TECHNICAL INFORMATION

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PV Systems on EPS Flat Roofs

Reduced Fire Spread through the Installation of Cement-bonded particleboard underneath the Roof Membrane

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Background and objectives

A series of fire incidents involving photovoltaic (PV) systems installed on flat roofs has prompted a critical evaluation of their implications for overall fire safety, both in new constructions and in the refurbishment of existing buildings.

In response, EUMEPS and IVH have initiated a comprehensive program of full-scale fire testing under realistic conditions to investigate the dynamic interaction between PV components and flat roof assemblies.

This document presents targeted experimental setups designed to assess the effectiveness of cement-bonded particle boards, installed beneath the waterproofing membrane, as an additional fire protection measure for Building Applied Photovoltaic Systems (BAPV) on flat roofs.

The results indicate that expanded polystyrene (EPS) flat roof systems, when properly configured, can achieve safe fire safety performance even when PV systems are installed. These findings provide validated design strategies for improving the fire safety of EPS-based flat roofs in both new buildings and refurbishment projects.

The Use of Photovoltaic (PV) Systems on Flat Roofs

The use of photovoltaic (PV) systems on flat roofs represents a forward-looking solution for sustainable energy generation.

Given the growing demand for renewable energy and the increasing utilisation of previously unused roof surfaces, PV systems on flat roofs are gaining significant importance. They offer an efficient means of generating electricity for both new constructions and building renovations, whether on lightweight industrial roofs or flat roof structures with reinforced concrete decks.

Figure 1: Flat roofs insulated with EPS are ideal for the installation of PV systems.

PV systems can, in some cases, pose a fire hazard to the underlying flat roof. This risk primarily arises from improperly installed or inadequately maintained PV systems. From the perspective of

EUMEPS (Association of the European Manufacturers of Expanded Polystyrene) and the Industrieverband Hartschaum (IVH), the type of insulation material used in the flat roof is not the primary factor of concern.

The material layers installed above the insulation play a significantly greater role in determining the fire behaviour of a flat roof, including the potential for fire spread across the roof surface.

These layers include, for example, the top waterproofing membrane or the protective and separation layers positioned between the insulation and the upper waterproofing layer.

According to EUMEPS and IVH, the frequently proposed replacement of combustible insulation with so-called non-combustible insulation does not necessarily lead to an improvement in fire spread behaviour on flat roofs.

This is because the roof structure functions as a system that is subject to various interactions. A system is more than just the sum of the properties of its individual components.

Furthermore, such recommendations often generate uncertainty among stakeholders—including building owners, designers, and contractors—frequently resulting in unnecessarily complex and cost-intensive construction measures.

What remains unequivocal, however, is that the integration of a PV system inherently introduces an additional fire load due to the presence of its electrical and structural components. In parallel, thermal radiation from a fire occurring beneath a PV module significantly increases the thermal stress exerted on the underlying roof assembly.

Flat roofs insulated with EPS have been proven construction systems for decades, both in new builds and existing structures, and continue to offer safe solutions for lightweight industrial roofs as well as flat roofs with reinforced concrete decks.

The Industrieverband Hartschaum e. V. (IVH) commissioned large-scale fire tests conducted under real-world conditions, which are described below. The objective was to investigate the additional fire load introduced by PV system installed on an EPS flat roof system, in combination with an additional cement-bonded particle board layer. The tests were carried out and evaluated by the Dutch testing institute Kiwa BDA Testing B.V[1].

[1] 24L0474/3: REV 02 Large-scale fire test on a flat roof system with EPS insulation and a cement-bonded particleboard fire barrier;

25L0053/1: Large-scale fire test on a flat roof system with EPS insulation and a cement-bonded particle board fire barrier, with a PVC roof waterproofing sheet;

25L0271/1: Large-scale fire test on a flat roof system with EPS insulation and a cement-bonded particle board fire barrier, with a PVC roof waterproofing sheet.

25L0271/2 REV 02: Large-scale fire test on a flat roof system with EPS insulation and a cement board, with a PVC roof waterproofing system

Applied Testing Methodology

Flat roof systems with EPS insulation are tested in Germany according to Technical Specification TS 1187[2]. This is the standard test method for hard roofing systems to assess their resistance to flying sparks and radiant heat.

Currently, there is no standardised test method in Germany for evaluating the additional fire load introduced by PV systems. Therefore, the tests described below were conducted based on the CLC/TR 50670[3] methodology. This method was selected to ensure comparability with fire tests previously carried out in other industries, such as PU Europe[4].

In this test, a 15-kW gas burner is used to generate a test fire for 10 minutes, followed by a 50-minute observation period. The objective of the test is to evaluate fire spread across a 7 x 7-meter roof surface.

Test with Cement-Bonded Particleboard below the Roof Membrane

This test investigated the effect of a cement-bonded particle board installed between the PVC roof waterproofing membrane and the EPS flat roof insulation.

The test setup included a PV system with glass-film modules arranged in an east-west orientation, installed on a 7 x 7 meter EPS-insulated flat roof surface (**Figure 2**).

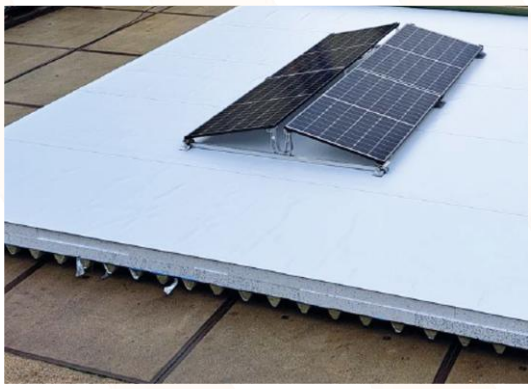


Figure 2: Tested PV system consisting of glass-film modules in an east-west orientation.

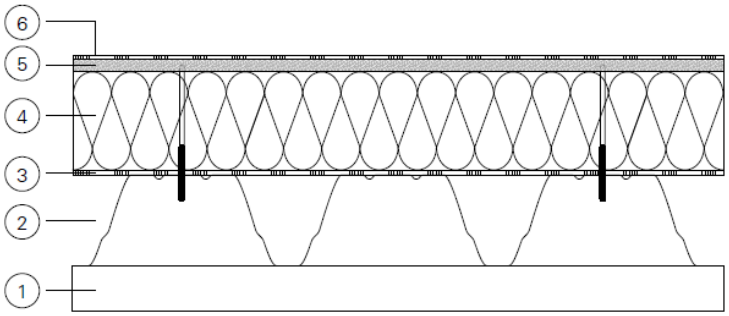
The selected flat roof construction consisted of a trapezoidal sheet metal roof (**Figure 3**), covered with a polyethene vapour barrier film. On top of the vapour barrier, an EPS thermal insulation

2 2 TS 1187: Test method for exposure of roofs to external fire – Test Method 1.

3 CLC/TR 50670: External fire exposure to roofs in combination with photovoltaic (PV) arrays – Test method(s) – Test Method 1

4 European Association of the Polyurethane (PUR/PIR) Insulation Industry: 0151-L-20/4, Additional test report, Kiwa BDA Testing B.V.: Comparative tests on the fire behaviour of flat roof waterproofing systems with different thermal insulation materials and equipped with identical photovoltaic systems, February 2022; Photovoltaics on flat roofs: Comparative fire tests on roof assemblies, IVPU, 2022.

with a total thickness of 220 mm and a compressive strength of 150 kPa (DAA dh) was installed. A 12, 8 or 6 mm thick cement-bonded particle board was then placed over the EPS insulation as a non-combustible protective layer, followed by a 1.8 mm thick PVC waterproofing membrane as the top roofing layer.



6. PVC membrane: Type M18

5. Cement-bonded particle board or fibre-cement board

4. EPS DAA dh, 220 or 100 mm

3. Vapour barrier: 250 micrometre, sd> 100 m

2. Trapezoidal steel deck: Type M 100/275, thickness 0.75 mm

1. Substructure: square tubing 50 x 50 mm

Figure 3: Cross-section of the roof structure – Lightweight industrial roof construction with EPS rigid foam and cement-bonded particle board (layer 5) beneath the PVC waterproofing membrane.

Figure 4: Flat roof with EPS rigid foam and overlying cement-bonded particle board (12 mm here)– damage pattern showing negligible fire spread.

Figures 5 and 6: Flat roof with EPS rigid foam and top-layer cement-bonded particle board (12 mm here)– extremely limited fire spread across the roof surface and minimal damage to the insulation material.

Summary of results

- **The cement-bonded particle board** installed beneath the roof waterproofing layer prevented the fire from penetrating into the underlying flat roof structure during the test setups. Fire spread above the cement-bonded board was extremely limited and confined to the footprint of a single PV module.
- **The test results demonstrate** that the cement-bonded board acts as a reliable fire barrier, successfully inhibiting vertical fire penetration into the roof assembly and, by extension, into the building interior. In all test scenarios, the fires self-extinguished within a short timeframe.
- **These observations confirm** that even in the event of prolonged, undetected PV system fires, there is no immediate risk of full-scale fire development in EPS-insulated flat roofs with PVC membranes, provided that cement-bonded particle boards are incorporated beneath the waterproofing layer

According to the results of the large-scale fire tests conducted with the specific setup and materials described, the increased fire risk for an EPS flat roof system caused by the installation of a PV system can be mitigated by the additional protection provided by cement-bonded particleboards installed beneath the waterproofing layer. This applies to both solid flat roof constructions and lightweight industrial roofs. Consequently, the fire performance of EPS flat roofs incorporating photovoltaic systems can be improved through appropriate design and material selection. EPS offers a viable option for both new builds and retrofit applications, with considerations for safety, installation efficiency, and cost management.

EUMEPS, Association of the European Manufacturers of Expanded Polystyrene
71 Avenue Cortenbergh, B-1000 Brussels, Belgium

IVH, Industrieverband Hartschaum
Friedrichstraße 95 / Pb 48, 10117 Berlin, Germany