Insulation materials for buildings


Fire hazards and safety risks: Challenges for safeguards and rescue teams
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Given the current climate protection goals, requirements for the energy efficiency of heating systems and the measures against thermal loss from buildings were tightened. The result is an increased demand for heat insulation, for new constructions as well as for thermal refurbishment of existing buildings.

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Insulation material solutions for climate protection

The tough requirements regarding energy savings in buildings can only be met through efficient heat insulation solutions. For this purpose Exterior Insulation Finishing Systems (EIFS) with insulation materials made of foamed plastic are preferred on exterior walls as well as in structural elements (sandwich elements). The primary reason for this is that insufficiently insulated exterior walls of buildings play a considerable role in heat loss. At the same time we can observe a development towards ever thicker insulating material, due to the gradual tightening of thermal insulation standards.

The insulation materials are predominantly used in the form of expanded (foamed) boards and their base material is plastic. New construction and refurbishments of residential buildings are primarily fitted with insulation boards made of expanded or extruded polystyrene (EPS, XPS), while for industrial buildings and commercial construction the use of polyurethane (PU) based foamed insulation materials within metal cassette panels (sandwich elements) is preferred.

The flip side of the coin – fire hazard
Building codes require that surfaces of exterior walls as well as exterior wall claddings, including the insulation materials, are flame-retardant only starting with category 4 buildings (resp. height > 7 m). Foamed plastics offer numerous advantages regarding low costs, easy application technique and good thermal performance and are therefore ideally suited for use as insulation materials. However, from a fire safety point of view, insulation materials made of foamed plastics have an essential disadvantage. Even if foamed insulation materials are officially approved and permitted when code compliant, hidden behind the term ‘flame-retardant’ (according to DIN 4102 B1) there is a very critical fire behavior. From a fire safety perspective, the technical term ‘flame-retardant’ can only be translated as:

Flame-retardant = fundamentally flammable

The paradox of a building material fire test

Furthermore, we need to take into account that the building material test used (e.g. in Germany) for establishing the fire safety rate (fire shaft method) is viewed by experts as highly controversial. This testing method for rating fire behavior is a lab test, which counts as passed if after a fire test the 100-cm long test piece shows an unburned length of 15 cm. Therefore a burn off rate of 85% is seen as acceptable.

This test method is regarded by fire safety experts as inexpedient, primarily because during the fire test the upright standing test piece distances itself more and more from the ignition source due to the melting process inherent to this material. This in turn continually reduces the energy level affecting the test piece during the test. Critics have observed that this test method offers ideal conditions for melting materials to pass and therefore it is virtually impossible to fail. Under these circumstances it is not surprising that polystyrene based insulation materials are formally categorized as ‘fire retardant’ (DIN 4102-B1), even though it is commonly known with which intensity this material burns (after the comparatively low minimal ignition point has been reached).
Given this, it is almost impossible to derive reliable statements from these lab tests regarding fire behavior and fire spread during real fire scenarios. For this reason the method used in Germany was discarded in the meantime (at European level) and replaced by a realistic test method (fire tests based on EN 13501-1). Based on this new test method, insulation material made of foamed plastic is placed in the category ‘normal combustibility’ (B2), which accommodates the demands of fire protection experts and also reflects the general loss experience.

The dilemma
If the realistic European building material test method were to become mandatory in Germany, based on current building codes (minimum B1) foamed plastics could no longer be allowed for use as insulation material for most construction projects. This brings us to the paradox situation that, despite better expert knowledge of the fire protection reality in Germany the inexpedient test method remains in place and therefore materials, which are critical from a fire protection point of view, continue to be used for insulation.

High property losses and tragic consequences for people

It is indisputable that insulation materials made of foamed plastics contribute substantially to the increase of the fire load of buildings and thereby also to a loss increase in case of fire. Foamed insulation materials, like the ones frequently used in façade insulation boards, have a high calorific value similar to classic energy sources (e.g. fuel oil). Moreover, numerous examples of previous damage incidents show that when foamed insulation materials are in place, even a normal room fire in which flames blaze through the bank of windows, a burning garbage container near an outer wall or the heat radiation from a fire incident in a nearby building, can quickly cause a widespread fire scenario which fire fighters can no longer control.

Besides residential fires, which typically cause a façade fire because the flames blaze through the windows, many more fire scenarios prove the multiple fire hazards of EIFS:

- 24 April 2009 – Konstanz: A burning scooter, which was parked near the façade, lead to ignition of the façade of a 4-story residential building all the way to the dormer on the 3rd floor.
- 22 May 2009 – Aachen: Starting from a fire in an annex, the façade of the adjacent 4-story building was fully destroyed over 2 floors.
- 11 June 2011 – Delmenhorst: 5 apartment buildings with over 50 units were almost completely destroyed through arson in a garbage container, which was placed near the EIFS façade.
- 20 May 2012 – Frankfurt: Arson on a construction site caused the large-scale destruction of the façade of a 6-storey EIFS covered building.
- 11 April 1996 – Airport Düsseldorf: Beside a hundreds of millions property loss, 17 people died and 88 were wounded, some seriously, as a result of the heavy smoke buildup and the fast spread of the fire.
Not only since the catastrophic conflagration at the Düsseldorf Airport, where polystyrene insulation plates largely contributed to the destructive fire scenario, do we know about the enormous fire load of foamed plastics insulation materials.

Due to the extreme heat buildup during a fire incident, a quick and uncontrollable fire spread with a large-scale façade burn-off can occur.

As a consequence of the flashover through the windows into the interior, façade fires become fully developed fires of the entire building within minutes. In addition, during façade fires the fire load is located outside the scope of active fire prevention systems (e.g. sprinklers), which often makes a total loss unavoidable. Moreover, plastic fires cause an intensive buildup of smoke, which contains a large quantity of toxic and environmentally harmful combustion residue. This leads to high demolition and disposal costs.

This knowledge of the fire safety disadvantages of foamed plastics insulation materials is no longer the sole purview of experts, but was also made accessible to the public at large through the media and through openly accessible information platforms. However, considering the continuous growth in the use of foamed plastics in building insulation, it can be concluded that the necessity of intensive education on its fire safety disadvantages continues unabated.

**Risks for people and the environment**

As to the negative properties of foamed insulation materials, the increased fire hazard is not alone in raising criticism.

Among experts numerous additional disadvantages of ‘plastic insulation agents’ are under discussion.

The light Styrofoam plates are often no match for everyday life. While the fact that birds hack holes into the façades or that rodent’s nest in building walls is an unpleasant side effect, it is by no means a serious argument against the use of foamed insulation plates.

However, since it has become commonly known that the use of foamed plastics as insulation material also bears dangers for human life and the environment, this aspect has received much more attention.
**Well-meant is not always well done**
For foamed plastics (flammable) to be code compliant in the first place, they must be enhanced with so called flame retardants. For this purpose, the harmful “HBCD (Hexabromcyclododecane)” was often used. Its negative effect on people and nature (persistent, bio accumulative, toxic) is categorized as highly problematic, which is why its production and use has been banned worldwide since August 2015.

Despite this, in the meantime thousands of tons of this highly toxic material have been incorporated in building façades and sandwich elements. According to a United Nations study, more than one ton of this toxin is released into the environment every year during mounting and demolition projects. In addition, these flame retardants, which should actually prevent a fire, paradoxically show an extremely negative behavior under the thermal stress of an extended fire incident. Under unfavorable conditions these substances can form carcinogenic dioxins during a fire.

**Banned for agricultural uses, permitted in the city**
When experts discuss environmental dangers of foamed insulation materials, they also discuss the issue of fungicides and algaecides. These toxic chemical additives must be mixed in high concentrations into the surface plaster to avoid mold formation and the growth of algae.

Due to the material properties of insulation plates, the EIFS façade can insulate heat but not store it. Conventionally built façades release the heat stored during the day slowly, while the cooling of insulation material plates proceeds virtually parallel to the cooling of the outside temperature. Should temperatures drop overnight and the outside air cool below the dew point, the condensed humidity settles as precipitation on cold surfaces (e.g. façades). These are ideal conditions for mold formation and algae growth.

A frequently used algaecide additive for surface plaster is the toxic chemical “Terbutryn”. This agent can cause cancer and is toxic for water organisms. This chemical used to be applied as an agricultural pesticide, whereas today these agents have long been forbidden all over Europe, but not for the use in surface plaster (and by the way also in wall paints). The concentration and dosage of these toxic additives are intentionally high, so that mold formation and algae growth are prevented at least during warranty periods.

However, long-term experience shows that, years later façade surfaces frequently show nasty stains and efflorescences. These are caused by the fact that, the toxic chemical additives are water soluble and are therefore washed out by the weather. This is why the used toxic agents inevitably end up in the water cycle, where they were detected in alarming concentrations in ground water and surface waters and so they can poison bodies of water and cause environmental damage. A study from Berlin documents, that the toxic Terbutryn load on the Havel is increased by a factor of 130 while the river flows through the city. A clear indication of the cause.

**Out of sight, out of mind**
The question is, how the insulation materials should be disposed of once a façade insulation needs to be renewed (experts assume a lifespan of 30 to 40 years). The quantity forecasts paint a shocking picture. Considering that only in Germany about 40 million square meters new EIFS-façade are being mounted yearly, valid sources assume approximately 10,000 tons of insulation material waste to be disposed of (per year). And so, we are now faced with an unsolved waste disposal problem.
In this context, we need to ask, how the legal requirements (currently 70% of building material waste must be recycled) can be met at all. Technologically, it is only with great effort (usually by manual stripping) that the attached insulation material can be separated from the construction material, so that the latter can be reused.

Experts are also divided on the question of how the separated insulation material waste, now contaminated with toxic agents, should be treated.

The fact of the matter is, that at the moment these materials are not classified as hazardous waste and may therefore be disposed-off in community waste incineration plants without raising questions.

In October 2016 the legal regulations regarding the disposal of foamed insulation material were drastically tightened. Since then styrofoam has been categorized as hazardous waste. A new regulation requires styrofoam to be incinerated separately. However many waste incineration plants do not have the necessary permit. The results are disposal bottlenecks and a dramatic cost increase. The cost for the disposal of styrofoam waste has risen within a couple of months from approximately 150 € per ton to thousands of Euros per ton.

Demolition companies, roofers and building renovation companies are under pressure. Since incineration plants refuse to accept this hazardous waste because they lack the necessary permits, mountains of styrofoam are left standing. Sometimes the quantities are so big that they cause delays or even downtimes at construction sites, which makes for very unhappy owners. More and more frequently there are cases in which, due to the delay, the owners attempt to hold the demolition companies liable. These are increasingly faced with damage claims.

**Long-term memory with gaps**

This is how history repeats itself. After all, it is not the first time that the enthusiasm for the alleged great technical properties of construction materials has led us to overlook their disadvantages for man and nature. Asbestos, which was already banned in 1979, still (after more than 30 years) causes high restoration expenses and is responsible for numerous illnesses and not to forget thousands of deaths.

But even knowledge and experience, which are culturally ingrained over generations, are sometimes forgotten over time. Over the past centuries catastrophic fire incidents that destroyed entire cities occurred frequently.

- Thessaloniki, August 5, 1917: Two-thirds of the Greek city went up in flames in a major fire. 9,500 homes including the urban commercial center were destroyed. Cause of fire was sparks of a hotplate.
- Hamburg, May 5, 1842: The fire disaster had its origin from the house of a cigar-wheeler and destroyed about 1700 homes. Affected was a quarter of the town area.
- London, September 2, 1666: The fire started from a bakery. Approximately 13,200 homes were destroyed.
The cause of the inexorable spread of these fires was often the, then typical, use of wood as construction material for buildings. It took many generations until the insight, that using non-flammable construction materials is an effective measure to prevent such large-scale fires, finally established itself as a construction standard.

In London, for example, after the great fire in 1666 wooden buildings were banned.

Since in today’s densely developed cities, the façades of entire streets are almost contiguously covered with flammable insulation materials, fire prevention experts fear that the catastrophic scenarios of the last centuries, in which whole neighborhoods were destroyed at once, could repeat themselves.

**Now what? Intensify the promotion of climate protection! But...**

In view of the high aims of climate protection it would surely be wrong to reduce the efforts made regarding the heat insulation of buildings. On the contrary, effective measures for the reduction of heat loss from buildings must continue to be taken and should, as such, continue to be promoted. However, when choosing such measures, it is imperative that the advantages and disadvantages are considered based on expertise and objectivity, while also taking into account critical long-term views and negative side effects. More and more experts start to see the use of foamed plastics for heat insulation as a folly.

The complementary role of property insurers in addition to expert opinions should not be underestimated. Technical developments, which have a negative effect on risk profiles and thereby lead to increased loss ratios in the long term, are categorized as a so called risk aggravation. For fire insurance, premium increases and additional risk premiums are often unavoidable. In contrast, effective risk reductions through appropriate fire protection measures are usually evaluated favorably and rewarded with reduced premiums by fire insurers. In view of this, when non-flammable construction materials are used exclusively (and therefore also non-flammable insulation materials) many fire insurers offer much more attractive premium models than they do when EIFS made of plastics are used.

**Multi-level approach towards loss prevention**

Valuable information on construction requirements can be found at VdS loss prevention (VdS-3461: Exterior Insulation Finishing Systems) and at the Center of Competence for Construction (DIBt). Unfortunately these valuable documents are available only in German language edition.

A multi-level approach can be devised to answer the questions of how effective heat insulation can be achieved without foamed plastics on the one hand, and which additional measures are necessary should we continue to use them, on the other hand.
1. **Fundamental requirement – no flammable insulation materials:** Regardless of the application advantages of insulation materials made of foamed plastics and even if building codes require the use of flame-retardant insulation materials only starting with category 4 buildings (height > 7 m), the application of non-flammable insulation materials (e.g. mineral rock wool, perlite-filled bricks, etc.) should be given preference in view of a sustainable protection of human life, environment and property.

2. **Strict construction requirements for the use of flammable insulation materials:** Should foamed insulation materials continue to be used, it is necessary to equip the façades with noncombustible thermal barriers. In this case, the lintel of each and every penetration (windows, doors) must be equipped with a fire barrier or an entire floor must have a wraparound firestop on every second floor. When EIFS systems with over 300 mm thick insulation materials are used, the exterior wall cladding must be non-combustible up to the second floor (minimum 6 meters).

3. **Extended requirements from the point of view of fire safety experts:** In the façade area, special attention must be given to the avoidance of direct ignition sources (e.g. smoking, hot work, etc.) and to placing potential ignition sources at an adequate distance (positioning of garbage cans, parking spaces for vehicles with combustion engines, etc.).

   During the planning phase of new developments as well as of restoration projects of existing buildings, the fire safety issues of foamed insulation materials must be given special consideration early on (close communication between planners, owners and contractors).

   Regardless of the graded code requirements (thickness of the insulation material sheet, building height, number of floors, etc.), an extended safety concept is recommended from a fire protection point of view whenever foamed insulation materials are used:
   - As a rule, exterior wall cladding should be non-combustible over the entire surface, up to the second floor ceiling.
   - As a rule, wraparound fire stops on every floor.
   - As a rule, a combination of fire stops AND lintel fire barriers for penetrations. (execution with side skirting)

Closing remark: Climate protection ostensibly aims to reduce the consumption of exhaustible raw materials. The focus is always on the basic raw material mineral oil. It is generally known that the plastics used for foamed insulation materials are made of mineral oil.

This raises the following question:

**How much sense does it make to use mineral oil products in order to save mineral oil?**
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