

AN INTRODUCTION TO

# **Fire Science & Flame Resistant Fabric Technologies**

## **for Protective Apparel**

White Paper Executive Summary



In order to understand flame resistant (FR) fabrics and the engineering behind them, it's important to understand what they are protecting against. This requires diving deep into the science of a flame, and identifying exactly how and when flame resistant technologies intervene to protect wearers against flammable hazards.

Fire is a complex chemical chain reaction that requires heat, fuel, and oxygen. Three technologies are commonly used to reduce the flammability of fabrics, each based on removing or reducing one of these factors: heat, fuel, or oxygen. Each method is used, to some degree, to produce FR fabric for protective apparel and has unique advantages and disadvantages.

## This white paper reviews the benefits and challenges of three technologies to produce FR apparel:

### 1 Thermally stable fibers

Thermally stable fibers, also commonly described as “**inherent**,” are fibers that have a molecular structure that doesn't burn until reaching extremely high temperatures. Thermally stable fibers are highly durable and are often used in military flight suits, turn-out fire gear, and motorsports. The FR properties of thermally stable fibers are permanent and cannot be washed out. However, thermally stable fibers have a few disadvantages, including high cost, a stiff feel, and color limitations.

### 2 Solid-state treatments

Solid-state technologies are chemical solutions that interrupt a flame's chain reaction on textile surfaces. When exposed to heat, a solid char forms on the fabric, creating a barrier between the flame and its fuel. This removes fuel from the fire while also protecting the underlying material. There are two approaches to solid-state technologies: treated, which remains on the top of a fabric's surface, and engineered, which is permanently bonded to fabrics to create a structurally-enhanced material.

In addition to FR apparel, solid-state treatments are used in commercial textiles found in public spaces from hotel curtains to bedspreads. Particularly important to FR garments, solid-state treatments, when bonded permanently, allow FR fabric manufacturers to offer products at a more economical price. They also preserve much of the inherent comfort of cotton blends, including breathability, moisture wicking, stain release, and dyeability, without compromising FR performance.

### 3 Gas-state treatments

Adding a gas-state or fuel-activated technology is another approach to creating FR fabrics. This method eliminates combustion fuel and stops the flame's chain reaction. Gas-activated treatments are used in a broad range of products, including televisions, blenders, electrical wire, and mattresses. Modacrylic fibers are the most widely used example of this technology in protective apparel.

Overall, each strategy can provide effective FR protection and reduce injuries in hazardous environments. As such, the choice of fabric for FR apparel is often based on properties other than FR performance, including: comfort, breathability, drape, hand, moisture and heat management, product lifetime, cost, and appearance. Determining the ideal FR fabric for protective apparel in a specific line of work balances all of these properties.

FR technologies are not visible to the eye, so industry standards exist to provide an even comparison across products for specific hazards, including arc flash, flash fire, and others. Even with these assurances and third-party certifications, it is critical to source fabric from reputable manufacturers who have established robust process controls and internal testing procedures to ensure the performance of FR apparel.

**This white paper is a nuts-and-bolts look at the “what,” “how,” pros, cons, and applications of each method and industry standards in place to help buyers compare FR fabrics.**



WHEN IT COMES TO  
**FR SAFETY** | WE ARE  
**ALL IN**

**Phone:** 866-493-7839 **Email:** [FRinfo@milliken.com](mailto:FRinfo@milliken.com)

**[westex.com](http://westex.com)**