# Fire Testing of Foams

The following Technical Information Pamphlet (TIP) examines Fire/Flammability Standards relevant to Cross-linked Polyethylene (XLPE) and Ethylene Vinyl Acetate containing foams.

## Introduction

Almost every application that uses XLPE foams has its own Fire standards. Each country's governing safety boards define their own standards. There are some "Internationally recognized" standards that are accepted for a number of fields (even though they were perhaps designated for one particular one), but until a unified "Euro-Standard" (or even, "World-Standard") is accepted, people in industry have to be aware of all of the possibilities that might confront them. There are also a couple of standards that were developed for particular materials and are used (often incorrectly) to test other types of materials. It is important that the customer and manufacturer agree on WHAT EXACTLY IS REQUIRED prior to ordering the wrong material.

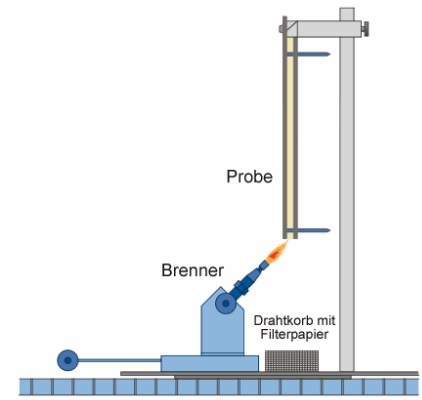
The flame retardant additives that are most often used in XLPE foam materials are Halogenated Hydrocarbons combined with an Antimony Trioxide synergist. Recent European rulings have banned the use of some of these materials and particularly for Electrical and Electronic applications, the terms "RoHS" and "RoHS compliant" are being heard more and more. In reality, these materials are simply free of "Deca-DBE"(and other Polybrominated diphenyl ethers).

Table 1. List of FR standards and applications

| **Standard** | **Country** | **Application** |
|---|---|---|
| Din 4102 B1/B2 | Germany | Construction |
| BS 476 Part 6/7 | UK | Construction |
| Class 1 | Italy | Construction |
| M | France | Construction |
| F | France | Train/Construction |
| M | Spain | Construction |
| UL94 | USA | Electrical |
| FMVSS302 / EC Directive 95/28/EC Annex IV | USA/EU | Automotive |

## DIN 4102 – B1/B2(German)

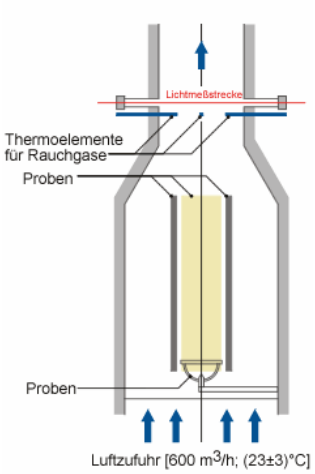
Pipe insulation is one application where DIN4102 is the "standard" fire test




Small fire test - DIN 4102 B2

B2 - The specimen is suspended vertically and a 20mm high flame is applied for 15 seconds to both the foam surface and edge. 5 samples are tested. The production of flaming droplets is determined by a piece of filter paper being placed below each specimen during testing.

A B2 classification is achieved if the tip of the flame does not reach a reference line marked on the foam within 20 seconds (150mm for bottom edge application, 40 and 190mm from the lower edge for face or side application).



Fire shaft test DIN 4102 B1

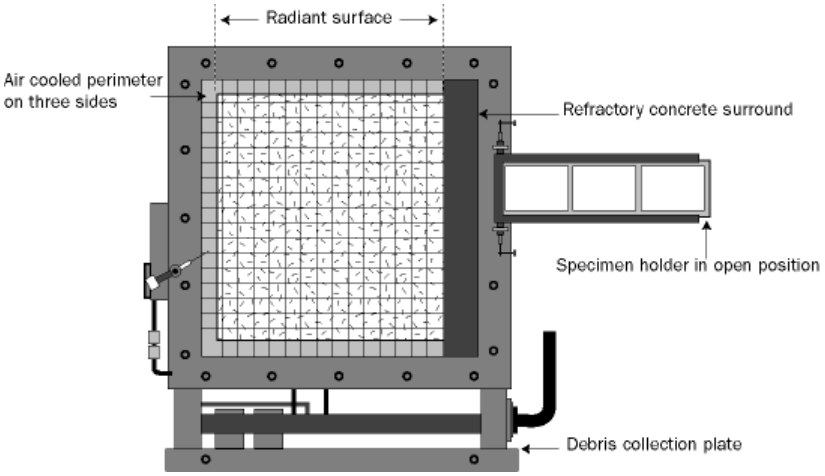
B1- The samples are held vertically in a supporting frame within a square shaped vertical housing (the "Brandschafht", or fire schaft). A gas burner subjects the samples to flames for 10 minutes. At the same time a constant, uniform flow of air is blown into the Brandschacht from below.

In evaluating the test, smoke gas temperature and the length of the specimen which has escaped burning (residual length) are taken into account.

For a B1 classification foam 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.

## BS 476 Part 6/7 (British)

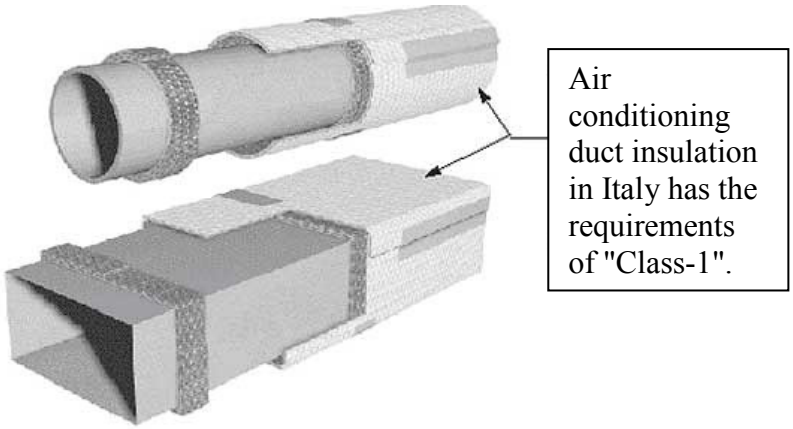
The British "Standard" 476 is actually a series of fire standards. Part 6 and 7 are Surface spread of flame tests (these are to prevent fire spreading to adjoining buildings). These standards are used in construction for the UK, British Commonwealth and countries that were previously part of the British Empire.




**BS 476 Part 7. Surface spread of flame**
This test shows how the spread of flames across the surface of a material gives an indication as to its ability to spread fire.
The sample is mounted in a water-cooled holder and exposed to the radiant panel for 10 minutes with a pilot flame applied for the first minute of the test.
The progression of the flame front is measured after 11/2 minutes and at the end of the test. The test grades material from 1 (best) down to 4 (worst).

**BS 476 Part 6. Fire Propagation**
This test measures the rate of heat release during combustion. Heat release during combustion will affect the rise in temperature of the surrounding un-burnt material and the subsequent rate of spread of fire.
The sample is mounted and subjected to 14 gas jet flames at intervals across the sample width. Two electric heaters generate a high background temperature. The temperature rise is measured using thermocouples and compared with the rise obtained with a standard asbestos cement board specimen.

## "Class 1"- CSE RF 2/75 A / CSE RF 3/77 - Surface application and spread of flame test ( Italy)




To achieve an overall classification a small burner ignitability test (CSE RF 1/75 A or CSE RF 2/75 A) must be conducted together with a surface spread of flame test (CSE RF3/77). The results of both tests are then used to determine an overall classification, from Class 1 (the best) to Class 5.

CSE RF 2/75 A uses surface application of a small flame for 30 seconds. 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:

CSE 3/77 – Surface spread of flame test
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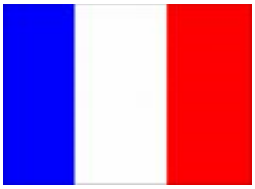
The sample is exposed to a small pilot flame and radiant panel. The position of the sample is varied to simulate end use in floors, walls and ceilings. Parameters measured are the rate of spread of flame, extent of damage, afterglow and flaming droplets, which are again divided into three grades.

The category on which classification is based is worked out by multiplying the different grades with various weighting factors, which for flaming droplets are distinguished between floor, wall and ceiling use. The categories from the different tests then form the basis for classifying products.

## "M" Class- NF P 92 503/NF P 92 504/ NF P 92 505 + "F" tests - STM S-001 (France)

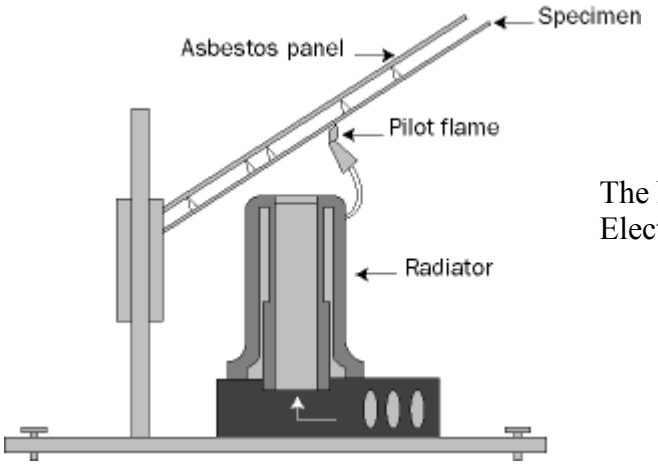


NF P 92 510 Determination of upper calorific potential
NF P 92 503 Electrical burner test used for flexible materials 5 mm thick or less

Complementary tests:
NF P 92 504 Speed of spread of flame test used for the materials which are not intended to be glued on a rigid substrate
NF P 92 505 Dripping test with electrical radiator, used for melting material

STM S-001 (Smoke):
NF X 70 100 Analysis of pyrolysis and combustion gases
NF X 10 702 Determination of the smoke opacity in a non-renewed atmosphere

## "M Class" – Construction




The NF P 92-503
Electrical burner test

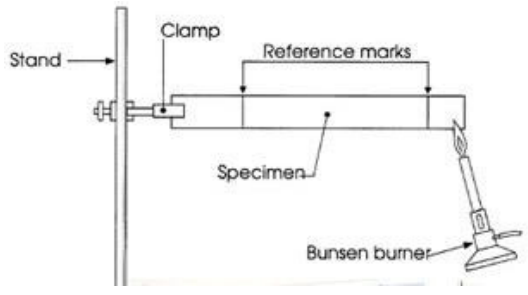
The French test known as the "Breleur electrique" - electric burner - is the principal method used not only in France, but also in Belgium, Spain and Portugal. It results in a classification of M1 to M4, with M1 being the highest classification.

The sample is placed face down on the test rig at an angle of 30$^{o}$ above an electric radiator which gives out heat. A small butane gas pilot flame is applied directly to the foam 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 | |



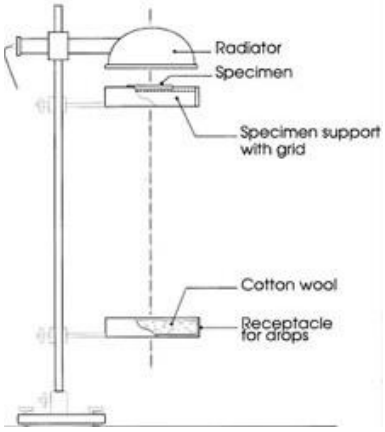

The NF P 92-504 Bunsen burner Test for Small-ignition Source Flammability.

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

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 |




The NF P 92-505 Dripping Test
The "reaction to fire" tests classify the material in 5 categories from M0 to M4. The specific standard that is applicable depends on the intended use (see table below). Class M0 is assigned if the requirements for class M1 are met and the heat of combustion (upper calorific potential test by NF P 92-510 does not exceed 2500 kJ/kg (typical M0 material are concrete, blaster, mineral based product). To determine the classifications M1 to M4 and NC, series of test is conducted.

## "F" Class – Railway/ Construction

Railroad tunnel insulation requires both fire and smoke standards to be tested.

## Smoke parameters

The "smoke" parameter, as described in the standard is obtained from the combination of "smoke emission" and the "toxicity index".
The first one is evaluated by the NF X 10-702 (Smoke Density Chamber) and the second one with NF X 70-100. The assessment of smoke toxicity is focused on CO, $CO_2$, HCl, HBr, HF, HCN, and $SO_2$. The toxic analysis can be tested with the ionic chromatography.

According to NF 16101, the combination of these two parameters gives the "smoke value" with classes from F0 to F5.

The Smoke Density Chamber (ASTM E 662 in USA) is used widely in testing of transportation.
This apparatus measures smoke generation from small, solid specimens exposed to a radiant flux level of 25 $kW/m^2$ in a flaming (piloted ignition) or non-flaming mode. The smoke produced by the burning specimen in the chamber is measured by a light source - photometer combination. The attenuation of the light beam by the smoke is a measure of the optical density or quantity of smoke that a material will generate under the given conditions of the test.

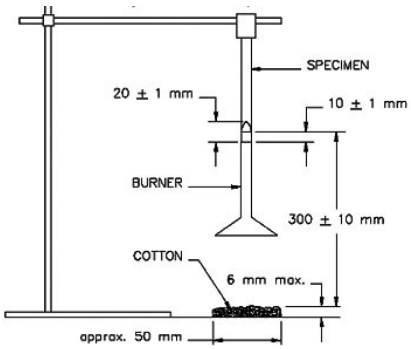
## "M1" - UNE 23.727-90 Reaction to fire test for building materials (Spain)

The test methods used are similar to those used in France. Besides,
the calculation mode according to the NF P 92-501 test of the M value differs from the French methodology. The tests are comparable but results and their extrapolations are quite different.

The test classifies the material in 5 categories from M0 to M4 on Flexible materials with a thickness < or = to 5 mm:

| Test | Description |
|---|---|
| UNE 23.723-90 | Reaction to fire test on building materials /electrical burner test |
| UNE 23.724-90 | Reaction to fire test on building material / Speed of the spread of flame test |
| UNE 23.725-90 | Reaction to fire test on building materials / Dripping test with electrical radiator |
| UNE 23.726-90 | Floorings: Reaction to fire test on building materials / Radiant panel test |

## UL94 - Determination of the relative flammability and for evaluating the dripping of plastics used in electrical & electronic equipment. (USA)




UL94 V0/V1/V2

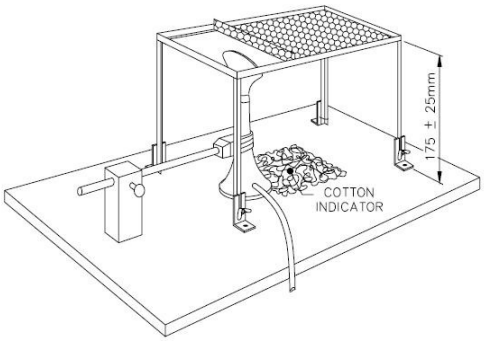
The standard classifies plastics according to how they burn in various orientations and thicknesses. From lowest (least flame-retardant) to highest (most flame-retardant), the classifications are:

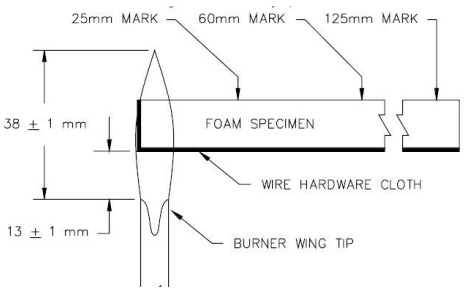
- **V2** burning stops within 30 seconds on a vertical specimen; drips of flaming particles are allowed.
- **V1**: burning stops within 30 seconds on a vertical specimen; no drips allowed.
- **V0**: burning stops within 10 seconds on a vertical specimen; no drips allowed

Tests are generally conducted on a 5" x 1/2" specimen of the minimum approved thickness

There are other classifications that apply to low density foam materials (HF-1, HF-2, HBF). These tests are done horizontally on foams with a density of less than 250kg/$m^3$.

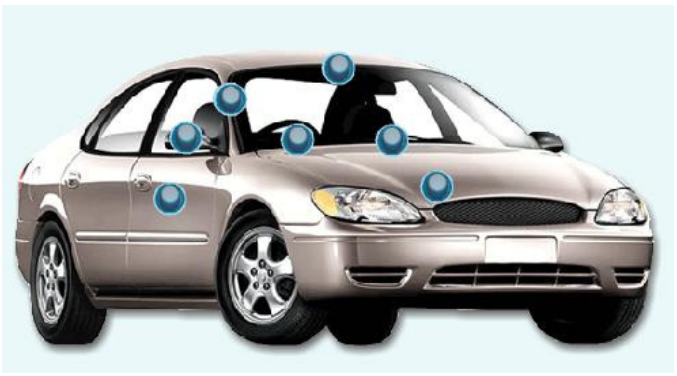
Test specimens, 150 x 50 mm, are each marked at 25 mm, 60 mm and 100 mm intervals from one end. Each specimen is supported horizontally with a wire gauze and the end closest to the 60 mm gauge mark is exposed to a specified flame from a wing tip burner for a period of 60 seconds. The time for the flaming or glowing front to travel between the 25 mm mark and the 125 mm mark, or when burning ceases is
recorded, and the extent of burning is measured. After flame / afterglow and the occurrence of flaming particles are also recorded.




Materials classified HBF shall not have any specimens with a burning rate exceeding 40 mm per minute over a 100 mm span, or cease to burn before flaming or glowing reaches the 125 mm gauge mark. Materials classified HF-1 and HF-2 require self-extinguishing < 2 secs and after-glow < 30 secs. HF-1 also requires that a cotton wool indicator placed under the test sample is not ignited by burning drips.

**FMVSS302 / EC Directive 95/28/EC Annex IV / ISO 3795 – Automotive (VARIOUS)**



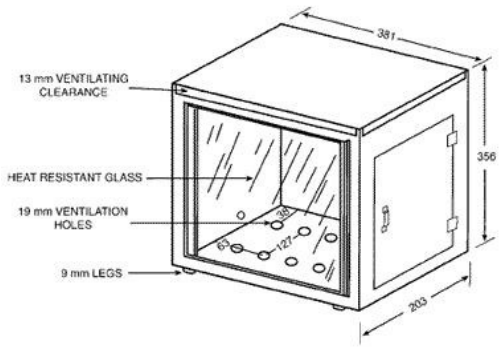
XLPE foam is used in large quantities in the automotive industry. In a car, Headliners, Watershields, Dashboards, Mirror gaskets, Door panels and Air conditioning vents are often made of XLPE foam. The standard fire test is FMVSS302 (or its Euro equivalent)

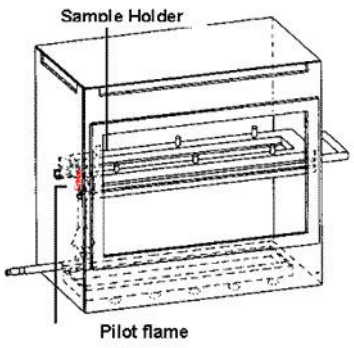
FMVSS302 is probably the easiest of fire tests to both carry out and to comply with. The idea that Flame retardant materials are used in a car is limited to allowing the person traveling, to exit the car in enough time, in the event that a fire breaks out. The "100mm/min" burn rate is deemed enough for most automotive applications that are not in the direct vicinity of the engine or high output electric equipment.

Complete test
5 tests: 8 test specimens, with the dimension 100 mm x 356 mm up to 12.5mm thick

Indicative test
2 test specimens, with the dimension 100 mm x 356 mm up to 12.5mm thick.

The test is conducted inside a test chamber where the test specimen is mounted horizontally. The exposed side of the test specimen is subjected to a gas flam from underneath. The burnt distance and the time taken to burn this distance is measured during the test. The result, the burning rate, is expressed in mm/min.



The test is conducted in a metal cabinet for protecting the test specimens from drafts. The interior of the cabinet is 381 mm long, 203 mm deep, and 356 mm high. It has a glass observation window in the front, a closable opening to permit insertion of the specimen holder, and a hole to accommodate tubing for a gas burner.
The test specimen is inserted between two matching U-shaped frames of metal stock 25 mm wide and 10 mm high. The interior dimensions of the U-shaped frames are 51 mm wide by 330 mm long.A specimen that softens and bends at the flaming end is kept horizontal by supports consisting of thin, heat-resistant wires, spanning the width of the U-shaped frame under the specimen at 25 mm intervals.
A Bunsen burner with a tube of 10 mm inside diameter is used. The gas-adjusting valve is set to provide a flame, with the tube vertical, of 38 mm in height. The specimen is oriented so that the surface closest to the occupant compartment air space faces downward on the test frame.

**Palziv Materials – FR tests**

| Material | Thickness mm | Standard |
|---|---|---|
| GA25FRH | 10 | UL 94 HF-1 |
| GA25FRH with Adhesive | 3,5,10,15,20 | M1 |
| GA25FRH with Adhesive | 10,15,20 | M1 |
| GA29FRG(f) | 5,10,15,20 | M1 |
| GA29FRG(f) | 5,10,15,20 | F2 |
| GA65HDBFR | | F1 |
| GA40TFR | | F1 |
| GA25FRH | 4,10 | M1 Spain |
| GA25FRH | 3,15 | M1 Spain |
| GA300FR | 15, 5 | DIN 4102-1 B2 |
| PA25FRB | 7 | DIN 4102-1 B2 |
| GA29FRI | 10,20 | Directive 95/28/EC |
| GA25FRH | 6, 10 | DIN 4102-1 B1 |
| GA29FRG | 5,15 | Class 1 |
| GA29FRG w/alu | 5,15 | Class 1 |
| GA29FRG | 12.7? | ASTM E84-1 Class 1 |
| GA29FRI | 10 | IEC 60707/UL 94 - HBF |
| GA36FRG w/alum | 19 | BS476-7 |
| GA29FRG w/alum | 19, 13 | BS476-7 |
| All GA/PA 25kg/$m^3$ or more | 5mm or more | FMVSS302 |
| PA300FR | 22 | UL 484 HF-1 |
| PA400FRB | 7 | DIN 4102-1 B2 |
| PA300FR | 1.5 | UL 94 V2 |
| PA220FR | 12.5 | UL 94 HF-2 |
| GA25FHZ | 8 | FAR 25.853 |
| GA25FHZ | 3-15 | M1 France |
| GA29FRF | 12.5 | FAR 25.853 |

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