DIRECT-TO-DECK SPRAY POLYURETHANE FOAM

Passes Factory Mutual Research Corner Test

By Roger Morrison, PE, RRC, James Andersen, and Phillip Smith, PE

On July 22, 1999, a six-inch thick spray polyurethane foam (SPF) roof applied directly to a galvanized, 22-gauge steel deck underwent a successful 25-foot-high corner test at Factory Mutual Research's West Glocester, Rhode Island test facility. The test was the culmination of a series of fire tests in preparation for Factory Mutual Research approval of spray polyurethane roofing systems installed direct to metal decks. Ten SPF manufacturers participated in the testing, which was overseen by the Spray Polyurethane Foam Alliance (SPFA), a business unit of The American Plastics Council (APC).

Typically, Factory Mutual Research tests roof systems for fuel contribution to interior fires using the Factory Mutual Research calorimeter. However, due to the physical characteristics of spray-applied polyurethane foam, the tested SPF systems vented flammable gasses upward, away from the flame source, invalidating the calorimeter test. Factory Mutual Research engineers determined a different testing protocol would be needed to evaluate SPF direct to deck roofing systems.

The internal fire spread protocol called for two large-scale tests:

- Uniform Building Code Standard 26-3: Roof Fire Test Standard for Interior of Foam Plastic Systems ("Small Room Test"), and

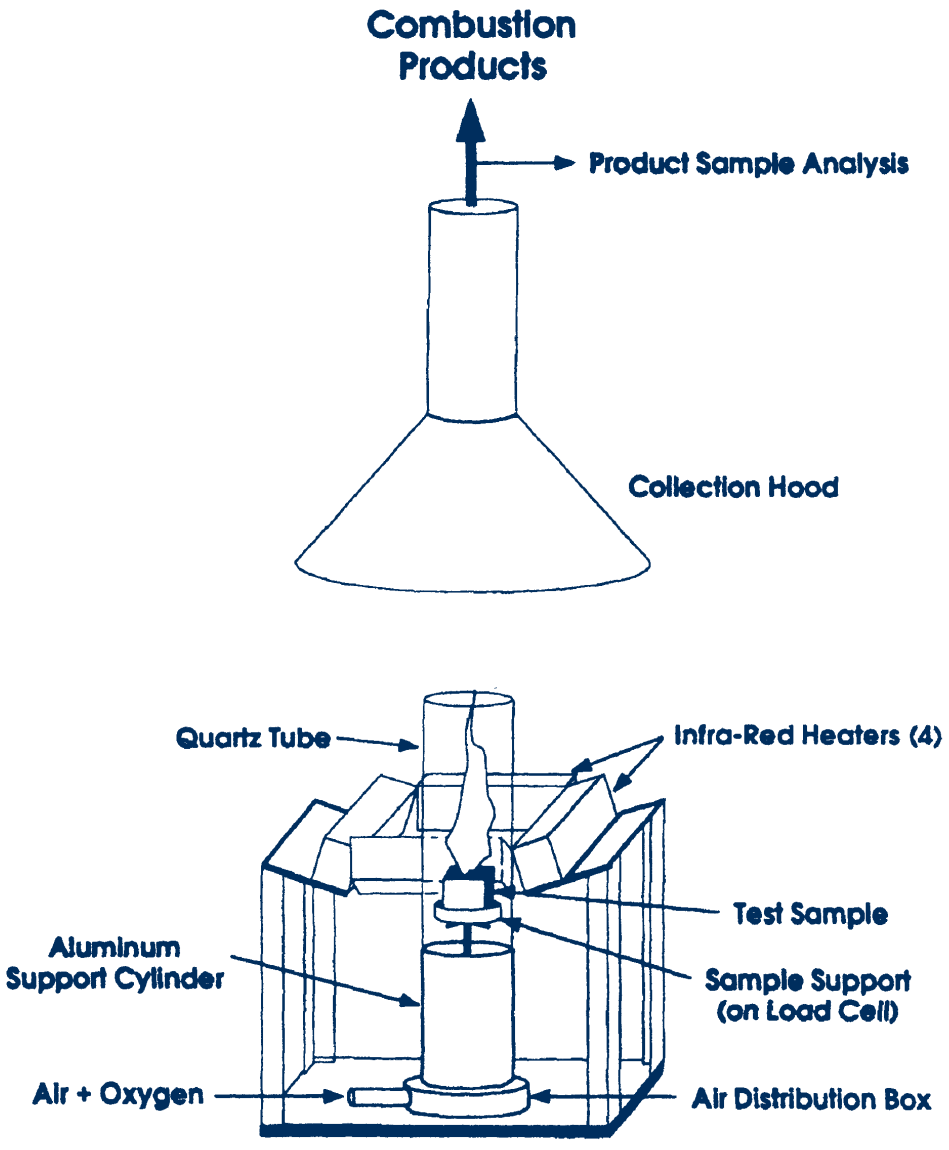


Figure 1: Factory Mutual Research 50 kW Scale Fire Propagation Apparatus (from Factory Mutual Research Approval Standard 4880.)

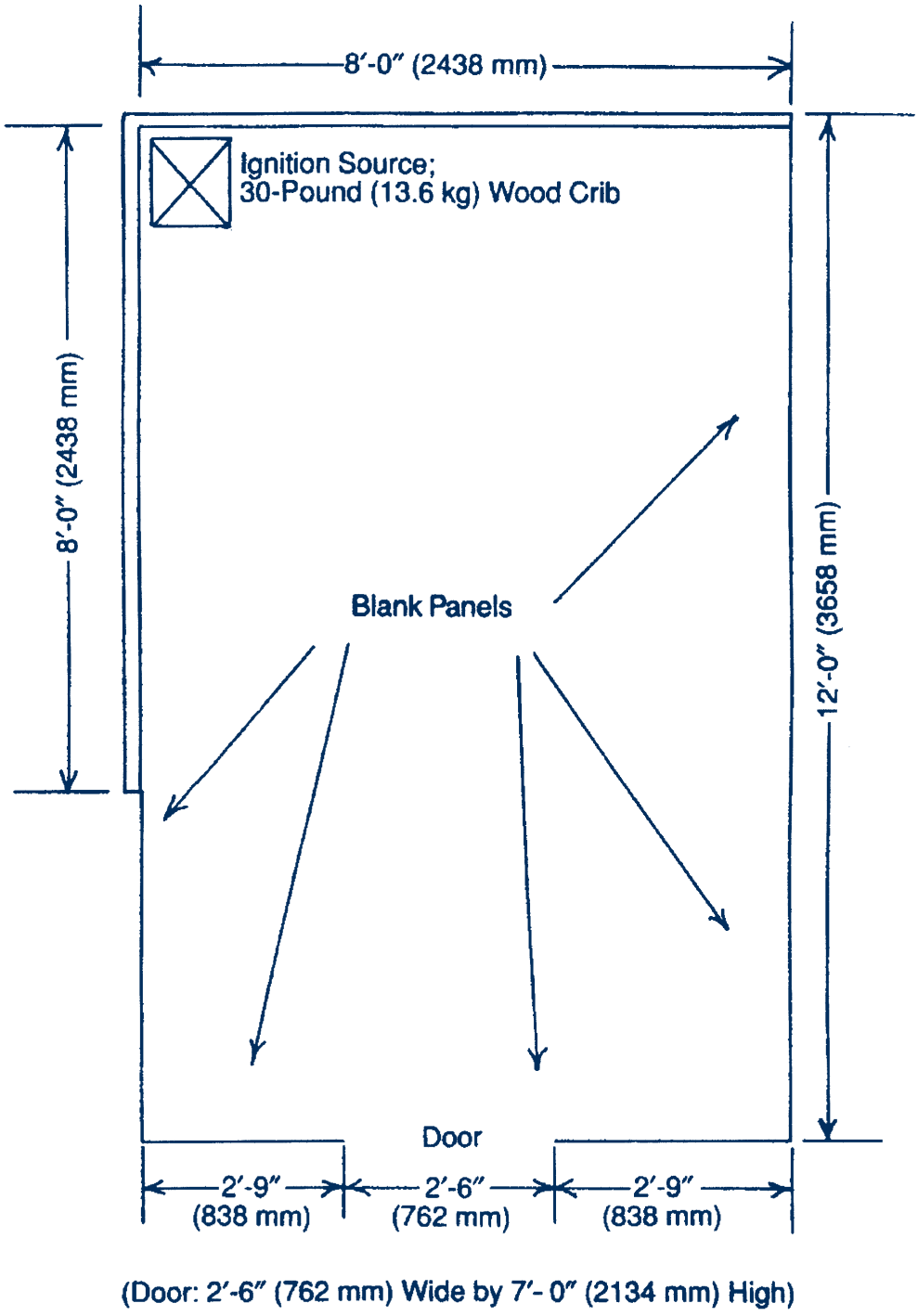


Figure 2: Small Room Test Configuration (from UBC Standard 26-3—Room Fire Test Standard for Interior of Foam Plastic Systems).

- Factory Mutual Research Approval Standard 4880: Class 1 Insulated Wall or Wall & Roof/Ceiling Panels ("25-Foot Corner Test").

Both the Small Room and the 25-Foot Corner tests measure the propensity of an assembly to propagate fire within a building. The Small Room Test primarily tests for radiative heat transfer during fire exposure, while the 25-Foot Corner Test is primarily influenced by convective heat transfer.

Because of the expense of full-scale testing, only one Small Room Test and one 25-Foot Corner Test were planned. To determine which of the ten manufacturers' foams to test, Factory Mutual Research ran a series of small-scale screening tests to determine each foam's convective flame spread parameter (FSP_c).

FSP_c (units are: $sec^{-1/2}$) is a function of the convective heat release rate and a material's resistance to ignition. A material's FSP_c is determined from its convective heat of combustion, effective heat of gasification, the critical heat flux for ignition, and the thermal response parameter (a measure of thermal inertia). The Factory Mutual Research 50 kW Scale Fire Propagation Apparatus was used to determine the factors used to calculate FSP_c. A detailed discussion of FSP_c can be found in Factory Mutual Research Approval Standard 4880.

Approximately ten samples of each of the ten participating foams were burned in the Fire Propagation Apparatus to determine each foam's FSP_c. Values for the ten foams were ranged from 0.39 to 0.81 $sec^{-1/2}$.

Prior testing with steel-faced, polyurethane foam core wall and ceiling/roof panels showed that foams with $FSP_c \leq 0.39$ $sec^{-1/2}$ will pass the 25-Foot Corner Test when the panels are installed on the walls and ceiling. For a ceiling/roof only application with non-combustible walls, Factory Mutual Research engineers performed additional analyses and advised that foam materials with an FSP_c of 0.85 $sec^{-1/2}$ or less were reasonable candidates for roof only 25-Foot Corner testing. Following the results of the Fire Propagation Apparatus screening tests, the participating foam manufacturers agreed to proceed with the Small Room and 25-Foot Corner tests using the foam with the highest FSP_c (0.81 $sec^{-1/2}$).

A Small Room Test structure was built at Factory Mutual Research's West Glocester test facility. In accordance with UBC Standard 26-3, the room dimensions were 8 ft by 12 ft with an 8 ft high ceiling. The roof/ceiling consisted of a galvanized steel deck to which 6 inches of the selected spray polyurethane foam had been applied to the top surface. The deck flutes were filled with SPF. The top surface of the SPF was coated with a Factory Mutual Research approved acrylic coating. The walls were constructed of 1/2-inch gypsum board. The ignition source was a

30-lb. wood crib located in one corner of the room.

This fire test was conducted on June 4, 1999. No fire propagation or burn through were observed during the 15 minute test, meeting the conditions of acceptance of UBC 26-3. Char varied from 1/2 inch deep directly over the ignition source to slight discoloration at four feet to no visible char eight feet from the ignition source.

Following the successful completion of the Small Room Test, the 25-Foot Corner Test was assembled. Again, 6 inches of SPF were applied to a galvanized steel deck with the flutes being filled with SPF. The foam was coated with a Factory Mutual Research approved acrylic coating. A layer of gypsum wall board was placed loosely over the coating to limit any venting. The walls were covered with gypsum board, simulating noncombustible walls. On July 22, this test was conducted. During the 15 minutes of this test, no fire propagation was observed beyond approximately 15 feet from the corner of the structure, meeting Factory Mutual's Approval Standard for a Class 1 system.

A "check" FSP_c test on the installed polyurethane foam indicated an actual FSP_c value of 0.69 $sec^{1/2}$, which will be used as the pass/fail benchmark for this particular configuration.

Factory Mutual Research then conducted a wind uplift test of SPF direct to steel deck. One 12 ft. by 24 ft. simulated wind uplift test sample was constructed as follows: 22 ga Factory Mutual Research Approved galvanized grade C deck was supported 6 ft. on center and fastened with Factory Mutual Research Approved

fasteners at 6 in. on center (every rib). The side laps were fastened with Factory Mutual Research Approved fasteners at 12 in. on center. The deck was washed with a TSP and water solution and dried. One of the selected foams was spray-applied to a thickness of 1 inch over the top flanges. This sample failed during the uplift pressure increase to 165 psf. Deck rupture at a fastener was the failure mode.

The direct to steel deck research program is the latest in a series of Factory Mutual Research programs for spray polyurethane roof systems. In 1995, several manufacturers of spray polyurethane foam roofing systems joined a cooperative effort headed by SPI/SPFD to gain Factory Mutual Research Class 1 approval (per Factory Mutual Research Approval Standard 4470). By sharing costs for certain tests, the cost for approval was significantly reduced for each participant.

Above: 25-Foot Corner Test, 14 minutes into the 15-minute test.

Right: Charring of SPF was limited to the foam within the deck flute and approximately 1/2 inch above the deck flanges. The char decreased with distance from the corner. Foam discoloration (not char) was observed 14 feet along the 38-foot wall and 24 feet along the 50-foot wall.

Data generated in the test program were shared with participating elastomeric coating manufacturers, resulting in extensive cross listings for Factory Mutual Research approved Class 1 spray-applied polyurethane foam roofing systems.

As a result of the 1995 round of testing, spray polyure - thane foam roof systems were approved as Class 1 Roof Covers over the following substrates:

1. Recover of certain Factory Mutual Research approved built-up roof systems over steel decks.
2. Recover of certain Factory Mutual Research approved built-up roof systems over concrete decks.
3. New construction over structural concrete decks.

With the latest round of testing, the application of spray polyurethane foam roofs directly to metal roof decks in buildings with noncombustible walls can be added to this list. ■

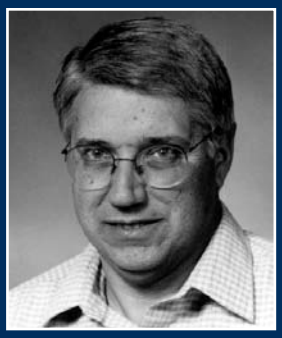
References

Approval Standard: "Class 1 Roof Covers—Class Number 4470." Factory Mutual Research, April 1986.

Approval Standard: "Class 1 Insulated Wall or Wall & Roof/Ceiling Panels, et. al.—Class Number 4880." Factory Mutual Research, August 1994.

Uniform Building Code Standard 26-3: Room Fire Test Standard for Interior of Foam Plastic Systems—Test Standard for the International Conference of Building Officials. 1994 Uniform Building Code.

About the Authors



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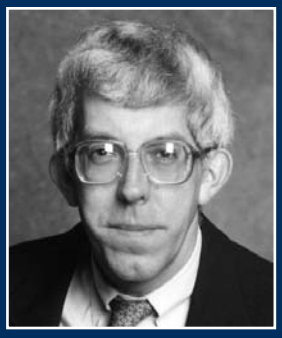

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