



T Y N D A L E

Technical Guide:

Flame Resistant Clothing for Electrical Hazards

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This document is a presentation of facts designed to help electrical safety professionals gain an integrated understanding of the protective characteristics of flame resistant clothing from electrical hazards.

Table of contents:

Occupational Safety and Health Administration	3
NFPA 70E	3
American Society for Testing and Materials	4-6
ASTM F1506	4
ASTM F1891	4
ASTM D6413	5
ASTM F1959	5
ASTM F1958	5
Definitions of ASTM Terms for FR Clothing	6
Compliance with OSHA Standards	7
Am I Required to Provide Laundry Services?	7
Protection from Electrical Hazards	8
Flame Resistant Fabric Information	9-10
Cool Touch	9
FireWear	9
Indura	9
Nomex IIIa	10
Indura Ultra Soft	10
Valzon	10
FR Wool	10
Protective Characteristics of Flame Resistant Fabrics	11



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Occupational Safety and Health Administration

OSHA 29 CFR 1910.269 (1) (6) (iii) states:

“The employer shall ensure that each employee who is exposed to the hazards of flames or electric arc does not wear clothing that, when exposed to flames or electric arcs, could increase the extent of the injury that would be sustained by the employee.”

From a practical standpoint, this means that if an employee’s clothing does not melt, ignite or continue to burn during or after an arc or flame exposure, the victim is in compliance. This is the only law relevant to flame resistant clothing for electrical applications.

The protective apparel portions of 1910.269 are currently under review by OSHA. OSHA intends to clarify the vague nature of the existing requirements by including the following items:

- Utilities must do hazard analysis to determine incident energy levels.
- Workers must wear sufficient clothing to reduce the incident energy level to 1.6 cal/cm², the point of 2nd degree burn onset.
- Flame Resistant Clothing will be required for certain tasks.
- 100% natural fiber garments will be allowed if there is a 95% confidence level that there is a 10% probability of ignition at a specific incident energy level.
- It is the utility’s responsibility to ensure workers are protected from 2nd degree burns resulting from electric arcs.
- ASTM Standards and Test Methods are referenced.

The changes are on the current agenda for approval in December of 2002, to be enforceable by 2004.

For a complete copy of the proposed draft, please contact Tyndale Company.

NFPA 70E

NFPA 70E is a voluntary standard for flame resistant clothing use for electrical hazards. NFPA 70E breaks all electrical procedures into five classes and assigns minimum flame resistant clothing layers and performance characteristics for each class. NFPA 70E specifies a minimum ATPV of 5.0 cal/cm² for shirt fabrics. Please see page 10 for fabrics that are acceptable under NFPA 70E.

NFPA 70E is the most comprehensive guide for flame resistant clothing use in the industry and will have a significant influence on OSHA 1910.269.



American Society for Testing and Materials

During the time when the OSHA issued 1910.269, the ASTM F-18.65 Sub-Committee on Wearing Apparel was attempting to determine, through scientific means, the thermal hazards that affect utility workers. Through years of research, the Sub-Committee has released several standards and test methods that quantify the hazards, define protection and further quantify the industry as a whole.

ASTM Standards for Flame Resistant Wearing Apparel:

ASTM F1506

Standard Performance Specification for Textile Material for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards

This is the governing ASTM Standard for Flame Resistant Clothing. The standard has two basic requirements: (1) A sample of fabric must self extinguish with <2 second afterflame and <6" char length according to ASTM Test Method D6413. This flammability test applies to an initial sample and after 25 washes / dry cleanings. (2) The fabric must be tested for Arc Thermal Performance according to ASTM Test Method F1959. The results of the Arc Thermal Performance testing must be reported to the end user as an Arc Rating on a garment label. **A garment that meets ASTM F1506 complies with OSHA 1910.269.**

ASTM F1506 is a pass/fail standard with requirements for reporting information not considered for the pass/fail criteria. All garments that meet the requirements of ASTM F1506 must state so on a garment label.

ASTM F1891

Standard Specification for Arc and Flame Resistant Rainwear

This is the governing ASTM Standard for Flame Resistant Rainwear. It is similar to F1506 in that the standard has two basic requirements: (1) A sample of fabric must self extinguish with <2 second afterflame and <6" char length according to ASTM Test Method D6413 and (2) The fabric must be tested for Arc Thermal Performance according to ASTM Test Method F1959. The results of the Arc Thermal Performance testing must be reported to the end user as an Arc Rating on a garment label. **Rainwear that meets ASTM F1891 complies with OSHA 1910.269.**

ASTM F1891 is a pass/fail standard with requirements for reporting information not considered for the pass/fail criteria. All garments that meet the requirements of ASTM F1891 must state so on a garment label.



ASTM Test Methods for Flame Resistant Wearing Apparel:

ASTM D6413

Standard Test Method Flame Resistance of Textiles (Vertical Test)

This is the defining Test Method for compliance with OSHA 1910.269. Formerly FTMS 191A or FTM 5903.1, ASTM recently adopted this Test Method. The purpose of this test is to determine whether a fabric will continue to burn after the source of ignition is removed. Using a 12 second Methane flame and a special testing apparatus, afterflame, afterglow and char length are measured. **If a fabric exhibits less than 2 second afterflame and 6" char length according to ASTM D6413, it is "Flame Resistant".**

ASTM D6413 is used to determine a pass/fail criteria for ASTM F1506 and ASTM F1891.

ASTM F1959

Standard Test Method for Determining Arc Thermal Performance (Value) of Textile Materials for Clothing by Electric Arc and Related Thermal Hazards (Formerly Provisional Standard-58)

This is the Test Method used to calculate quantitative results for fabrics relating to how they perform in an Electric Arc environment. The purpose of this test method is to determine how much heat a certain fabric (or system of fabrics) will block from an electric arc before the onset of second degree burns for the wearer. The amount of energy blocked by the fabric is reported as Arc Thermal Performance Value (or Breakopen Energy Threshold if the fabric breaks open before the onset of second degree burns is reached). Also determined is Heat Attenuation Factor (the percentage of total heat blocked by the fabric from reaching the sensor).

Test results from ASTM F1959 must be reported for all garments that meet ASTM F1506 or ASTM F1891. Additionally, ASTM F1959 is used to determine a pass/fail criteria for ASTM F1891.

ASTM F1958

Standard Test Method for Determining Ignitability for Clothing by Electric Arc Exposure Using a Mannequin (Formerly Provisional Standard-57)

This Test Method provides a secondary method of compliance with OSHA 1910.269. ASTM F1958 is used to determine whether a specific non-flame resistant fabric will ignite and continue to burn during an arc. At low incident energy levels, ASTM F1958 demonstrates that some 100% natural fibers self-extinguish and will not contribute to the severity of burns incurred from an electric arc (resulting in compliance with OSHA



1910.269). Many industry leaders feel this is a risky approach to compliance because actual incident energy levels vary greatly due to numerous factors and are difficult to calculate due to a dynamic work environment.



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Definitions of ASTM Terms for FR Clothing

The following terms are the key performance characteristics of flame resistant fabrics in an arc environment. When comparing the performance of specific flame resistant fabrics and weights, these values should be given careful consideration.

Arc Thermal Performance Value (ATPV)

“*n* – in arc testing, the incident energy on a fabric or material that results in sufficient heat transfer through the fabric or material to cause the onset of a second degree burn based on the Stoll curve.”

Note: ATPV is measured in cal/cm².

Breakopen Threshold Energy (E_{BT})

“*n* – the average of the five highest incident energy exposure values below the Stoll curve where specimens do not exhibit breakopen.”

Note: Breakopen Threshold Energy is similar to ATPV, except it is determined when breakopen occurs before the onset of a second degree burn according to the Stoll curve. E_{BT} is measured in cal/cm².

Heat Attenuation Factor (HAF)

“*n* – in electric arc testing, the percent of the incident energy which is blocked by a material at an incident energy level equal to ATPV.”



Compliance with OSHA Standards

Compliance with OSHA is guaranteed by wearing flame resistant clothing (i.e. fabrics that pass ASTM D6413 vertical flame test).

Additionally, compliance with OSHA is possible through comprehensive hazard analysis and extensive testing with ASTM's Standard Test Method for Determining Ignitability for Clothing by Electric Arc Exposure Using a Mannequin. Essentially, this method of compliance required a utility to calculate the maximum possible incident energy level for each task using computer software. Second, the utility must demonstrate that it requires specific types of non-flame resistant clothing that will not ignite at the maximum incident energy levels present. Most industry experts believe that this method of compliance is disproportionately risky because of the high degree of variability in work and clothing conditions. If this method of compliance is used, and non-flame resistant clothing is worn in hazardous environments, it is distinctly possible that conditions surrounding an electric arc will result in clothing ignition – and OSHA compliance failure.

Am I Required to Provide Laundry Services for FR Clothing?

According to OSHA, “NO”.

In a document issued by Federal OSHA from Jim Stanley, Deputy Assistant Secretary for OSHA, to Edison Electric Institute on February 6, 1995:

“The employer is responsible to ensure the clothing retains its flame retardant properties through conditions of use and laundering... An employer can fulfill this obligation by establishing, and having employees follow, work practices on the proper care and laundering of garments....”

“Lint Contamination” is not a Factor.

Laundries allege that by washing FR and Non-FR garments together, non-FR lint can shield FR characteristics. Tyndale has done extensive vertical flame testing and performed arc testing at Kinectrics High Current Lab in Ontario, Canada to study this claim. The results of our testing show that non-FR lint is not a factor in flammability or protection from an electric arc.



Protection from Electrical Hazards

Protection from electric hazards starts with flame resistant clothing. Flame resistant clothing guarantees that once the arc is over that the victim will receive no further injuries. However, to achieve true protection, the worker must be protected from the arc blast, itself.

In essence, protection is achieved when the ATPV of a material or system of materials is greater than the energy created by the arc. If this is the case, a worker's clothing will protect him from a second degree burn.

Protection is achieved through two steps:

- Determine the incident energy level of the potential exposure.
- Select fabrics with ATPV or E_{BT} sufficient to reduce the incident energy level to less than zero. In cases where exposure is greater than 7 or 8 cal/cm², layering will be required.

Note: A layer of air between layers of flame resistant fabrics adds approximately 7 cal/cm² of protection to the clothing system.

An electrical worker who has potential for exposure to an electric arc should dress as follows:

- All garments, except underwear, should be flame resistant and constructed exclusively of flame resistant components.
- Underwear should be 100% cotton, wool or silk.
- A minimum of two flame resistant layers should be worn on the upper body.



Flame Resistant Fabric Information

In today's Flame Resistant Clothing marketplace, there are numerous fabrics that provide varying amounts of protection and comfort. All of the fabrics listed below are common in the FR marketplace and meet ASTM F1506.

In addition to the required compliance with OSHA 1910.269, protection has become an increasingly important topic. Each of these fabrics has been tested against ASTM F1959 for arc performance. **A close review of the arc test results reveals a similarity of protective characteristics among the different FR fabrics.** Because of this, traditional methods of evaluating fabrics (comfort, durability, weight, color fastness, resistance to wrinkling, etc.) should be used when choosing an FR fabric to wear.

Cool Touch

Cool Touch is a Southern Mills trademark for a 65% Nomex, 35% FR viscose Rayon blend. Cool Touch was developed as an effort to address the "too hot" and "not comfortable" aspects of Nomex IIIa. Cool Touch blends are available in 4.5 oz. wovens only. Although official wear tests are unavailable, fabric experts expect Cool Touch fabrics to exhibit slightly shorter wear life than Nomex IIIa.

FR Modacrylic Cotton (FRMC)

FR Modacrylic Cotton is a generic term that refers to flame resistant fabrics manufactured from a blend of FR Modacrylic and Cotton. FRMC is an inherently flame resistant fabric, a characteristic that cannot be degraded through laundering. **It is normally perceived as the softest, most comfortable and most breathable FR fabrics.** FRMC is available in knit and woven fabrics in a variety of colors and weights. It has an expected wearlife of 18 to 30 months when worn and home laundered once per week. FRMC fabrics include EMC by Johnston Industries, FireWear by Springfield LLC and Valzon by Westex Inc.

Indura

Indura is a Westex, Inc. trademark for FR 100% cotton fabrics made flame resistant through an ammonia cure process. The process has only a minor affect on the positive characteristics of cotton (soft hand, wear, breathability and shrinkage). **The ammonia cure process is guaranteed by Westex to ensure compliance with ASTM F1506 for the life of the garment.** Indura is available in woven fabrics in a variety of colors. You should expect an Indura garment to last 12 to 18 months when worn and home laundered once per week



Nomex IIIa

Nomex IIIa is a DuPont trademark for 93% Nomex (an aramid fiber), 5% Kevlar and 2% static dissipative fiber fabric. It is inherently flame resistant, a characteristic that cannot be degraded by laundering. Nomex IIIa was the FR Industry Standard, but is being replaced by fabrics and blends that offer similar protection and superior comfort characteristics. Nomex has an expected wear life of 36-60 months.

Indura Ultra Soft

Ultra Soft is a Westex, Inc. trademark for an 88% Cotton/12% High Tenacity Nylon blend made flame resistant through an ammonia cure process. Additionally, the UltraSoft finish gives the fabric a soft hand for comfort. Similar to Indura in most aspects, Ultra Soft wears approximately 50% longer and costs only marginally more. **The ammonia cure process is guaranteed by Westex to ensure compliance with ASTM F1506 for the life of the garment.** UltraSoft is available in woven fabrics in a variety of colors. You should expect an UltraSoft garment to last 24 to 42 months when worn and home laundered once per week.

FR Wool

FR Wool is 100% new wool treated to make it flame resistant. FR Wool maintains the positive qualities of regular wool in that it provides substantial warmth with little bulk. Wool maintains warmth when wet. FR wool is often "Dry Clean Only". It is available in knit and woven fabrics in a variety of colors.

Note: Industrial laundering will create more wear on a garment than home laundering. Also, Tyndale found that heavy facial growth will have a negative effect on wear life of a collared shirt. Additionally, repeated abrasion of any type will shorten wear life in the area on the garment where the abrasion occurs.



Protective Characteristics of Flame Resistant Fabrics

The following Arc Test Results were reported to Tyndale Company by the respective fabric manufacturers. All tests were conducted to the specification of ASTM F1959 using a 12" distance from the arc and 12" arc gap. All fabrics are flame resistant according to the vertical flame test, ASTM D6413.

Fabric	Weave/Knit	Spec. Weight	Arc Rating (cal/cm ²)	HAF %
Common Shirt Fabrics				
Nomex/Rayon	Twill	4.5 oz	4.2	N/A
FireWear	Double French Terry	9.5 oz	8.8	77.7
FireWear	Jersey	6 oz	5.1	61.4
FireWear	Lacoste	6.2 oz	5.5	62.4
FireWear	Poplin or Chambray	5.5 oz	5.1	60.1
Indura	Twill	7 oz	6.0	68
Nomex IIIa	Twill	4.5 oz	4.8	N/A
Nomex IIIa	Twill	6 oz	5.7	N/A
PBI	Twill	4.5 oz	6.5	70
Ultra Soft	Twill	7 oz	8.2	71
Valzon	Jersey	6 oz	5.8	68
Common Pant / Outerwear Fabrics				
FireWear	Denim	14 oz	15.0	85.3
FireWear	Twill	9.5 oz	11.2	79.6
Indura	Denim	11.5 oz	13.8	80
Indura	Twill	9 oz	7.9	75
Nomex IIIa	Twill	6 oz	5.7	N/A
PBI	Twill	6 oz	7.8	77
Ultra Soft	Duck	12 oz	12.7	80
Ultra Soft	Sateen	9 oz	13.2	82

Some multi-layer testing has been done by various fabric manufacturers and ASTM Task Groups. Currently, the ASTM Task Groups F-18.65.01 is investigating the effect of layering and color on arc test results. Tyndale Company has the most up to date information available anywhere regarding these investigations. If you have questions regarding the information presented here, or require further information, please contact Robert Whittenberger at (800) 356-3433 x112 or at rwhittenberger@tyndaleusa.com.

