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## **Fire Testing of Membrane Roof Systems**

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During the past several years, the Midwest Roofing Contractors Association (MRCA) and National Roofing Contractors Association (NRCA) have been working jointly on a long-term research program of fire testing aged and new membrane roof assemblies. This research has revealed some findings that should be of concern to roofing professionals including contractors, designers, manufacturers, distributors, building owners and operators, testing agencies and code authorities.

This report provides a brief background and overview of the MRCA/NRCA research program and makes specific recommendations for action MRCA and NRCA feel are appropriate at this time.

### **Background**

Beginning in 1991, MRCA and NRCA conducted a field research study<sup>1</sup> where 109 polymer-modified bitumen roof systems were inspected and their conditions documented.

Recognizing fire resistance is an important performance attribute of most roof systems, in 1996, MRCA undertook a limited series of fire tests<sup>2</sup> on existing, coated, polymer-modified bitumen roof systems. The purpose of this test series was to determine whether the "aged" roof systems maintained their initial fire-resistance ratings. In all, samples from four existing roof systems were taken by MRCA and were tested by Underwriters Laboratories Inc. (UL), Northbrook, Ill., in accordance with the spread-of-flame portion of ASTM E108, "Standard Test Methods for Fire Tests of Roof Coverings." Specimens from two of the aged roof systems passed the fire tests, while specimens from the two other aged roof systems did not pass the fire tests.

In 2001, MRCA conducted an additional series of fire tests on aged, existing membrane roof systems. Again, the purpose of this test series was to determine whether the aged roof systems maintained their initial, published fire-resistance ratings. Specimens were obtained from 10 roof systems that were believed to have been designed and installed as fire-rated systems: two coated, polymer-modified bitumen membrane roof systems; two granule-surfaced polymer-modified bitumen membrane roof systems; two PVC membrane roof systems; two EPDM membrane roof systems and two TPO membrane roof systems. The specimens were tested in accordance with the spread-of-flame portion of ASTM E108 by Intertek Testing Services, NA (ITS), Middleton, Wis., a code-accredited fire-testing laboratory. Five of the specimens (one coated and one granule-surfaced polymer-modified bitumen membrane, both PVC membranes and one EPDM membrane) passed the fire tests, while the five other specimens (one coated, polymer-modified bitumen membrane; one granule-surfaced polymer-modified bitumen membrane; one EPDM membrane and both TPO membranes) failed.<sup>3</sup>

In 2002, MRCA, with assistance from NRCA and a number of other interested parties,<sup>4</sup> conducted an additional series of fire tests on new and aged existing EPDM and TPO membrane roof systems believed to have been designed and installed as fire-rated systems. The purpose of this test series was to again determine whether the aged roof systems maintained the initial fire-resistance ratings and evaluate whether the "new" roof systems tested exhibited fire characteristics similar to those of aged roof systems tested. A total of 34 EPDM and TPO membrane roof system specimens were tested in this series—eight new and 10 existing aged EPDM membranes systems; and 10 new and six existing aged TPO membrane systems. The specimens were tested in accordance with the spread-of-flame portion of ASTM E108 by ITS. Only 13 of the 34 specimens tested passed the fire tests; 21 of the specimens tested failed. Of the 13 specimens that passed the fire tests, 12 were from systems that included a cover board. Eighteen of the 21 specimens that failed the fire tests were from roof assemblies that consisted of either an EPDM or TPO membrane installed in a mechanically attached system configuration directly over polyisocyanurate insulation.<sup>5</sup>

Following MRCA's presentation of the data from the 2002 test series, two single-ply membrane manufacturers and UL publicly criticized<sup>6</sup> the fire testing. Concerns raised included the appropriateness for MRCA to sponsor fire testing of roof systems; whether the ASTM E108 test method is applicable to aged, existing roof systems and the specific specimen mounting methods used in the 2002 testing. The manufacturers and UL claimed mechanically attached single-ply membrane roof systems typically are tested with "wrapped edges" along the long edges of the test deck. ASTM E108 does not specifically indicate this; the 2001 and 2002 tests were conducted by ITS with flush (unwrapped) edges as is indicated in ASTM E108.

## **HAI test series**

In late 2002, based in part on the apparent disparity in results and concerns raised from the previous fire testing, NRCA and MRCA retained a widely recognized, independent fire consultant, Hughes Associates Inc. (HAI), Baltimore, Md., to develop and oversee an additional series of fire tests. The purpose of this fire test series was to investigate variability issues associated with the ASTM E108 spread-of-flame test method.

HAI developed a "basic matrix" fire test series that called for testing of identical, mechanically attached EPDM and TPO membrane roof systems at four recognized fire-test laboratories. Materials from the same manufacturing lots were used for the specimens tested at each of the laboratories to eliminate any possible material lot variability concerns. EPDM and TPO systems were selected specifically because the previous results for these systems exhibited the largest variability. All the systems tested were listed and approved by UL and Factory Mutual Approvals (FM), respectively, as meeting the requirements of Class A exterior fire resistance.

Testing was conducted at UL, ITS, FM in West Gloucester, R.I., and Southwest Research Institute in San Antonio, in accordance with the spread-of-flame portion of ASTM E108. To address the issue raised of "unwrapped" and "wrapped" test specimen edges, test specimens of both edge termination configurations were tested at each laboratory.

The results of the basic test matrix show none of the EPDM specimens tested and only one-half of the TPO specimens tested passed the requirements for Class A.

At two of the laboratories, additional fire tests also were conducted to investigate the effects of different roof slopes, insulation components and thicknesses, and edge termination methods.

While conducting the basic matrix and additional fire tests, HAI noted the following.

- Repeatability of spread-of-flame test results within a laboratory appears good; however, reproducibility of results between laboratories appears very poor.
- There are significant differences in the way the different laboratories address specimen edge termination, and ASTM E108 does not provide sufficient direction to provide for the necessary consistency. For example, the results indicate the choice of edge termination used by one laboratory may influence the result for TPO systems; this same influence was not apparent with EPDM systems.
- There are significant differences in the way the laboratories interpret the test method's pass/fail criteria. As an example, two of the laboratories considered burning to one edge of a test specimen to be a failure (lateral failure), and the other two laboratories considered a lateral failure to take place when burning occurred to both edges of a specimen. This issue has been somewhat clarified in a recent revision to ASTM E108; however, inconsistent interpretation of results still appears likely.
- Burn patterns on similar specimens indicate significant differences between some laboratories and sometimes within the same laboratory over time. Also, tests of comparable specimens sometimes showed similar burn patterns but produced different results.

In all, 31 ASTM E108 spread-of-flame tests were conducted on Class A listed and approved EPDM system specimens; 28 of these tests did not exhibit Class A results. Twenty-one tests were conducted on Class A listed and approved TPO system specimens; 11 of these did not exhibit Class A results.

HAI has concluded the ASTM E108 spread-of-flame method as it is currently written is problematic, has significant shortcomings and potentially can provide misleading results for low-slope membrane roof systems. Also, the method may not be appropriate for evaluating the exterior fire performance of mechanically attached single-ply membrane roof systems.<sup>7</sup>

## **Conclusions and Recommendations**

This research began in 1996 as a continuation of the MRCA/NRCA field performance of polymer-modified bitumen systems study and was originally intended to provide roofing contractors with useful information regarding the elapsed time projected for recoating membrane roof systems to maintain fire-resistance ratings. Unfortunately, the results of this research objective are inconclusive because of the variability in results found using the ASTM E108 spread-of-flame method. The variability discovered using this test method is so pronounced that at times recognized Class A listings and approvals for newly installed, mechanically attached EPDM and TPO membrane systems could not be duplicated under controlled laboratory conditions.

As a result of the findings from this research, MRCA and NRCA are concerned the spread-of-flame portion of ASTM E108 may not accurately represent the exterior fire performances of low-slope membrane roof systems, particularly for mechanically attached, single-ply membrane roof systems. This same concern also applies to roof systems tested using UL 790, "Standard for tests for fire resistance of roof coverings," and NFPA 256, "Standard methods of fire tests for roof coverings," which are largely similar to ASTM E108. Because one or more of these test methods is included in the model building codes and most local and state codes as the basis for determining roof systems' compliance with exterior fire-exposure requirements, the issue of code compliance for these systems also is of concern.

The results of this research and our concerns already have been shared with ASTM, UL, FM and the other fire-testing laboratories involved in this research, and the individual roof system manufacturers whose products were involved in this testing. ASTM Subcommittee E05.14, Exterior Fire Exposure Tests, which has jurisdiction over ASTM E108, already has appointed a task group that is evaluating the results of this research and is working toward addressing the concerns raised. MRCA and NRCA implore all participants in this task force and ASTM Subcommittee E05.14 to work constructively in an expeditious manner to satisfactorily address the issues raised. NRCA, several individual contractors and several roof system manufacturers are actively involved in this task force and subcommittee.

MRCA and NRCA feel strongly the testing laboratories and agencies that use ASTM E108 and its related test methods (UL 790, NFPA 256) bear a large part of the responsibility for addressing and resolving the issues raised by this research. These testing laboratories and agencies possess significant experience and expertise relating to these test methods, and they also profit from the roof industry's need to conduct this testing.

Until ASTM E108 and its related test methods are appropriately revised to address the concerns this research raised, NRCA and MRCA recommend roof system designers consider the following.

- When specifying a low-slope membrane roof system, designers should ensure the roof system design and specific components specified comply with an appropriate exterior fire-resistance rating determined by a code-approved testing agency (e.g., UL, FM). Roof systems complying with UL's requirements are described in the current edition of UL's *Roofing Materials and Systems Directory* and the certifications section of UL's Web site, [www.ul.com](http://www.ul.com). Questions regarding UL's listings can be directed to UL's Architectural Services Group at 1 (888) UL-HELPS (854-3577) or e-mail [nbk.architectural.services@us.ul.com](mailto:nbk.architectural.services@us.ul.com). Roof systems complying with FM's approvals are described in FM's RoofNav application ([www.roofnav.com](http://www.roofnav.com)). Designers also are encouraged to contact roof system manufacturers for additional information.
- When using a low-slope membrane roof system, designers should include in their designs a suitable cover board that is consistent with an appropriate listing or approval from a code-approved testing agency. This recommendation is consistent with the guidelines already contained in *The NRCA Roofing and Waterproofing Manual, Fifth Edition*. Furthermore, for mechanically attached single-ply membrane roof systems, designers of newly installed roof systems are now recommended to include a noncombustible cover board that is consistent with an appropriate listing or approval from a code-approved testing agency. Examples of noncombustible cover boards include glass-mat-faced gypsum boards and gypsum roof boards.

MRCA and NRCA remain committed to keeping their members and the roofing industry informed of any additional developments relating to this issue.

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#### References:

- <sup>1</sup> *APP and SBS Modified Bitumen Membrane Roofs: A Survey of Field Performance*, Midwest Roofing Contractors Association and National Roofing Contractors Association, March 1996.
- <sup>2</sup> MRCA Technology & Research Committee, "T and R Update" presentation, MRCA 47th Annual Convention and Trade Show, Oct. 24-27, 1996, Indianapolis.
- <sup>3</sup> MRCA Technology & Research Committee., "Fire Test Results on Aged Roof Membranes" presentation, MRCA 52nd Annual Convention and Trade Show, Oct. 11-12, 2001, Nashville, Tenn.
- <sup>4</sup> Associated Roofing Contractors of Greater Kansas City Inc., Kansas City, Mo.; Building Envelope Technology & Research, Seattle; Chicago Roofing Contractors Association, Hillside, Ill.; Dixie Roofing Inc., La Follette, Tenn.; Oklahoma Roofing & Sheet Metal Inc., Oklahoma City; Omaha Roofing Contractors Association, Omaha, Neb.; Ridgeworth Roofing Co. Inc., Bridgeview, Ill.; Southwestern Roofing & Sheet Metal Inc., Oklahoma City; The McDowall Company, St. Cloud, Minn.; The union roofing contractor members of Roofer's Local No. 2, St. Louis; Twin Cities Roofing Contractors Association, Minneapolis; Wisconsin Roofing Contractors Association, Milwaukee.
- <sup>5</sup> MRCA Technology & Research Committee, "Fire Test of Aged EPDM and TPO Roof Membranes" presentation, MRCA 53rd Annual Convention and Trade Show, Sept. 18-20, 2002, Chicago.
- <sup>6</sup> "Exterior Fire Performance of Low-slope Roof Assemblies," Kenneth D. Rhodes, Underwriters Laboratories Inc., Northbrook, Ill.; Joseph Malpezzi, Carlisle SynTec Inc., Carlisle, Penn.; Greg Brandt, Firestone Building Products Company, Carmel, Ind.; *RCI Interface*, Feb. 2004, pages 22-26.
- <sup>7</sup> Jesse J. Beitel and Arthur J. Parker, "Fire Performance of Mechanically-attached Single-ply Membrane Roof Assemblies" Hughes Associates Inc., Baltimore, Sept. 28, 2005.