

Fabric flammability and burning accidents

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Foreword

This Published Document was prepared under the direction of the Textiles and Clothing Standards Policy Committee (TCM/-). It supersedes PD 2777:1977 which is withdrawn.

Committee TCI/63 has declared PD 2777:1994 obsolescent.

The data of burning accidents is superseded by more recent data available on the DTI HASS database which can be found at http://www.dti.gov.uk/homesafetynetwork/gh_stats.htm

The committee decided that whilst PD 2777:1994 has been useful historically, it is dependent on HASS data which is revised every 12 months. Furthermore, any revision of PD 2777:1994 would be pre-emptive in the light of changes taking place to:

- Fire Safety Regulations;
- the Workplace Directive;
- EC Guideline; and
- the development of new European standards related to the burning behaviour of textiles.

Any publication that attempts to relate fire accident data to standards and regulations must be kept at the same stage of currency as the data to which it refers.

Therefore, it was decided, that PD 2777 should not be revised yet. If it was revised subsequently it should also:

- relate those standards specifically for contract use and separately, those for domestic use;
- refer to guidelines for risk assessment;
- propose a CEN technical report within CEN/TC 248, concurrent with any revision, to establish relevance.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 23 and a back cover.

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Section 1. General

1.1 Scope

This Published Document provides background information on the flammability of textile materials and their involvement in burning accidents. It reviews the development of test methods derived from the original BS 5438:1976 and of performance specifications based on these test methods, up until August 1993. It also briefly outlines legislative measures which have been used to reduce textile burning accidents and alternative test methods which have been developed for specific textile products. It provides a summary of the state of the art as a basis for future developments within the European framework.

1.2 Informative references

This Published Document refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this document are listed on page 22.

NOTE As this document provides an historical review some of the publications referred to are obsolete, obsolescent, or in draft form only.

Section 2. Burning behaviour of textiles

2.1 General burning behaviour

Combustion or burning is a chemical reaction in which a material is consumed by oxidation with the production of heat and light. There are three essential components in any burning reaction; heat, fuel and oxygen. The burning reaction uses up fuel and oxygen but produces heat which enables it to spread, normally with a flame but sometimes with a glow (emitting heat and light but with no flame).

The burning reaction goes through a series of stages.

- a) *Thermal decomposition*. Heat causes the material to break down into simpler flammable materials.
- b) *Ignition*. Heat causes the breakdown products to start to burn.
- c) *Propagation*. Heat from the burning reaction causes decomposition and burning to spread at an increasing rate.
- d) *Termination*. Burning normally ceases when all the fuel has been consumed. In some cases, in an enclosed space, burning may be extinguished when all the oxygen is consumed.

2.2 Burning of textiles

Flammable textile materials are readily decomposed by the application of heat. Because they are used in the form of thin sheets, they can be ignited by a short contact with a small ignition source and burning spreads rapidly. Materials which form gaseous decomposition products tend to burn upwards with a flame which increases in speed and intensity. The material tends to burn away completely exposing any underlying material. The heat from a burning textile acts as a secondary ignition source which can ignite other materials which may not have ignited with the initial small ignition source. Burning apparel fabrics produce sufficient heat to cause severe skin burns.

Some materials are thermoplastic and melt on the application of heat. If the material forms a hole it exposes the underlying material to the effect of the primary ignition source. Molten drops may separate and fall down from the material, and if these drops are flaming they may ignite other materials.

The main hazard from burning textile materials arises from the build-up and transfer of heat. In the case of flammable apparel, large areas of the skin can be burnt if clothing is ignited by a small ignition source, such as a match flame. In the case of furnishing fabrics the heat is transferred to other flammable materials, enabling a small ignition source to develop into a major fire. The combustion products of all materials are toxic and irritating, and when large quantities of material burn in a confined space the atmosphere becomes lethal.

Some textile materials are more flammable than others. Attempts have been made to classify the flammability behaviour of textiles by fibre type and a general classification scheme based on fibre type is illustrated in Table 1. However, the actual classification depends on various other factors, related to either the test procedure or to the fabric construction.

The choice of the flammability test conditions and performance levels can influence the classification. Burning behaviour is influenced by the position and intensity of the ignition source, the availability of oxygen supply, and the test specimen orientation in the test employed. The performance levels set and the terms used to describe the different classes are therefore not consistent from one standard to another.

Fabric factors which affect the flammability include the fabric weight and the surface construction. In general the lighter the weight of the material the more easily it is ignited and the more rapidly it burns. Thus, different weights of cotton fabric can be rated as slow burning, flammable, or highly flammable.

Pile fabrics and those with a brushed or raised surface tend to burn very rapidly. If the base fabric burns at a high speed the material may be considered as unsuitable for apparel use. If the material exhibits surface flash, that is rapid spread of flame over the surface of a material without ignition of its basic structure (see BS 4569), the flame is so weak that it is unlikely to cause any burning damage. Materials which surface flash are used for apparel, but should be kept away from sources of flame.

Thermoplastic fibres, which melt on the application of a flame, may not ignite or may give only limited flame spread. They are liable to give very erratic burning behaviour but normally are classed as of low flammability. The burning behaviour of fabrics made from blends of fibres or of composites made from different materials cannot be predicted from tests of the separate materials. In particular, thermoplastic fibres burn more readily if supported by non-melting materials which provide a so called scaffold effect.

The flammability of various fibre types can be modified by the presence of textile finishes. Flame retardant treatments are used to reduce the flammability but other treatments may increase the flammability. Grease and soil acquired during use can also affect the flammability properties as can the cleansing procedures used to remove them. Fibres which give only restricted flame spread are normally divided into two types: inherently flame retardant fibres in which the properties are a feature of the fibre structure, and flame retardant treated fibres which contain a flame retardant which is added at the fibre extrusion or fabric finishing stage. Special fibres have been developed, which not only restrict the spread of flame but resist decomposition on contact with flame, and these are used for specialist protective clothing and equipment.

Table 1 — Burning behaviour of textile materials

Flammability class	Features	Typical materials ^a	Comments
Highly flammable	Very rapid flame spread with base material burning	Very lightweight or highly raised cotton or viscose	Not allowed as apparel fabrics under US Flammable Fabrics Act
Surface flash	Rapid flame spread over fabric surface, but without ignition of base material	Brushed, raised and Knitted fabrics of cotton and viscose	Surface flash occurs more readily if fabric surface is brushed up and if the fabric is very dry
Flammable	Easily ignited, burns rapidly and completely	Acetate, acrylic, cotton, flax, modal, ramie, triacetate, viscose	—
Low flammability: Thermoplastic	Melt on application of heat, may ignite, may give molten drops which may be flaming	Polyester, polyamide, PVC	Burns more readily when supported, e.g in blends with non-thermoplastic fibres, and when treated with certain prints and finishes
Limited flame spread	May ignite but no flame spread Forms solid char with no melting	Flame retardant cotton, viscose and wool modacrylic	Properties may be inherent or achieved by durable or non-durable flame retardant treatment
Not ignited	Do not ignite	Aramid, polybenzamidazole (PBI), carbon and glassfibres	Used in heat protective equipment
^a The materials listed are examples only. They may fall into another class if different weights or grades of fibre are used or if a different test method is employed.			

2.3 Restricted fabric flammability

Certain textile materials exhibit restricted flammability.

Flame spread is restricted because the fabric either:

- a) does not decompose; or
- b) decomposes but does not ignite; or
- c) ignites but does not propagate flame; or
- d) ignites but burning does not increase in intensity.

The extent of the restricted flame spread can vary from one test specimen to another, and it is very difficult to observe the different stages listed above whilst an igniting flame is still in position. It is therefore usual to measure the after-effects of applying an igniting flame under standard test conditions. The time of flame persistence after removal of the ignition source (afterflame time) and the resultant damage to the material caused by decomposition and flame spread (damaged length, hole size) may be measured.

The classification of restricted burning behaviour is based on limits set for the levels of these after-effect measurements. It is dependent on the choice of the specified levels of flame persistence in the specific performance requirements. The terms “not ignited”, “flame resistant”, and “limited flame spread” are used in different performance specifications to describe a specified restricted flame spread under the specified test conditions.

In other performance specifications flammability indices are used to describe the level of performance. The terms or indices used can be related to two concepts of restricted flame spread.

- 1) *Limited extent of flame spread.* A small test specimen does not burn to the edge and gives limited afterflame time.
- 2) *Limited rate of flame spread.* A large test specimen does not bum as quickly as a normal flammable fabric (this usually means that the specimen also does not burn completely).

Where textiles are used as covering materials, especially for upholstered furniture or mattresses, limited extent and rate of flame spread are not the only factors involved. The ability to resist penetration by heat and flames is also a vital factor, because it influences the ignitability of the inner materials. Materials which do not decompose or which decompose to form a solid char can act as a thermal barrier and protect the underlying materials. Materials which melt and form a hole eventually expose the underlying material to the effect of the ignition source.

Textiles used in combination with other materials are tested in the actual material combination. In the case of apparel and curtains this requires the testing of material assemblies rather than single layer fabrics. In the case of furniture and mattresses it involves the testing of the actual composite of materials, as used (see 5.1).