

TECHNICAL BRIEF

INDURA®

Ultra Soft

QUALITY FLAME RESISTANT
PROTECTIVE CLOTHING FABRICS

*Fabric for Industry
Comfort for People*

Garments Manufactured by

AGO
INDUSTRIES INC.

London, Ontario CANADA
Phone (519) 452-3780 Fax (519) 452-3053



WESTEX INC.

2845 West 48th Place, Chicago IL 60632 □ (312) 523-7000 □ FAX (312) 523-0965
Specialty and Flame Resistant By Western Piece Dyers and Finishers



TECHNICAL BRIEF

Flame Resistance Defined

Flame resistance is the characteristic of a fabric that causes it not to burn in air. Flame resistance is often confused with flame retardant which is a term used to describe a chemical substance that imparts flame resistance on fabric.

The most commonly used test method for measuring flame resistant (FR) fabrics is ASTM D6413* Standard Test Method for Flame Resistance of Textiles (Vertical Test) (formerly; Method 5903.1 of Federal Test Method Standard 191A).

The test uses an enclosed cabinet in which 12-inch long specimens are suspended vertically over a controlled flame which is impinged on the bottom edge of the fabric for 12 seconds. From this exposure three sets of data are analyzed:

- Char Length: The length of fabric destroyed by the flame so that it will readily tear by application of a standard weight. (Average of 5 specimens each; Warp and Fill)
- Afterflame: The number of seconds during which there is a visible flame remaining on the fabric after the ignition source has been removed.
- Afterglow: The number of seconds during which there is a visible glow remaining on the fabric after all flaming has ceased. (Not typically a requirement of most standards)

The vertical flame test ASTM D6413* is a test method with no pass/fail requirements. Westex has established standards for flame resistance of a maximum of 5.0 inches (125mm) char length and 2.0 seconds afterflame. For the purpose of this document, we will consider "passing" the vertical flame test as meeting this criteria.

Although passing the vertical flammability requirements is an essential criterion for protective clothing fabrics, it is only one of a battery of tests that fully describes the protective characteristics. After a material has demonstrated that it has a self-extinguishing characteristics both initially and throughout the garment service life, additional specific tests can be employed to determine the protective capabilities to exposures such as electric arc, flash fire and molten metal splash. The performance of INDURA® and INDURA Ultra Soft® to these exposures is highlighted later in this document.



TECHNICAL BRIEF

State-of-the-Art Finishing Technology

Westex guarantees the flame resistance of INDURA[®] Ultra Soft[®] and INDURA[®] fabrics for the life of the garment. We achieve this durability through proprietary processing controls. This guarantee has been proven repeatedly in lab testing and through the auditing samples from the millions of garments in the protective clothing marketplace for over a decade. Some of these garments are worn well beyond typical expected life cycles. There has never been an instance of failure to meet original FR requirements. This high level of performance is achieved by Westex's proprietary treatment process, which forms a long chain flame retardant polymer impregnated into the core of each cotton fiber. Westex utilizes the complex and demanding "ammonia cure" process in which phosphonium salt precondensate flame retardant chemicals are applied and then polymerized with gaseous ammonia.

How Does INDURA[®] Compare to Inherently FR fabrics?

Flame resistance in fabrics can be achieved either through the application of an FR chemical to a fabric as with INDURA[®] engineered cotton and cotton-rich fabrics or as an inherent property of the fiber, such as Nomex[®] IIIA synthetic fiber-fabric. Since passing the vertical flammability requirements is an essential criterion for protective clothing fabrics, viable flame resistant fabrics should remain flame resistant throughout their useful service life.

Both INDURA[®] and Nomex[®] fabrics are acceptable for protective clothing because they each self extinguish and pass the vertical flame test throughout their service life; therefore, additional more specific tests should be employed to assist in comparing the protective characteristics of each fabric.

The performance of INDURA Ultra Soft[®] and INDURA[®] to electric arc and flash fire exposures will be compared to Nomex later in this brochure.

How Does INDURA[®] Self Extinguish?

In INDURA[®] engineered fabrics, the flame retardant chemical impregnated in the core of the cotton fiber acts as a catalyst promoting the charring of the fabric. This accelerated charring prohibits the support of combustion by reducing the fuel source. The flame retardant chemical acts in the solid phase to produce this char. The mechanism of action is **not** based on a gaseous process of extinguishing or "snuffing out" the flame.

It is very important that flame resistant fabrics be maintained in a clean condition to realize the full benefit of the protective characteristics. Please contact a Westex representative for industrial and home laundering procedures to properly clean INDURA[®] fabrics.

INDURA[®] should not be laundered with hypochlorite (chlorine) bleach because repeated exposures will break down the finish and are destructive to the fabric and the color. Most flame resistant fabrics, including Nomex[®], bear instructions prohibiting the use of chlorine bleach because it is destructive to the fabric strength and color even if the flame resistance is not affected.

A NOTE REGARDING "OFFGASSING": Gaseous decomposition of products form when any flame resistant fabrics decompose (including synthetic fabrics such as Nomex[®] or engineered fabrics such as INDURA[®]), however, the exposure level from decomposition products is below any hazard to the individual.



TECHNICAL BRIEF

THE PRODUCT

Indura Ultra Soft® 88% Cotton 12% High Tenacity Nylon

Westex's INDURA Ultra Soft® flame resistant fabrics are a blend of 88% cotton and 12% high tenacity nylon. The nylon fibers are intimately blended with cotton fibers in the warp yarns. These fibers are spun using ring-spinning technology to produce the highest strength fabric possible. By blending the high tenacity nylon in the warp yarns, the superior abrasion resistant performance of the nylon is focused predominantly on the face of the fabric, which leads to an extended garment wear life. The fill yarns, which are all cotton, are focused towards the skin of the wearer to optimize the comfort characteristics of cotton.

These fabrics were originally introduced as INDURA Tuf Stuf® in 1996 but through the application of proprietary finishing technology, Westex further enhanced the comfort level by providing an extremely soft and supple feel. The name was changed to INDURA Ultra Soft® in 1999 to identify this new product.

The fabrics are fully flame resistant and the addition of 12% Nylon in no way represents a hazard to the wearer. In the event of an exposure to flame or other thermal source, the nylon fibers are fully absorbed into the cotton fibers. In fact, as we will highlight later in this brochure the 12% nylon actually enhances the protective performance in some cases, such as electric arc exposure.

The significant increase in the abrasion resistance of INDURA Ultra Soft® has been demonstrated to increase the garment life expectancy conservatively by 50% over 100% cotton fabrics. Therefore, **assuming garments of INDURA Ultra Soft® are industrially laundered every other week, the following expected garment wear life can be followed.**

Industrial Launderings*	Service Life
54-75	27-37 months

Advanced INDURA Ultra Soft® flame resistant fabrics offer:

- **Guaranteed flame resistance** for the life of the garment
- **New softer feel** for enhanced cotton comfort
- **Extended garment wear life** due to increased abrasion resistance.
- **Better value equation**
- **Enhanced Protection from Electric Arc Exposure**

**The number of launderings cited above are based on market experience for these types of fabrics and relate to average expected wear life. These estimates do not take into account work activities leading to extreme wear and exposure to thermal sources of high heat and long duration.*

It is important to recognize that the flame resistance of INDURA Ultra Soft® is guaranteed for the life of the garment regardless of the number of servicings in either home or industrial laundering.



TECHNICAL BRIEF

The Need

Everyday, workers in the utilities, oil, gas, petrochemical and steel industries work in environments that may expose them to hazards that could cause severe or fatal burn injuries. In the event of a momentary electric arc, flash fire or molten metal splash exposure, everyday non-flame resistant work clothes can ignite and will continue to burn even after the source of the ignition has been removed. Untreated natural fibers will continue to burn until the fabric is totally consumed and non-flame resistant synthetic fabrics will burn with melting and dripping causing severe contact burns to the skin.

Government reports note that the majority of severe and fatal burn injuries are due to the individuals clothing igniting and continuing to burn, *not* by the exposure itself.

The use of flame resistant clothing will provide thermal protection at the exposure area. The level of protection typically rests in the fabric weight and composition. When the source of the ignition is removed, flame resistant garments will self extinguish, limiting the body burn percentage.

Secondary Vs. Primary

Protective clothing that is designed for continuous wear in designated locations *where intermittent exposure* to molten substance splash, radiant heat, and flame *is possible*, is defined in the ASTM standard F1002 as **Secondary Protective Clothing**. INDURA® and INDURA Ultra Soft® flame resistant fabrics are designed for use as secondary protective clothing.

Primary protective Clothing is defined as clothing that is designed to be worn for work activities where *significant exposure* to molten substance splash, radiant heat, and flame *is likely to occur*. An example of primary protective clothing is firefighter turnout gear. **INDURA® and INDURA Ultra Soft® is clothing for every-day wear and is not designed for use as primary protective clothing.**

PROTECTIVE COMPARISON

What weights of INDURA® Compare with Nomex?

The weight of any natural fiber fabric when compared to synthetic counterparts is generally heavier for a variety of reasons. The cotton comfort factor allows for the additional weight, which is necessary to increase to the physical characteristics for wearability purposes. This scenario holds true in the case of INDURA® and INDURA Ultra Soft® in comparison to Nomex®. The following chart illustrates the comparative weights of garments typically offered in the marketplace.

The higher comparative weights of natural cotton-rich fabrics such as 7 oz/yd² (237 g/m²) INDURA Ultra Soft® (as compared to synthetic-fiber fabrics such as 4 ½ oz/yd² (152 g/m²) Nomex®), provides increased thermal insulating properties leading to enhanced protection-**while remaining cooler and more comfortable to the wearer.**

COMPARATIVE WEIGHTS OF GARMENTS TYPICALLY OFFERED IN THE MARKETPLACE

	INDURA Ultra Soft® & INDURA®	Nomex®
Shirts *	7 oz/yd ² (237 g/m ²)	4 1/2 oz/yd ² (152 g/m ²)
Pants/Jackets/Coveralls	9 oz/yd ² (305 g/m ²)	6 oz/yd ² (203 g/m ²)

* Please note, 7 oz/yd² (237 g/m²) INDURA Ultra Soft® and 4 ½ oz/yd² (152 g/m²) Nomex® shirting fabrics are also commonly utilized in constructing light-weight coveralls for hot/humid climates.



TECHNICAL BRIEF

PROTECTION FROM ELECTRICAL ARC EXPOSURE

The intense energy and very short exposure time of an electric arc flash represents a very unique exposure. **Everyday work clothes made from regular cotton or poly/cotton garments can be readily ignited at some exposure level and will continue to burn adding to the extent of injury sustained from the arc alone.** The need to protect against arc exposures has necessitated the development of new test procedures. ASTM F1506 (Standard Performance Specification for Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Arc and Related Thermal Hazards) was developed to give minimum performance specifications for protective clothing. The major requirement of this specification was that the fabric is flame resistant, determined by using the standard vertical flame test. The method is currently under revision to include arc thermal performance ratings.

OSHA (Occupational Safety & Health Administration) in the United States has confirmed that **garments which meet the requirements of ASTM F1506 are in compliance with OSHA 29 CFR 1910.269 Electrical Power Generation, Transmission and Distribution**, with regard to garments not contributing to burn severity.

To address the industry's request to utilize non-flame resistant clothing based on an analysis of their exposure level, ASTM developed F1958, whereby non-flame resistant garments, which do not meet the requirements of ASTM F1506, are tested on a mannequin to determine the probability of ignition. The employer would be required to supply a set of prescribed criteria detailing the potential exposure of each employee. To reliably determine ignition probability, numerous series of arc exposures must be run. The *major problem* associated with applying this test protocol is that *accidents typically do not follow a prescribed set of rules* and a burn injury enhanced by clothing ignition could be the result of deviations from unanticipated conditions. **By utilizing flame resistant garments this uncertainty can be averted, compliance to OSHA requirements can be assured and potentially more serious burn injuries from garment ignition may be avoided.**

ASTM has developed an additional test method to assist in determining and comparing the protective capacity of various flame resistant fabrics — (ASTM F1959; *Standard Test Method for determining the Arc Thermal performance Value of Materials for Clothing*). When this test method is run, the arc discharge causes a dramatic temperature rise in the receiving monitor sensors (to almost 158° F, 70° C) in a short period of time (less than 1 second).

When a flame resistant fabric is placed on the panel, the energy seen by the sensor is blocked by a significant degree (total temperature rise <36°F, 20°C, over 10 second period). The percentage of blocking is called the Heat Attenuation Factor (HAF). When the fabric blocks the temperature rise to a level below the Stoll second degree prediction, no second degree burn results.

Several factors impact significantly on the test results generated this way, including:

1. The energy of the arc
2. The distance from the arc
3. The composition and weight of fabric employed

Using this method, the data for ATPV (Arc Thermal Performance Value) is obtained. The En value for each fabric is the average energy of arc exposure below which a second degree burn is not predicted to occur within the statistical constraints of the method.

Generally speaking, **the heavier the fabric, the greater protection level.**



TECHNICAL BRIEF

PROTECTION FROM FLASH FIRE EXPOSURES

In the oil, gas, chemical and petrochemical industries the threat of flash fire exposures has necessitated the use of flame resistant clothing. Flame resistant clothing will minimize burn injury and provide the worker a few seconds escape time. Again, non-flame resistant clothing can ignite in a flash fire exposure providing an additional fuel source dramatically increasing the burn injury percentage and severity well beyond that of the initial exposure.

To compare the protective capabilities of INDURA[®] and INDURA Ultra Soft[®] in relation to Nomex IIIA[®], thermal instrumented mannequin tests were conducted at the independent labs of Textile Analysis Service at The University of Alberta.

To measure the rate of heat transfer to the mannequin surface, 110 skin simulant sensors were used. The flash fires were produced with propane delivery burners. The selected flux level was set by gas flow and the exposure was carried out for a selected period of time. Temperature rise data from each of the sensors was collected and processed by a sophisticated computer program designed to provide a degree and extent of injury to the total body area as a function of the exposure condition.

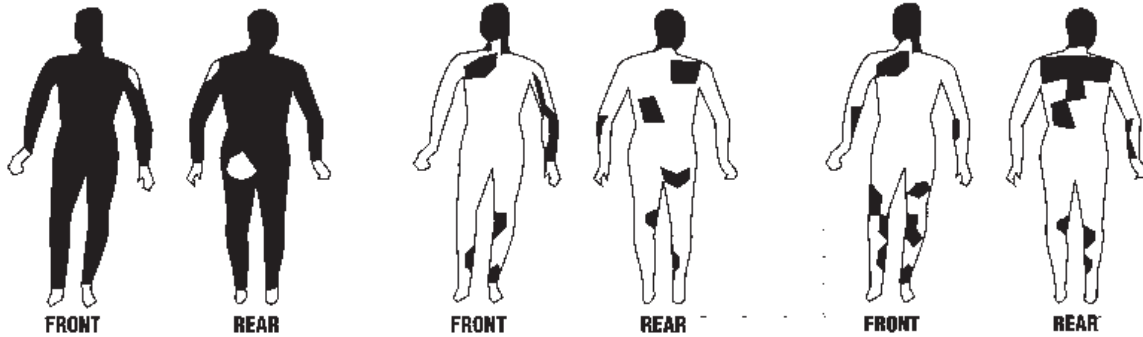
Data was collected from the "nude" mannequin to calibrate the exposure and from the "clothed" mannequin to measure protection potential for a garment. Examination of this data provides additional insight into the nature of burn injury and the capacity of a garment to offer protection from flash fire exposures.

Standard commercial coveralls were manufactured at a single location. These coveralls were identical in all manufacturing respects to those commonly sold. It should be recognized that multiple layers of fabric exist in pocket locations and at the front closures. All of the garments were laundered once in a single load commercial laundry process. Wash temperature was 140° F (60° C) and the garments were tumble dried also at 140° F (60° C). The garments were conditioned prior to testing for several days at 72° F (22° C) 65% relative humidity, and were then transported to the test facility. Temperature and relative humidity at the time of the testing were recorded.

As indicated earlier in this brochure, the comparative weights offered in the marketplace for shirts and pants constructed with INDURA[®] and INDURA Ultra Soft[®] are 7 oz/yd² (237 g/m²) and 9 oz/yd² (305 g/m²) compared to 4 ½ oz/yd² (150 g/m²) and 6 oz/yd² (200 g/m²) Nomex IIIA[®] fabric respectively. Therefore, the mannequin tests were conducted segregating categories of "Shirting" and "Pant/Coverall" weights to accurately represent the garments that are commercially available.

Westex has identified a 50% maximum total body burn as a criterion for selecting exposure times to develop useful comparative information between competitive fabrics. Selecting exposure times for secondary protective clothing that produce body burns in excess of 50% brings additional variables into the equation. In those instances when body burn exceeds the 50% level, Westex highly recommends the use of protective clothing systems that offer additional protection. These systems could include multiple fabric layers and other means appropriate to the level of exposure. For this reason, if a test exposure produces body burns in excess of 50%, Westex has elected not to utilize the results for comparative purposes.

Shirting weight fabrics were tested at 2.5 seconds and pant weight fabrics were tested at 3.5 seconds. The results are listed on the next page.



THE UNIVERSITY OF ALBERTA DEPARTMENT OF HUMAN ECOLOGY	
Fire Protective Clothing Evaluation System 10-05-1999 Muds Test g/sq. in.	
Exposure.....	80.0 kW/m2
Exposure Time.....	2.5 sec.
Time of Plot.....	60.0 sec.
◆ 2nd Degree Burn	43.95%
◆ 3rd Degree Burn	42.45%
TOTAL BURN	86.40%
BURN NUMBER	1637

THE UNIVERSITY OF ALBERTA DEPARTMENT OF HUMAN ECOLOGY	
Fire Protective Clothing Evaluation System 10-05-1999 S/301 INDURA Ultra Soft Coverall 244 g/sq. m	
Exposure.....	80.0 kW/m2
Exposure Time.....	2.5 sec.
Time of Plot.....	60.0 sec.
◆ 2nd Degree Burn	12.25%
◆ 3rd Degree Burn	4.00%
TOTAL BURN	16.25%
BURN NUMBER	1638

THE UNIVERSITY OF ALBERTA DEPARTMENT OF HUMAN ECOLOGY	
Fire Protective Clothing Evaluation System 10-05-1999 S/451 INDURA Ultra Soft Coverall 322 g/sq. m	
Exposure.....	80.0 kW/m2
Exposure Time.....	3.5 sec.
Time of Plot.....	60.0 sec.
◆ 2nd Degree Burn	15.20%
◆ 3rd Degree Burn	4.50%
TOTAL BURN	19.70%
BURN NUMBER	1641

SUMMARY OF MANNEQUIN TEST RESULTS		
Fabric	Weight	% Total Mannequin Surface Reaching Burn Criteria for 2nd & 3rd Degree Burn*
SHIRTING FABRICS		
	oz/yd ² (g/m ²)	1.9 cal/cm ² sec 2.5 seconds
◆ INDURA Ultra Soft Style 301	7.2 (241)	16.9
◆ Nomex IIIA	4.8 (162)	31.1
PANT/COVERALL FABRICS		
	oz/yd ² (g/m ²)	1.9 cal/cm ² sec 3.5 seconds
◆ INDURA Style 45	9.7 (329)	21.6
◆ INDURA Ultra Soft Style 451	9.9 (336)	20.9
◆ Nomex IIIA	5.9 (200)	48.5

*Note: 87% is the maximum possible since the hands and feet are excluded. All figures include 7% for the head.
 **Note: Fabric weights reported here represent the weight of a sample removed from the garment after washing.

PROTECTION FROM FERROUS METAL EXPOSURE

For nearly 40 years, heavyweight flame resistant cotton fabrics have been utilized by the steel industry for secondary protective clothing for workers doing routine tasks in steel processing. Secondary protective clothing is defined as “protective clothing for continuous wear during work activities in designated locations in which intermittent exposure to molten substance splash, radiant heat and flame sources is possible”.

The essence of protection in this category rests in two critical factors:

1. The fabric must be flame resistant so that it will not ignite and continue to burn when the heat source is removed.
2. In the specific instance of exposure to molten ferrous metal, the fabric must demonstrate the ability to shed molten metal from its surface without sticking or forming a hole.

Because temperatures in excess of 2000° F (1090° C) may be encountered, only the heavier weight range of fabrics (10 oz/yd², 339 g/m²) or greater have found general acceptance for this function. INDURA® and INDURA Ultra Soft® fabrics that meet this weight requirement

have been tested for exposure to 2.2 lbs (1 kg) of steel splash and meet the two criteria established for performance. ASTM F955 covers the standard test method to evaluate fabric performance using the apparatus illustrated on page 17.

It should be recognized that worker protection from second degree burn in ferrous metal processing is highly dependent on the quantity of metal exposed to and the number of layers and weight of fabric worn. INDURA® and INDURA Ultra Soft® fabrics, weighing as little as 9.0 oz/yd² (305 g/m²), have found use in smaller scale foundry operations and for workers performing welding/cutting operations involving ferrous metals. While in all instances, some damage in the form of charring of the fabric may occur from metal exposure, ignition of the fabric is precluded by the flame retardant treatment and the wearer is protected from the thermal levels of the exposure.

Nomex fabrics are inappropriate for such exposures since ferrous metals adhere to aramid fabrics.

*Please note that INDURA® and INDURA Ultra Soft® are **not** intended for use near molten aluminum and/or cryolite bath.*

Please contact Westex for information about Vinex flame and aluminum splash resistant fabrics and our new ALUGUARD® flame resistant, aluminum and cryolite splash resistant fabrics for use in the aluminum industry.

