Plastics and fire safety
in building & construction

PlasticsEurope
Association of Plastics Manufacturers

Foreword

To meet major challenges of the coming decades, creative minds and innovative materials need to come together to develop smart solutions. As cities rapidly develop, new buildings will need to emerge to shape their skylines and reflect economic development and societal change.

To accommodate the needs of an ever-growing world population, while striving to meet ambitious climate and energy targets, buildings will have to be more performing and less energy consuming.

Plastics have an important role to play in meeting these challenges. Few, if any, construction materials can offer the same combination of functionality, cost-effectiveness, environmental performance and durability over time. Plastics are used in a wide and growing range of applications, from durable piping and window frames to state of the art insulation solutions. They are also at the heart of cutting edge architectural innovations that will shape the buildings of the future and stand the test of time.

However, first and foremost, our buildings have to be safe. Fire safety has always been a major objective for the plastics industry and an integral part of product design and manufacturing.

Historically, plastic products in the building and construction sector have been assessed according to their reaction and resistance to fire in different applications. Over the years, improvements in building fire safety standards, and increased efforts by the plastics industry to develop plastic materials and products with lower ignitability and limited impact on fire spread, have contributed to the ongoing reduction of casualties and property damage due to fire.

This brochure provides an overview of the role of plastics in building and construction and their specific characteristics with regard to fire safety.

Karl Foerster

Executive Director PlasticsEurope

Plastics in building and construction in Europe

Benefits of plastics in building and construction

In an ever growing and changing world, plastics play a major role in delivering and sustaining the quality, comfort and safety of modern lives, while conserving natural resources and helping to protect the environment.

Plastics are innovative materials and are increasingly used in building and construction.

Meeting ambitious energy efficiency targets of buildings would be difficult without the solutions provided by plastic materials. Their use in building and construction helps to save energy, reduce costs, enhance the quality of life and also protect the environment.

Plastic products also tend to be easily installed, are durable and require minimal maintenance. As such, very limited additional consumption of energy and resources is needed to ensure their continued functionality during their lifetime.

There are over 50 different families of plastics and most of them have something unique to offer to the construction industry. Among other aspects, plastics contribute to insulation, window framing, wiring, piping, wall-covering, flooring and roofing.

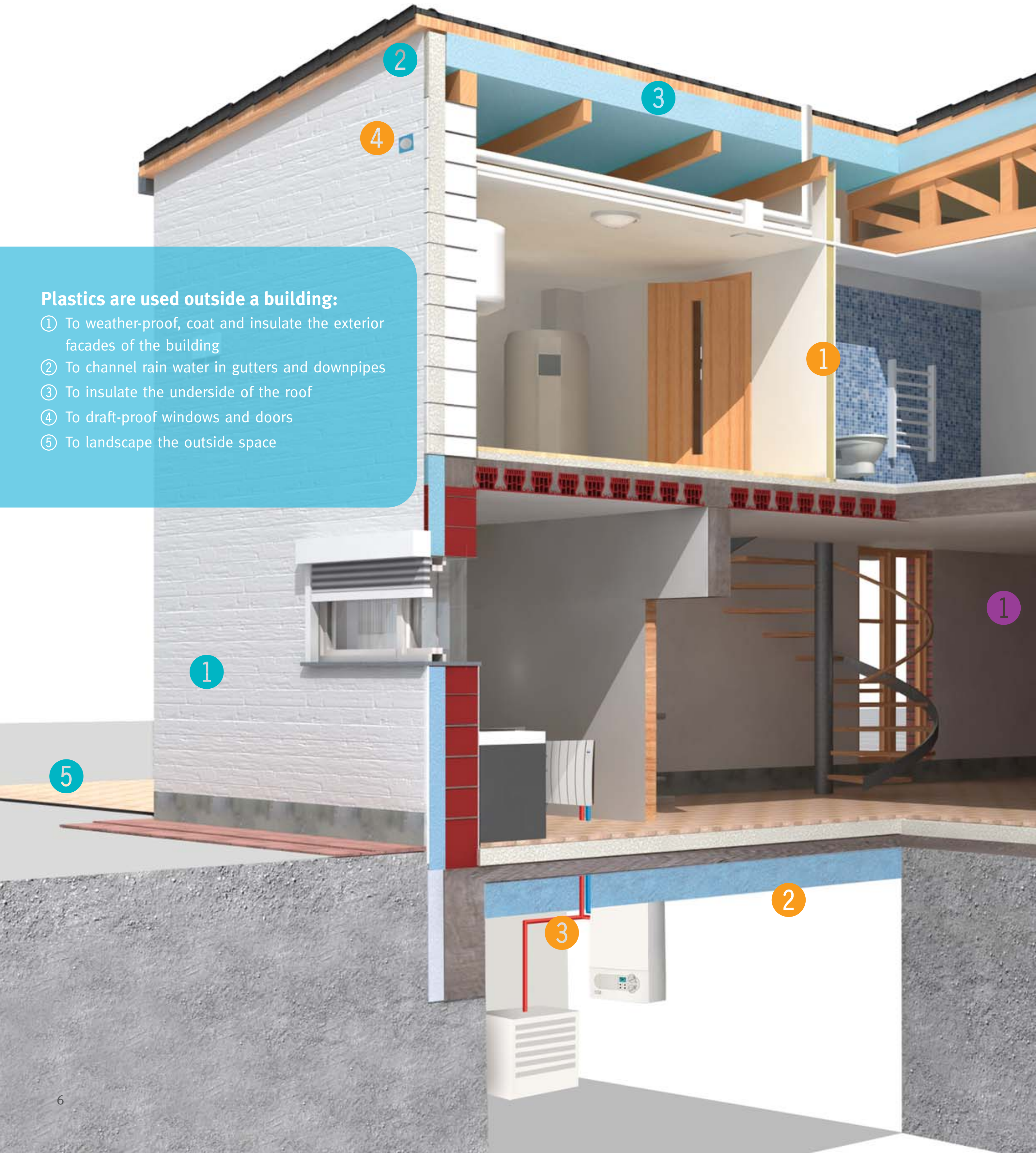
Not only do plastics allow for great practical solutions, but they also contribute largely to improving the energy efficiency of buildings, which is necessary to tackle climate change. In fact, in terms of their whole life cycle, plastics are among the most energy efficient materials.

Did you know?

The typical life span of plastic applications in building and construction is 30 to 50 years, with many plastics pipes installed over 50 years ago continuing to function today as well as ever.

Applications of plastics in building and construction

Affordable, quality, energy saving and environmentally-friendly living can be achieved by equipping our buildings with plastics. Their versatility, functionality, performance and aesthetics are such that they can be found throughout the house, from roof to cellar.



Plastics are used outside a building:

① To weather-proof, coat and insulate the exterior facades of the building
② To channel rain water in gutters and downpipes
③ To insulate the underside of the roof
④ To draft-proof windows and doors
⑤ To landscape the outside space

Architects and engineers use plastics:

- To give shape to their imagination; all over the world architects are designing innovative buildings and structures which could only be realised with plastics
- To tailor-fit buildings to their surroundings
- To enable new technologies that harness renewable energy

Plastics are used in the structure of a building:

① To insulate and sound-proof inner walls

② To insulate cellars

③ To supply drinking water and drain wastewater

④ to provide fresh air and heating through ventilation and heat recovery systems

Plastics are used inside a building:

① To enable a myriad of features, furnishings, appliances

② To paint, tile and clad living spaces, particularly those that must remain hygienic, like kitchens and bathrooms

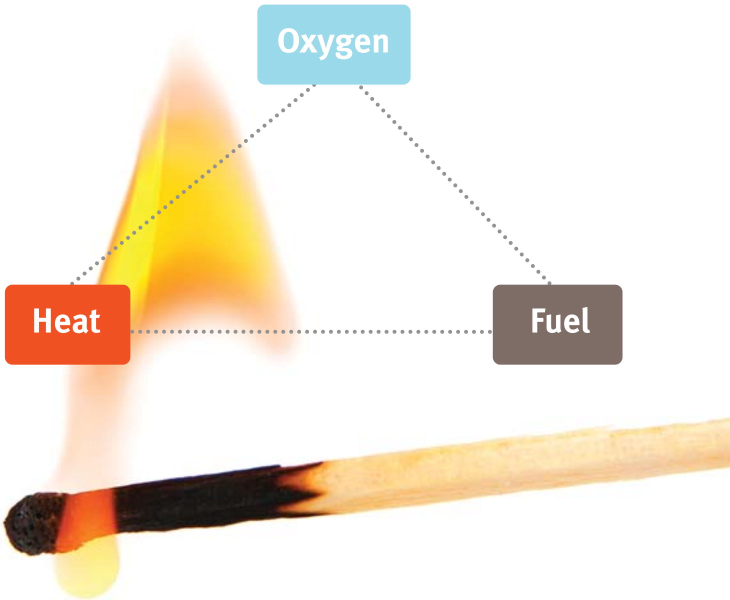
③ To sheath wires and cables

Fire safety

While developing solutions to make buildings even more durable, energy-efficient and cost-effective, safety remains paramount. Before specifically describing the fire performance of plastics, it is important to consider some of the most fundamental elements of fire safety.

What is fire?

Fire is a complex phenomenon influenced by a range of factors. At its most basic, fire needs the combination of three elements at the right mixture to occur: heat, fuel and oxygen. Removing at least one of these crucial elements will lead to extinction of the fire.



Upon ignition of an item, the development of a room fire is influenced by the type and quantity of materials present, room configuration and ventilation. In most cases, its progression follows a specific pattern. Has an item ignited and the resulting fire is sufficient to heat up adjacent objects, fire might spread until all contents of the room are involved. This growth goes along with a rise in smoke and heat production until all items in the room are consumed and extinction occurs.

Did you know?

Origins of fire

- From 2008 to 2012, in EU Member States in which data is available (excl. Luxemburg and Malta), the total number of fires of all types was, on average, **3.5 fires per 1,000 inhabitants**, while the US registered **4.35 fires per 1,000 inhabitants** for the same period[1]
- Approx. **30%** of the total number of fires that occurred in 18 EU countries **originated in buildings**[2].
- Causes of fire can differ from one region to another. **From 1996 to 2012, chimney fires (lack of maintenance, etc.) were the main cause of building fires (15%) in Nordic countries** (Denmark, Norway, Sweden, Finland, Iceland)[3]. In contrast, **accidental dwelling fires in UK between 2011 and 2012 were mainly caused by the misuse of equipment and appliances**[4].

1 World Fire Statistics/2014/n°19 – International association of fire and rescue services (CTIF)

2 World Fire Statistics/2014/n°19 – International association of fire and rescue services (CTIF)

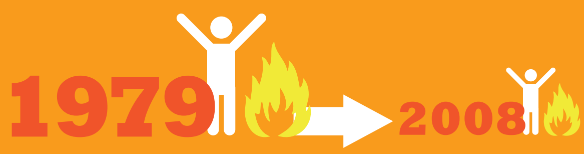
3 Nordstat (Nordic statistics regarding incidents) http://ida.msb.se/nordstat#page=a0002

4 Fire statistics – Great Britain, 2011 to 2012 – Department for communities and local government – December 2012

Fire fatalities – Key statistics

- Only a very small proportion of fires are fatal. The number of deaths from fires between 2008 and 2012 (for the 19 EU countries in which data is available) amounted to ~ 0.8 death per 100,000 inhabitants. This is lower than the figures for the USA (0.97 death per 100,000 inhabitants) and Russia (9.2 fire deaths per 100,000 inhabitants, but steadily decreasing)[5].

- The fire death rate in Western Europe has decreased by 2/3 between 1979 and 2007 (28 years)[6].
  This downward trend has continued in more recent years, with the number of fire fatalities dropping, by approx. 11%[7] between 2008 and 2012, in the 19 EU countries for which fire statistics are available.



- Fire fatalities represent a minor portion of the total number of accidental deaths: a 2008 study on deaths in France has shown that deaths from fires represented **2,4%** of all home and leisure injuries-related deaths in that year. These are significantly less than deaths related to other causes such as falls and suffocations resulting from choking.

- Buildings represent the predominant location of places where fire deaths occur. For example, in 2011, **88.5%** of all fire fatalities in France occurred in buildings (incl. high-rise buildings, public buildings, dwellings, etc)[8]. Considering accidental dwelling fires only, they represented two thirds of all fire fatalities in England between April 2013 and March 2014[9].

- According to available statistical data and publications, intoxication by CO (carbon monoxide) and other gases represent between **34%**[10] and **80%**[11] of all fire fatalities. Other causes of fire fatalities include burns, defenestration and fall of materials.

5. World Fire Statistics/2014/n° 19 – International association of fire and rescue services (CTIF)
6. World Fire Statistics bulletin n° 28, October 2012 – The Geneva Association
7. World Fire Statistics/2014/n° 19 – International association of fire and rescue services (CTIF)
8. Les statistiques des services d'incendie et de secours – édition 2012 – Ministère de l'Intérieur
9. Fire statistics monitor: England April 2013 to March 2014 – Department for Communities and Local Government – 2 July 2014
10. Fire statistics – Great Britain, 2011 to 2012 – Department for communities and local government – December 2012
11. "Smoke and CO poisoning in fire victims" – Zikria, Weston and Chodoff – Urgencepratique – 2010

Impact of fire

Fire incidents are preventable disasters that have the potential to cause extensive property damage for individuals or communities, impacting business continuity, causing injuries or in the worst case, fatalities.

The impact of fire depends on its intensity. If a fire is detected at an early stage, it can be stopped and its impact limited. The further a fire is allowed to develop, the harder it can be confined and extinguished, which then increases the resulting impact. Any measure aimed at taking appropriate action during the early stages of a fire or its prevention in the first place is to be encouraged.

Building fires can locally reach temperatures exceeding 1000°C, and can affect the integrity of the structure, building contents or supply systems. Regardless of the type of materials burning, damage is influenced by many different factors such as the intensity, size and location of the fire.

Apart from excessive temperatures that can develop during compartment fires, an even larger threat to occupants is the inhalation of toxic gases (smoke) which are produced regardless of the material on fire.

Measures such as smoke extraction systems and compartmentation further decrease the risk of smoke inhalation.

Objectives and strategies for fire safety

Regardless of the type of products used, fire safety is an essential consideration in building design. A variety of experts, from architects and specialised consultants to product manufacturers, closely work together to ensure buildings, even the most complex ones, are safe in all aspects including fire safety. Effective measures need to be taken to prevent or reduce the likelihood of fires that may result in casualties, injuries or property damage.

National codes and regulations are the basis of such fire safety measures.

There are two possible ways of achieving fire safety in a building:

- **A prescriptive approach**, which provides strict criteria as to how a building should be constructed. While this approach relies on product performance described by classifications or defined standard fire tests, it fails to allow for how a given fire will actually develop in practice.
- **A performance based approach**, which states how a building has to perform under given criteria. This approach requires an advanced Fire Safety Engineering analysis. State of the art computing technologies and scientific calculations are used to provide a more fundamental, comprehensive and sometimes more economical solution to fire safety than traditional approaches. It is an effective way of addressing the complexities of modern methods of construction and building design when products and assemblies cannot be tested.

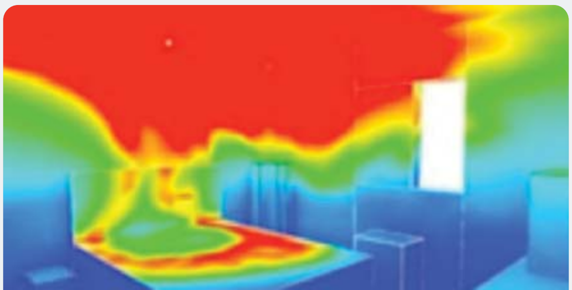
Fire strategy in practice

Prescriptive approach

"The maximum distance people should have to travel to escape is 30 m and there should be one fire exit for every 50 people. Each exit should be at least 1,1 m wide."

Performance based approach

"There should be enough fire exits of sufficient size so that all people in the building can escape safely within 5 minutes."



Example of a computer modelling of a room fire

Two different concepts of fire safety can also be used:

- **Passive fire protection products and systems** can be integrated during the construction of all buildings to contain fire to its point of origin and prevent fire and smoke from spreading throughout the building. These products, such as fire resistant walls, floors and doors, are always 'switched on' and do not require activation in order to fulfil their role.
- **Active fire protection systems**, such as smoke detectors or fire sprinklers, can be added during or after the construction of the building and require some form of response or activation in order to start operating.

Fire protection is most effectively achieved through a combination of passive and active approaches, just as a modern car has both laminated safety glass windshields (passive) and brakes and airbags (active) to provide passenger safety in case of a crash.

Did you know?

While fire detectors are required by law in Norway in dwellings since 1991 and currently protect **98%** of all homes, they have also become mandatory in France and in several German and Austrian states since 2015.

Fire tests and classifications

From early attempts in the 1890s to study the behaviour of fire at the request of insurance companies, fire test methods are now carried out by officially recognised material testing institutes.

Fire tests are a critical component when designing fire safe environments since the behaviour of products under specific testing conditions can be investigated.

These tests define standard procedures and equipment to be used to assess different parameters and classify products according to their fire performance and contribution to the generation and spread of fire and smoke.

Products used in building and construction are subject to various codes and regulations depending on their function and use. In the European Union, the recent 2011 Construction Products Regulation requires construction products, including plastic ones, to be tested and classified regarding their fire performance according to the Euroclass system, a harmonised classification system for reaction to fire.

The comparison of the reaction-to-fire performance of construction products across all 28 member states is possible, thanks to harmonised classes.

Based on these classifications, EU member states have included into their national legislation different performance requirements for construction products, depending on their final use.

In some countries (e.g. UK, Sweden, the Netherlands) and for some specific situations, the use of performance based standards and fire safety engineering approaches may be applied to replace prescriptive requirements.

Certain products, for which historic data is available or which have well-established performance criteria, are considered ‘deemed to satisfy’ or classified without further testing.

This means that manufacturers can refer to a relevant European Commission decision to declare their product's performance, reducing routine testing costs without compromising on safety.

Primary classification for contribution to fire development: A1, A2, B, C, D, E or F, with A1 being the highest level of performance

Additional classification for smoke release: s1, s2 or s3 with s1 being the highest level of performance

Additional classification for flaming droplets: d0, d1 or d2 with d0 being the highest level of performance

B – s2, d0

Reaction to fire classification of flame retarded PVC pipes and fittings (thickness: 3mm) according to the Euroclass system under the Construction Product Regulation 305/2011, applicable to construction products, excluding floorings, linear thermal insulation products and cables, for which specific classification systems apply

[Commission delegated regulation (EU) 2016/364]


FIRE-FOX
TEXPORT

Plastics and fire safety

The versatility of plastics means that they can be produced in a rigid or flexible, heavy or lightweight, solid or liquid form, to accommodate a wide range of different needs and to be incorporated in different elements of a building's structure.

Public authorities and specifiers need to consider their choice of material against a range of criteria, including combining cost-effectiveness and performance over time, but most importantly, assuring an adequate protection of human life.

Like any other material, plastics have to be used in the correct application and in appropriate conditions. Installed and used in the correct manner, plastics comply with all relevant regulations for the location and type of application in which they are used.

The following section takes a closer look at key characteristics of the performance of plastics in a fire.

Factors such as thickness, density and surface characteristics also influence the reaction of plastic products in a fire. For instance, plastic products in a compact form catch fire less easily than plastic products in the form of a thin film.

The specific Euroclass of a given plastic product does not mean that this product can be used safely in all situations. For instance, selecting a construction product for an inappropriate application in terms of regulation may lead to an increased fire risk.

How do plastics behave in fire?

Fire is a complex phenomenon. The type (and quantity) of materials involved, is only one of the various parameters influencing the development and consequences of a fire. The other factors that come into play include building design, location, potential ignition sources and environmental factors.

A fire usually involves a combination of a range of different materials. Plastics have a similar fire behaviour to other organic materials, which means that a mixture of toxic gases can be produced.
The nature and amounts of the substances released by a fire depend more on the fire conditions than the materials involved. Despite the large number of potentially hazardous components in fire gases, the toxic hazard from combustion comes from a limited number of components. Among them is carbon monoxide (CO) which is always released and, in most cases, is the predominant factor.

Like all natural organic products, plastics can be ignited once fire conditions are met.

Did you know?

- In a study on fatal domestic fires in 2008 in the Netherlands, fire-fighters involved in a fatal domestic fire were asked to name the factors that accelerated the fire. Plastics were mentioned in only 2 cases out of 22 fires where fatalities occurred[12].
- Plastics were considered as a major combustible contributor in only 12% of all fires (with or without fatalities) dealt with by the Paris Fire Brigade (BSPP) in 2011[13].

12. http://www.verbraucherrat.at/content/01-news/05-archiv-2009-2010/01-studie-brandschutz/firesafetyconsumer.pdf
13. BSPP 2010 Annual Operational Activities Report

Fire performance(s) of plastic products

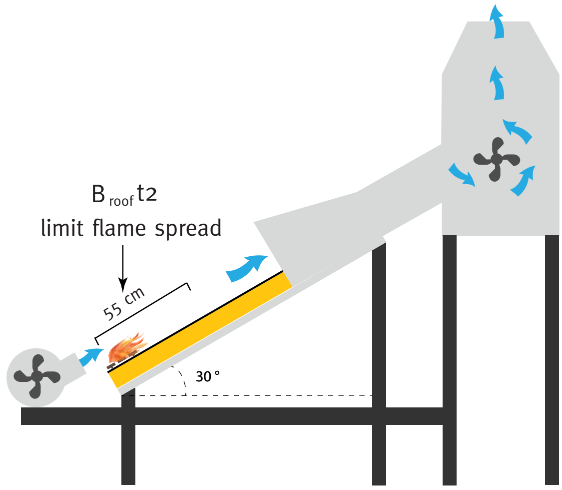
Plastics have changed our lives like no other material. As plastics continue to push the barriers of modern architecture and contribute to greater energy efficiency and cost savings, they have also become increasingly safe.

Plastics can be tailored to meet specific needs and reduce their contribution to the propagation of a fire. A range of different families of plastics inherently have a superior fire performance. The same performance can be achieved or even improved with other plastics by:

- Adding flame retardants
- Covering them with less combustible layers e.g. thermal insulation protected by gypsum plasterboard, mortar or reinforcement layers.

Over the years, building and construction techniques and plastic products have been developed to achieve the best possible level of fire safety. These improvements can be seen at different stages, including for example:

- Improved product design (e.g. weight reduction) to influence behaviour under fire
- Improved composition of products to reduce ignitability
- Improved installation techniques to prevent fire spread.



A membrane / PU insulation (B-s1,do) combination meets the Broof (t2) requirement in the EN 1187 roof standard.

S Messa, Proof in real conditions – Room Corner Test and Broof(t2), ANPE Conference, 26th May 2015, Bologna

What are flame retardants?[14]

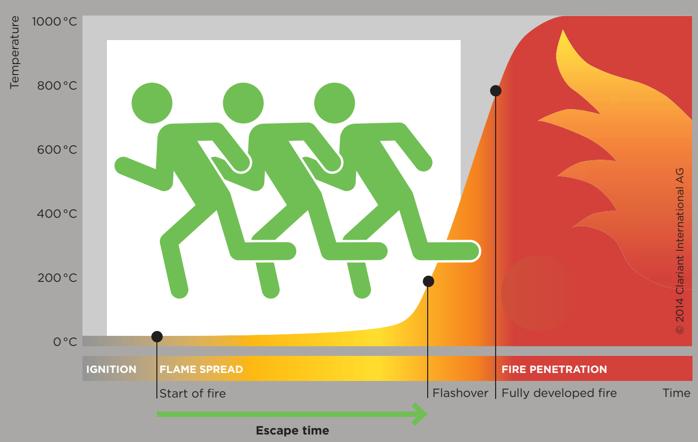
The term "flame retardant" describes a property and not a chemical class. Flame retardants are a range of additives of various chemical compositions that can be added to materials to improve their fire behaviour and reduce the risk of fire. The presence of flame retardants leads to a reduction in fire occurrence, in fire spread, and human casualties by increasing escape time.

Altogether there are over 200 different types of substances that can be used as flame retardants and they are often applied in combination with each other. Such a wide range of types is valuable, as all flame retardants do not provide their functionality for all materials and some are often specific to materials, their physical form and use conditions.

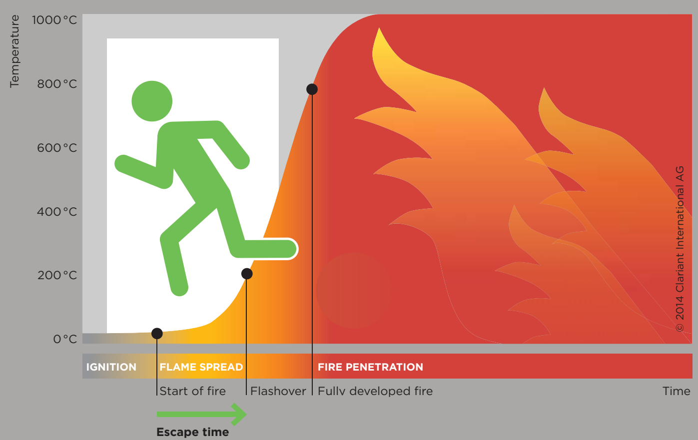
14. EFRA Brochure "Keeping Fire in Check" March 2012

How flame retardants can increase escape time in fires

With flame retardants



Without flame retardants



Plastics – an ally in the fight against fire

In addition to this, certain plastic products are known for their capacity to perform under extreme conditions and have even established themselves as trusted allies in the fight against fire.

Fire-proof plastics capable of resisting arson (bins, seats) and intumescent PVC pipes preventing the propagation of fire through walls are just two examples of the efforts put into making plastics safer.

Some plastics, thanks to their lightness and their resistance to severe fire conditions, have become an everyday partners for fire-fighters:

- items of safety equipment, such as helmets or suits
- C-PVC sprinklers
- PVC or PUR coated fire hoses

Industry wide efforts to further improve fire safety

The construction industry makes significant efforts to protect society from the dramatic consequences of fires. As a result 1% – 8% of total construction costs are spent on fire safety measures. These costs are directly dependent on the type of building and can increase considerably for sensitive buildings like schools and theatres. In the case of shopping centres, fire safety measures can amount to 10% of total building costs[15].

For the plastics industry, the safety of products used by the construction industry comes before any other consideration. As such, plastic manufacturers design their products to comply with existing European and national regulations and standardization measures addressing fire risk.

Each type of building has its specific potential fire risks. This is why plastics, like all other materials, have to be used in the correct applications and under appropriate conditions.

The plastics industry is working continuously with its supply chain to develop new products with improved or specific fire performance characteristics.Through a dedicated Fire Safety Group, PlasticsEurope members are actively taking part in research, standardisation and regulatory activities regarding fire safety.

Fireman helmet

Fireman protection suit

C-PVC sprinkler

PUR coated fire hose

15. World Fire Statistics Bulletin no. 29, April 2014 – The Geneva Association

Myths and realities

MYTH

Newly built houses are less safe than the ones our grandparents used to live in, because modern construction uses more and more plastics .

REALITY

Based on available statistics, while the use of plastics in building and construction has almost doubled in the last 20 years in Western Europe, fire fatalities have drastically decreased.

MYTH

Modern plastics are highly flammable and increase the risk of a room fire to flashover and fill the room with smoke and fire before the fire service can get to the scene.

REALITY

Flashover is a particular stage during the course of a fire and involves all combustible products in a room, which means it is not specific to plastics.

MYTH

Plastics emit more toxic fumes than natural products when burning.

REALITY

All combustible materials, whether synthetic or natural, emit carbon monoxide when burning. Fire experts agree that carbon monoxide, irrespective of its source, is the major cause of intoxication due to fires.

MYTH

Fire safety is determined by the choice of material.

REALITY

The choice of materials is only one amongst many factors determining fire safety. The design of products, the way they are installed, protected and used, passive and active fire safety measures, and evacuation processes, all play a significant role in fire safety.

MYTH

Smoke acidity is a good indicator of smoke toxicity.

REALITY

Any smoke emitted during a fire is toxic. The most important factor in relation to disorientation, incapacitation and death is the concentration of carbon monoxide, CO, which is not acidic. Likewise, many toxic chemicals are not acids.

Glossary

- **Fire hazard:** potential for injury and/or damage from fire (ISO 13943)
- **Fire risk:** product of (a) probability of occurrence of a fire to be expected in a given technical operation or state, and (b) consequence or extent of damage to be expected on the occurrence of a fire (ISO 13943)
- **Fire scenario:** detailed description of conditions, including environmental, of one or more stages from before ignition to after completion of combustion in an actual fire at a specific location or in a real-scale simulation (ISO 13943)
- **Fire safety engineering:** application of engineering methods based on scientific principles to the development or assessment of building designs
- **Reaction to fire:** response of a material in contributing by its own decomposition to a fire to which it is exposed, under specified conditions (ISO 13943)
- **Fire resistance:** ability of an item to fulfil, for a stated period of time, the required stability and/or integrity and/or thermal insulation, and/or other expected duty specified in a standard fire-resistance test(ISO 13943)
- **Fire load:** quantity of heat which could be released by the complete combustion of all the combustible materials in a volume, including the facings of all bounding surfaces (ISO 13943)
- **Flammability:** ability of a material or product to burn with a flame under specified conditions (ISO 13943)
- **Flashover:** transition to a state of total surface involvement in a fire of combustible materials within an enclosure (ISO 13943)
- **Carbon monoxide (CO):** colourless, odourless and tasteless gas, found in the combustion gases from the partial oxidation of all combustible materials containing carbon, such as wood, paper, cardboard, textile, plastics, fuels, etc.

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PlasticsEurope AISBL
Avenue E. van Nieuwenhuyse 4/3
1160 Brussels – Belgium
Phone +32 (0)2 675 32 97
Fax +32 (0)2 675 39 35
info@plasticseurope.org
www.plasticseurope.org
www.plastics-themag.com

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www.fsc.org
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