

# Flame retardant developments for cotton, polyester and blends

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## Abstract

Flame retardants are applied onto textile substrates to prevent fire from initiating and spreading reducing the potential damage to the textile or its user. The use of flame retardants varies from fibre to fibre as every fibre behaves differently when subjected to flames, given their different physical and chemical properties.

As a result, different types of flame retardants must be matched appropriately to different types of material. For instance, a flame retardant suitable for cellulosic fibres would not be suitable for synthetic fibres and vice versa. The most difficult material in which to achieve flame retardancy is polyester and polyester-cotton blended fabrics. Polyester and cotton blends are a popular textile combination for many applications and Sarex has developed two different flame retardants to be applied to polyester and cotton substrates: Saraflam-CWF (M) and Saraflam-PDR.

Saraflam-CWF (M) is a flame retardant for cellulosic fibres and Saraflam-PDR is a non-durable flame retardant available in powder form and suitable for all substrates, following a series of ASTM D 6413-94 vertical tests.

The treated fabric showed positive results and passed the criteria of flame retardancy. The Saraflam-CWF (M)-treated cotton fabric also showed durable results even after 10 home launderings.

## Keywords

Durable flame retardant, powder flame retardant, polyester, and cotton blended fabric.

## 1. Introduction

Flammability refers to the ease with which a substance may ignite and support a fire. Flame retardant fabrics are designed to resist igniting when exposed to a flame, to inhibit the spread of a flame, or to be self-extinguishing. Flame retardancy can be achieved using flame retardant fibres or by the use of flame retardant finishes on fabrics.

Today, flame retardant fabrics are finding importance across all industrial and commercial workspaces where workers are in direct contact with sparks, flames, or fire.

Flame retardant fabrics can make up uniforms for: firefighting agents; workers of foundries; welders; automotive workers; or engineers working across several industries. These professions in particular benefit from flame retardant textiles as exposure to flames or fire is more commonplace. The purpose of flame retardant garments and textiles is to impart resistance on the substrate to flames or sparks to protect human lives and prevent injuries.

There are two key types of flame retardant finishes and fibres: durable and non-durable. Durable flame retardant fibres or finishes are still effective after home laundering or washing, whereas non-durable flame retardants contain phosphate or phosphonate salts and are used for fabrics which are not washed frequently.

Durable finishes are usually used for cellulosic fibres containing tetrakis (hydroxymethyl) phosphonium salts which react with urea and are cured with gaseous ammonia. Softer versions have been recently developed using chemical or process modifications, which do not require gaseous curing.

Polyester-cotton blends pose a special flammability problem as the thermal and mechanical properties of the two fibres are so different. Cotton tends to char on heating but generally maintains some structural integrity whereas polyester normally melts and flows at temperatures of 260°C. If a mixture of the two fibres is burned, the molten polyester frequently tends to wick on the cotton char, resulting in the phenomenon of material scaffolding.

Considering the limitations of existing flame retardants for polyester-cotton blends, Sarex has developed a flame retardant for cotton, as well as a non-durable flame retardant which will work on all substrates, including blends.

## Saraflam-CWF (M)

Saraflam-CWF (M) is a durable flame retardant for 100% cellulosic fabric. Saraflam-CWF (M) chemically reacts with these fibres thereby imparting durable flame retardancy which can withstand several launderings and dry cleanings. Saraflam-CWF (M) prevents flame propagation in presence of fire. To get accurate and desired results, a sufficient add-on of the Saraflam-CWF (M) should be given on the



A vast number of everyday textile items require fire retardancy for safety and protection

fabric. The product has passed the NFPA-701, BS 3119, BS 5852 regulation tests. Saraflam-CWF (M) is an 80% product.

### Saraflam-PDR

Saraflam-PDR is a water soluble, flame retardant which is also available in powder form. It can be applied on 100% cotton, 100% polyester and polyester-cotton blended fibres. It is durable to dry cleaning but not durable to washing. It allows for a soft handle and has a minimum effect on the shade of fabric. To get the desired results, a sufficient add-on of the Saraflam-PDR should be applied to the fabric.

## 2. Application condition

A piece of 100% cotton shirting fabric and a piece of 100% cotton bottom weight fabric were finished with Saraflam-CWF (M) by padding the application with 70% expression, they were then dried at 120°C for two minutes and cured at 160°C for three minutes. The recipe used is in graph below.

Recipe No.	gm/litre
Saraflam-CWF(M)	300
Saralink-ULF	55
Phosphoric-Acid(85%)	15
Saralube-2975	40
Sarawet-NF	0.5

Afterwards, a piece of 100% cotton shirting fabric, a piece of 100% cotton bottom weight fabric, a piece of 100% polyester fabric and a piece of polyester-cotton blended fabric were finished with 150 gpl Saraflam-PDR, with a 70% expression. The fabrics were then dried at 110°C for four to five minutes.

## 3. Test method

The finished fabrics were evaluated for flame retardancy using the vertical ASTM D 6413-94 test, an industry benchmark for flame retardancy. Samples were weighed before being mounted in a frame and placed in the flame chamber. The methane (C.P. grade) burner flame was adjusted to a height of 1.52 inches and the specimen set to 0.75 inches above the burner. The bottom of the specimen was exposed to the flame for 12 seconds at which point it was observed for melting and dripping behavior. The after-flame time, the length of time for which a material continues to flame after the ignition source has been removed, was recorded. Furthermore, any afterglow time was recorded.

## 4. Results & discussion

From Table 1 it is seen that the fabrics treated with 300 gpl Saraflam-CWF (M) show excellent flame retardancy on the piece of 100% cotton shirting fabric and the piece of 100% cotton bottom weight fabric.

Moreover, the afterglow time of the treated fabric is zero indicating it is not propagating the flame after the flame is withdrawn. The main reason for this flame retardancy action is because a carbon scaffold is formed by the dehydration of the flame retardant-treated cellulose, counteracting heat penetration and the spread of fire.

The durability of treated fabrics was tested after washing the fabric using AATCC-61 2A (accelerated washing) where one wash is equal to five washes - the results are summarised in Table 1 (p. 20). It was seen that all the fabrics treated with flame retardants showed good durability even after 10 home launderings.

From Table 2 (p. 20) it is seen that the fabrics treated with 150 gpl Saraflam-PDR show excellent flame retardancy on the piece of 100% cotton shirting fabric, the piece of 100% cotton bottom weight fabric, the piece of 100% polyester fabric and the piece of polyester-cotton blended fabric. It also evidences that the afterglow time of treated fabric is zero indicating it is not propagating the flame at all after the flame is withdrawn.

## Technical briefing: fire retardancy

**Table 1 : Flame retardancy action of Saraflam-CWF (M) on 100% cellulosic fabrics**

Sr. No.	Fabric	300 gpl Saraflam-CWF (M)	
		Char length (cm)	After Glow time (sec)
1	<b>100% Cotton Shirting - Unfinished</b>	Completely Burn	-
	Initial	9	0
	After 5HL	11	0
	After 10 HL	12.5	3
2	<b>100% Cotton bottom weight - Unfinished</b>	Completely Burn	-
	Initial	4	0
	After 5HL	6	0
	After 10 HL	6	0

HL: Home Laundering

**Table 2: Flame retardancy action of Saraflam-PDR on 100% cotton (shirting and bottom weight), 100% polyester and polyester-cotton blended fabric**

Sr. No.	Fabric	150gpl Saraflam-PDR	
		Char length (cm)	After Glow time (sec)
1	100% Cotton Shirting Unfinished	Completely Burn	-
	Finished	9	0
2	100% Cotton bottom weight Unfinished	24	45
	Finished	8	0
3	Polyester/Cotton Unfinished	Completely Burn	-
	Finished	6	0
4	100% Polyester Unfinished	Completely Burn	0
	Finished	7	0

### 5. Conclusion

Cotton is one of the most widely used fibres in a number of fields including military textiles and home furnishings, so developing a cost-effective durable flame retardant for cotton is of utmost importance. The Sarex flame retardant Saraflam-CWF (M)-treated fabric shows durable results at an economical price. This finish is also durable for up to 50 home

laundryings in some cases when a sufficient dry add-on of 25-28% is applied to the fabric.

Moreover, non-durable flame retardants like the Saraflam-PDR can be applied on all substrates including polyester-cotton blended fabrics which are one of the most difficult fabrics to be given flame retardancy - the development is quite new to this field.