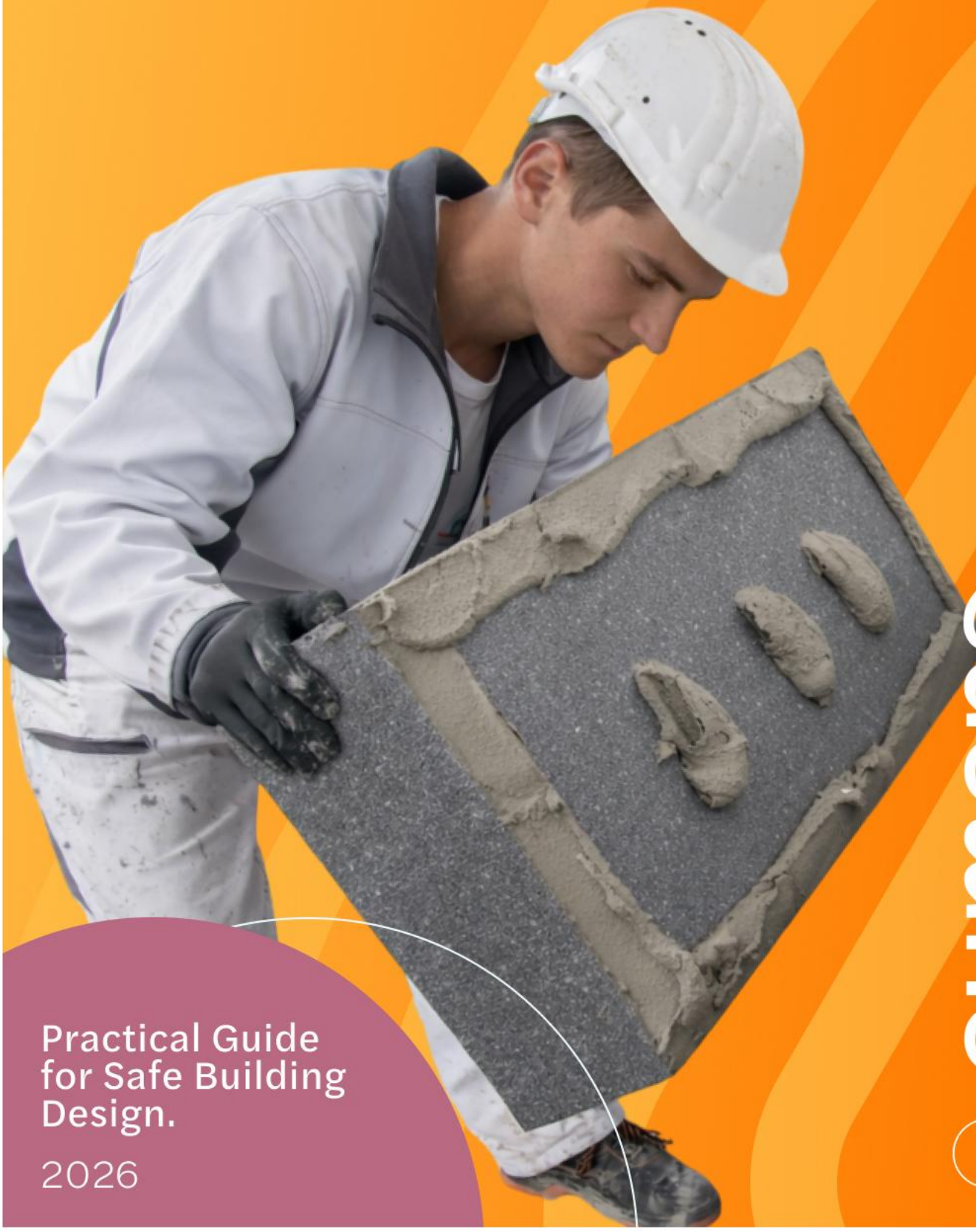
EPS Insulation and Fire Behaviour



Practical Guide for Safe Building Design.

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General information



Credit: eumeps.

Insulation materials made from EPS rigid foam are safe and proven construction products. In the building sector, they are primarily used as insulating materials for thermal and/or impact sound insulation, as well as for cold insulation in technical installations.

This "Insulation Practice – Fire Behaviour" primarily refers to EPS rigid foam products in accordance with EN 13163 1[1], which are used for thermal and/or impact sound insulation in walls, ceilings, floors, and roofs in both residential and non-residential construction.

EPS rigid foams are organic materials and therefore combustible—similar to wood and other natural products. Most EPS insulation sold in Europe is manufactured with self-extinguishing additives. The main purpose of this additive is to comply with fire safety regulations and laws.



EPS insulation used in an ETICS. Credit : BASF.

Self-extinguishing EPS shrinks in the presence of heat and combustion stops when the ignition source is removed. When relevant design and installation guidelines are properly observed, the fire safety of EPS under fire conditions is fully ensured.

[1] EN 13163 – Thermal Insulation Products for Buildings – Factory-Made Products of Expanded Polystyrene (EPS) – Specification

Fire resistance properties

Ignitability and fire propagation

Insulation materials made of EPS rigid foam begin to soften gradually at temperatures above 80°C. With continued heating, the material melts. Upon prolonged thermal exposure, the melt releases gaseous, combustible decomposition products that, under fire conditions, form flammable gases at temperatures above 350°C.

In the absence of an ignition source, these thermal decomposition products self-ignite at temperatures ranging from 450 °C to 500 °C. Up to this range, EPS rigid foam is not self-igniting, nor can it sustain smouldering combustion.

Characteristics	EPS-FR temperature	EPS non-FR temperature
Softening, shrinking, melting	>100°C	>100°C
Ignition temperature with pilot flame	370°C	350°C
Self-ignition temperature	500°C	450°C

When briefly exposed to an ignition flame (e.g., a match), flame-retardant EPS rigid foam shrinks away from the flame source without igniting. Only with prolonged flame exposure to the molten material can ignition occur; however, the flame spread rate remains low, and combustion is confined to the surface layer of the foam.

Once the external flame is removed, no sustained burning, afterburning, or glowing combustion is observed. The fire behaviour of white and grey EPS rigid foams is identical.

Only when EPS is directly exposed to other combustible materials (for example, as part of a system that adversely affects the overall fire performance), or during a fully developed fire with extremely high thermal loads, flame-retardant EPS will completely combust.

Heat of combustion

The heat produced by the combustion of the material is one of the factors that determine how a fire develops. This is why fire load is often one of the prevention criteria and must be calculated during the design phase. The calorific value of EPS per kilogram is 40 MJ/kg, i.e. twice that of wood products at around 20 MJ/kg.

However, 98% of the volume of EPS is air, giving the product a typical density of 15-20 kg/m3, which translates into a low contribution to the overall fire load.

The table below[2] shows the small difference in the contribution to the fire load by different insulation materials compared with different parameters.

[2] "Research in the causes of fire", Prager, F.H., Cellular Polymers nr. 20-3 / 2001

Material	Thermal conductivity λ (W/mK)	Density ρ (kg/m3)	Heat of combustion H (MJ/kg)	Fire load/m3 Qv (MJ/m3)	Fire load/M2 Identital R-value Q (MJ/m2)
EPS	0,035	20	39,6	792	92
XPS	0,040	32	39,6	1.267	169
MW	0,045	170	4,2	714	107

Gas emissions

The composition of fire gases depends on the type of fuel, the air supply, the combustion temperature, and the duration of the fire. Of the approximately 5000 toxic components currently known in fire smoke, the following substances are relevant for the acute treatment of smoke poisoning:

- Carbon monoxide;
- Hydrogen cyanide.



External grey EPS insulation in Brussels. Credit: eumeps.

Especially due to the use of nitrogen-containing organic substances such as wool and various plastics, among others, in residential furnishings, offices, factories, cars, or airplanes, increasing amounts of hydrogen cyanide are released alongside carbon monoxide and lung irritants. These are identified as rapidly lethal respiratory toxins. During the combustion of EPS rigid foam, neither hydrogen cyanide nor formaldehyde vapours are produced.

The toxicity of fire and smouldering gases cannot be assessed solely based on the composition of individual components. Biological studies of acute inhalation toxicity have shown that the fire and smouldering gases developed by EPS rigid foam can be toxic, as is the case with the decomposition of all organic materials.

Every burning building material also produces carbon monoxide (CO) as a combustion product. Carbon monoxide itself is highly toxic. In relative comparison to natural building materials, EPS produces comparatively low amounts of CO during combustion. Furthermore, HCN (Hydrogen cyanide) cannot be produced by EPS fires.

Although burning EPS gives off black smoke, the toxicity of the released smoke fumes is considerably less than those of other commonly used materials. This was already concluded in

1980 by the TNO[3] Centre for Fire Safety for both EPS in its standard design and FR-EPS. The toxicity of fumes was measured for wood, wool, silk, cotton, fire-retardant-treated cotton and three sorts of EPS (see table). In the case of EPS, the toxicity of the smoke appeared to be considerably smaller than that of the other materials Table 2 shows results from comparative investigations.

Extensive research into the toxicity of smoke fumes from burning EPS has also been conducted in accordance with the DIN 53436 method which is a small scale combustion toxicity test, which gives results of relevance to full scale fires.

The relative risk from fire or smouldering gases of EPS is low compared to the risks from thermal decomposition products of cellulosic building materials, such as wood fibre-boards or cork. The release of dioxins from EPS in the event of a fire is not to be expected.

Important. Deadly carbon monoxide is always generated in combustion processes—regardless of whether fibres, wood, or plastics are involved in the fire.

There are no hydrogen cyanide fumes, identified as rapidly fatal respiratory poisons, produced when burning EPS rigid foam.

3 De giftigheid van de bij verbanding van polystyreenschuim vrijkomende gassen', juni 1980, ir. H. Zorgman, TNO Delft, Centrum voor Brandveiligheid

Sample		Emitted fractions (v/v) in ppm at different temperatures			
EPS	Smoke Gases in a fire	300°C	400°C	500°C	600°C
	Carbon Monoxide	50*	200*	400*	1000**
	Monostyrene	200	300	500	50
	Aromatic compounds	Fractions	10	30	10
	Hydrogen bromide	0	0	0	0
FR-EPS	Carbon Monoxide	10*	50*	500*	1,000**
	Monostyrene	50	100	500	50
	Aromatic compounds	Fractions	20	20	10
	Hydrogen bromide	10	15	13	11
Deal	Carbon Monoxide	400*	6000*	12000*	15000*
	Aromatic compounds	-	-	-	300
Chip board	Carbon Monoxide	14000*	24000*	59000*	69000*
	Aromatic compounds	Fractions	300	300	1000
Expanded cork	Carbon Monoxide	1000*	3000*	15000*	29000*
	Aromatic compounds	Fractions	200	1000	1000

*smoldering/glowing. | **as a flame. |- not detected
Remarks: Test conditions specified in DIN 53 436; air flow rate 100 l/h; 300mm x 15mm 20mm test specimens compared at normal end-use conditions.

Table 2: Toxicity of smoke fumes from EPS and various 'natural' materials

Fire protection classification of EPS rogid foam

The fire behaviour of rigid foam insulation materials is assessed and classified according to EN 13501-1[4] and DIN 4102-1[5].

Expanded polystyrene (EPS) is classified under the European reaction-to-fire class E according to EN 13501-1, meaning it is normally combustible. Flame-retardant grades of EPS can achieve higher classifications. In these classifications, EPS rigid foam is considered to have limited combustibility and does not produce flaming droplets under standard test conditions.

[4] EN 13501-1 – Classification of construction products and building types according to their fire behavior - Part 1: Classification using the results from tests on the reaction to fire of construction products.

[5] DIN 4102-1 – Fire behaviour of building materials and components - Part 1: Building materials; terms, requirements, and tests.

In construction, the critical factor extends beyond the classification of the material alone; it encompasses a thorough evaluation of the material in its installed condition. The interaction between the installed material and adjacent building components can create composite systems that significantly impact fire performance—either enhancing or diminishing it. A holistic approach[6] is essential—considering the full system performance and interaction of materials in their installed context ensures a more accurate and comprehensive assessment of fire safety, rather than focusing solely on individual material properties. This approach supports safer, more effective design and regulatory compliance by addressing the complex realities of building assemblies.

Summarising:

- EPS rigid foam is considered flame-retardant B1 (DIN 4102-1) in Germany and normally combustible class E under EN 13501-1.
- It does not produce burning droplets in fire scenarios.
- Fire behaviour always depends on the installed system and the possible combination with other materials.

[6] https://www.modernbuildingalliance.eu/assets/uploads/2019/07/EU-Fire-Safety-Guide-printable-version.pdf

Fire safety of EPS in different application areas

In this section, a number of fire-safe applications of EPS are described. If applied correctly, EPS has no influence on the start or development of fire in a building. Covered by a surface material, EPS is never the material facing the fire and determining the fire behaviour of the construction. It's nearly always possible to design a construction with EPS fulfilling all requirements, including fire requirements.

Flat Roofs



Application of white EPS on a flat roof. Credit: IVH.

The European classification system for external fire EN 13501-5[7] refers to four different methods mentioned in the CEN/TS 1187[8]. For each of these methods, it is easily possible to design a construction with EPS insulation which fulfils the requirements. Normally, there is a layer of glass fleece included somewhere in the build-up.

The testing for the roof construction is usually commissioned by the producer of the roofing felt. Nearly all current waterproofing felts have been tested in combination with EPS because the roofing felt producer wants to make use of the superior qualities of EPS as a flat roof insulation material regarding durability, walkability, ageing and price

Roofs must generally be resistant to flying sparks and radiant heat (hard roofing). Proof of suitability as hard roofing can be provided by testing the roof structure (including insulation materials) in accordance with CEN/TS 1187. EPS flat roof insulation boards are classified as normally flammable – i.e., Class E according to EN 13501-1 or building material class B2 according to DIN 4102.



EPS based- flat roof, combined with rooftop PV Panels

The fire performance of roof systems incorporating EPS insulation must be verified according to European standards, such as EN 13501-1 (reaction to fire) and EN 13501-5 (external fire exposure to roofs).

The corresponding test report or classification document serves as proof of suitability and describes the complete roof build-up tested.

[7] EN 13501-5 Fire classification of construction products and building elements- Part 5: Classification using data from external fire exposure to roofs tests

[8] *CEN/TS 1187; Test methods for the exposure of roofs to external fire*

EPS insulation products from different manufacturers can generally be interchanged only if they have the same fire classification and are used in equivalent roof constructions as those tested. The validity of the fire classification typically extends to variations such as greater insulation thicknesses, provided these do not adversely affect fire performance.

For large industrial or lightweight roof constructions, additional national or project-specific fire safety measures may apply (for example, the use of intermediate protective layers or specific design solutions), which must be verified in accordance with local regulations or additional testing requirements.

Façades



External insulation with EPS, Brussels. Credit: eumeps.

EPS rigid foam is generally used on facades as part of an External Thermal Insulation Composite System (ETICS).

Depending on state building regulations, for buildings up to two or three storeys, exterior wall claddings and insulation layers made of normally flammable materials (class B2 or E) may be used if adequate measures are taken to prevent fire spread. For facade claddings where classification as “hardly flammable” is required, the system must be tested in a laboratory fire test — either in the fire shaft test according to the Single Burning Item (SBI) test according to EN13823[9].

For External Thermal Insulation Composite Systems (ETICS), the standardised large-scale facade fire tests according to DIN 4102-20 and DIN 4102-24 are used.

For External Thermal Insulation Composite Systems (ETICS), the fire performance of façades is assessed using large-scale test methods in accordance with European or national standards (for example, EN 13501-1 for reaction to fire and relevant large-scale façade fire test methods, such as EAD 040083-00-0404 or national equivalents).



EPS insulation applied as ETICS. Credit: eumeps.

These tests form the basis for system approvals or technical assessments that serve as proof of fire performance.

[9] EN 13823; Reaction to fire tests for building products – Thermal exposure to a single burning item for building products, excluding floorings

Test results show that ETICS with EPS insulation classified as normally combustible (Euroclass E) can be used on low-rise buildings, where national regulations permit such materials without additional fire protection measures.

For taller buildings, higher fire performance requirements typically apply. In these cases, flame-retardant or higher-classified ETICS (e.g., Euroclass B systems) must be combined with constructive fire protection measures, such as non-combustible fire barriers or horizontal/vertical fire stops, as specified by national building regulations.



ETICS consists of finishing layers, reinforcements, base coat, and insulation board.

EPS insulation boards have been essential components of External Thermal Insulation Composite Systems (ETICS) for decades. The first ETICS were introduced in the early 1960s as external facade insulation. Initially, facade insulation systems were constructed solely with EPS rigid foam boards and synthetic resin renders. Later, mineral-based systems were also developed. The excellent performance of EPS-based ETICS over more than 60 years has been confirmed through regular inspections by the Fraunhofer Institute for Building Physics (IBP)[10].

The fire behaviour of EPS boards used at that time has not changed compared to that of today's EPS insulation materials in ETICS. The current declaration of fire performance for EPS in ETICS is made in accordance with the European Construction Products Regulation and the associated EPS product standard DIN EN 13163, designated as FR-EPS as class E.

Ceilings and floors



Top floor ceiling EPS insulation. Credit: eumeps.

EPS rigid foam is used on and beneath ceilings as well as in floors for thermal insulation and impact sound insulation.

These insulation layers are classified as normally flammable (Class– E; building material class B2). Only when used as visible ceiling cladding or under screed is EPS assigned to building material class B1 (hardly flammable).

The classification is defined by the European standard EN 13501-2[11].

[10] BP Report HTB 005/2023; Evaluation of the Long-Term Durability of Installed External Thermal Insulation Composite Systems.

[11] EN 13501-2; Classification of construction products and building elements according to their reaction to fire – Part 2: Classification using data from fire resistance tests, excluding ventilation systems.

The fire resistance class of building components, including ceilings, is verified by testing in accordance with EN 1363-1[12].

For insulating the top floor ceiling (attics), walkable composite elements are suitable. As with the EPS insulation material itself, the OSB, chipboard, or other construction boards used must also be at least normally flammable (Euroclass E; building material class B2).

Insulation under screed



Preparation of under screed insulation. Credit: eumeps.

Impact sound insulation made of EPS rigid foam, EPS type DES according to DIN 4108-10, is installed as a single, continuous layer beneath floating screed in accordance with DIN 18560 (wet or dry screed, excluding cast asphalt). These are classified as normally flammable (Euroclass– E; building material class B2).

The same applies to floor insulation boards of EPS type DEO according to DIN 4108-10, which are often additionally installed beneath impact sound insulation boards on concrete or timber ceilings.

Ceiling undersides

EPS according to EN 13163 (and XPS according to EN 13164[13]) as well as other European harmonized product specifications such as ETAs (European Technical Assessment), and composite building products with polystyrene rigid foam layers according to European harmonized product specifications, must not be installed horizontally if the regulatory requirement “hardly flammable” applies for the intended use of these products.

This rule applies, for example, to underground garage ceilings, which generally must be insulated at least with hardly flammable materials.

[12] EN 1363-1; Fire resistance tests – Part 1: General requirements

[13] EN 13164; Thermal insulation products for buildings – Factory-made products of extruded polystyrene (XPS) – Specification

Perimeter and plinth insulation



Credit: eumeps.

EPS rigid foam is used in the soil-contact area as perimeter insulation and in the adjacent area up to beneath the exterior wall cladding (typically ETICS) as plinth insulation boards.

Both types of boards are hardly flammable (building material class B1). Additional requirements beyond fire behaviour for EPS perimeter insulation boards are specified in general building authority approvals, while requirements for plinth insulation boards are described by the application type WAS in DIN 4108-10.

Conclusion

Fire safety is a key aspect of every building design. While the contribution of insulation materials to overall fire performance is sometimes overstated, this document demonstrates that buildings can be safely designed using EPS insulation, fully meeting all thermal and fire safety requirements when appropriate system design and tested solutions are applied.