Fire Protection for Plastics

Comments on the following documents:

These documents are to be regarded as general information on fire protection. The writer accepts no liability for their completeness or accuracy.

The information for this compilation originates from:

- Folder “Masterbatch Symposium 2000” by Clariant
- Folder “Brandschutz für Kunststoffe 2001” by Dr. Jürgen Troitzsch
- “Kunststoffpraxis: Eigenschaften”, published by Fachverlag für technische Führungskräfte

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1. Flame retardants

1.1 Types of flame retardant

Types	Names	Uses	Advantages / disadvantages
Halogen flame retardants	- Chloroparaffin - Bromine compounds (aliphatic, aromatic)	- For all plastics, especially where the requirements are very high e.g. B1 and V-0.	Disadvantage: - Harmful to the environment - Banned from use in certain fields
Phosphorous flame retardants	- Red phosphorous - Polyphosphate (Ammonium polyphosphate) - Organophosphorous compounds	- Essentially for all plastics - Good alternative to halogen flame retardants.	
Hydroxide flame retardants	- Aluminium hydroxide - Magnesium hydroxide	- Primarily for inherently slow-burning plastics - In situations where the level of flame protection required is not very high. → Aluminium hydroxide: PVC, PE, thermosetting plastics such as SMC, especially at low processing temperatures. → Magnesium hydroxide: PP, PA, higher processing temperatures (higher temperature stability)	Advantage: Very environmentally friendly
Intumesent flame retardants	- Mixture of phosphorous and nitrogen compounds with special propellants		

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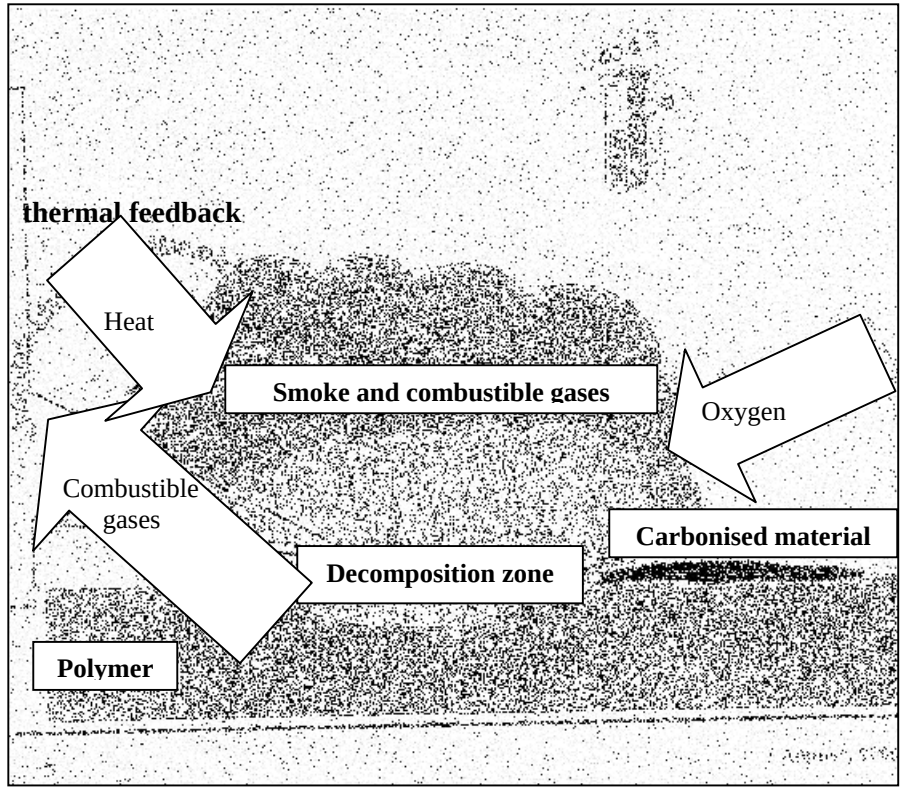
1.2 Actions of the different types of flame retardant

A) Halogen flame protection additives:

→ Halogen flame protection additives act with a chemical reaction in the gas mixture in the region of the flame

- Halogen radicals are released from the flame protection additive
- The highly reactive radicals which occur in the combustion are neutralised
- The highly exothermic radical chain mechanism is interrupted



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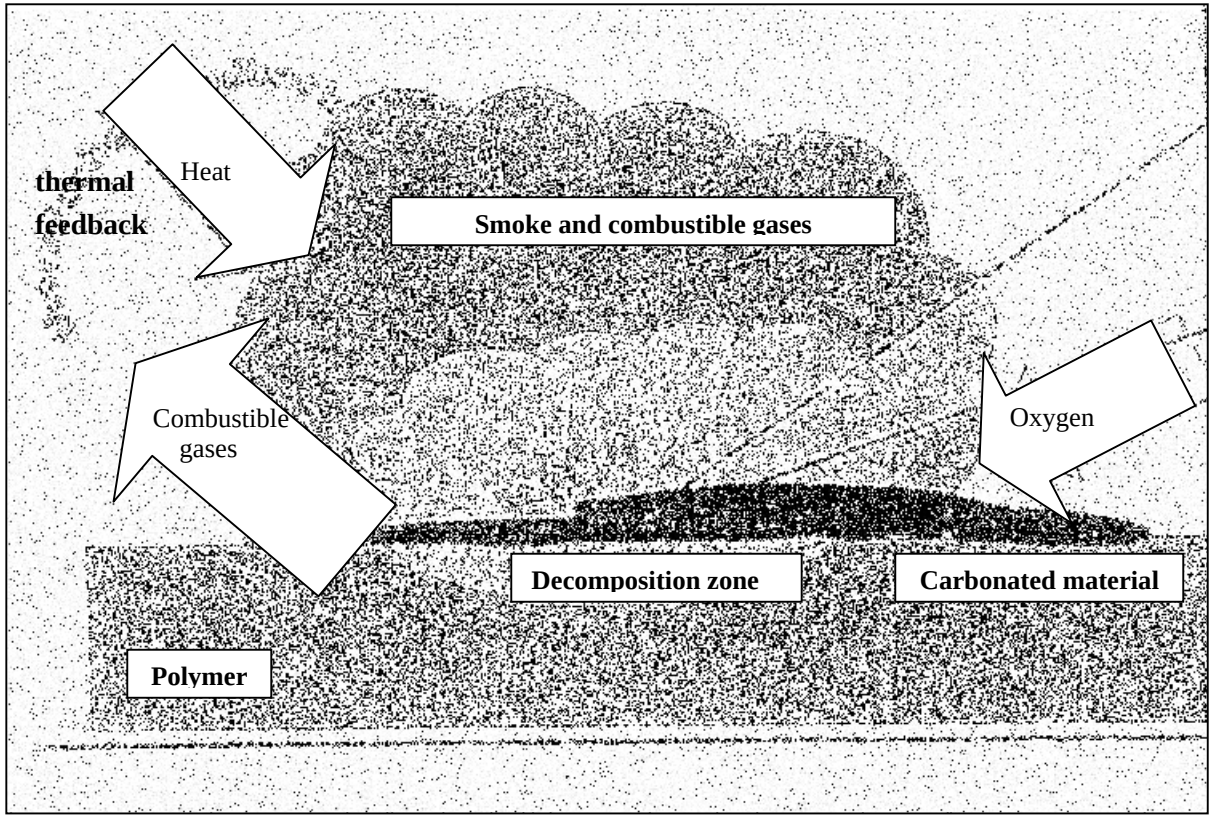
B) Phosphorous flame protection additives:

→ Phosphorous flame protection additives act on the polymer surface

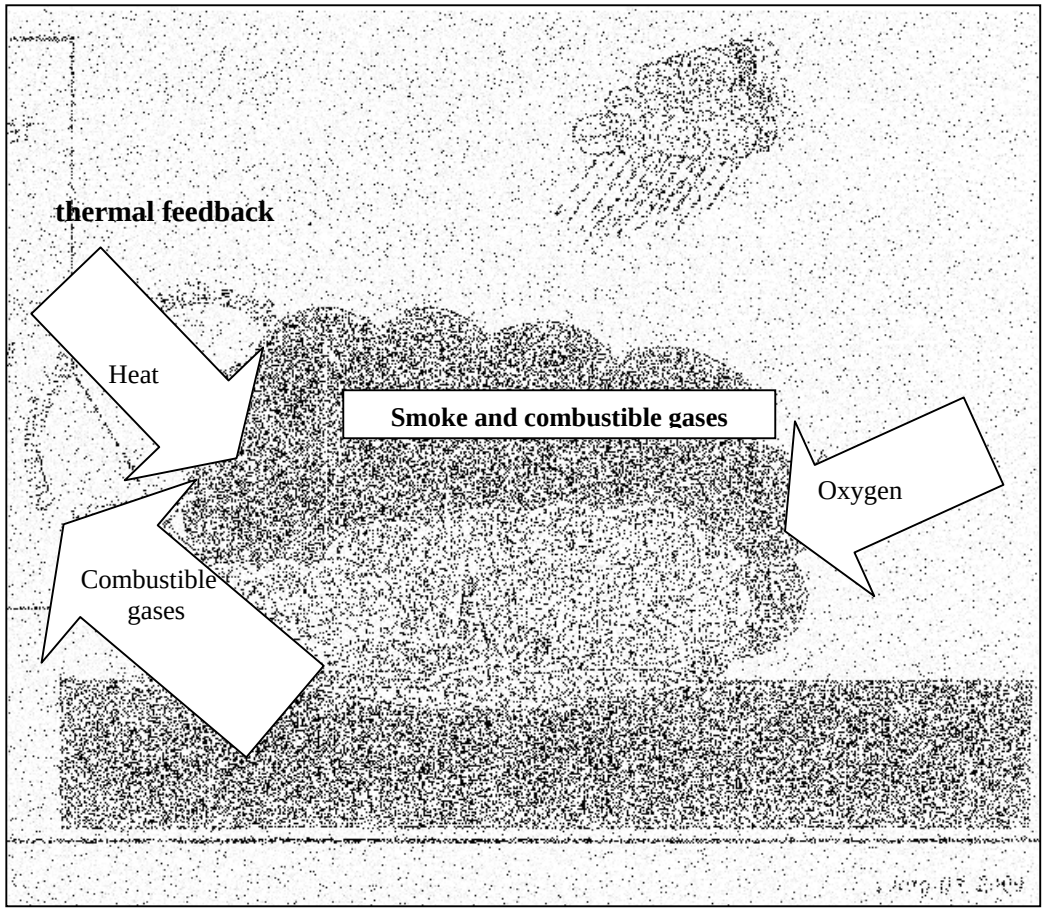
- Polyphosporic acid is released from the flame protection additive
- Polyphosporic acid promotes carbonisation, the escape of combustible material is reduced
- A protective layer is formed which reduces the escape of gases and impedes return heat flow



C) Hydroxide flame retardants:

→ Aluminium hydroxide and magnesium hydroxide release water while absorbing energy

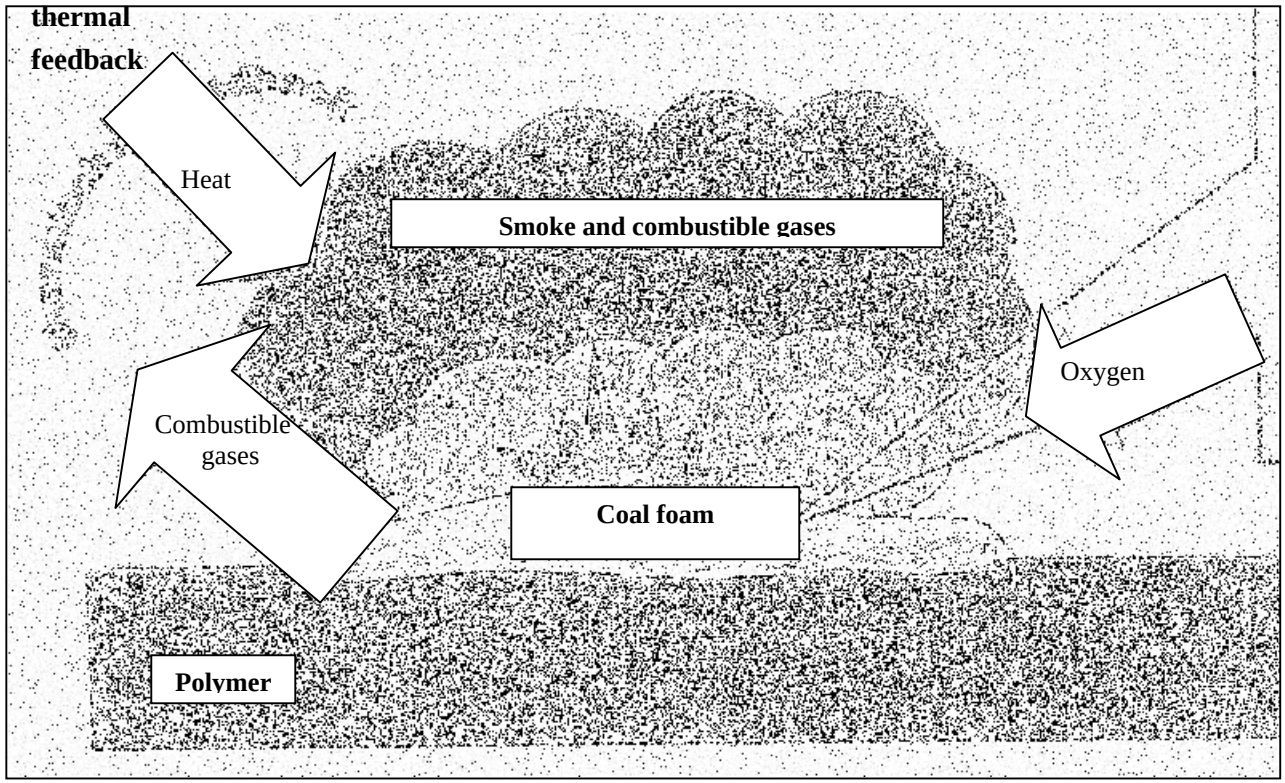
- The energy consumed brings a degree of cooling to the decomposition zone
- The resulting water vapour dilutes the flammable reaction gases
- In addition an insulating protective layer is formed



D) Intumesent flame retardants:

→ Intumesent systems act on the polymer surface

- The flame protection additive turns into a bulky protective layer. Carbonisation reduces the escape of combustible material
- The insulating protective layer impedes return heat flow and impedes the escape of gases.



1.3 Advantages and disadvantages of flame retardants

Advantages	Disadvantages
- Worldwide use of the products possible - Opening up new markets -The greater the level of fire protection, the lower the insurance premium - Less building equipment required (sprinklers, smoke detectors) - Image gain thanks to additional product safety	- No approval for foodstuffs use possible - High price - Finished components may give off odours - Reduction in mechanical properties - Need to buy in ready coloured raw material - Processing and recycling is more dangerous (gas formation) - Mould cleaning due to build-up of deposits - In some cases special hot channel systems

1.4 Future prospects for flame retardants

- Flame retardant market share increasing by over 5% per annum

- Fire protection requirements increasing (EU / USA)

- Prohibition of halogen flame retardants (building and electrical sector) make material selection more difficult

- No new flame retardant developments → too expensive

2. Standards and flame protection categories

2.1 Swiss building construction code (Building materials)

Combustibility category BKZ X.X

- Building materials are classified into combustibility categories of 3 to 6 according to their burning behaviour.
- Materials that are highly flammable and burn away very quickly (combustibility categories 1 and 2), are not classified as building materials.
- *Flammability and combustion rate are the decisive factors for assessment of combustibility categories.*

Classification	
3	easily combustible
4	moderately combustible
5	hardly combustible
5 (200°C)	hardly combustible at 200° C
6q	virtually non-combustible
6	non-combustible

Smoking behaviour

Building materials are classified into smoke categories 1 to 3 according to their smoking behaviour.

Smoke category
Light absorption is the decisive factor for assessment of smoke generation.

Classification

1 dense	maximum light absorption over 90%
2 moderate	maximum light absorption over 50% to 90%
3 low	maximum light absorption 0% to 50%

Fire class

The **fire class** is composed of the **combustibility category (first figure)** and the **smoke category (second figure)** determined in the tests, e.g. fire class BKZ 4.3.

Note:

Prolongation of fire protection approvals for building materials:
Test certificates submitted for the prolongation of a fire protection approval must not be more than one year old!

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Building components

- The behaviour in fire of building components is designated principally by their fire resistance time. This is the minimum time in minutes for which the building component must fulfil its designated requirements.
- Building components are allocated to classes F, T, R, K, S, A and marked in accordance with their fire resistance time.

		Fire resistance classes
F	Load-bearing and room-dividing building components	F 30bb, 30, 60, 90, 120, 180, 240
T	Moveable elements such as doors and gates	T 30, 60, 90
R	Smoke and flame-proof closures	R 30, 60
K	Fire protection dampers	K 30, 60, 99
S	Fire walls	S 30, 60, 90
A	Elevator shaft doors	A 30, 60

Source of information

Vereinigung Kantonaler Feuerversicherungen VKF
Swiss Coordination Office for Fire Protection

Bundesgasse 20, Postfach, 3001 Bern
Telephone 031 320 22 22
Fax 031 320 22 99
E-mail mail@vkf.ch

Reference work: Brandschutzregister

2.2 The most important standards and flame protection classes for construction / transport

Product	Country	Designation
Building materials and building components	Germany	DIN 4102 / A / A1 / A2 / B / B1 / B2 / B3
Building materials and building components	Austria	ÖNORM 3800 Part 1 / B, B1, B2, B3
Building materials	France	NFP 92-501 / M0, M1, M2, M3, M4, M5
For (electrotechnical) components in appliances und products	USA	Underwriter Laboratories – UL 94 / V0, V1, V2, HB
Motor vehicle passenger compartment components	USA	FMVSS 302
Electrotechnical products		VDE 0471 Part 2 – 1 = DIN IEC 695 Part 2 – 1 / Temperature information
Upholstered furniture	UK	BS 5852 7 Crib 4, 5, 6, 7
Test method for solid and liquid fuels		DIN 51900-1
Standard test method for measuring the minimum oxygen concentration to support candle like combustion of plastics		ASTM D 2863
Plastics; determination of temperature of deflection under load		ISO 75-1
Railway standard		DIN 5510 S 1- 4 SR 1- 2 ST 1 – 2

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2.3 Summary of standards

11.6 Standards, Directives,
Regulations, Laws

5/11.6.5 Fire Protection

Standards and Directives	Title
DIN VDE 0304-3	Glowing rod test, class, (identical to IEC 707-BH)
DIN VDE 0471	Glow-wire ignitability test, (identical to IEC 695-2-1) TI.2.2
DIN VDE 0471	Needle flame test, (small burner test), (identical to IEC 695-2-2)
DIN EN ISO 1043-4	Plastics - symbols and abbreviations – flame retardants
DIN EN 2310	Aerospace industry - Test procedures for classification of the fire behaviour of non-metallic materials
DIN 4102	Behaviour in fire – building material classification - containing the following building material classes
A	Non-combustible
..A1	Non-combustible
A2	Non-combustible
..B	Combustible
..B1	Hardly inflammable
..B2	Normally inflammable
..B3	Highly inflammable
DIN EN ISO 9773	Plastics - determination of fire behaviour of thin, flexible vertical test pieces -
DIN 12 925	Storage of flammable liquids
DIN 53438	Ignition with small burner, (wall thickness), fire class
DIN EN 60695-1	Test methods for assessing the fire hazard of electrotechnical products - Corrosion caused by the conflagration gases -, (IEC 695-5-1993) -
DIN EN 60695-2	Test methods for assessing the fire hazard of electrotechnical products – Definitions for fire testing – (identical to VDE 0471-4)

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Note:
Of these test methods for materials, the most commonly used is the combustibility test in accordance with UL94 as this is in common international use.
When testing finished components, the glow-wire ignitability test is of particular importance.

11.6 Standards, Directives, Regulations, Laws

Standards and Directives	Title
DIN EN 6075-1 to -3	Classification of environmental conditions
DIN 75200	Determination of the behaviour in fire of materials used for motor vehicle interiors (largely identical to MVSS 302 and ISO 3795-1976
VDE 0427	Tests on cables and insulated wiring, (TI 308, 502, 804, 814, 815)
VDE 0470	Glowing rod (identical to CEE 7)
VDE 0472-813	Corrosiveness of conflagration gases
TVbF	Technical rules for inflammable liquids

EU and international directives

Directives	Title
ISO 3795-76	see DIN 75200
ASTM D 635-75	Combustibility in accordance with ASTM, also known as LOI (Limiting Oxygen Index) test
ASTM E 662-83	Smoke gas density
ASTM D 2863-77	Oxygen index (details in %)
IEC 695-2-1	see DIN VDE 0471
IEC 695-2-2	see DIN VDE 0471
IEC 707	see UL 94
IEC 707-BH	see DIN VDE 0304
FMVSS 302	Combustibility regulation for the USA for the automobile industry (combustion speed, depending on wall thickness)
UL 94 (IEC 707)	Underwriters Laboratory (USA) various fire classes, depending on test piece thickness
ATS	Airbus Industrie fire testing regulation
BSS	Boeing fire testing regulation
FAR	International fire testing regulations in the aviation industry
IMO/Solas	International fire testing regulations in the commercial maritime industry

Note:
Of these test methods for materials, the most commonly used is the combustibility test in accordance with UL94 as this is in common international use.
When testing finished components, the glow-wire ignitability test is of particular importance.

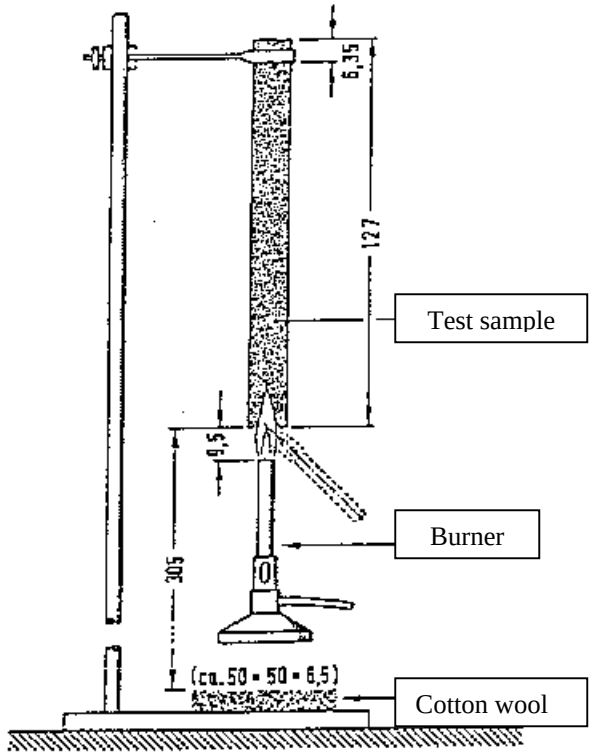
3. Tests on the burning behaviour of plastics

3.1 Test criteria UL 94, classes V-0, V-1, V-2 in the electrotechnical / electronic industries

Class V-0:
- Afterburning < 10 s
- Sum of the afterburning times for 10 ignition procedures max. 50 s
- No burning drips
- Afterglow max. 30 s

Class V-1:
- Afterburning max. 30 s
- Sum of the afterburning times for 10 ignition procedures max. 250 s
- No burning drips
- Afterglow max. 60 s

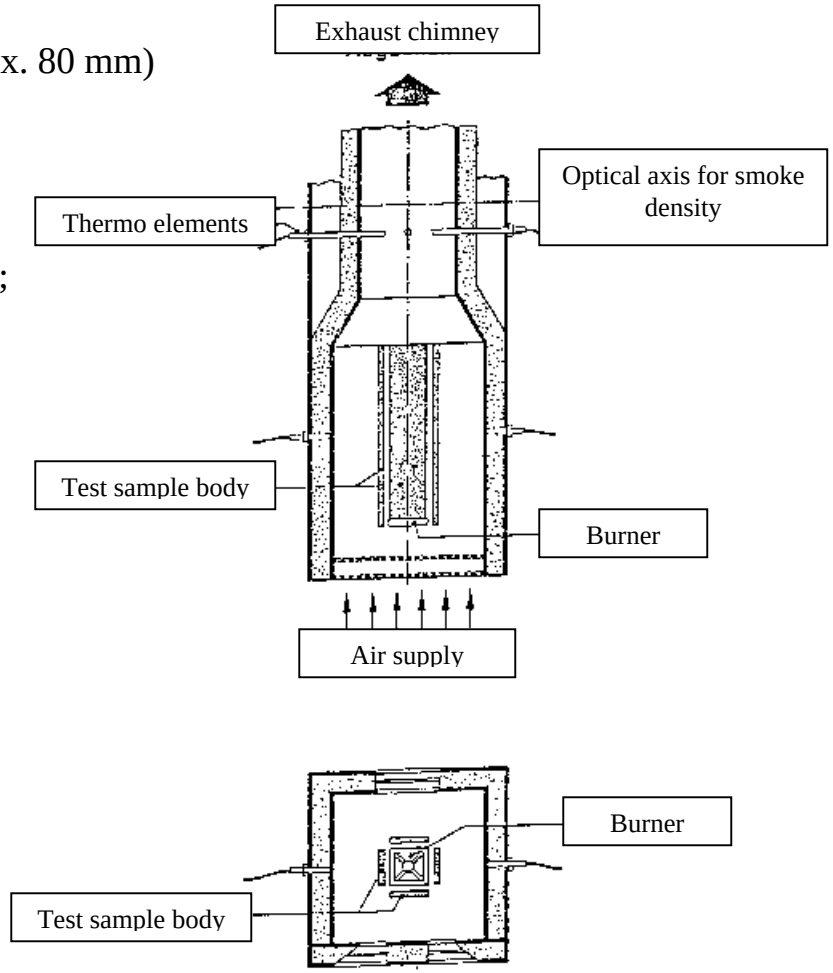
Class V-2:
- Afterburning max. 30 s
- Sum of the afterburning times for 10 ignition procedures max. 250 s
- Cotton wool ignition caused by burning drips
- Afterglow max. 60 s



3.2 Test criteria “Brandschacht test” DIN 4102 part 1

Test pieces:	4 samples 190 mm x 1000 mm x original thickness (max. 80 mm)
Test arrangement:	Vertical, samples at right angles to one another
Ignition source:	Ring burner
Test time:	10 min.
Result:	The test is passed if:

- Mean value of the residual lengths is at least 150 mm; No sample has a residual length of 0 mm
- Mean exhaust gas temperature does not exceed 200°C
- No other doubts exist



“Brandschacht test” in accordance with DIN 4102 Part 1

3. 3 Classification and test procedure for building materials according to DIN 4102 part 1

Building material class		Building inspection designation	Test procedure
A	A1*	Non-combustible	- Oven test 750°C - “Brandschacht test” - Optical density of smoke in accordance with ASTM D2843-70 or DIN E53436/37 - Toxicity in accordance with DIN E 53436 - Calorific value according to DIN 51900 part 2 and generation of heat according to DIN 4102 part 8 (draft) or oven test 750°C
B	B1**	Combustible, hardly inflammable	- “Brandschacht” and small burner test special case floor coverings Radiant Panel Test (NBSIR 75- 950) and small burner test (DIN 54332)
	B2	Normally flammable	- Small burner test - Special case floor coverings (DIN 54332)
	B3	Easily inflammable	- No testing

4. Checklist for the use of flame protection materials

→ Which standard has to be fulfilled?
→ Is there a specific national or regional standard / requirement?
→ Does this standard call for building component tests?
→ Does the schedule situation allow for additional tests?
→ Are the components subject to impact stress?
→ Is the fire protection used together with UV stabilisation?
→ What is the target price for these components with flame retardant (or what savings can be made with this finish in respect of insurances / fire protection equipment)?
→ Do the fire fighting facilities call for design measures on the component (such as holes for fire-fighting water)?
→ Do the fire protection requirements have to be fulfilled in combination with other additives such as UV stabilisers or with electrically conductive material, etc, and what requirements have to be fulfilled in this respect?
→ Does the component have to be suitable for foodstuffs use?

5. Previously realised projects with flame retardant

Stadium seat

PP-Polifor 5020:
DIN 4102 B1
Mat. PA6:
DIN 4102 B1 / BKZ 5.3 (2)

Backrest shell

PC/ABS
DIN 5510 / BKZ 5.3 (2)

Tray with Container

Container: PP-Polifor
Tray: ABS
UL94 V0

Cover

ABS
UL94 V0

6. Other sources of information:

Brochure	Description of the contents	Association / Address
Brand Aktuell	Plastics and fire on the building site	Verband Kunststofferzeugende Industrie E. V. Karlstrasse 21 D-6000 Frankfurt / Main 1 Tel. ++49 69 25 56 303 / 310 http://www.vke.de/ info@vke.de
Kunststoffpraxis: Eigenschaften	General overview of plastics characteristics	Fachverlag für technische Führungskräfte
VKF Vereinigung Kantonaler Feuerversicherungen	Information on requirements in Switzerland	Vereinigung Kantonaler Feuerversicherungen VKF Bundesgasse 20 Postfach 3001 Bern Telephone 031 / 320 22 22 Fax 031 / 320 22 99 http://www.vkf.ch/ mail@vkf.ch
Folder Brandschutz für Kunststoffe 2001	Course documentation	Dr. Jürgen Troitzsch
Brandverhalten von Baustoffen	Information on requirements in Germany	Otto-Graf Institut, FMPA Pfaffenwaldring 4 70569 Stuttgart Department 16: Brandverhalten von Baustoffen Brandverhalten von Baustoffen Department Head: Dr. S. Lehner Tel. +49 711 / 685-2713; Fax: -6724 http://www.fmpa.de/deutsch/Startseite_deutsch_frame.html
“Kunststoffe, Brandschutz und Flammschutzmittel”	Fire protection information	SKZ Tagungsbuch