European Fire Standards

Flammability testing is arguably one of the most important testing procedures within the textile industry because it has crucial safety implications in the event of a fire. It has been statistically shown that the major cause of fatalities in fire can be directly attributed to the accidental ignition of upholstery and textiles, so it is only sensible that proper flammability standards should be in place. Flammability performance can be improved by the fabric manufacturer at the design stage to ensure a safer interior environment.

Unfortunately, there is no single flammability standard for upholstery or vertical surface fabrics which has been adopted as the norm throughout the world and the plethora of different standards in force internationally reflects the different ways of approaching the whole flammability issue. A single standard has been brought in which is acceptable throughout the European Union, EN 1021 : 1994, but this only covers cigarette and match tests - nothing more rigorous - and other national tests continue to proliferate.

This guide looks at some of the most important international standards and test methods which apply to upholstery fabrics. Sadly, it can never be a definitive document, but should hopefully provide a better insight into the main regional variations and the complex issue that flammability testing has become.

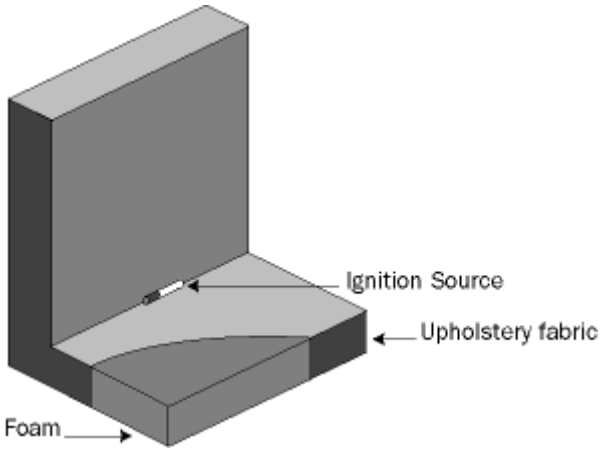
European standards

EN 1021 - 1/2 : 1994

This standard is valid throughout the EU and examines a fabric's reaction to a burning cigarette and butane flame (simulated match). It replaces a number of national tests, including DIN 54342 : 1/2 in Germany and BS 5852 : 1990 in the UK.

Test Methods

A standard test rig is constructed from fabric and foam to form a simulated chair with the back at a right angle to the base. This enables the ignition source to be kept in permanent contact with both back and seat throughout the test. Watersoak prior to testing is compulsary.



EN 1021 : Part 1

In Part 1 of the test a lighted cigarette is placed in the angle of the test rig and left to smoulder along its entire length. After 60 minutes no smouldering or flaming of the fabric should be observed.

EN 1021 : Part 2

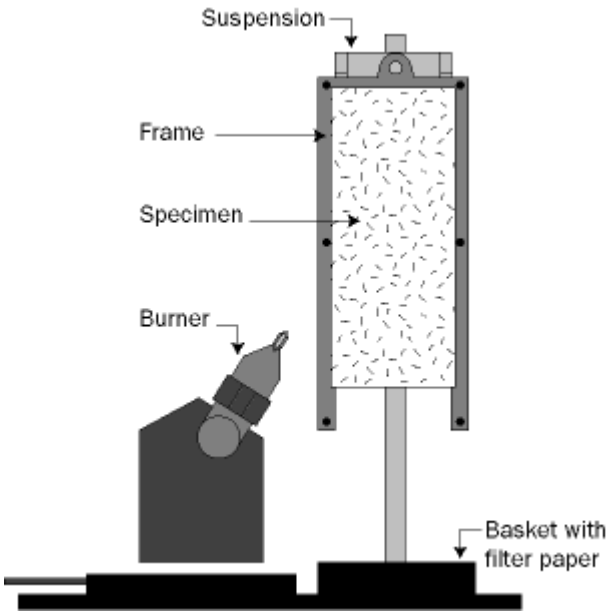
Here a butane flame 35mm in height is used to represent a burning match and is applied for 15 seconds, again in the angle between the test rig base and back. After the flame is removed, no burning of the fabric should occur after 2 minutes have elapsed.

Germany

In Germany, upholstery fabrics are tested in accordance with DIN 4102 which has been established by the Deutsches Institut fŸr Bautechnik.

DIN 4102 Part 1 - Kleinbrenner (B2)

All materials used in buildings in Germany need to meet the B2 requirement which is determined using a small flame test.

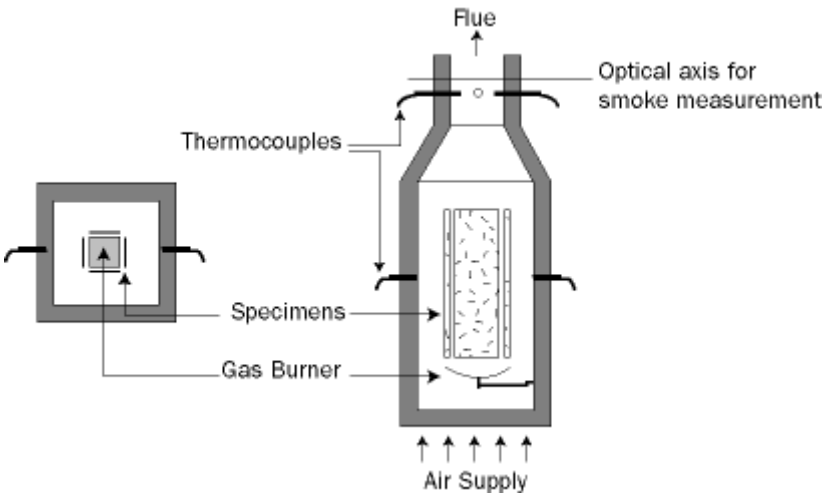


The fabric specimen is suspended vertically and a 20mm high flame is applied for 15 seconds to both the fabric surface and edge. Reference lines are marked on the specimen, which achieves B2 classification if the tip of the flame does not reach the reference marks within 20 seconds on any sample. 5 samples are tested with filter paper being placed below each to determine the production of flaming droplets.

DIN 4102 Parts 15/16 - Brandschacht (B1)

Referred to as the "Brandschacht test", this is the main test method in Germany which measures reaction to fire and is considered the highest flammability standard in the country for upholstery fabrics.

The term Brandschacht, literally "fire shaft", refers to the testing apparatus itself which consists of a square-shaped vertical housing equipped with a gas burner. Four fabric samples are held vertically in a supporting frame and subjected to flames for 10 minutes. At the same time a constant, uniform flow of air is blown into the Brandschacht from below.



In evaluating the test, smoke gas temperature and the mean residual length of the sample are taken into account (residual length is the part of the specimen which has escaped burning). In order to be classified as B1, the tested fabric must show:

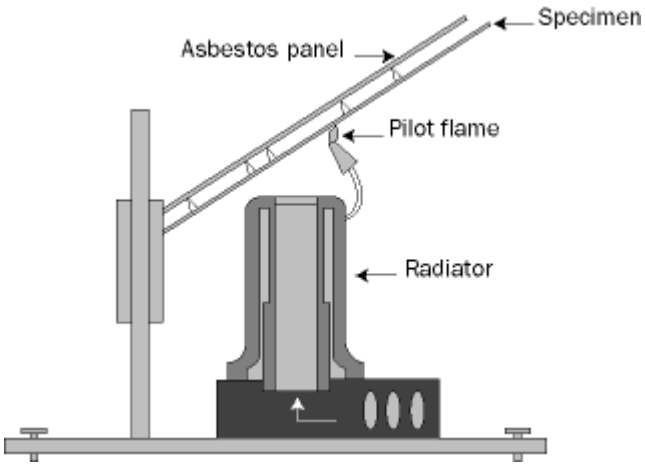
1. A mean residual length of not less than 150mm, with no specimen being burned away completely

2. A mean smoke gas temperature of less than 200oC

France

NFP 92 - 503 - Bržleur *f*lectrique

The French test known as the "Bržleur *ƒ*lectrique" - electric burner - is the principal method used not only in France, but also in Belgium, Spain and Portugal. It results in a classification of M1 to M4, with M1 being the highest classification.



The sample is placed face down on the test rig at an angle of 30o above an electric radiator which gives out heat. A small butane gas pilot flame is applied directly to the fabric surface at 20 seconds into the test, held in position for 5 seconds then withdrawn. The flame is applied again at 45 seconds and subsequently every 30 seconds for the duration of the 5 minute test. If any flaming continues after 5 minutes, the test is continued until the specimen extinguishes completely.

The following aspects are noted during the test:-

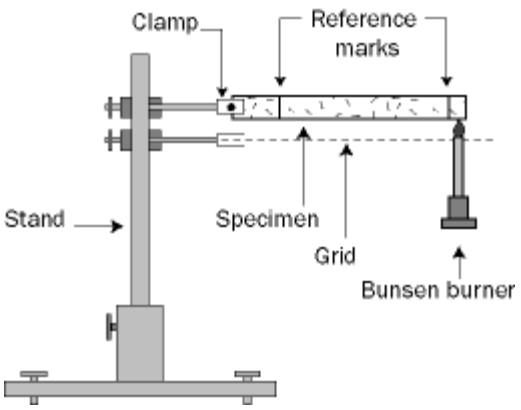
- duration of flaming
- production of burning droplets
- length/width of the damaged specimen

Actual classification requirements are given below:-

Classification			M1	M2	M3	>M3
Duration of Combustion		s	<=5	>5	>5	>5
Damaged	Length	mm	-	<350	<600	600
	Width	mm	-	-	<90	>90
Droplets			none	none	none	

NFP 92-504 - Rate of flame spread test

This complimentary test to the Electric Burner helps establish a classification on samples which behave unusually during the primary test - for example, melting rapidly or shrinking away to form a hole so that the pilot flame cannot come into contact with the sample at 20 seconds, or if samples were unable to achieve an M3 rating.



For materials which melt or shrink away from the heat source, after flame, non-propagation of flame and burning/non burning droplets are observed. Rate of flame spread is also measured if the material does not achieve M3.

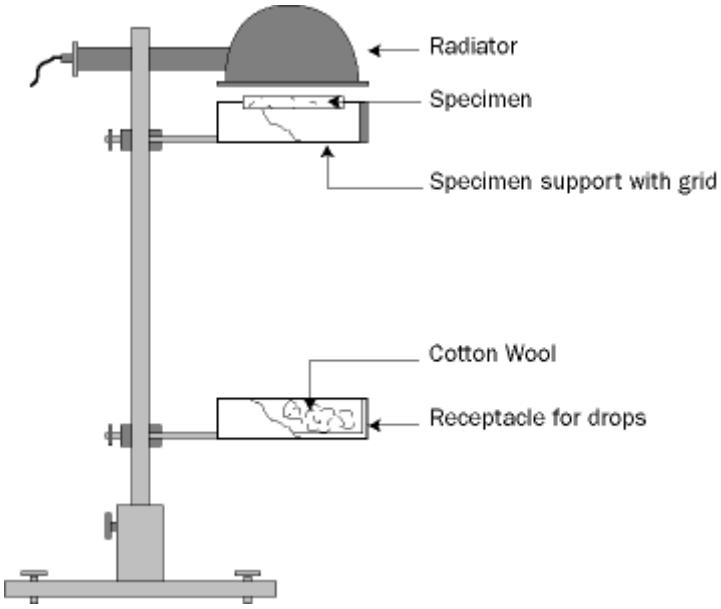
The non-propagation of flame test involves a flame being held against the free end of a horizontal sample, 10 times for 5 seconds; the time of after flame is measured.
In the flame spread test, the time taken for flame to spread between two reference marks at 50mm and 300mm is established. The production of burning droplets is also noted.
Classification criteria are given below:-

Classification	M1	M2	M3 a	M3 b	M4
Duration of Combustion	none	<5s	<5s	>5s	>5s
Droplets	None or non burning	None or non burning	Burning	None or non burning	Burning

NFP 92-505 - Dripping test

Again complimentary to the electric burner, the dripping test is employed to investigate further into the potential hazard of burning droplets observed during the primary test.

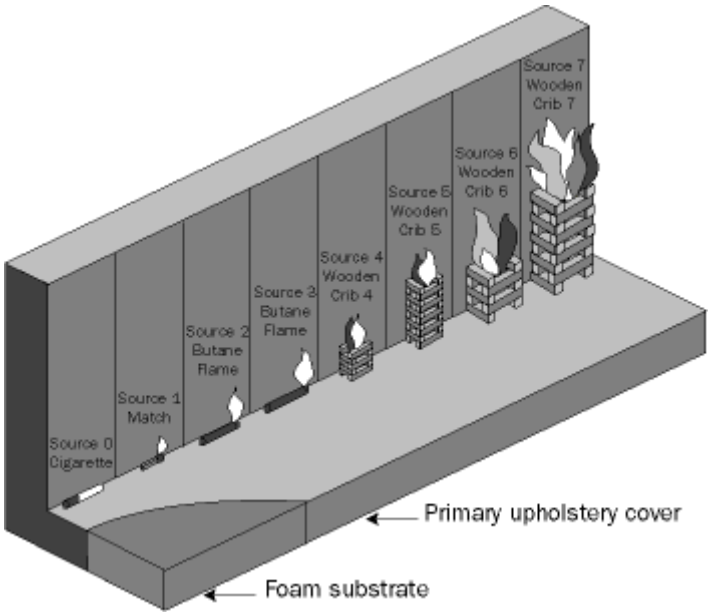
A sample is placed on a grid 30mm below a radiator and a receptacle containing cotton wool is positioned 300mm below the grid. Heat is applied from the radiator for 10 minutes and the test is repeated 4 times. If the cotton wool sets alight, the fabric is classified M4. If it does not ignite, even if flaming or molten drips are produced from the sample, the original classification from the electric burner test is retained.



United Kingdom

BS 5852 : 1990

This defines the actual test method whereby a specially constructed test rig is designed to form a simulated chair, as described in EN 1021. The foam used is not specified.



Of the eight ignition sources, the most frequently used are Ignition Source 0 (cigarette), Ignition Source 1 (butane flame/simulated match) and Ignition Source 5 (Crib 5). Moving up the ignition source scale, the heat intensity roughly doubles as compared to that of its predecessor.

The requirements for the cigarette and match tests are the same as those detailed under EN 1021, although the match application time was previously 20 seconds before the European Norm was introduced.

The Ignition Source 5 test is more rigorous due to the increased intensity of heat which is generated from the wooden crib structure. Alcohol is added to the small piece of lint at the bottom of the crib which is then placed on the test rig and ignited within 2 minutes. For a pass to be recorded, all flaming should cease within 10 minutes.

BS 7176 : 1995

BS 7176 is a performance standard based on BS 5852, but with three additional parameters:-

(i) Watersoak procedure
(ii) Predictive "Worst Case" testing
(iii) Hazard categories

Watersoak

This procedure is defined precisely in BS 5651 : 1990 Clause 3, but in simple terms requires that a fabric be soaked in water and dried prior to testing. This is done because chemically treated material may be adversely affected by watersoaking and its additional flame retardant characteristics may be greatly reduced or completely eliminated.

Predictive worst case testing

Here the foam used on the test rig is 35kg/m3 High Resilient (HR) foam (not CMHR foam). This has been adopted as a 'worst case' foam on the assumption that the vast majority of manufacturers use Combustion Modified foam which gives better flammability performance.

Hazard Categories

BS 7176 also helps to identify varying 'hazard' categories which are linked directly to the ignition source used for testing. There are four categories:-

	Low Hazard	Medium Hazard	High Hazard	Very High Hazard
Typical Examples of usage	Offices, Colleges, Museums, Exhibitions,	Hotel Bedrooms Public Buildings Restaurants Services Messes	Sleeping accomodation in certain hospital wards and in certain hostels.	Prison cells

	Day Centres, Schools	Places of Public entertainment Public Halls Public Houses Bars and Casinos Hospitals Hostels	Offshore installations	

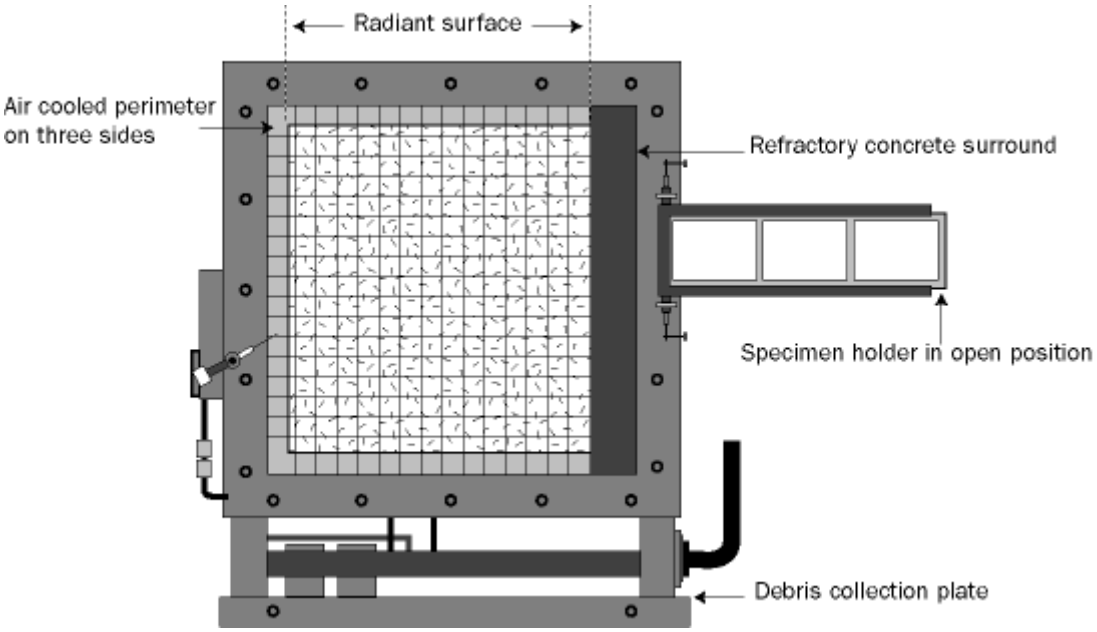
1. If a particular premise in the Low Hazard area is used for sleeping purposes then consideration should be given to specifying a higher performance level.

2. Upholstered furniture which is ordinarily intended for private use in a dwelling is subject to Government Regulations.

Typical examples of end usage are indicated by BS 7176 so that the user (and fire officer) knows what specification of fabric is required where. Classifications cover low, medium, high and very high hazard categories with offices coming in the lowest risk category and public buildings, hotels, restaurants, etc being labelled medium hazard. However, it is important to note that these are guidelines only and fire officers and specifiers alike can demand higher standards; this is often true of office environments where "Medium Hazard" fabrics are increasingly preferred.

BS 476: Part 7 (1997)

This standard assesses the flammability performance of flat materials, composites or assemblies, which are used as the exposed surfaces of walls or ceilings. Hence this is the standard which is applied to vertical surface or panel fabrics. The spread of flame along the surface of a specimen held in a vertical position is determined and the subsequent classification system is based on the rate and extent of flame spread.



The test equipment consists of a vertically mounted radiation panel, supplied with a gas-air mixture, together with a specimen holder and pilot flame arrangement mounted to one side. The specimen holder swivels so that it is located at 90o to the face of the radiation panel during the test.

The fabric sample is exposed to the radiation panel for 10 minutes (or until the flame has reached a reference line drawn at 825mm - whichever occurs first) and for the first minute a pilot flame is applied to the bottom corner of the sample. During the test, the time taken for the flame to reach various reference marks is noted, along with the extent of flame spread at 1.5 minutes and at the end of the test. A minimum of six and a maximum of nine samples are tested and are classified according to the performance results shown in the table below.

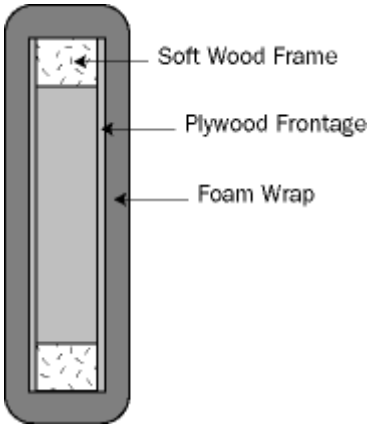
Classification of spread of flame				
Classification	Spread of flame at 1.5 min.		Final spread of flame	
	Limit (mm)	Limit for one specimen in sample (mm)	Limit (mm)	Limit for one specimen in sample (mm)
Class 1	165	165+25	165	165+25
Class 2	215	215+25	455	455+45
Class 3	265	265+25	710	710+75
Class 4	Exeeding the limits for class 3			

Vertical Surface Test

The Vertical Surface Test has been specifically devised by Interface Fabrics to assess the flame retardancy of panel systems in typical installation conditions. It has not been formally adopted under national or international legislation, but is the test we are seeking to promote and advocate as being better indicative of how a panel structure is likely to react in a fire.

Test Method

The test utilises the standard test rig and ignition sources as per EN 1021 which is the standard for upholstered furniture. An "L" shaped construction in this instance simulates a panel in direct contact with its base.



For testing purposes a typical panel construction consists of a soft wood frame with plywood frontage covered in 2mm HR foam. The panel fabric to be tested is then clipped around the panel and positioned the test rig. The base is constructed of chipboard covered in laminate to simulate a desk top. The vertical surface test also includes a watersoak procedure for the fabric.

Ignition Sources

The ignition sources used and the length of time for which they are applied are identical to those for testing upholstered furniture, ie. Ignition Source 0 (cigarette), Ignition Source 1 (match). The pass criteria are also the same.

Italy

Numerous building laws and regulations exist in Italy relating to fire protection. "Circolare No.12" of the Ministry of the Interior contains test procedures enabling the flammability performance of building materials - including fabrics - to be established and classified. To achieve an overall classification, the

small burner ignitability test (CSE RF 1/75 A or CSE RF 2/75 A) must be conducted together with the surface spread of flame test (CSE RF 3/77). The results of both tests are then used to determine an overall classification, from Class 1 to Class 5 - Class 1 being the best.

CSE = Centro Studi ed Esperienze (Research Centre of the Ministry of the Interior)

RF = Reazione al fuoco (Reaction to fire)

CSE RF 1/75 A, CSE RF 2/75 A

These small burner tests roughly correspond to the German Kleinbreiner test (DIN 4102 Part 1) except for the size of specimen and the absence of filter paper to check for burning droplets.

CSE RF 1/75 A is an edge application flame test, with the flame applied for 12 seconds, while CSE RF 2/75 A uses surface application of the small flame for 30 seconds. In both tests, after flame time, afterglow time, extent of damage and flaming droplets are observed and recorded. These parameters are then divided into three grades, as shown in the table below:

Grade	Afterflame time (s)	Afterflame time (s)	Extent of damage (mm)	Time for drippings to extinguish (s)
1	<5	<10	<150	non burning
2	>5 - <60	>10 - <60	>150 - <200	<3
3	>60	>60	>200	>3

The grades of the four parameters are then multiplied by "weighting factors" in order to establish the category into which a product falls, which then serves as the basis for assigning a classification to a product.

Parameter	Weighting Factor
After flame time	2
After glow time	1
Extent of damage	2
Dripping	1
Category	Weighted sum of grades (grade x weighting)
i	6 - 8
ii	9 - 12
iii	13 - 15

iv	16 - 18

CSE RF 3/77

In the spread of flame test, the sample is exposed to a small pilot flame and radiant panel. The position of the test specimen is varied to simulate end use in floors, walls and ceilings. Parameters measured are the rate of spread of flame, extent of damage, afterglow and flaming droplets, which again are divided into three grades. The category on which classification is based is then worked out by multiplying the different grades with various weighting factors, which for flaming droplets are distinguished between floor, wall and ceiling use.

Grade	Rate of spread of flame (mm/min)	Extent of damage maximum length	Afterglow time (s)	Time for drippings to extinguish (s)
1	not measurable	=<300	=<180	not burning
2	=<30	=>300 - =<600	=>180 - =<360	=<3
3	>30	>600	>360	>3

Parameter		Weighting factor		
Rate of spread of flame		2		
Extent of damage		2		
Afterglow		1		
Dripping	floor	0		
	wall	1		
	ceiling	2		
Category		Weighted sum of grades (grade x weighting)		
		Floor	Wall	Ceiling
i		5 - 7	6 - 8	7 - 9
ii		8 - 10	9 - 12	10 - 13
iii		11 - 13	13 - 15	14 - 17
iv		14 - 15	16 - 18	18 - 21

Classification

The categories obtained from the different tests form the basis for classifying products, as follows;- For classification in classes 2, 3 and 4 respectively, two, five and seven combinations of categories

obtained are available.

Test Method	Conditions							Class
method CSE RF	Compliance with categories to choice							
1/75/A or 2/75/A 3/77	i i							1
1/75/A or 2/75/A 3/77	ii i	i ii						2
1/75/A or 2/75/A 3/77	iii ii	ii iii	i iii	iii i	ii ii			3
1/75/A or 2/75/A 3/77	iv iii	iii iv	iii iii	iv ii	ii iv	iv i	i iv	4
1/75/A or 2/75/A 3/77	iv iv							5

USA

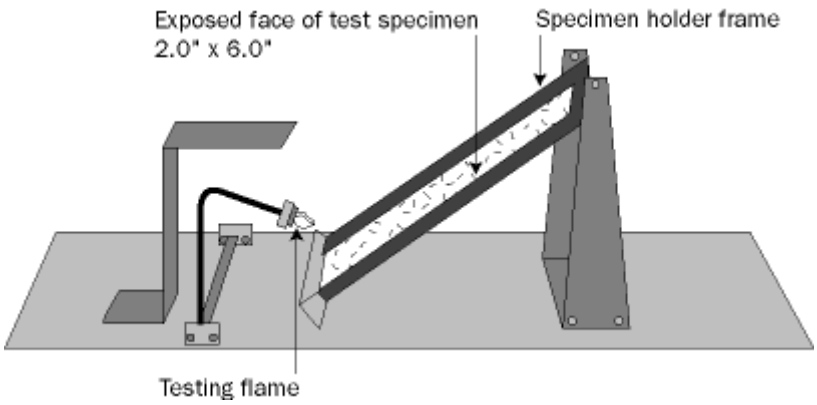
There are currently no national rules which regulate the requirements either of contract fabrics or the furniture they cover. Instead, regulation is left to local fire officers or building code officials who most often follow one of a number of different models.

California Technical Bulletins (TB)

The State of California is one of the few states to regulate seating products through both mandatory and voluntary requirements.

TB 117 Section E

TB 117 is a mandatory requirement for components of upholstered furniture and Section E looks at a fabric's resistance to a small flame. Fabric mounted at a 45o angle is exposed to a 5/8" (1.6cm) butane flame for 1 second. A pass is achieved if the fabric does not ignite or if the time of average flame spread is 3.5 seconds or longer for a 5" length. Virtually all upholstered fabrics pass this test.



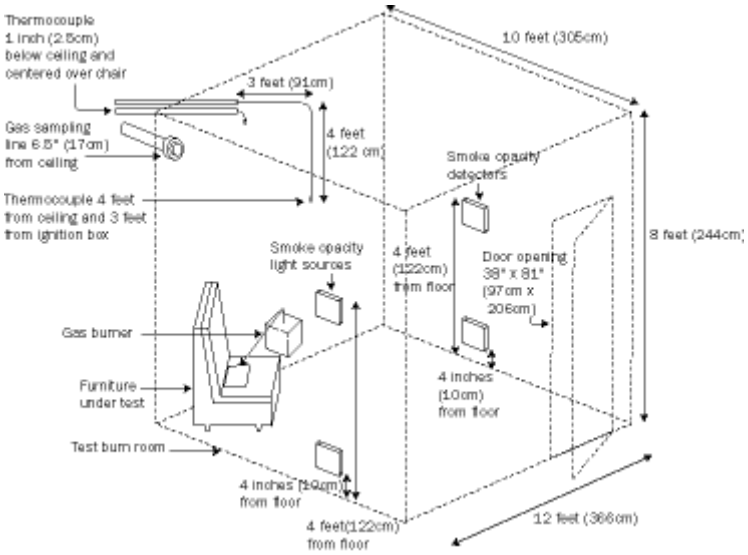
TB 116

This is a voluntary cigarette ignition test for completed items of furniture (or mock ups which simulate a given furniture design) rather than individual fabrics. It requires that lighted cigarettes are placed on all horizontal surfaces which could conceivably support a dropped cigarette - on cushions, arms, base, etc. Three cigarettes are placed in each area, no closer than six inches apart, and a 6" x 6" piece of white cotton or cotton/polyester sheeting fabric is used to cover each cigarette.

A fail is recorded if obvious flaming occurs or if a char develops more than 2" long in any direction from the cigarette.

TB 133

This is another test for completed items of furniture intended for use in "high risk" occupancies - including hospitals, nursing homes, prisons, public areas of hotels, etc. In California it is a mandatory standard in these kinds of occupancy, although there is relaxation of the requirements in areas with sprinklers. The City of Boston has also adopted TB 133, but here it is specified for all non domestic properties and provision of sprinkler systems is not taken into account. The test is very stringent with rigorous pass/fail criteria. It consists of exposing a piece of upholstered furniture to an open flame in a standard room.



The ignition source is a square gas burner placed in the furniture seat, 2" from the back and 1" above the base. The flame exposure time is 80 seconds.

The pass/fail criteria are given below. "Criteria A" were the original parameters and are still acceptable, although "Criteria B" are currently preferred.

Criteria A - A failure is recorded if any of the following occur:- (

i) The temperature measured at the ceiling thermocouple increases by 200oF or more above ambient

(ii) The temperature, measured at the 4ft thermocouple, increases by 50oF or more.

(iii) Greater than 75% opacity at the 4ft smoke opacity monitor

(iv) CO concentration of 1000ppm or more for 5 minutes

(v) Chair weight loss of 3lbs or more during the first 5 minutes.

Criteria B

(i) Maximum heat release of 80kw or greater

(ii) Total heat release of 25MJ or greater in the first 10 minutes

(iii) Greater than 75% opacity

(iv) CO concentration of 1000ppm or greater

Boston Fire Department

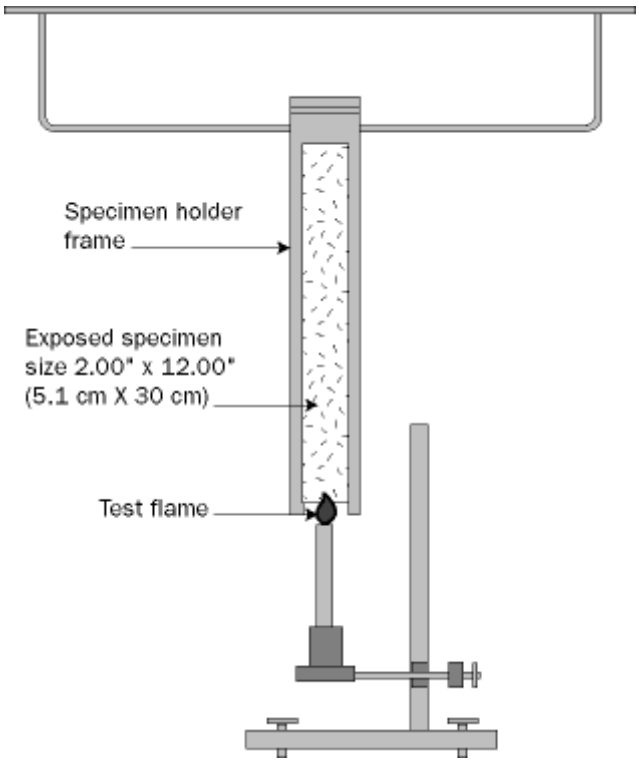
Boston adopted California TB 133 in 1995 which virtually eliminated their previous "Boston Fire Test".

The old Boston Fire Code regulated both the flammability of the chair (using a full-scale chair test with a paper bag filled with newspaper as the ignition source) and of component materials, including

upholstery fabrics. The fabric test (BFD 1X-1) was a vertical open-flame test using a propane flame applied to the specimen for 10 seconds. Afterflame, afterglow and char length were measured.

New York / New Jersey Port Authority Test

Again, California TB 133 is currently in force for all chairs going into its buildings, but there is also an upholstery fabric requirement for a vertical open flame test.



The fabric specimen is suspended vertically and subjected to a 1.5" methane flame for 12 seconds. Afterflame, drip burn and char length are monitored.

Afterflame: max average 15

seconds Drip burn: max average 8 seconds

Char length: max average 8 inches

"Steiner" Tunnel Test - ASTM E-84 T

his test is best used to assess the flammability characteristics of composites - (ie. upholstered panels) - although panel fabric is more often tested by itself. It is a ceiling fire simulation carried out in a 25 feet long and 2 feet wide enclosure - the "tunnel". Test materials are suspended on the tunnel ceiling and subjected to a 4.5 ft long flame for 10 minutes. The rate at which the flame advances is measured and used to produce a calculated value known as the "Flame Spread Index". At the same time, the

opacity of the smoke exiting the chamber is monitored to calculate the "Smoke Developed Index". These two indices are then used by building code officials to classify materials into usage categories.

N.B. The test procedure itself describes neither a classification system nor pass/fail criteria.

The most common classification categories come from the National Fire Protection Association 101 Life Safety Code. There are different requirements for panels listed with Underwriters Laboratories and yet further differences for panels sold to the US government (GSA - General Services Administration).

	Life Safety Code			U.L.	GSA
	Class A	Class B	Class C		
Flame Spread	25 max	75 max	200 max	200 max	25 max
Smoke Developed	450 max			200 max	450 max

In general, panel products are expected to meet Class A requirements, though some occupancies have more relaxed standards.