EXTERIOR FIRE PERFORMANCE of Low-Slope Roof Assemblies

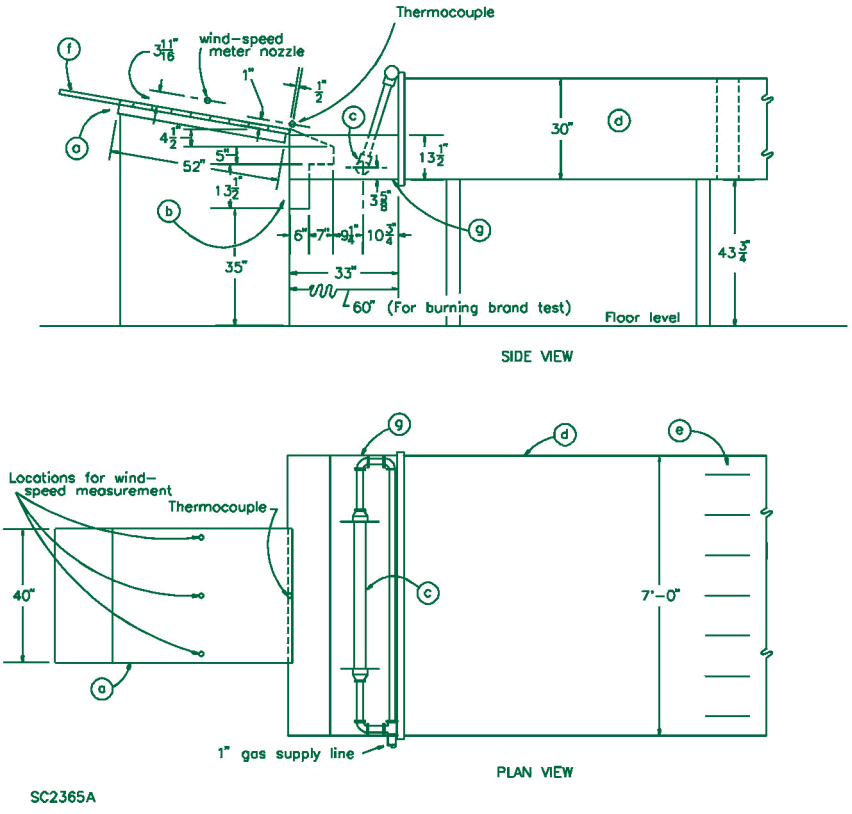
By Kenneth D. Rhodes, PE, Joseph Malpezzi, and Greg Brandt

Introduction

This article will focus on fire testing of roof assemblies as described in ASTM E 108, NFPA 256, and UL 790 standards, all initially adopted and published by their respective organizations in 1958. The three standards are virtually identical in terms of the fire testing procedures used to evaluate roof assemblies, so, for simplicity, only the E 108 Standard will be referenced in this document.

Background

The ASTM E 108 Test Standard was developed based on fire testing procedures utilized by Underwriters Laboratories Inc. (UL) since 1914 to classify roof assemblies. The purpose of this fire test evaluation is to provide comparative laboratory flammability characteristics of roof assemblies in order to comply with building code requirements. The E 108 Standard evaluates the entire assembly, not individual components or membranes. Roof assemblies are tested using newly manufactured materials, representative of those utilized in actual building construction. The test data are developed from simulated fire sources reproduced in a laboratory environment as described in the standard, which would originate outside the



ASTM E 108 Test Apparatus

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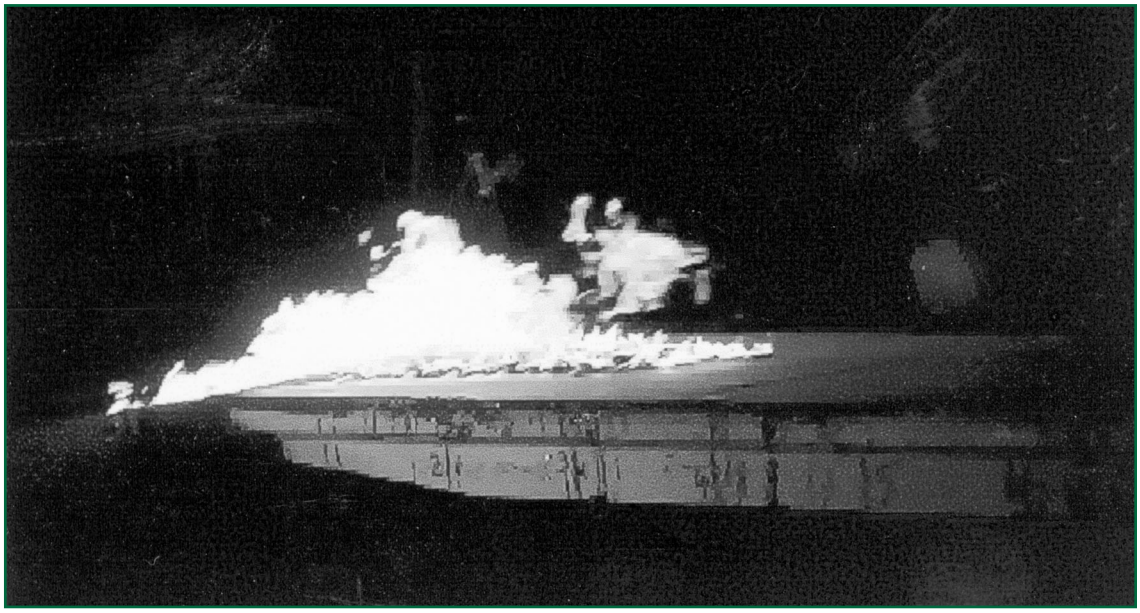
building. However, the E 108 Standard is not intended to predict the expected performance of roof assemblies under all actual fire conditions.

The standard does not apply to aged samples removed from existing roofs. Removal of samples from the field, with the intention of testing per E 108, would require a detailed sampling protocol to control items such as the sample selection process, verification of the materials used in the installation, verification of the initial fire rating of the assembly, and conditioning of the specimen prior to testing. The possibility of testing field-obtained samples is discussed in greater detail later in this article.

SPREAD OF FLAME TEST

Classification	Flame Temperature, °F	Wind Speed, mph	Test Duration, Minutes	Number of Tests to Pass
Class A	1400 ± 50	12 ± 1/2	10	2
Class B	1400 ± 50	12 ± 1/2	10	2
Class C	1300 ± 50	12 ± 1/2	4	2



Class A Spread of Flame Test

The ASTM E 108 Procedure

Successful testing following the ASTM E 108 procedure will result in a fire classification of Class A, Class B, or Class C. Class A assemblies are considered to be effective against severe fire test exposures. Class B assemblies are considered to be effective against moderate fire test exposures. Class C assemblies are considered to be effective against light fire test exposures.

Testing is conducted on unaged roof assemblies installed over combustible (wood) or non-combustible (concrete, gypsum, or metal) roof decks. Combustible deck assemblies require successful performance for all of the following tests: Spread of Flame, Intermittent Flame, and Burning Brand. Non-combustible deck assemblies require successful performance for only the Spread of Flame test. The assembly is mounted in the test apparatus and inclined between 1/8 inch and 5 inches per foot (as desired by the material manufacturer) before testing. Classification is obtained at the maximum slope tested if all required tests are passed (successful testing at a 5-inch slope gains classification without any limitation on slope). The following section summarizes these three testing procedures.

Spread of Flame Test

The Spread of Flame Test measures the potential for flame spread across the surface of the roof assembly using a constant flame source.

Class A is achieved if the maximum flame spread does not exceed 6 feet. Class B is achieved if the maximum flame spread does not exceed 8 feet. Class C is achieved if the maximum flame spread does not exceed 13 feet. For all classifications, the fire cannot spread laterally to both edges of the test deck, burning or glowing particles cannot fall to the floor and continue to burn or glow, and a combustible roof deck cannot be exposed (visible) at the conclusion of the test.

Intermittent Flame Test

The Intermittent Flame Test measures the potential for fire to penetrate from the outside of the roofing assembly to the underside (inside the building) of the combustible roof deck using a variable flame source.

INTERMITTENT FLAME TEST

Classification	Flame On, (Minutes)	Flame Off, (Minutes)	Number of Cycles	Test Duration	Number of Tests to Pass
Class A	2	2	15	1 hour after last cycle	2
Class B	2	2	8	1 hour after last cycle	2
Class C	1	2	3	1/2 hour after last cycle	2

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BURNING BRAND TEST

Classification	Brand Mass, (grams)	Wind Speed, (mph)	Test Duration	Number of Brands per Deck	Number of Decks
Class A	2000 ± 150	12 ± 1/2	1-1/2 hour	1	4
Class B	500 ± 50	12 ± 1/2	1-1/2 hour	2	2
Class C	9-1/4 ± 1-1/4	12 ± 1/2	1-1/2 hour	20	2

The flame temperature and wind speed are identical to those listed in the Spread of Flame Test table on page 23. Successful results are achieved provided there is no sustained flaming (a continuous burning flame) of the underside of the test deck and burning or glowing particles do not fall to the floor and continue to burn or glow.

Burning Brand Test

The Burning Brand Test measures the potential for fire to penetrate from the outside of the roofing assembly to the underside (inside the building) of the combustible roof deck using a burning brand fire source.

The brands are positioned on the top surface of roof assembly at locations as described in the standard. Successful results are achieved provided there is no sustained flaming (a continuous burning flame) of the underside of the test deck and burning or glowing particles do not fall to the floor and continue to burn or glow.

Sample Preparation

The roofing assembly to be tested is installed over the test deck as follows. The insulation or membrane underlayment is attached to the deck using adhesives or mechanical fasteners, or is loose-laid. The membrane is also attached to the insulation or underlayment using adhesives or mechanical fasteners, or is loose-laid. (The actual application depends on the assembly type being tested). The membrane may be trimmed along the edges of the test deck, or may be wrapped over the edges and nailed to the test frame. The intent of the membrane application (and the wrapping or not wrapping), as stated in Section 6.5 of ASTM E 108, is to prevent air from traveling under the material being tested. Wrapping the membrane edges creates a simulated field installation where no exposed edges are encountered.

Testing Variation Potential

The potential for variation in test results does exist with ASTM E 108. The flame calibration temperature and the wind speed calibration ranges shown in the Spread of Flame Table on the previous page provide for the possibility of a 100°F temperature variation and a 1 mph wind speed variation from one day to the next (calibrating every day). Testing at the high end of the calibration window one day can produce results different than those obtained from testing at the lower end another day.

Roof assembly installation methods can influence the test results. Adhered membrane assemblies behave differently than mechanically fastened or loose-laid membrane assemblies. Adhered membranes do not allow air to pass between the membrane and the substrate layer, thus helping to retard flame spread. Loose membranes allow air to pass under them, creating a more severe condition. All roof assemblies should be tested as intended for installation in the field.

Sample preparation methods can also influence the results. Mechanically fastened and loose-laid roof assemblies typically have the membrane wrapped over the sides of the test deck and nailed to the frame when tested. These type assemblies, tested without wrapping the membrane, allow air to blow under the membrane and out the sides, creating a tunneling affect not encountered on the roof. Attachment of these assemblies must be consistent to achieve accu rate results.

Variability is also possible between different laboratories. The placement of the test apparatus within the room and the room's dimensions can influence the test. The location, size, and operating speed of the smoke exhaust system can alter the airflow within the test room and create different burn patterns.

Fire Performance of Aged or Weathered Roof Assemblies

There are no provisions in the current E 108 Standard with respect to testing aged or weathered low-sloped asphaltic or single-ply roof assemblies. Typically, the fire performance characteristics of aged roof assemblies have not been a concern within the fire community as long as the assembly is maintained and not compromised by factors such as damage, pollutants, or deterioration. Roof assemblies utilizing asphalt, asphaltic membranes, polymeric membranes, and EPDM membranes will actually exhibit improved fire resistance over time since they

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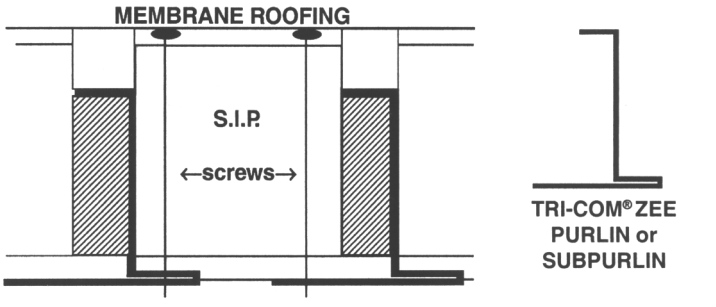

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lose combustible volatiles with aging. This phenomenon has been demonstrated with E 108 fire tests conducted by UL on weathered low-sloped roof assembly specimens.

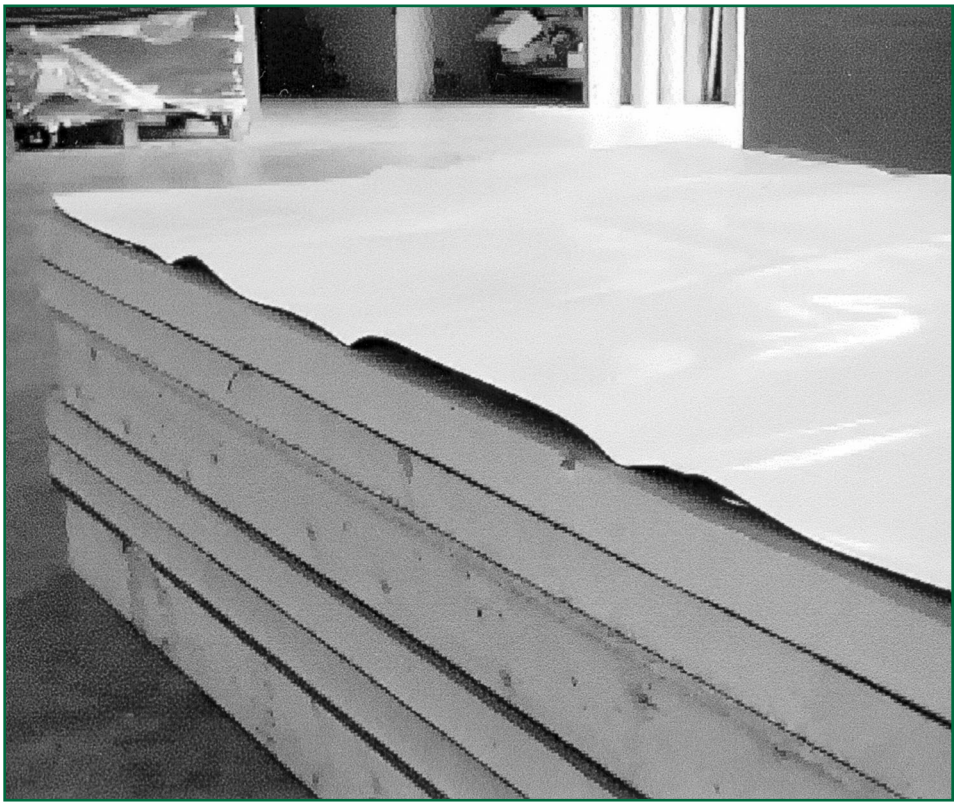
Underwriters Laboratories completed a study where multiple sample assemblies were prepared in its laboratory, tested unaged, and tested after at least two years of outside aging. The study revealed that the fire performance of these assemblies either remained unchanged or improved. Recent attempts by roofing industry groups to evaluate the fire performance characteristics of roof assemblies by using weathered test specimens not prepared in the laboratory, but obtained from actual field installations, have not been validated through the ASTM consensus process.

Field Sampling

If the ASTM E 108 testing procedure were to be used for field-obtained roofing assembly testing, the sample selection methodology would be critical. Specific guidelines would need to be established to ensure meaningful results. Careless sampling will compromise the usefulness of the data. Some examples of the guidelines that would need to be followed are highlighted below:

- First and foremost, the existing roofing assembly must have a documented fire rating (Class A, B, or C) as installed. Testing a non-fire-rated assembly would generate useless data since the assembly, if not fire classified, would not be expected to pass any fire test.
- The entire roofing assembly must be removed without disturbing the membrane or its attachment method. Disturbing the membrane assembly (for example, by peeling an adhered membrane off a substrate and testing it in a loose-laid condition) would again invalidate the resultant data.
- The sample must be shipped as removed and protected from damage during transport. Removing a membrane and folding it for shipment would create wrinkles that would influence burning characteristics.

Non-Folded Membrane



Folded Membrane

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- The exposed surface of the membrane must be cleaned to remove dirt and other accumulated contaminants. The cleaning products chosen and the thoroughness of cleaning are key elements to ensure meaningful results.

- The condition of the extracted sample is also vitally important. Materials in a deteriorated condition will not burn in the same manner as non-deteriorated materials. Also, trapped moisture within the assembly will influence burning characteristics.

- The mounting of the sample for testing must replicate as nearly as possible the method used in the original tests, otherwise valid comparative data will not be generated.

- Testing should be conducted at the agency that performed the original assembly test to ensure consistency.

Conclusion

The ASTM E 108 Standard provides a means for determining the fire performance of roof assemblies. The procedure was developed by Underwriters Laboratories in the early 1900s for testing new representative specimens in a laboratory environment. Variations in test results are possible due to variations in temperature and wind calibration ranges, sample installation methods, sample preparation methods, and inter-
laboratory equipment and facilities.

Aged assembly testing, previously conducted by UL, supports the physics-based logic that roof assemblies utilizing asphalt, asphaltic membranes, and polymeric membranes will actually exhibit improved fire resistance over time since they will lose combustible volatiles with aging.

There is currently no concern within the fire community in regard to life-safety concerns on in-place fire rated roof assemblies, supporting the need for fire testing of aged field samples. If an industry group insists on testing field-obtained samples for fire resistance, testing should not be conducted unless recognized sampling and testing procedures are developed and followed. ■

About the Authors

Kenneth D. Rhodes, PE, has been with Underwriters Laboratories for 37 years, where he has been involved with fire testing and wind resistance testing of building materials and roofing products. He is a senior staff engineer at UL, and a registered professional engineer in the state of Illinois, having received a degree in civil engineering from the University of Illinois. Rhodes is a member of the Society of Fire Protection Engineers.

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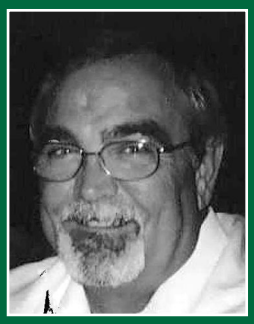
Joseph Malpezzi



Greg Brandt has been employed by Firestone Building Products Company for the last 19 years and currently holds the position of product manager for codes and standards, a position he has held for the past three years. Prior to attaining this position, he was the manager for the Codes Department at Firestone for 13 years. He has been a member of BOCA, ICBO, and SBCCI, and is currently a member of ICC. He is also the technical committee chairperson at SPRI, a member of ASTM E5, and sits on STP panels at Underwriters Laboratories for UL 580, UL 790, UL 1256, and UL 1897.

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