylene solvent.

For best results, follow garment label laundry instructions.

MODACRYLIC/WOOL BLENDS

There are modacrylic fibers blended with wool fibers primarily for fleece outerwear. Wool adds natural water resistance and warmth. The common modacrylic/wool fleece blend is 44% modacrylic/40% wool/11% aramid/5% lyocell. They are designed to achieve NFPA® 70E CAT2 and NFPA® 2112 compliance.

APPLICATIONS

Used by

- utility and other electrical workers
- petrochemical and chemical plants
- oil & gas drilling
- outdoor work environments with potential garment ignition hazards.

NOT RECOMMENDED FOR
Do not use around molten substances or welding operations, as these substances may stick to the fabric. Also, not for use in critical static control applications.

FLAME RESISTANCE
The Modacrylic fiber polymer provides the fabric with self-extinguishing properties guaranteed flame resistant for the life of the garment when laundry instructions are followed. The other fibers derive self-extinguishing characteristics from the presence of the modacrylic fibers.

COLORS
Dyeable in a range of colors with good colorfastness.

EFFECT OF ACIDS AND ALKALIS
Resistant to many alkalis and most solvents. Many acids will destroy cellulosic fibers like Lyocell. Wool is vulnerable to attack by weak alkalis. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
FR properties are unaffected by most bleaches and solvents; however, wool is irreversibly damaged by dilute oxidizing bleaches such as hypochlorite. Reducing agents cause wool to dissolve. Laundering with chlorine bleach is not recommended as it will weaken the fabric and accelerate color loss.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Moderate resistance to aging, and abrasion. Relatively poor resistance to mildew. Wool may be attacked by short ultraviolet wavelengths in sunlight.

THERMAL STABILITY
Good thermal stability and does not melt.

MOISTURE REGAIN/STATIC CONTROL
Good moisture regain resulting in low static propensity except in low relative humidity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent. Garments have been tested for home laundering. They have performed well for wash fastness, strength retention, and appearance. Shrinkage results will vary depending upon the temperature and cycle used to launder the garment.

Recommended dryer temperatures are between 140-150° F (60-65° C). Excessive temperatures in washer and dryer cycles may have negative impact on shrinkage and color retention.

For best results, follow garment label laundry instructions.

MODACRYLIC KNIT BLENDS

Various blends of modacrylic, lyocell and aramid fibers have been introduced in knit fabric constructions for use in T shirts, polo shirts, sweatshirts, and hoodies. These fabrics are characterized by excellent, cotton-like hand, moisture wicking and durability.

Various blends of modacrylic/lyocell/aramid are manufactured by Tencate ™ under the name of Tecasafe™ Plus Swiss Pique Knit. Antex Knitting produces FR Fleece in modacrylic/lyocell/aramid blends including Spandex for stretch comfort in sweatshirts and hoodies.

High visibility colors are achievable in these blends for creating apparel including outerwear meeting the ANSI 107 standards. These fabrics are designed to achieve NFPA® 70E CAT1 or CAT2 and NFPA® 2112 compliance.

Bulwark Protection produces and sells knit shirts, sweatshirts, and hoodies made from both Tecasafe and Antex knits. The Antex fleece fabrics are prominent in Bulwark's Hi-Visibility collection.

APPLICATIONS

Used by

- utility and other electrical workers
- petrochemical and chemical plants
- oil & gas drilling
- firefighter station/work uniforms

Excellent as a base layer

NOT RECOMMENDED FOR
Do not use around molten substances or welding operations, as these substances may stick to the fabric. Also, not for use in critical static control applications.

FLAME RESISTANCE
A blend of fibers that are inherently flame resistant which means the FR property cannot be removed by wear or laundering. The Lyocell fiber is not FR treated 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
Resistant to many alkalis and most solvents. Many acids will destroy cellulosic fibers like Lyocell. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
FR properties are unaffected by most bleaches and solvents. Laundering with chlorine bleach is not recommended as it will weaken the fabric and accelerate color loss.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Excellent resistance to mildew, aging, and abrasion. Colorfastness to sunlight is superior to higher aramid content fabrics.

THERMAL STABILITY
Good thermal stability and does not melt. Not recommended for use around molten substances.

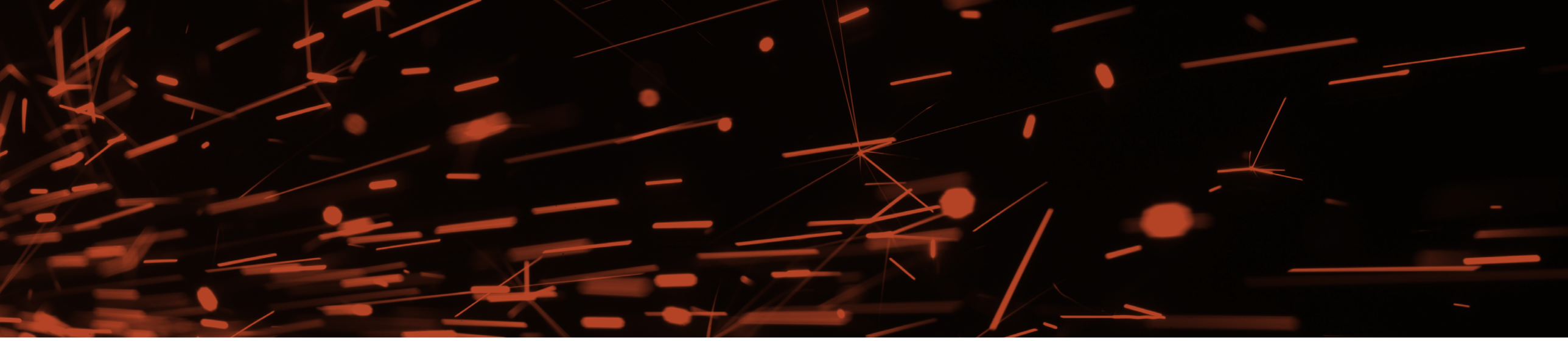
MOISTURE REGAIN/STATIC CONTROL
Good moisture regain resulting in low static propensity except in very low relative humidity. However, since static control depends on ambient relative humidity, the garment should not be considered for applications where critical static control is required without proper wearer grounding. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Wash in low alkalinity, surfactant-based detergent at temperatures up to 140°F (60°C). In home laundering, use the permanent press setting on the washer.

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 dryer.

For best results, follow garment label laundry instructions.



RAYON RICH BLENDS

Rayon rich blended fabrics are used to protect from hazards like molten metal splash, welding spatter, and a combination of thermal exposures.

Bulwark® PROTECTION

RAYON/WOOL BLENDS

These fabrics are designed to deliver protection against molten metal splash, radiant heat, and other smelting hazards. They deliver molten metal splash shedding properties for many metals, some including aluminum. Protection from molten metal splash requires very specialized garments, so thorough evaluation for the application is required.

Among these fabrics are

- Oasis, a blend of 50% Lenzing FR/40% wool/10% nylon
- Vinex, a blend of 85% vinal/15% polynosic

Both may be used in aluminum smelting operations.

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

NOT RECOMMENDED FOR
Do not use where flash fire or electric arc flash protection is needed or in critical static control applications.

FLAME RESISTANCE
FR Rayon fibers (Lenzing FR) are made FR in the spinning process and laundering cannot degrade this property. The wool portion may or may not be FR treated. See information from fabric or garment manufacturer.

COLORS
Dyeable in a range of colors.

EFFECT OF ACIDS AND ALKALIS
Resistant to attacks by acid. Extremely vulnerable to attack by weak alkalis, even at low dilutions. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

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
Poor resistance to mildew. Attacked by short ultraviolet wavelengths in sunlight. Resistance to abrasion is fair.

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

MOISTURE REGAIN/STATIC CONTROL
Excellent moisture regain resulting in low static propensity except in very low relative humidity. 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. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Neither chlorine bleach nor perborate may be used because they will destroy the wool fiber. Do not use starches, fabric softeners or other laundry additives.

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.

Wash in low alkalinity, surfactant-based detergent. 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.

For best results, follow garment label laundry instructions.

RAYON/ARAMID BLENDS

Rayon and aramid fabrics provide the ability to shed small molten metal spatter created in the welding process. These fabrics resist the molten spatter from sticking to the fabric which may create holes and minor burn injuries. These fabrics are designed to achieve NFPA® 70E CAT 2 and NFPA® 2112 compliance.

AMONG THESE FABRICS ARE

- Tuffweld® 60% FR Rayon/40% Aramid by Tencate
- ArcWeld 60% Lenzing FR/40% Twaron by Norfab

APPLICATIONS
Metal welding, grinding, and cutting.

NOT RECOMMENDED FOR
Do not use where flash fire or electric arc flash protection is needed or in critical static control applications.

FLAME RESISTANCE
FR Rayon fibers (Lenzing FR) are made FR in the spinning process and laundering cannot degrade this property. Aramid fibers are inherently flame resistant, and laundering cannot degrade this property. See information from fabric or garment manufacturer.

COLORS
Brown.

EFFECT OF ACIDS AND ALKALIS
Resistant to many alkalis and most solvents. Many acids will destroy cellulosic fibers like FR Rayon and Lenzing FR. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
FR properties are unaffected by most bleaches and solvents. Laundering with chlorine bleach is not recommended as it will weaken the fabric and accelerate color loss.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Excellent resistance to mildew, aging, and abrasion. Colorfastness to sunlight is superior to aramid fabrics.

THERMAL STABILITY
Excellent thermal stability and does not melt.

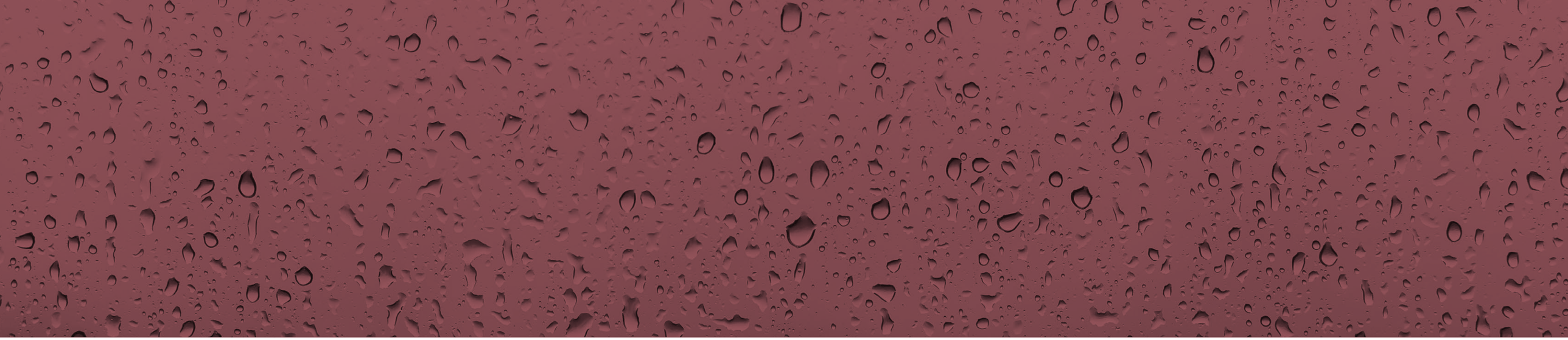
MOISTURE REGAIN/STATIC CONTROL
Excellent moisture regain resulting in low static propensity except in very low relative humidity. However, since static control depends on ambient relative humidity, the garment should not be considered for applications where critical static control is required without proper wearer grounding. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Processing at hotter temperatures could affect color and shrinkage, but not the FR performance. Garments should be dried at 140°-160°F (60°-71°C) maximum stack temperature so the temperature in the dryer basket does not exceed 280°F (138°C). Exceeding these temperatures will accelerate color loss.

Wash in low alkalinity, surfactant-based detergent. In home laundering, use the permanent press setting on the washer and dryer. Remove promptly from the dryer.

For best results, follow garment label laundry instructions.



OTHER FIBERS & FABRICS

There are a variety of other fabrics with specialized fibers and fiber blends designed for other workplace exposures beyond the common arc flash and flash fire hazards.

Bulwark® PROTECTION

100% POLYESTER

Rayon and aramid fabrics provide the ability to shed small molten metal spatter created in the welding ShieldCSR uses a base fabric of 100% spun Polyester with a proprietary technology providing chemical repellency properties. This fabric is NOT flame resistant.

This fabric is not flame resistant.

APPLICATIONS
Used in academic and commercial research laboratories where inadvertent liquid chemical splash is a hazard - without potential for flash fire or other clothing ignition sources.

NOT RECOMMENDED FOR
Do not use around any molten substances, welding, flammable or combustible chemicals or gases. Large volume splash hazards, splash hazards under pressure, non-polar organic liquid chemicals.

Note: See the list of chemicals tested to be certain the fabric meets the hazard assessment.

FLAME RESISTANCE
ShieldCSR is NOT a flame resistant fabric.

COLORS
Available in white only.

CHEMICAL REPELLENCY
Effective in repelling liquid chemicals that have medium to high surface tension and medium to high polarity at atmospheric pressure. Examples: Sulfuric Acid, Hydrochloric Acid, Hydrofluoric Acid, Nitric Acid, Hydrogen Peroxide, Acetonitrile, Methanol, Ethanol, i-Propanol and more. See www.bulwark.com/bulwark-cp for more information.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
ShieldCSR has some resistance to mildew, aging and abrasion – similar compared to standard 100% Polyester fabrics.

THERMAL STABILITY
ShieldCSR is NOT a flame resistant fabric; therefore, it is not designed for thermal exposures.

MOISTURE REGAIN/STATIC CONTROL
Poor moisture regain. ShieldCSR does not have any static dissipative fibers. It should not be considered for use in critical static control applications without proper wearer grounding. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Wash separately using soft water (<1.5 grains (25 ppm)) in low alkalinity, surfactant-based detergent at laundry temperatures up to 120°F (50°C).

Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

ShieldCSR will maintain its chemical splash resistance up to 50 industrial launderings when laundered according to recommended guidelines.

Note: Higher wash temperatures and higher alkalinity may negatively impact the life of the repellency properties.

For best results, follow garment label laundry instructions.

FR INSULATION

Fabrics may be intimate or discrete blends containing modacrylic, FR rayon, nylon, or other fibers. Nomex and/or modacrylic fibers may be pressed into batting layers. FR batting is sandwiched between layers of FR fabric to created insulated jackets and coats.

APPLICATIONS
Used as winter insulation for outerwear garments worn in electric utility and petrochemical areas.

NOT RECOMMENDED FOR
Do not use in critical static control applications.

FLAME RESISTANCE
Usually blends of inherently flame resistant fibers; this property cannot be degraded by wear or laundering.

COLORS
Limited colors. Insulation is sandwiched between layers of other FR fabric.

EFFECT OF ACIDS AND ALKALIS
Fairly inert except for weakness to highly concentrated acids and strong bases. The fiber and fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Excellent resistance to organic solvents. Poor resistance to oxidizing agents and bleaches.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Depending on the fiber surface treatment the fabrics may have excellent resistance to mildew, aging, and sun exposure. Fair durability to abrasion.

THERMAL STABILITY
Excellent thermal stability and will not burn, melt, soften or drip. Often used in molten metal exposures as the outer primary protection garment and as gloves, sleeves, and gauntlets for specific applications.

MOISTURE REGAIN/STATIC CONTROL
Depending on the blend, moisture regain and stiffness may be good. Very conductive. Without proper grounding these fabrics should not be used in critical static control applications. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Garments may be home laundered in warm or hot water and dried on a medium/permanent press setting. The fabric dries quickly so some adjustment in drying time may be required.

For best results, follow garment label laundry instructions.

CARBON/OXIDIZED PAN BLENDS

Polyacrylonitrile (PAN) is an oxidized, thermally stabilized black fiber that will not burn, melt, soften or drip. Because it has a high LOI (Limiting Oxygen Index) value, PAN is used for heat-resistant, thermal and acoustic insulation, and technical textiles. PAN is usually blended with at least one additional fiber such as para-aramid to provide increased tensile strength and abrasion resistance. Fabrics may be intimate or discrete blends containing modacrylic, FR rayon, nylon, or other fibers.

Companies including CarbonX (Chapman Innovations), Tecgen and Spentex (National Safety Apparel) offer fabric and/or garments in knit and woven constructions made from Carbon/Oxidized PAN blended fiber fabrics

APPLICATIONS
Used as fire blocking fabric for seating in aircraft, trains, cars or reinforcement for fire fighter turnout gear, race car drivers, molten metal, electric utility, and petrochemical.

NOT RECOMMENDED FOR
Do not use in critical static control applications.

FLAME RESISTANCE
Carbon/Oxidized PAN fiber fabrics are generally blends of inherently flame resistant fibers; this property cannot be degraded by wear or laundering.

COLORS
Limited colors due to the PAN fiber being black.

EFFECT OF ACIDS AND ALKALIS
Fairly inert except for weakness to highly concentrated acids and strong bases. The fabric does not provide chemical protection to the wearer. Where chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
Excellent resistance to organic solvents. Poor resistance to oxidizing agents and bleaches.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Depending on the fiber surface treatment the fabrics may have excellent resistance to mildew, aging, and sun exposure. Fair durability to abrasion.

THERMAL STABILITY
Excellent thermal stability and will not burn, melt, soften or drip. Often used in molten metal exposures as the outer primary protection garment and as gloves, sleeves, and gauntlets for specific applications.

MOISTURE REGAIN/STATIC CONTROL
Depending on the blend, moisture regain and stiffness may be good. Very conductive. Without proper grounding these fabrics should not be used in critical static control applications. **Do not don or remove these garments in a hazardous area.**

LAUNDERING
Do not use chlorine bleach. Do not use industrial laundry detergents or other chemicals containing hydrogen peroxide. Do not use starches, fabric softeners or other laundry additives. Detergents containing bleach alternatives (sodium perborate) are acceptable for home laundering.

Garments made from Carbon/Oxidized PAN fiber may be home laundered in warm or hot water and dried on a medium/permanent press setting. The fabric dries quickly so some adjustment in drying time may be required.

For best results, follow garment label laundry instructions.

DISPOSABLE NON-WOVENS WITH FR PROTECTION

These fabrics 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. This fabric will burn in the presence of an ignition source but will self-extinguish when the ignition source is removed. This fabric is primarily used for disposable coveralls and must be worn over suitable FR clothing meeting the needs identified by a hazard assessment.

The Bulwark® line of FR Disposables is made from Precision Fabrics Group limited use/disposable hydro entangled nonwoven fabrics.

Note: Non-FR disposable garments should never be worn over FR garments.

APPLICATIONS
This garment is highly breathable. It protects FR clothing from dirt and contaminants. It may extend the life of more expensive thermal protective garments. See applicable product literature for more information. Don the garment when needed.

NOT RECOMMENDED FOR
Do not use as a primary source of thermal protection and must be worn over suitable flame resistant apparel. Not for asbestos removal.

FLAME RESISTANCE
This fabric will burn in the presence of an ignition source but will self-extinguish when the ignition source is removed.

COLORS
This coverall is 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. Where full chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

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
Avoid exposure to sunlight and/or moist conditions to avoid mildew. No significant abrasion resistance as these disposable coveralls are for limited use.

THERMAL STABILITY
Will burn in the presence of an ignition source but will self-extinguish when the ignition source is removed. It is not designed for primary thermal protection and must be worn over suitable FR clothing.

LAUNDERING
This coverall is not washable.

Use as disposable supplemental protection from a specific hazard, or to prevent soiling of expensive reusable protective garments. Typically, a single use garment, but the number of wears will depend on the work activity. Always dispose of in a responsible manner when soiled.

DISPOSABLE LAMINATES WITH FR/CP PROTECTION

This fabric is 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. The base hydro entangled nonwoven fabric is then laminated to a clear PVC film with hot melt polyester making an impervious laminate with chemical-resistant properties. This fabric will burn in the presence of an ignition source but will self-extinguish when the ignition source is removed. This fabric is primarily used for disposable coveralls and must be worn over suitable FR clothing meeting the needs identified by a hazard assessment.

The Bulwark® line of FR Disposables is made from Precision Fabrics Group limited use/ disposable hydro entangled nonwoven fabrics.

Note: Non-FR disposable garments should never be worn over FR garments.

APPLICATIONS
This garment may extend the life of more expensive thermal protective garments. It has some liquid chemical splash-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. See applicable product literature for more information.

NOT RECOMMENDED FOR
Do not use as a primary source of thermal protection and must be worn over suitable flame resistant apparel. Not for asbestos removal. This coverall is not suitable for all liquid chemicals.

FLAME RESISTANCE
This fabric will burn in the presence of an ignition source but will self-extinguish when the ignition source is removed.

COLORS
This coverall is only available in Sky Blue.

EFFECT OF ACIDS AND ALKALIS
This Disposable Coverall has limited chemical resistance. Refer to applicable product literature for the performance characteristics. Where full chemical exposure is a hazard, specialized garments should be used based on a hazard assessment.

EFFECT OF BLEACHES AND SOLVENTS
The coverall has limited chemical resistance. Refer to applicable product literature for the performance characteristics.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION
Avoid exposure to sunlight and/or moist conditions to avoid mildew. No significant abrasion resistance as these disposable coveralls are for limited use.

THERMAL STABILITY
Will burn in the presence of an ignition source but will self-extinguish when the ignition source is removed. It is not designed for primary thermal protection and must be worn over suitable FR clothing.

LAUNDERING
This coverall is not washable.

RAINWEAR LAMINATES

Non-breathable fabrics are made by single or double coating an arc rated and/or flash fire rated, flame resistant fabric with polychloroprene, PVC, or other waterproof, nonbreathable substance.

Please note: some products labeled as “FR” use a nylon substrate. This material is inferior to coated Nomex® fabrics.

Breathable fabrics are made by laminating an arc rated and/or flash fire rated woven outer shell fabric to a waterproof, breathable, polyurethane or ePTFE membrane in a tri-laminate system.

APPLICATIONS

Used in

- electric utilities
- oil and gas operations
- work activities where a risk of thermal exposure
- exists in a wide range of climatic conditions

NOT RECOMMENDED FOR

Non-breathable rainwear with PVC waterproof coating should never be used for protection from a flash fire hazard. Always ensure your rainwear is labeled ASTM F2733 for protection against flash fire hazards. 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 nonbreathable rainwear is flame resistant.

COLORS

Arc-rated and/or flash fire-rated 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 107, Standard for High-Visibility Safety Apparel, the garment must also be labeled with a statement that the garment meets this standard.

EFFECTS OF ACIDS AND ALKALIS

Arc-rated and/or flash fire-rated 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. Do not use fabric softener.

EFFECT OF MILDEW, AGING, SUNLIGHT AND ABRASION

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

THERMAL STABILITY

Fabrics used in arc-rated and/or flash-fire rated rainwear do not melt. They have extreme thermal stability. Molten substance contact with flame resistant rainwear will cause burn through and pin-holing.

MOISTURE REGAIN/STATIC CONTROL

Not applicable.

LAUNDERING

Arc-rated and/or flash fire-rated rainwear should be wiped clean with a mild detergent and/or water solution and rinsed or machine washed, warm, using mild detergent.

Do not use solvents or abrasive cleaners.

Hang to dry.

Do not dry clean.

For best results, follow garment label laundry instructions.

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.

Bulwark®
PROTECTION

THE BEST FIBER OR FABRIC

There is no perfect flame resistant garment system meeting all needs. Each FR fiber or treated fabric has certain properties that may 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 performance requirements of a given application.

KEY POINTS TO CONSIDER WHEN CHOOSING FR GARMENTS

A review of fabrics should consider protection against thermal or chemical hazard, static resistance, comfort, durability and wear life, dimensional stability, and employee acceptance. An awareness of special circumstances, such as electric arc, molten substance, or chemical hazards, must be considered.

Flame resistant 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 and pilling (surface appearance change) or excessive shrinkage.

ON THE HORIZON

New fibers, fabrics, and innovative garment designs 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. These developments have led to demands for multi-purpose or "dual- hazard" PPE with an arc rating of at least 8 cal/cm^2 (CAT 2) and compliance to NFPA® 2112. An increasing number of applications for arc flash protection requires an even higher arc rating of at least 12 cal/cm^2 and many new developments have satisfied this need. In addition, the ability for garments to repel small amounts of certain hazardous liquid chemical splashes (acids, corrosives, polar organic solvents) has been identified as a common need in various industries requiring FR; therefore, new fabric technologies and garments using them continue to be developed.

In the electric arc flash protection market, NFPA® 70E PPE Category 2 (CAT 2), between 8.0 to 25 cal/cm^2, continues to be the most recognized requirement for industrial applications. OSHA inspection activities in workplace electrical safety continues to use NFPA® 70E as evidence of hazard recognition in evaluating General Duty Clause violations under the OSHA Act. The latest edition of NFPA® 70E no longer specifically requires garments to meet ASTM F1506 but lists it as the most recognized standard for arc flash protective clothing. In addition, the OSHA Final Rule for Electric Power Generation, Transmission, and Distribution Maintenance and Construction (29 CFR 1910.269) requires employers conduct an arc flash hazard analysis and provide appropriately arc rated FR protective garments for workers exposed to electric arcs and associated hazards.

High visibility FR garments are also in high demand for many industries and compliance with ANSI/ISEA 107 is the primary requirement. High visibility garments are now identified with both a Type and a Class and, if FR, they must meet one of six FR standards – ASTM F1506, ASTM F1891, ASTM F2302, ASTM F2733, NFPA® 1977, or NFPA® 2112.

Comfort is desired in all work clothing and the addition of stretch fibers and yarns into fabrics helps with bending and reaching work activities. Stretch fibers are being added to all fabric types from denim for jeans and twill for work pants to shirting fabrics without affecting the FR characteristics. The addition of fibers such as Spandex into knits will improve the fit of t-shirts, Henleys, and base layers.

Work clothing is moving toward having a "retail" appearance. Denim washes and distressing comparable to retail wear is finding its way into FR clothing lines. Retail inspiration can be seen in all product categories.

Nearly all FR garments are 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. Bulwark is on the forefront of FR fabric and garment development to provide the latest FR, chemical splash, and high visibility technologies available.

COMMON QUESTIONS ABOUT FR CLOTHING

WHAT IS THE LIFE OF AN FR GARMENT?

The life of an FR 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. Garments are removed from service for the same reasons as everyday clothing. The garment no longer fits comfortably. It is contaminated with a flammable substance that cannot be completely removed. There are stubborn, unsightly stains on the garment. It has become threadbare. Finally, if a garment has rips, tears, or holes which cannot be repaired, it must be removed from service.

Bulwark® guarantees the garments will retain the flame resistant properties for the life of the garment when recommended laundering guidelines are followed.

HOW DO FR FABRICS REACT TO IGNITION?

Flame resistant (FR) fabrics and garments are intended to resist ignition, to 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.

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.

HOW DO NON-FR FABRICS REACT TO IGNITION?

Non-FR 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. Non-FR fabrics will continue to burn until extinguished or until all flammable material is consumed.

WHAT TYPE OF UNDERGARMENTS SHOULD BE WORN?

National Fire Protection Association (NFPA) 70E, Standard for Electrical Safety in the Workplace, states non-melting, flammable fiber undergarments may be used in conjunction with FR garments; however, flame resistant t-shirts and base layer garments may provide additional wearer protection. Non-FR undergarments are acceptable only if they are made from non-melting fibers (cotton or other natural fiber).

MAY EMBLEMS AND EMBROIDERY BE ADDED TO FR GARMENTS?

NFPA® 2112 has a non-mandatory reference to size and total area of non-FR emblems. Both ASTM F1506 and NFPA® 2112 make recommendations for the area of non-FR emblem materials. If these items are not made from flame resistant materials and are attached to the outside of an FR garment, their overall area should individually occupy no more than 16 in^2 and, in total, occupy no more than 40 in^2.

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 perception is 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.

WHAT IS THE BEST WAY TO REPAIR FR GARMENTS?

Minor repairs not affecting 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 having 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 flame resistant garments is essential to remove potentially hazardous soils and to avoid a build-up of flammable materials that could mask performance of the garment.. Wash separately using soft water (<1.5 grains (25 ppm)). Hard water affects cleaning and contains mineral salts which may form insoluble deposits on the fabric negating the FR characteristics and may serve as fuel if exposed to an ignition source. To ensure continued flame resistant performance of the garment, it is necessary to follow the manufacturer's recommendations for laundering of each type of flame resistant garment. Whenever deviations from manufacturer's recommendations are necessitated by local conditions, testing must be conducted to ensure the protective properties are maintained through the expected service life of the garment.

ASTM has two standard guides providing good general references for care and cleaning of flame resistant and thermal protective clothing: ASTM F1449, Guide for Home Laundering, Care and Maintenance, of Flame, Thermal, and Arc-Resistant Clothing and ASTM F2757, Guide for Industrial Laundering of Flame, Thermal and Arc-Resistant Clothing.

Bulwark® provides care instructions on the garment label for all garments they manufacture as required by the Federal Trade Commission (FTC). Additional information is available in the Bulwark® Care and Cleaning Information Bulletins which provide laundry instructions for Bulwark's flame resistant protective apparel.

Bulwark Protection
Technical Services
545 Marriott Drive,
Nashville, TN 37214.

www.bulwark.com

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

Bulwark® garments are designed for continuous wear. They meet the flame resistance requirements specified in ASTM International Standard F 2302 for labeling protective clothing as heat and flame-resistant. They also meet the performance requirements of National Fire Protection Association (NFPA) Standard 70E, *Electrical Safety Requirements for Employee Workplaces*, 2012 Edition, ASTM Standard F1506, *Flame-Resistant Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards*. Because these fabrics are flame-resistant, they are acceptable under the Occupational Safety & Health Administration (OSHA) Final Rule 1910.269, *Final Rule on Electrical Protective Equipment*. For complete information on these products, as well as laundering instructions, please visit www.bulwark.com.

Bulwark®, a brand of Worwear Outfitters, LLC.

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