

The persistence and performance of plastic insulation

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Despite the difficulties of testing combustible building materials, their performance must be evaluated

A few years ago, I inspected a 50,000m² food storage warehouse constructed of polystyrene composite panels more than 1m thick. My reservations about the purchase were dismissed by the investor with a curt 'You worry about defects and let us worry about the investment.'

Suitably chastened I pondered the facts: a fire developing in such a building could soon become a fire of the building, a worry that was vexing underwriters in the late 1990s following a number of significant losses at the time. However, in those pre-recession, pre-Grenfell fire days, investors were happy to part with their cash. Would they do so with the same happy abandon now?

Types of plastic insulation

Polystyrene is one of a number of common rigid foam products in either expanded (EPS) or extruded form (XPS). It is a thermoplastic material, meaning that it can change shape when heated, and will melt readily in fire.

EPS and XPS are often modified with fire-retardant substances, but can still melt at temperatures as low as 100°C, decomposing at 300°C and igniting at 360°C. However, the foam can shrink rapidly from a flame due to melting, and for that reason may not ignite immediately. When it does, styrene and carbon dioxide are the main products of combustion, in a characteristic dense black smoke.

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Not being suitable for composite panels other than in cold stores or internal divisions, EPS is often used as external wall insulation, protected by silicone or polymer-modified thin render systems. Unsurprisingly, many surveyors question the wisdom of using a combustible product in such a vulnerable application.

Other insulation types include polyurethane (PUR), polyisocyanurate (PIR) and phenol formaldehyde resin (PF). All of these are thermosetting materials, which means that they can be formed only once and not remoulded.

PUR and PIR are chemically similar, both being based on polyol and isocyanurate. But whereas pure PUR degrades at about 250°C, PIR is able to sustain temperatures up to 350°C before it starts to decompose; it also forms a more stable char that improves its fire resistance.

While early formulations of PF foam, which is also thermosetting, proved unreliable, this particular material has become almost universal in floor and wall insulation systems.

Prior to Grenfell, it was considered to perform very well in the event of a fire, and is certainly superior to PUR in that regard. PF foam exhibits favourable char-forming properties, but usually ignites at temperatures of 530-580°C.

Appropriate use of plastic insulation

There is now confusion as to the appropriate use of thermosetting and thermoplastic insulation; whether these will satisfy the Building Regulations' fire requirements, or continue to satisfy them after the [Hackitt Review's](#) revisions are implemented, has yet to be established, as has whether or not they can continue to be used in buildings below the current 18m storey height threshold.

While the performance of stonewool insulation products as an alternative is well understood, these materials are not always as thermally efficient as thermosets, particularly PF, and so construction has to make provision for thicker insulation if it is to accommodate it. This may not be a problem when it comes to new construction, but could well bring challenges for retrofit applications.

In the face of conflicting advice, it often helps to go back to basics. The former *European Construction Products Directive ? Safety in Case of Fire* listed 5 key principles to bear in mind:

- the construction can be expected to carry its loads for a specific time period;
- the generation and spread of fire and smoke in the construction works are limited;
- the spread of fire to neighbouring construction works is limited;
- occupants can escape or be rescued from the construction by other means; and
- the safety of any rescue teams is taken into consideration.

These criteria have found their way into the Building Regulations and publications such as [BS 9991: 2015 Fire safety in the design, management and use of residential buildings](#) ; but many of those documents lack clarity, with inconsistent terminology and much that is still left open to interpretation.

Evaluating the performance of various materials is fraught with difficulty, as it relies on the results of small-scale tests that do not necessarily reflect what happens in an actual fire.

The tests undertaken by the [Building Research Establishment](#) in the immediate aftermath of the Grenfell fire demonstrated that the combination of materials and the way they were used are the proper subjects of examination. Latterly, organisations such as the [Association of British Insurers](#) have also argued that standard test methods fall short because they do not replicate the amount of plastic in modern construction.

Phase by phase

There are 3 recognised phases to a fire:

1. the growth, pre-ignition or smouldering phase;
2. the fully developed phase; and
3. finally the decay phase.

Matters such as combustibility, flame spread smoke and toxic gas generation are relevant to the first of these.

The second phase starts at flashover, the point where all fuel sources in the vicinity suddenly become involved in the fire. This is associated with rapid heat generation and a big increase in heat radiation, and temperatures can exceed 1,000°C. During the final phase, the combustion temperature and release of gas gradually reduce as the available fuel source is exhausted.

Risks to life will be prevalent during the first phase, particularly given that many fatalities are a result of smoke inhalation. While alternative stonewool products are non-combustible and contribute low levels of smoke and toxic product, the same cannot be said of plastic materials.

PUR foams yield toxic smoke, particularly before the fire is fully developed. Isocyanates and carbon monoxide are common at this stage, and hydrogen cyanide can be released by both PUR and PIR. Once open flaming has occurred, the emissions are mainly carbon monoxide. Even small concentrations of these can be lethal, although the inhalation of hot gas can cause severe burns within seconds.

There has been a tendency to exploit vagaries in terminology as a way of demonstrating compliance

One might be sceptical about the use of plastic foams in any building, but of course the situation is seldom simple; as noted earlier, it is often the case that the overall performance of a system needs to be considered. However, there has been a tendency to exploit vagaries in terminology as a way of demonstrating compliance. For example what does 'limited combustibility' actually mean?

The essential point is that all plastic foams are combustible; by varying the constituent raw materials, it is possible to improve char rates or flammability, but standardised tests may not replicate what will happen in an actual fire.

To conclude, an investor today might not be quite so keen to purchase a warehouse built from 12,000m³ of combustible insulation. In my example, the fire load of the polystyrene equalled more or less the total fire load of the building's contents.

However, that was a warehouse with a low level of human occupancy. Our obsession with plastics means that many thousands of homes have been built – and continue to be built – with products that seem to comply with current standards, but can and do cause harm to their occupants.

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Further information

- Related competencies include: [Fire safety](#) and [Risk management](#)
- This feature is taken from the [RICS Built environment journal](#) (February/March 2019)
- Related categories include: [Building control](#) , [Building elements](#) and [Fire and life safety](#)

Fire safety conferences 2020

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