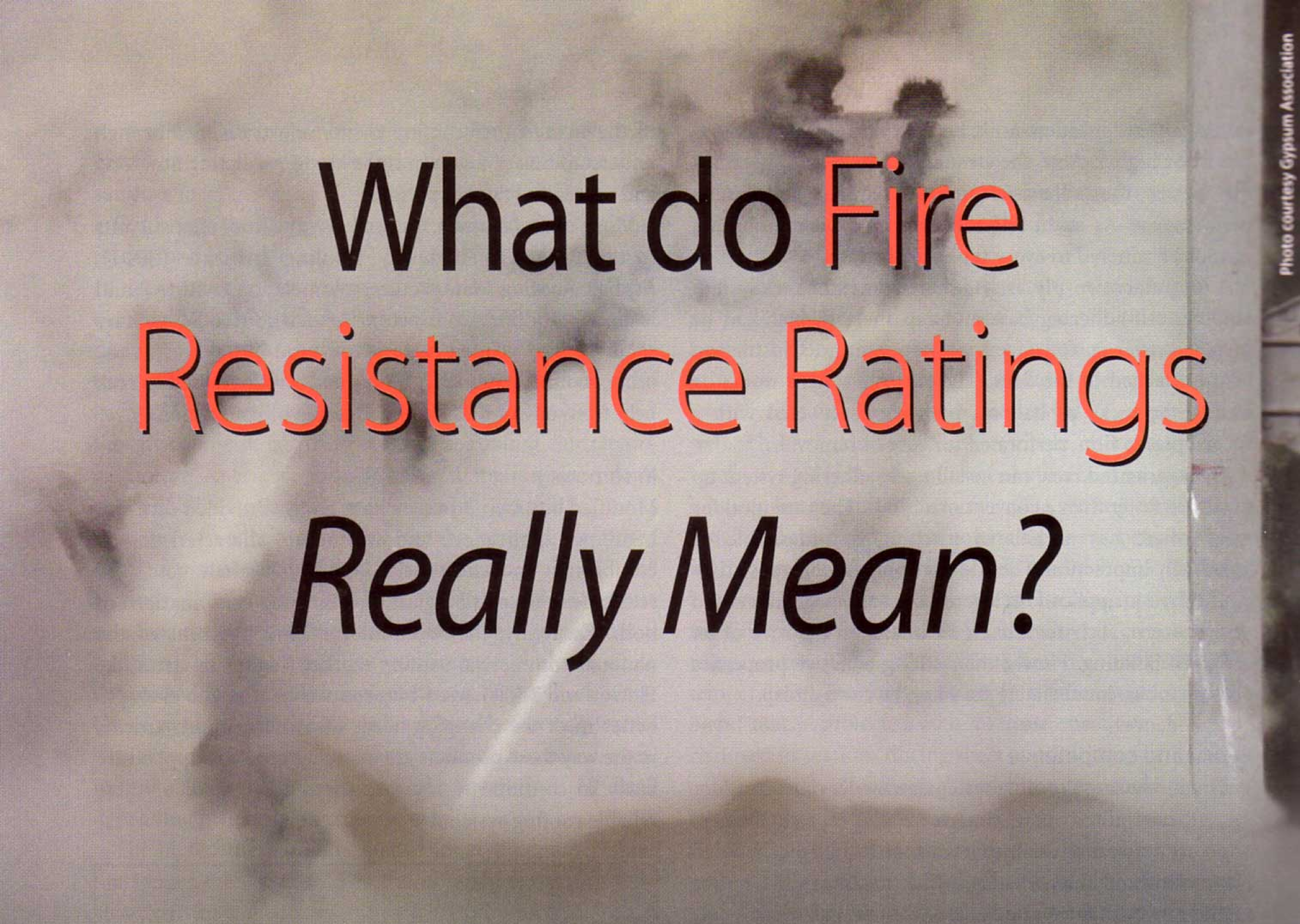


Photo courtesy Gypsum Association

What do Fire Resistance Ratings *Really Mean?*

by Robert Wessel and Michael Gardner

Model building codes mandate the use of ASTM International E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials,* to establish the fire resistance rating of building elements and systems. (Similar practices established by Underwriters Laboratories Inc. and NFPA also exist, and are used/accepted in most cases.) Use of the ASTM standard allows the fire-resistive properties of systems containing the same or dissimilar materials to be measured and evaluated using a standard, comparative test method.

ASTM E 119 tests the "performance of walls, columns, floors, and other building members under fire exposure conditions" using a "fire of controlled extent and severity." It judges performance as "the period of resistance to standard exposure before the first critical point in behavior is observed," and it produces results "reported in units in which field exposures can be judged and expressed."[1]

The test method determines the fire-resistive ability of bearing and non-bearing walls and partitions; steel columns; floor- and roof-ceiling systems; and beams. Systems tested to the standard typically incorporate materials such as steel, wood, gypsum wallboard, concrete masonry, concrete, and glass, but the test can be used to evaluate any combination of code-allowed materials.

Test methodology

The test method prescribed by the standard exposes a specimen (representative of the intended construction) to a controlled fire to achieve specific temperatures over a specific period. The heat and flame of the fire are created by a series of fixed-in-place burners. While the standard does not describe the construction of the test furnace, most test facilities use gas-fired burners—similar in appearance to a flaming torch.

The effect of the fire generated by the burners is carefully regulated. The amount and severity of heat produced must conform to a prescribed time-temperature curve, where exposure temperature increases (rapidly at first, then slower) as a function of time. The curve intentionally replicates the rapid heat build-up occurring during the early stages of a severe building fire. (The curve is a composite based on the experience and practice of the testing laboratories and other involved organizations who created the initial version of the standard in 1918.[2] The parameters of the curve have been kept almost constant since its creation.)

The specimen is secured in a frame (restraining device) and placed against the test furnace in the orientation identical to the intended end use of the system. Walls are tested in an upright frame and placed vertically against the test furnace. Floor- and roof-ceiling systems are tested in a horizontal plane, and are configured so they rest directly atop the furnace.

The conditions of acceptance for most systems require the measurement of heat transmission through the specimen, so a series of thermocouples (temperature sensing devices) and pads are placed on the unexposed surface of the specimen (the side opposite the heat source). A minimum of nine thermocouples are required when a floor, roof, wall, or partition system is tested, and a minimum of eight for columns.

Tested systems must comply with minimum total-area and dimensional-size requirements. Wall and partition systems must be at least 9.3 m^2 (100 sf) in area with no dimension less than 2.7 m (9 ft). Floor- and roof-ceiling systems must be no less than 16.7 m^2 (180 sf) in area with no dimension less than 3.7 m (12 ft).

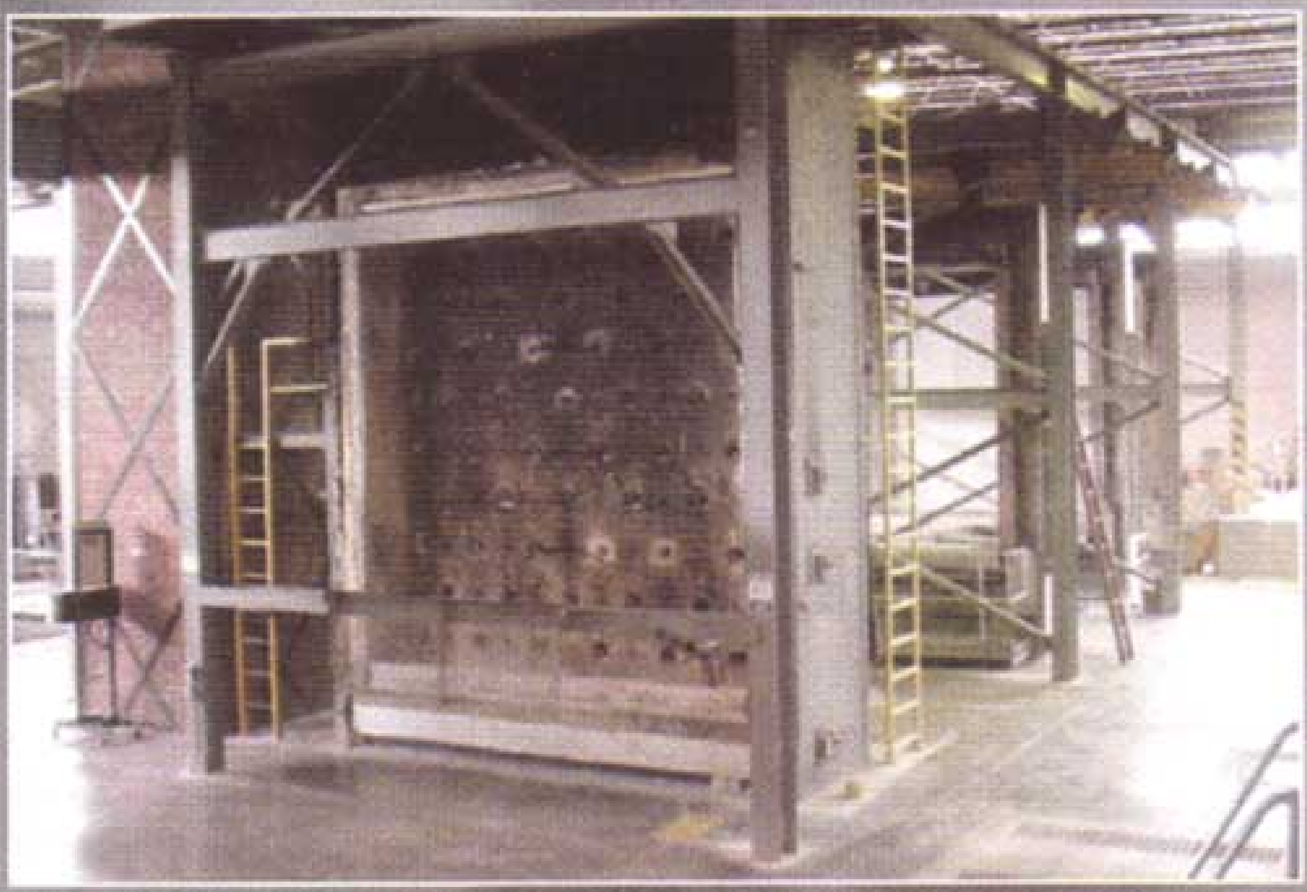
A superimposed load is always applied to a floor/roof-ceiling system or column, and is applied to a wall or partition system when a load-bearing rating is desired. When a loaded system is being tested, one of the conditions of acceptance is its ability to sustain the applied load during the entire test period.

Assessing performance

ASTM E 119 sets forth specific criteria for assessing the performance of a specimen, and while the criteria are not identical between system types, they do contain basic similarities.

As noted previously, load-bearing walls and floor/roof-ceiling systems must sustain the applied load during the

History of Fire Testing



Vertical furnace used for fire testing.

Fire-resistance testing of materials and systems in the United States likely dates back to 1890, when tests were conducted on floor systems used in the construction of the Denver Equitable Building. These were followed by tests on partition and column systems over the next two decades. Most early U.S. fire tests were performed to determine how various materials or systems would function under fire conditions—not to establish specific fire ratings.

ASTM E 119 was first published in 1918 as ASTM C 19-1917T, *Standard Test Methods for Fire Tests of Building Construction and Materials*—which was partially derived from an ASTM standard for floor tests (ASTM C 2-09, *Method of Test for Fireproof Floor Construction*) and a partition test standard (ASTM C 3-09, *Test for Fireproof Partition Construction*). The initial version of the standard was the first fire test standard to incorporate a scheme classifying systems according to their fire rating.*

ASTM E 119 has been used continuously since its first publication as the principle method for testing the fire resistance of a range of building materials. A variety of refinements have been made to the standard since 1918, but several of the test criteria—including the conditions required to achieve a specified fire-resistance rating—have remained essentially unchanged.

*Shoub, Harry, "Early History of Fire Endurance Testing in the United States," *Symposium on Fire Test Methods* (1961), ASTM Special Technical Publication No. 301, pg. 1.

Photos courtesy Gypsum Association

Townhouse units showing gypsum board area separation wall systems in place.

entire test. Collapse of the specimen under load during testing constitutes an end point, and the test is terminated.

The specimen must withstand the passage of gases hot enough to ignite combustible materials. This is evaluated by attaching cotton waste, an easily ignited cellulosic material, to long poles or rods manually located and relocated during the test. The cotton waste is placed against the unexposed surface of the specimen at the point where any cracks or other openings develop during the test. Ignition of the cotton waste from hot gases passing through the test specimen constitutes an end point for the test.

Systems must also prohibit the passage of heat. This is evaluated by monitoring the temperature of the thermocouples placed on the unexposed side of the specimen. Should the average thermocouple temperature rise more than 139 C (250 F) above ambient temperatures on unexposed surfaces during the test, or should the temperature of any single thermocouple rise more than 180 C (325 F), then the specimen is deemed to have reached an end point. Floor/roof-ceiling systems have similar requirements. Thermocouple readings for a system are monitored continuously and recorded at regular intervals.

Beams are generally tested in conjunction with a floor-ceiling system, where they are exposed to the test fire from below. Columns are tested in a specially designed furnace—one designed to expose the column to flame on all four sides simultaneously. Columns and beams also have maximum temperature rise criteria based on the readings from thermocouples placed on the beam/column being tested. Columns and beams are required to sustain imposed loads during the test period and resist the passage of heat and flame.

The process of exposing a test specimen to heat and flame in a controlled laboratory environment constitutes a "fire endurance test" as defined by the E 119 standard. A specimen exposed to the conditions of acceptance for a fire endurance test is assigned a resistance period rating coinciding with the point at which an end point was achieved.

The hose stream test

In addition to passing a fire endurance test, walls and partitions—but not columns, beams, or floor/roof-ceiling systems—are required to withstand the impact, cooling, and erosion effects of a stream of water from a fire hose. This hose stream test is described in ASTM E 119 using either of two alternate methods.

The first method, commonly known as the 'primary' or 'standard' method, requires the hose stream test be conducted on a duplicate specimen, identical to that assigned the resistance period rating, which has been "subjected to a fire endurance test for a time period of one-half the fire endurance classification period determined from the fire endurance test on the initial specimen."

Immediately upon conclusion of the duplicate specimen fire endurance test, a steady stream of water is directed onto the specimen using a 64-mm (2.5-in.) hose placed approximately 6 m (20 ft) away from, and perpendicular to, the test sample. The water is directed across the entire test specimen at 310 kPa (30 psi) for 2.5 minutes (for a two-hour rated assembly). The specimen is deemed to have failed the hose stream test when an opening develops, permitting a projection of water from the stream beyond the unexposed surface.

The second methodology, described in ASTM E 119 as the "optional program," allows the hose stream test to be applied directly to the test specimen used in the initial fire endurance test. Use of the alternate method negates the need for—and the added cost of—constructing and testing a duplicate specimen.

Much debate has occurred over the actual role of the hose stream test in fire testing. The requirement mandating a hose stream test for floor/roof-ceiling systems was eliminated from the E 119 standard in the 1950s primarily because "there is no record of failure in the hose-stream test because of openings formed in the floor."[3] It was eliminated from British fire testing standards entirely—for both floor/ceiling and wall systems—over 40 years ago.

Both the primary and optional methods of hose stream

History of the Hose Stream Test

In the late 1890s, cast and wrought iron were commonly used in construction. Unlike steel, they failed in a brittle manner when heated in a fire, creating a risk for firefighters. As a result, the hose stream was created to test the integrity of these support members. In 1918, the first edition of ASTM standard E 119—known then as ASTM C 19-1917T, *Standard Test Methods for Fire Tests of Building Construction and Materials*—included a hose stream test to measure a material's integrity.

The hose stream serves as an indicator for two important attributes: 1) the integrity of an assembly during fire exposure, and 2) the overall reliability of the material to perform its intended function.

It is important to note the test is not in any way intended to replicate or determine the affects of firefighting tactics on systems. While the hose stream apparatus is adapted from firefighting equipment, its intent is to provide an impact, erosion, and cooling exposure applied in a standard manner to the tested specimen. The hose stream test effectively screens out systems performing acceptably in the furnace environment but have insufficient integrity to withstand real-world fire exposure.

— With files from Chad Stroike, fire protection engineering manager, Hilti Inc.

Photos courtesy Gypsum Association

Liner panels are easily cut to facilitate installation.

testing are viewed as equivalents within the perspective of the ASTM E 119 test method, and neither is deemed superior to the other. The hose stream test is neither a test of system durability nor impact resistance. Its application as a determinant of a system's ability to withstand anything other than the impact of a stream of water within the context of the test should be viewed with circumspection.

The classification of a system

Once a specimen has passed all requisite portions of the procedure (*i.e.* fire endurance and hose stream [if necessary]), it is assigned a fire-resistance classification rating. Classifications are stated in hourly terms to allow the comparison of systems and materials, and model building code requirements.

Although test-chamber conditions represent a standardized severe fire exposure to facilitate the comparison of one system to another, they are neither indicative of, nor do they replicate, every fire situation. According to the standard, "hourly fire-resistive ratings derived from the ASTM E 119 test do not mean that a specific structure will remain intact for the indicated rating period."[4] The standard is clear in this regard when it states:

> [This] standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.

Photo courtesy Gypsum Association

Erection of liner panels in a gypsum board area separation wall system.

Future of the test method

Recently, Dr. William L. Grosshandler (chief of the Fire Research Division, Building and Fire Research Laboratory, National Institute of Standards and Technology [NIST]), authored a paper following an international forum of fire research directors motivated by the collapse of the World Trade Center towers. Grosshandler observed the following about the hourly ratings achieved via the ASTM E 119 test.

It is expected that a two-hour rated wall would resist failure in a real fire for a longer period of time than a one-hour rated wall, and this is invariably the case. What cannot be expected, however, is that a structure composed of elements that are two-hour rated would necessarily withstand an actual fire for two hours, nor that it would necessarily fail after two hours. The inability of the fire resistance rating to act as an absolute predictor of performance in an actual fire was recognized from the beginning when the forerunner of ASTM E 119 was published in 1918. Over the years, however, the reference to fire resistance ratings in common time units has become interpreted to relate closely (or at least conservatively) to the actual expected time that a structure or element would be expected to resist a fire. This problem of misinterpreting a fire rating is unique to fire resistance tests because the use of time as the rating unit is easy to apply in a manner not reflected in the standard... The end point (i.e. time to failure due to a certain temperature or deformation limit) is prone to misconception by a layperson. The FORUM recommends that the standards organizations consider a new rating system that is more immune to misinterpretation.[5]

Grosshandler went on to describe an alternative to the hourly rating employing a highly fire-resistant element (such as a five-hour system as determined by current methods) and assign a rating of 100 to that level of resistance. All other ratings would flow from that benchmark: a one-hour system would be considered to have

Additional Information

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Abstract

Interpreting ASTM Standard E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials,* outside the context of the explicit testing methods carries inherent risk. To specify fire ratings properly requires a thorough understanding of precisely what the ratings do and do not mean. Confusion surrounding the methods may be curtailed with the adoption of a new rating system.

a rating of 20, and a two-hour system would be rated at 40, etc. Such a change in nomenclature could help further the correct interpretation of ASTM E 119 test results.

Summary

The ASTM E 119 test method has been used for over 85 years to establish fire-resistance test ratings for a variety of materials and systems. It continues to serve as a satisfactory barometer for evaluating the fire-resistive characteristics of a variety of comparative systems and building materials.

Correct application of the system for comparative purposes requires it to produce test results that can be correctly evaluated on systems tested using equivalent parameters. Its use as a measurement for system qualities outside of the scope of the test method should be strongly discouraged.

Notes

[1] "Introduction to ASTM E 119-00a, *Standard Test Methods for Fire Tests of Building Construction and Materials,*" West Conshohocken, PA: ASTM International, 2000.

[2] Bono, Jack, "Method for Fire Tests of Floor and Ceiling Assemblies," Symposium on Fire Test Methods (1962), ASTM Special Technical Publication No. 344, pg. 69.

[3] Ingberg, S.H., "The Hose-Stream Test as a Part of Fire-Testing Procedure," Symposium on Fire Test Methods (1962), ASTM Special Technical Publication No. 344, pg. 57.

[4] Berhinig, Robert, "Protecting the Foundation of Fire Safety", *Building Standards,* September-October 2002, Vol. LXXI, No. 5, pg. 47.

[5] Grosshandler, William L., "A Position Paper on Evaluation of Structural Fire Resistance," n.d.