

UNDER FIRE!

Fire Resistance Testing of Single-Ply Roof Membranes

by Peter Bonavita

The performance classification for fire resistance is an important selection factor for single-ply roofing systems. Understanding the test procedures and marketing used by Underwriters Laboratories, Inc. (UL) and Factory Mutual Approvals (FM) will clarify any confusion about fire classification ratings, and provide you with a better understanding of the value and significance of the different types of fire tests.

In short, ANSI/UL 790 “Tests for Fire Resistance of Roof Covering Materials,” and ASTM E 108 “Fire Tests of Roof Coverings,” cover the performance of roof covering materials exposed to fire originating outside the building. Both standards essentially use the same test procedures and products tested with either standard are given the same Class A, B or C rating. It is also important to note that UL 790 includes other test procedures — i.e. Flying Brand, Rain Test and Weathering Test — that are in the standard but not applicable to single-ply roof membrane; however the tests are applicable to wood shakes and shingles.

Underwriters Laboratories Testing

UL is an independent organization established to test products for public safety. The organization uses three types of fire tests to rate a roofing assembly’s resistance to fire: spread of flame, intermittent flame and burning brand tests. Each test is designed for different types of decks, non-combustible or combustible, and roofing assemblies. Combustible decks must pass all three to

achieve a Class A, B or C rating. Roof assemblies used over steel, concrete or poured gypsum are not subject to the intermittent flame or burning brand tests because those tests are used to determine if a fire can penetrate a roof deck.



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Spread of Flame Test

The spread of flame test measures the roofing material’s ability to resist the propagation of flame spread. This test is performed on both combustible and non-combustible test decks depending on which ratings the roofing system manufacturer seeks. For the test, two, 40-inch wide test decks are constructed with the roofing membrane installed according to

the manufacturer’s specifications. The membrane is installed flush with the sides and back edge of the test deck, and overhangs the leading edge by 1 inch. Various test deck lengths of 8, 9 and 13 feet are used to determine a Class A, B or C rating respectively.

The test deck is positioned at a given slope and subjected to a 1400°F flame ($\pm 50^\circ\text{F}$), and driven by a 12-mph wind for 10 minutes. A Class A rating is given if the flame spread is 6 feet or less. A Class B rating is assigned if the flame spread is limited to 8 feet. In a Class C test, the flame temperature is reduced to 1300°F ($\pm 50^\circ\text{F}$), and applied for four minutes. For this test, the flame cannot spread further than 13 feet. For all the tests, there should not be any significant lateral flame spread.

During the tests, the sample is observed for flame spread, production of burning brands, and dislodging of the sample.

Intermittent Flame Test

The intermittent flame test measures the roofing material’s ability to resist flame penetration when flames are inconsistent. Two test decks each 40-inches wide by 52-inches long are used with the roofing membrane in place as specified by the system manufacturer. The test deck is positioned at a specific slope and subject to a 1400°F flame ($\pm 50^\circ\text{F}$) along the width of the test deck, fanned by a 12-mph wind. The flame is applied intermittently in cycles of two minutes on, two minutes off for Class A and B

ratings, and one minute on and two minutes off for Class C. The number of cycles “passed” determines the Class A, B or C rating.

A Class A rating is achieved if both test samples withstand 15 cycles without any sustained flame on the underside of the test deck, no production of flaming brands (embers) and no displacement of portions of the test assembly. A Class B rating is awarded if both test samples successfully pass eight cycles of the test. A Class C rating is given if both samples pass three cycles.

The Burning Brand Test

The burning brand test measures the roofing assembly’s resistance to flame penetration caused by a severe burning object or ember that falls onto the roof. For this test, the same plywood-based test decks used in the intermittent flame test are used with slightly different construction depending on the A, B, or C classification. For instance, Class A and B decks are both 40-inches wide x 52-inches long. The Class B deck has two vertical joints while the Class A deck has only one joint. The Class C deck is 40-inches wide x 48-inches long with five horizontal joints.

For a Class A rating, a grid of kiln-dried Douglas fir (12 inches x 12 inches x 2.25 inches and weighing about 4.5 pounds) is fully ignited and put onto the roof assembly and subjected to a 12-mph wind. The temperature of the ignited flame is 1630°F ($\pm 50^\circ\text{F}$).

Each test continues until the brand is fully consumed and until all evidence of flame and smoke has disappeared. If the roof assembly resists flame penetration until all activity dies out in each of four consecutive brands, a Class A rating is achieved.

For a Class B rating, the roof assembly must resist moderate flame penetration from two, one-pound brands, each measuring 6 inches x 6 inches x 2.25 inches.

For a Class C rating, the roof assembly must resist flame penetration from 20 brands, each measuring 1.5 inches x 1.5 inches x $\frac{25}{32}$ inches and weighing about $\frac{1}{3}$ pound.



Spread of Flame Test



Burning Brand Test



Intermittent Flame Test

Internal Fire Testing

“Fire Test of Building Construction and Materials” (UL 263) evaluates the entire roof and ceiling assembly for resistance to heat buildup from an internal fire. The assembly encompasses everything from the internal ceiling to the external roofing membrane, including ducts, electrical conduit, and structural supports.

Classifications for the UL 263 test are measured by a time/temperature curve. In general, the test provides an hourly rating for a specific design relevant to floor, ceiling or roof assemblies. Each roof/ceiling assembly tested is given an hourly rating and listed in the UL Fire Resistance Directory under design numbers. A design number preceded by the letter “P” designates roof/ceiling assemblies. Only specified UL-labeled components can be used for any particular design number.

Another UL fire test is the “Fire Test of Roof Deck Constructions” (UL 1256). This test is used to evaluate the performance of roof deck constructions when subjected to internal fire exposure. This test is used to determine what, if any, contribution the roof covering material and roofing components (i.e. insulation, etc.) provide to a fire within the building.

A catastrophic fire in 1953 in the General Motors transmission plant in Livonia, Michigan prompted this test. During that event, the intense heat on the underside of the metal roof deck melted the bituminous roofing system that had been applied directly to the steel deck. The melting asphalt roof cover entered the building and ignited and significantly contributed to the spread of fire in the building. The roof system continued to feed the fire until some 35 acres of roof collapsed. As a result of this fire, UL constructed a 20-foot wide x 100-foot long test structure to determine how various construction products contribute to internal fire spread.

There are essentially two test methods – large-scale testing and small-scale testing. The large-scale test involves a 10-foot tall x 20-foot wide x 100-foot long structure, which is open at one of the 20-foot wide



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ends. A roof deck construction is built, complete with perimeter terminations, parapets and flashing representative of standard details as specified by the system manufacturer. The structure includes a variety of thermocouples below the roof deck, on the topside of the roof deck as well as on the topside of the roof covering.

A fire is created at one end to simulate fire exposure within the first 20 feet of the structure, fanned by a (maximum) 12-mph wind, and allowed to burn for 30 minutes. The material passes if after 30 minutes the maximum sustained flame progression within the structure due to underdeck flaming does not exceed 60 feet from the ignited flame starting point.

In addition, flaming or molten residue falling from the roof deck or on the floor of the structure can not exceed 60 feet from the starting point. Further, intermittent underdeck flaming, tips of flaming along deck seams or flaming dissociated from the main flame front within the structure are not to exceed 72 feet from the starting point.

In the small scale testing a Steiner Fire Test Chamber is used. A 20-inch wide x 24-foot long test specimen is built of the roofing assembly for which classification is specified. This can either be a continuous length or sections pieced together.

During this “pass/fail” test, the sample is exposed to an open flame delivered by two gas burners directed upward to the surface of the test sample. Roof assem-

blies that prevent flame spread from exceeding 10-feet during the first 10 minutes, and 14-feet during the entire, 30-minute test, are acceptable.

Factory Mutual Testing

Like UL, Factory Mutual is an independent testing agency. Factory Mutual Approvals is the nonprofit research arm of FM Global. FM Approvals has set many test standards for single-ply roofing towards property loss prevention due to fire and wind.

FM approves roof assemblies on the basis of performance in a comprehensive series of tests, one of which is outlined in “Class I Roof Covers” (FM 4470). FM 4470 evaluates roofing materials for resistance to fire, wind, hail, leakage and corrosion of metal parts. A Class I rating is given when the roofing assembly successfully completes all the tests in FM 4470, including the following fire-related test procedure:

Exterior Combustibility

Exterior combustibility evaluates external fire spread in terms of severe, moderate or light and relies on the ASTM E 108 test series to measure the exterior combustibility of a roof assembly. The FM test procedure and rating structure for exterior combustibility is identical to the UL 790 procedure.

According to the ASTM E 108 procedure, the minimum classification for approval is Class 1C, in which the roof membrane and deck must be effective against a light test exposure, and “afford a light degree of fire protection to the roof deck.” In the case of FM Class 1C, light is equivalent to a UL Class C rating. FM class 1A and 1B ratings are equivalent to UL Class A and B classifications.

Understanding how Factory Mutual and Underwriters Laboratories test roofing membranes is important for building owners and specifiers alike. Detailed descriptions of these tests can be obtained by contacting FM and UL directly. ▲

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