

TECHNICAL BULLETIN



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FLAME RESISTANT COTTON FABRICS

ANSWERS TO MOST FREQUENTLY ASKED USER QUESTIONS

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INTRODUCTION

Durable flame resistant (FR) cotton fabrics treated using the "Precondensate"/NH₃ Process, offer a most favorable balance of properties for people who work in fire risk situations. Today's FR cotton fabrics are the result of more than a decade of cooperative effort between the producing mills and Cotton Incorporated, the Fiber Company of American Cotton Producers. The most modern chemical and finishing technology has been employed to engineer safety apparel fabrics of cotton, one of the earliest fibers known to man. The product is the result of dedicated scientific investigations, cooperation between producers and users, and millions of dollars in research and development investment.

Durable flame resistant cotton fabrics are high technology, engineered products that match the performance characteristics in personal protection of competitive products at a fraction of the cost. The apparel characteristics -- comfort, capacity of modification, styling and versatility -- that make cotton a preferred fiber are not compromised.

The following subjects are covered in the bulletin: flame resistance, insulative protection, wash durability, static resistance, comfort, versatility and health and safety.

FLAME RESISTANCE

A fabric's ability to self-extinguish when exposed to flame is fundamental for safety apparel intended for occupations where fire is a hazard. If ignited, FR cotton will not continue to burn, nor will it shrink or drip molten residue. Flame resistance of FR fabrics is usually measured by a standard vertical flammability test like Federal Test Method Standard 191A Method 5903. A 1½ inch flame is exposed to the bottom edge of a 12 inch x 2¾ inch specimen for 12 seconds. The user determines the char length specification, usually five inches for an average for ten specimens. When repeated on laundered fabric, this test verifies the durability of flame resistance.

To the user, this test means that fabrics meeting the requirements will not sustain combustion. Using only the vertical flammability test, one cannot predict protective characteristics for actual fire risk situations. Heat insulation tests reveal more about fabric's total protective qualities.

INSULATIVE PROTECTION

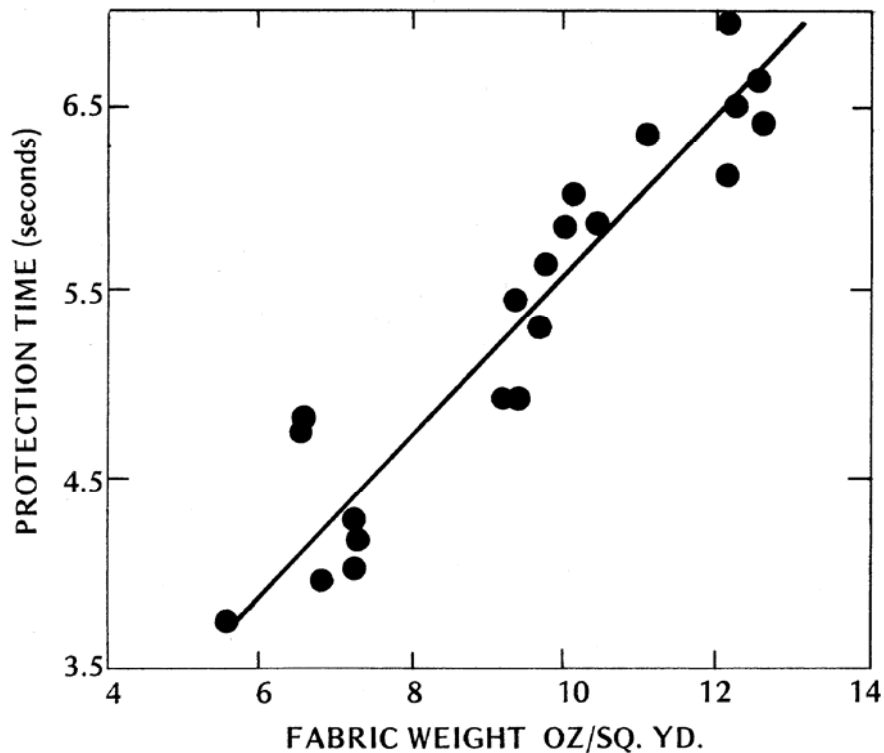


FIGURE 1

Protection from radiant, convective and conductive heat is the essence of an effective safety apparel fabric. To measure a fabric's thermal insulative properties accurately, controlled laboratory studies with sophisticated equipment are required. Figure 1 above summarizes results of such a study. Twenty-one fabrics ranging from 5.7 to 12.5 oz/yd² were exposed to a combination radiant/convective heat source set at 2.0 cal/cm²-sec. Each point represents the average of three replicate tests of the same fabric. The temperature rise behind the fabric was measured by thermocouples embedded in a copper disc. By comparing the rate of temperature rise with Stoll's* burn injury data, the time to predicted second degree burn, a 2.0 cal/cm²-sec. flux protection is established for each fabric.

To bring this data into perspective for the user, the test simulates excessive heat and flame exposure in actual conditions. The test fabric is effectively destroyed. The protection time is directly related to fabric weight and thickness. The fabric itself, not the flame retardant treatment, provides the insulative protection. Increasing fabric weight or multiple fabric layering provides additional protection. The data is used to compare candidate fabrics' insulative capacity. The test relates to a real-life hazard only to the degree that the actual hazard is identical to test conditions.

* Stoll, A.M. and Chianta, M.A., *Aerospace Med.*, 40 (11), 1232-1237. 1969.

WASH DURABILITY

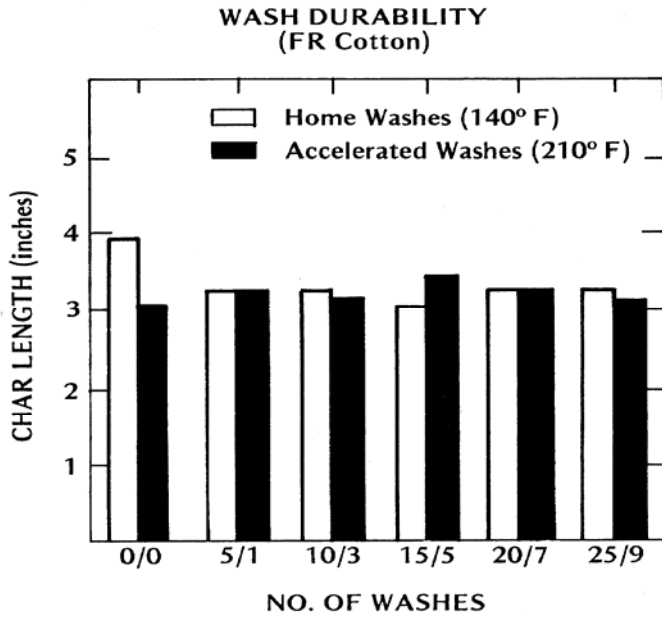


FIGURE 2

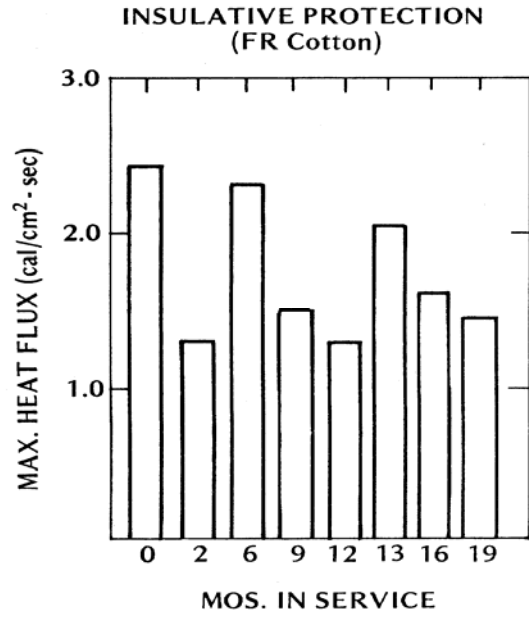


FIGURE 3

Durability of the flame resistance and insulative protection of FR cotton fabrics is measured after either home launderings at 140°F or laboratory accelerated procedures at an elevated temperature (210°F), near boiling. Using the vertical flammability test, comparison of char lengths of the unlaundered samples (0/0) with samples laundered multiple times (e.g., 25/9) shows that the self-extinguishing properties are maintained (Figure 2).

Durability of insulative properties can be demonstrated in another way. When garments removed from service after various time periods were subjected to a molten metal splash test, no loss of insulative properties was seen (Figure 3). The insulative properties actually increase in laundered garments, as evidenced by the lower values for heat transmitted through the fabric (heat flux).

Both of these demonstrations verify that the flame resistance and insulative properties measured on original fabrics are retained in normal use including laundering. In simple terms, the protective properties as purchased are and will be there when needed by the wearer.

STATIC RESISTANCE

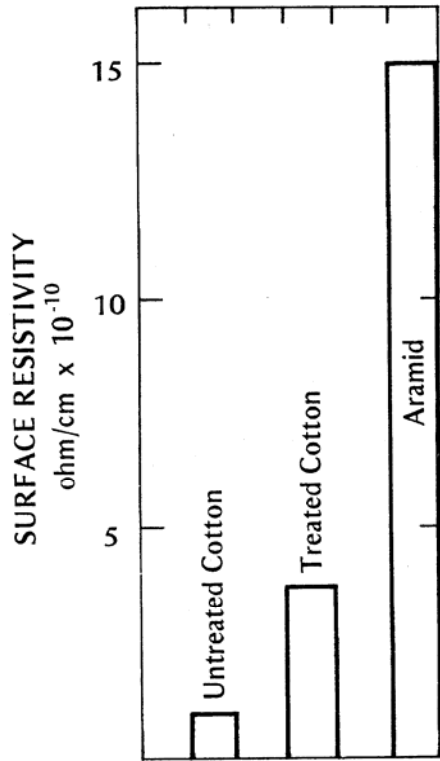


FIGURE 4

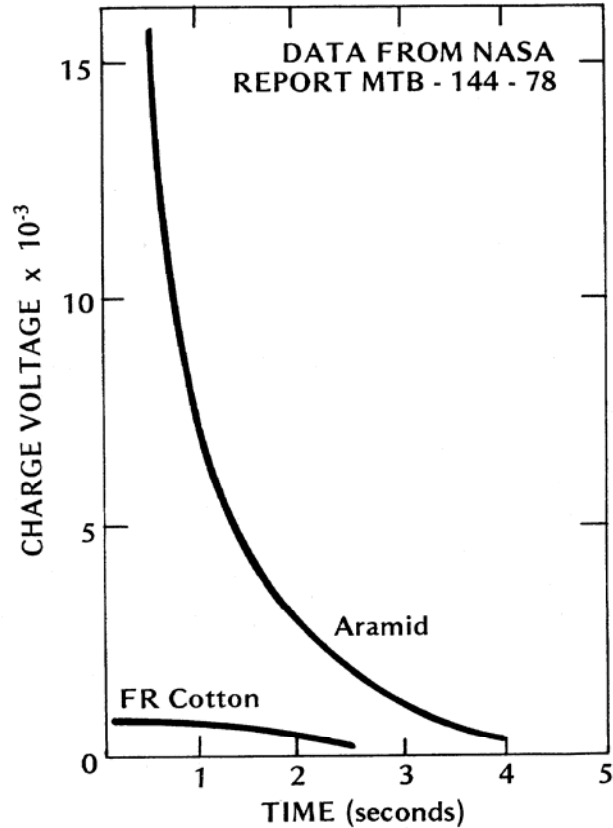


FIGURE 5

Cotton's natural moisture regain (5-8%) makes it particularly resistant to surface static charge buildup. Experience has shown few problems with static for fabrics with a surface resistivity of less than 10^{11} (10×10^{10}). Figure 4 shows that the values for untreated cotton and the average value for 9 FR treated cotton fabrics are well below this cut-off value. Comparison of the value for aramid, heat resistant fabric, further emphasizes FR cotton's advantage. The flame retardant treatment does not increase static buildup tendencies.

The rate at which charge decays is equally important when considering static discharge from fabric. Figure 5 compares charge decay rates for FR Cotton and aramid fabrics. For FR cotton, high initial charge is never obtained because the discharge rate is so fast. For aramid, the high initial charge decays over 3-5 secs. -- ample time for spark discharge to occur. What this means is that the use of FR cotton protective apparel substantially eliminates the possibility of static discharge.

COMFORT/VERSATILITY

The inherent properties that give cotton superior electrical resistivity -- natural moisture content and the ability to absorb and move moisture -- also make FR cotton the most comfortable flame resistant fabric available. Employees will favor FR cotton particularly in hot, humid weather. Synthetic alternatives feel hot and may irritate the skin.

Some wearers equate comfort with weight. Flame resistant cotton fabrics as lightweight as 5 oz/yd² are available for safety apparel, but also remember the inherent comfort of a pair of cotton blue jeans (12 oz/yd²) and note the added protection available for the heavier weight fabrics (Figure 1).

FR cotton garments, in comparison to non-FR cotton and competitive synthetic fiber garments, have been evaluated in controlled, subjective comfort studies by independent research groups. The statistically meaningful findings corroborate actual wear experience that proves the wearer cannot distinguish between the comfort of FR and non-FR cotton that are otherwise identical. Further, the wearer unequivocally prefers the FR cotton garment over the synthetic because of comfort differences.

Cotton fabrics can be dyed to a full range of colors with excellent wash and lightfastness properties. Cotton fabrics that have been treated with flame retardants can be chemically modified further to give specific characteristics. Water repellency is an example.

HEALTH AND SAFETY

The suppliers of chemicals used to confer flame resistance to cotton fabrics have conducted required studies to ensure their safe use. Work by Albright and Wilson has shown that neither skin irritation nor anti-cholinesterase activity exists.

Cotton Incorporated, Albright and Wilson and American Cyanamid Company tested treated cotton fabrics that were extracted with urine, saliva and perspiration at independent laboratories and found no mutagenic activity in the extracts.

The statements, recommendations and suggestions contained herein are based on experiments and information believed to be reliable only with regard to the products and/or processes involved at the time. No guarantee is made of their accuracy, however, and the information is given without warranty as to its accuracy or reproducibility either express or implied, and does not authorize use of the information for purposes of advertisement or product endorsement or certification. Likewise, no statement contained herein shall be construed as a permission or recommendation for the use of any information, product or process that may infringe any existing patents. The use of trade names does not constitute endorsement of any product mentioned, nor is permission granted to use the name Cotton Incorporated or any of its trademarks in conjunction with the products involved.

RESEARCH AND TECHNICAL SERVICES

Cotton Incorporated is a research and promotion company representing cotton worldwide. Through research and technical services, our company has the capability to develop, evaluate, and then commercialize the latest technology to benefit cotton.

- Agricultural research leads to improved agronomic practices, pest control, and fiber variants with properties required by the most modern textile processes and consumer preferences. Ginning development provides efficient and effective machines for preservation of fiber characteristics. Cottonseed value is enhanced with biotechnology research to improve nutritional qualities and expand the animal food market.
- Research in fiber quality leads to improved fiber testing methodology and seasonal fiber analyses to bring better value both to growers and then mill customers.
- Computerized fiber management techniques result from in-depth fiber processing research.
- Product Development and Implementation operates programs leading to the commercialization of new finishes and improved energy and water conserving dyeing and finishing systems. New cotton fabrics are engineered -- wovens, circular knits, warp knits, and nonwovens -- that meet today's standards for performance.
- Technology Implementation provides comprehensive and customized professional assistance to the cotton industry and its customers -- textile mills and manufacturers.
- A fiber-to-yarn pilot spinning center allows full exploration of alternative methods of producing yarn for various products from cotton with specific fiber profiles.
- The Company operates its own dyeing and finishing laboratory, knitting laboratory, and a laboratory for physical testing of yarn, fabric, and fiber properties including High Volume Instrument testing capable of measuring micronaire, staple length, strength, uniformity, color, and trash content.

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