Skin deep

How safe is external cladding? **Esko Mikkola** and **Edmar Meuwisse** report on a technical research study into the fire risks of using thermal cladding to insulate residential multi-storey building facades

IN EUROPE, the building sector is responsible for 40% of energy use and 36% of carbon dioxide (CO_2) emissions in Europe, the largest proportion of which results from either heating or cooling of poorly insulated buildings.

The European Union has formulated targets for climate action and energy efficiency, stating that by 2050, CO_2 emissions from buildings in Europe should be reduced on average by over 80%, compared to a 'business as usual' scenario[1]. Energy-saving renovation of the building stock is a task for all countries across Europe. The capital investment in building renovation pays off within a short time through reduced heating costs.

One important method used in energetic renovation is the insulation of the building façade by applying external thermal insulation composite systems (ETICS).

The first EPS ETICS were applied in Berlin in 1957, at which time insulation thickness was 4cm. Since then, in Germany alone, more than 900 million m^2 have been successfully applied and the average insulation thickness there had increased to 12.3cm in 2012.

ETICS have also gained wide acceptance in many other countries in Europe, with applications totalling around 150 million m^2 per year in 2009[2]. About 80-85% of this volume is based on EPS as insulation material.

Sustainable buildings

The use of EPS ETICS in buildings is expanding because of its good thermal insulation properties. EPS is a combustible material,

which starts to shrink and melt at elevated temperatures. If the fire exposure is high enough, ignition will occur and heat will be released. Compared to other combustible products, the amount of heat that can be released if ignition occurs is relatively small, due to the low density of EPS. In addition, in an ETICS, the EPS is protected against ignition by the outer rendering layers and in taller buildings in most countries, additional protection is granted by fire barriers above windows or around the building between different floors.

National regulations and guidelines have been established in order to minimise the fire risks when combustible products are used for façade insulation. In some cases there are limitations regarding the reaction to fire performance of the products used and special requirements for the protection of the insulation layers (quality of render, fire barriers, etc).

Alternatively, regulations may define performance-based fire safety requirements (performance levels) for products used in façades or for the whole façade system.

VTT study

Recently, the Technical Research Centre of Finland (VTT) undertook an extensive fire risk assessment of EPS ETICS[3]. This shows that the life safety risks of EPS ETICS fulfilling at least B class criteria are limited and within the same level of safety as façade systems using only non-combustible materials.

The study covered residential multi-storey buildings up to eight floors and analysis focused on fires starting inside buildings using statistical data on, for example, room areas and fire loads of typical dwellings in multi-storey buildings. In addition, an assessment was completed of the construction and renovation phase.

Research methodology

VTT used fire safety engineering methods to study the effects of EPS ETICS on fire safety in residential multi-storey buildings. The study covered buildings up to eight floors with the focus on analysis of fires starting inside buildings, as those are often more severe than fires initiating from external ignitions, and most building fires start inside a room and affect the façade after flashover and breaking of windows.

The probabilities of the spread of fire to apartments above the room of fire origin were assessed by calculating heat exposures and consequences caused by the external flaming both for the EPS ETICS façade and for a façade made of non-combustible materials.

In the VTT study, it was assumed that EPS insulation is protected from internal room fires by structures with a fire separating function of at least 30 minutes. From outside, EPS insulation is assumed to be protected at least with an approved 5-8mm thick reinforced rendering system according to the ETICS standard ETAG 004: 2013: *External thermal insulation composite systems with rendering*, including fire performance of the system Euroclass B according to EN 13501-1: 2002: *Fire classification of construction products and building elements,* or large scale evidence and fire barriers are used to prevent fire spread in the insulation layer in buildings with more than two floors.

To establish a check for the calculated estimates of fires spreading in non-combustible façades, a statistical survey was carried out using the Finnish rescue service's resource and accident statistics system (PRONTO) for 2004-2012 and the statistics database of the Swedish Civil Contingencies Agency (IDA) for 2004-2011.

According to statistics, by the arrival of the fire service, the fire development situation for fire spread outside the fire compartment is from 1% (Sweden) to 3-4% (Finland) per ignited fire. Information on fire spread due to window breaking (according to Finnish statistics) indicated that 0.7% of cases could lead to spreading through windows.

EPS contribution

Fire performance parameters for both white and grey (containing carbon/graphite) EPS with and without flame retardants have been reported in the VTT study. At high heat exposure levels there are only small differences between the products with and without flame retardant. The efficiency of the flame retardant becomes more significant at lower heat exposures. The experimental results also

show very clearly the protective effect of a thin (about 5 mm) non-combustible layer.

There is also experimental evidence on fire performance of EPS ETICS in large-scale tests of 5-6m high façades above a fire room and simulating the fire loads of real rooms. When using the protective measures mentioned earlier, EPS contributed to the fire only in a limited area and no fire spread occurred beyond the window two floors above the fire room.

This behaviour is well illustrated by a recent fire incident last November in Offenbach, Germany, when a fire developed inside an apartment on the fifth floor of an apartment building. The ETICS system was exposed to the flames coming from the apartment. The heat severely damaged the ETICS system above the broken window, including the EPS insulation, but did not spread to next floor.

Façade fires

The study included the simulation of 200 random fires (with several parameters having statistical distributions) starting from apartments and spreading to the façade through a broken window.

Results from the comparison of fire spread probabilities were as follows: the second floor window was broken in 31±5% of the cases (per fires which have spread through the fire room window to the façade) with non-combustible façade and in 36±5% of the cases with EPS insulation. Until about 25 minutes from the start of the fire, the window breaking probabilities for both façade types are very close to each other. In the third floor, the final probabilities were the same (5±1%), but with EPS insulation the window breaking tends to occur slightly earlier.

According to accident statistics, 0.7% of fires have the potential to spread through a window to the apartments above. As a result of the fire risk analysis, the probabilities were calculated to be 1.9% for non-combustible façades and 2.3% for EPS ETICS façades per ignited fire. These calculated estimates are somewhat higher than statistical data shows, which indicates that a safety factor is included in the results.

Acceptable risk

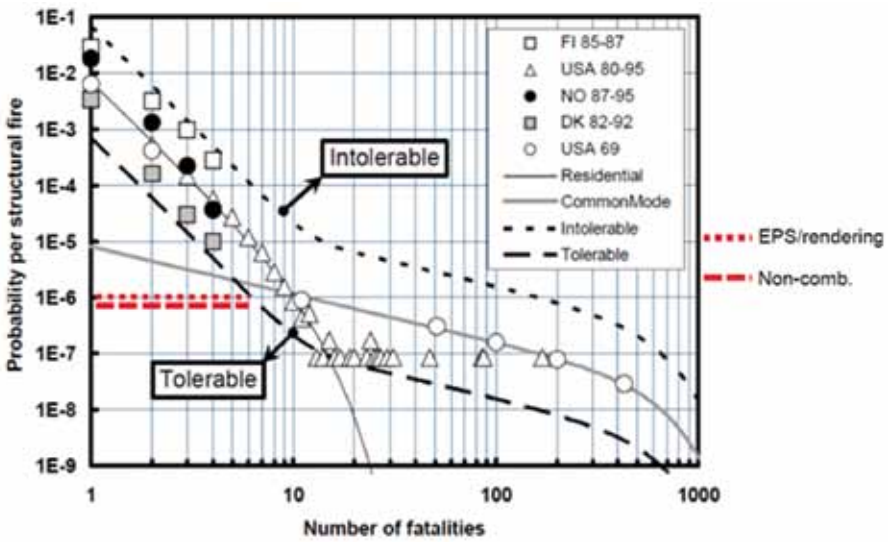
A common way of expressing life safety risk is an F-N curve, where the frequency (F) of an incident is plotted as a function of the number of fatalities (N) for that incident. An example of F-N curves of fire fatalities[4] illustrating the significant differences in acceptance levels between single and multiple casualties is shown in the figure below. According to accident statistics, there are 1-2 fire deaths per 100 building fires. Combining this with the estimated fire spread probabilities leads to the following fire death probabilities per building fire: $0.8 \cdot 10^{-6}$ for non-combustible façades and $1.0 \cdot 10^{-6}$ for EPS ETICS systems that fulfil the fire performance characteristics mentioned earlier. When this value is compared with the tolerable limit of the F-N-curve, it can be concluded that practically the same life safety level is reached with both systems (tolerable up to six fatalities in a fire).

Site safety

Uncovered EPS with flame retardant can resist small ignition sources such as cigarettes or small flames. However, at higher heat exposures EPS without any protective rendering may contribute to fire development. The main principles and actions concerning construction site fire safety for the time when EPS is uncovered during the installation phase are the following:

- reduce the risks of ignition by minimising the use of flammable liquids and gases, and the amount of fire load near the building under construction
- follow the hot work instructions/regulations
- ensure that everybody involved understands all fire safety instructions
- if the apartments are occupied during the installation process, limit the time EPS insulation is uncovered and provide proper safety instructions and means for escape

The effect of EPS insulation on the fire safety of the building was studied using fire safety engineering methods. Taking into account uncertainties and sensitivity analysis, it was estimated that there is a small difference between the two studied façade types: The overall window break probability in the floors above for EPS ETICS façades is 2.3% and for non-combustible façades is 1.9% per ignited fire. The estimated overall probability values for the window breaking in the floors above



are on the upper limit compared to statistical data for which conservative values were used. Thus, a safety factor is included in the results.

As regards consequences for life safety, the fire death probability was found to be not more than 10^{-6} per building fire ($0.8 \cdot 10^{-6}$ for non-combustible façades and $1.0 \cdot 10^{-6}$ for EPS ETICS systems. When this value is compared with the tolerable limit of F-N curves (probability of an event and consequences in terms of number of deaths), it can be concluded that life safety objectives are reached.

Concerning construction site fire safety, the following rules need to be respected: reduce the risks of ignition, follow the hot work instructions, ensure that everybody on the site knows and understands the fire safety instructions and, if the apartments are occupied during the installation process, limit the time EPS insulation is uncovered and provide proper safety instructions and means for escape.

The study has shown that ETICS with EPS with an appropriate and approved rendering and fire barriers (for higher buildings) do not represent an additional risk for inhabitants in case of a fire in a building, compared to a building that is not insulated or insulated with non-combustible products. During construction, the level of safety is improved if flame retarded EPS is used. Nevertheless it is important to have safety precautions during this phase, whenever combustible products are used, or stored near the building under construction or renovation ■

> **“ In Germany alone, more than 900 million m² have been successfully applied ”**

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References

1. *EU Energy, Transport and GHG Emissions Trends to 2050*, reference scenario 2013, European Commission DGs Energy, Climate Action and Mobility and Transport.
2. *WDVS in Europe*, Bombös L, EAE presentation, 2010.
3. *Fire safety of EPS ETICS in residential multi-storey buildings*, Mikkola, E, Hakkarainen, T and Matala, A, VTT Technical Research Centre of Finland, Espoo, Finland, 2013, Research Report VTT-R-04632-13, p37 + app. p4, http://www.vtt.fi/inf/julkaisut/muut/2013/VTT-R-04632-13.pdf.
4. *A proposal for the goals and new techniques of modeling pedestrian evacuation in fires,* Proceedings of the 8th International Symposium on Fire Safety Science, Beijing, China, 18-23 September 2005, Korhonen,T, Hostikka, S, Keski-Rahkonen, O, International Association of Fire Safety Science, 2005, pp557-569.