ASTM E119-98
Fire Tests of Building Construction and Materials*

Protective Structures, Ltd.
Bullet-Resistant FRP Panel

Project No. 16410-108710

ONE-HOUR FIRE RESISTANCE TEST OF A NONBEARING STEEL STUD WALL WITH ½" TYPE X GYPSUM ON THE EXTERIOR AND ½" TYPE X GYPSUM WALLBOARD OVER PROTECTIVE STRUCTURES FRP PANEL ON THE INTERIOR

*Modified in that the sample size was less than 100 ft.^{2} and the fire test was Performed from the interior side only.

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INTRODUCTION

The performance of walls, columns, floors, and other building members under fire exposure conditions is an item of major importance in securing constructions that are safe, and that are not a menace to neighboring structures or to the public. Recognition of this is registered in the codes of many authorities, municipal and other. It is important to secure balance of the many units in a single building, and of buildings of like character and use in a community; and also to promote uniformity in requirements of various authorities throughout the country. To do this it is necessary that the fire-resistive properties of materials and assemblies be measured and specified according to a common standard expressed in terms that are applicable alike to a wide variety of materials, situations, and conditions of exposure.

Such a standard is found in the methods that follow. They prescribe a standard exposing fire of controlled extent and severity. Performance is defined as the period of resistance to standard exposure elapsing before the first critical point in behavior is observed. Results are reported in units in which field exposures can be judged and expressed/

The methods may be cited as the "Standard Fire Tests," and the performance or exposure shall be expressed as "2-h," "6-h," "1/2-h" etc.

When a factor of safety exceeding that inherent in the test conditions is desired, a proportional increase should be made in the specified time-classification period.

The ASTM E119 test procedure is identical or very similar to the following standard test methods:

UL 263
UBC 7-1
NFPA 251
ANSI A2.1

1. Scope

1.1 The test methods described in this fire-test-response standard are applicable to assemblies of masonry units and to composite assemblies of structural materials for buildings, including bearing and other walls and partitions, columns, girders, beams, slabs, and composites slab and beam assemblies for floors and roofs. They are also applicable to other assemblies and structural units that constitute permanent integral parts of a finished building.

1.2 It is the intent that classifications shall register performance during the period of exposure and shall not be construed as having determined suitability for use after fire exposure.

1.3 *This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.*

Note 1 – A method of fire hazard classification based on rate of flame spread is covered in ASTM Method E84, Test for Surface Burning Characteristics of Building Materials.

1.4 The results of these tests are one factor in assessing fire performance of building construction and assemblies. These methods prescribe a standard fire exposure for comparing the performance of building construction assemblies. Application of these test results to predict the performance of actual building construction requires careful evaluation of test conditions.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitation prior to use.*

4. Significance and Use

4.1 This test method is intended to evaluate the duration for which the types of assemblies noted in 1.1 will contain a fire, or retain their structural integrity or exhibit both properties dependent upon the type of assembly involved during a predetermined test exposure.

4.2 The test exposes a specimen to a *standard fire exposure* controlled to achieve specified temperatures throughout a specified time period. In some instances, the *fire exposure may be* followed by the application of a *specified standard* fire hose stream. The exposure, however, may not

be representative of all fire conditions which may vary with changes in the amount, nature and distribution of fire loading, ventilation, compartment size and configuration, and heat sink characteristics of the compartment. It does, however, provide a relative measure of fire performance of comparable assemblies under these specified fire conditions. Any variation from the construction or conditions (that is, size, method of assembly, and materials) that are tested may substantially change the performance characteristics of the assembly.

4.3 The test standard provides for the following:

4.3.1 In walls, partitions and floor or roof assemblies;

4.3.1.1 Measurement of the transmission of heat.

4.3.1.2 Measurement of the transmission of hot gases through the assembly, sufficient to ignite cotton waste.

4.3.1.3 For load bearing elements, measurement of the load carrying ability of the *test specimen* during the test exposure.

4.3.2 For individual load bearing assemblies such as beams and columns: Measurement of the load carrying ability under the test exposure with some consideration for the end support conditions (that is, restrained or not restrained).

4.4 The test standard does not provide the following:

4.4.1 Full information as to performance of assemblies constructed with components or lengths other than those tested.

4.4.2 Evaluation of the degree by which the assembly contributes to the fire hazard by generation of smoke, toxic gases, or other products of combustion.

4.4.3 Measurement of the degree of control or limitation of *the passage of* smoke or products of combustion through the assembly.

4.4.4 Simulation of the fire behavior of joints between building elements such as floor-wall or wall-wall, etc., connections.

4.4.5 Measurement of flame spread over surface of tested element.

4.4.6 The effect of fire endurance of conventional openings in the assembly, which is electrical receptacle outlets, plumbing pipe, etc., unless specifically provided for in the construction tested.

16. Conditions of Acceptance – [Loadbearing Walls]

16.1 Regard the test as successful if the following conditions are met:

16.1.1 The wall or partition shall have sustained the applied load during the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period equal to that for which classification is desired.

16.1.2 The wall or partition shall have sustained the applied load during the fire and hose stream test as specified in Section 11, without passage of flame, of gases hot enough to ignite cotton waste, or of the hose stream. The assembly shall be considered to have failed the hose stream test if an opening develops that permits a projection of water from the stream beyond the unexposed surface during the time of the hose stream test.

16.1.3 Transmission of heat through the wall or partition during the fire endurance test shall not have been such as to raise the [average] temperature on its unexposed surface more than 250° (139°C) above its initial temperature.

18. Conditions of Acceptance – [Nonloadbearing Walls]

18.1 Regard the test as successful when the following conditions are met:

18.1.1 The wall or partition has withstood the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period equal to that for which classification is desired.

18.1.2 The wall or partition shall has [sic] withstood the fire and hose stream test as specified in Section 10, without passage of flame, of gases hot enough to ignite cotton waste, or of passage of water from the hose stream. The assembly shall be considered to have failed the hose stream test if an opening develops that permits a projection of water from the stream beyond the unexposed surface during the time of the hose stream test.

18.1.3 Transmission of heat through the wall or partition during the fire endurance test shall not have been such as to raise the [average] temperature on its unexposed surface more than 250°F (139°C) above its initial temperature.

The E119 standard further states:

7.4 Where the conditions of acceptance place a limitation on the rise of temperature of the unexposed surface, the temperature end point of the fire endurance period shall be determined by the average of the measurements taken at individual points; except that if a temperature rise of 30% [325°F above initial temperature] in excess of the specified limit occurs at any one of these points, the remainder shall be ignored and the fire endurance period judged as ended.

TEST PROCEDURE

SMALL SCALE VERTICAL FURNACE

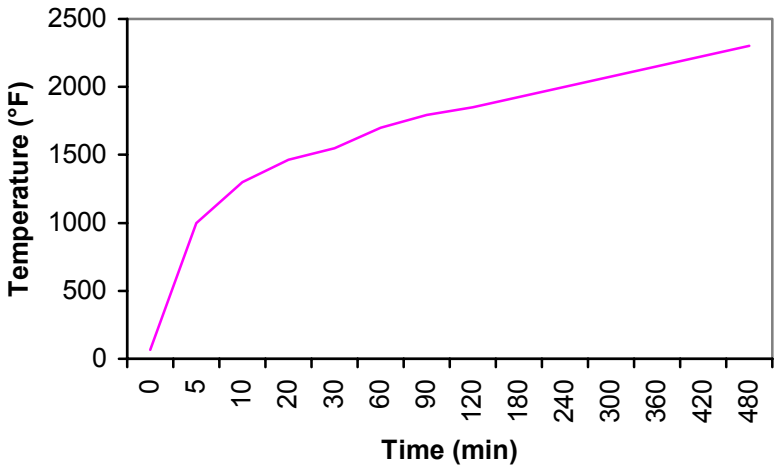
The small scale vertical furnace is 48 in. wide, 48 in. high and 2 ft deep, with six inch thick sides. The furnace consists of a structural steel frame, clad in sheet metal, and insulated with six inches of ceramic fiber insulation. The furnace is equipped with nine self-inspiring burners, evenly distributed across the rear wall and adjusted to run with no input air. This results in a diffuse, yellow flame which closely simulates those found in a real fire.

Fired by propane, this furnace is capable of meeting both the ASTM E119 and UL1709 (high rise) heating curves, and its capable of running only at slightly negative pressures.

The temperature within the furnace is determined to be the mathematical average of thermocouples located symmetrically within the furnace and positioned six inches away from the exposed face of the test specimen. The materials used in the construction of these thermocouples are those suggested in the test standard. During the performance of a fire exposure test, the furnace temperatures are monitored at least every 15 seconds and displayed for the Furnace operator to allow control along the specified temperature curve. All data is saved to disk every 60 seconds.

The fire exposure is controlled to conform with the standard time-temperature curve shown in Figure 1, as determined by the table below:

Figure 1



Time (min)	Temp (°F)
0	68
5	1000
10	1300
20	1462
30	1550
60	1700
90	1792
120	1850
180	1925
240	2000
300	2075
360	2150
420	2225
480	2300

The furnace interior temperature during a test is controlled such that the area under the time temperature curve is within 10% of the corresponding area under the standard time temperature curve for 1 hour or less tests, 7.5% for those less than 2 hours and 5% for those tests of 2 hours or more duration.

Temperatures of Unexposed Surfaces

Temperatures of unexposed surfaces are monitored using 24 gauge, Type K thermocouples placed under 6 in. x 6 in. x 0.4 in. thick dry, felted pads as described in the standard. Temperature readings are taken at not less than nine points on the surface, at intervals not exceeding 1.0 minute. The temperature on the unexposed surface of a test specimen during the test is taken to be the average value of all thermocouples.

Applied Load

If required, this test method may be used to expose a horizontal or vertical assembly to fire while maintaining a live load on test specimen. This is accomplished by applying a uniform load hydraulically, with actuators designed for that purpose.

Fire Endurance Test

The fire exposure is continued on the specimen with its applied load if applicable, until failure occurs, or until the specimen has withstood the test conditions for the desired fire endurance rating.

Hose Stream Test

11.1 Where required by the conditions of acceptance, subject a duplicate specimen to a fire exposure test for a period equal to one half of that indicated as the resistance period in the fire endurance test, but not for more than 1 h, immediately after which subject the specimen to the impact, erosion, and cooling effects of a hose stream directed first at the middle and then at all parts of the exposed face, changes in direction being made slowly.

11.2 *Exemption* – The hose stream test shall not be required in the case of constructions having a resistance period, indicated in the fire endurance test, of less than 1 h.

11.3 *Optional Program* – The submitter may elect, with the advice and consent of the testing body, to have the hose stream test made on the specimen

subjected to the fire endurance test and immediately following the expiration of the fire endurance test.

11.4 *Stream Equipment and Details* – The stream shall be delivered through a 2 ½-in. (64-mm) hose discharging through a National Standard Playpipe of corresponding size equipped with a 1 1/8-in. (28.5-mm) discharge tip of the standard-taper smooth-bore pattern without shoulder at the orifice. The water pressure and duration of the application shall be as prescribed in Table 1.

TABLE 1 Condition for Hose Stream Test

Resistance Period	Water Pressure at Base of Nozzle, psi (kPa)	Duration of Application, Min/100 ft² (9m²) Exposed area
8 h and over 45	(310) 6	
4 h and over if less than 8 h	45 (310)	5
2 h and over if less than 4 h	30 (207)	2 1/2
1 ½ h and over if less than 2 h	30 (207)	1 1/2
1 h and over if less than 1 ½ h	30 (207)	1
Less than 1h, if desired	30 (207)	1

11.5 *Nozzle Distance* – The nozzle orifice shall be 20 ft (6-m) from the center of the exposed surface of the test specimen if the nozzle is so located that when directed at the center its axis is normal to the surface of the test specimen. If otherwise located, its distance from the center shall be less than 20 ft by an amount equal to 1 ft (305-mm) for each 10 deg of deviation from the normal.

Correction Factor

When the indicated resistance period is ½ h or over, determined by the failure criteria of the standard, a correction shall be applied for variation of the furnace exposure from that prescribed, where it will affect the classification/ This is to be done by multiplying the indicated period by two thirds of the difference in area between the curve of average furnace temperature and the standard curve for the first three fourths of the period and dividing the product by the area between the standard curve and a base line of 68°F(20°C) for the same part of the indicated period, the latter area increased by 3240°F min to compensate for the thermal lag of the furnace thermocouples during the first part of the test. For a fire exposure in the test higher than standard, the indicated resistance period shall be increased by the amount of the correction. For a fire exposure in the test lower than standard, the indicated resistance period shall be similarly decreased for fire exposure below standard. The correction is accomplished by mathematically adding the correction factor, C, to the indicated resistance period.

The correction can be expressed by the following equation:

$$C = \frac{2I\,(A - As)}{3\,(A + L)}$$

Where:

C = correction in the same units as I,
I = indicated fire-resistance period
A = area under the curve of indicated average furnace temperature for the first three fourths of the indicated period.
As= area under the standard furnace curve for the same part of the indicated period, and
L = lag correction in the same units as A and As (54°F· h or 30°C·h) (3240°F·min or 1800°C·min)

TEST SPECIMEN CONSTRUCTION

The test specimen identification is as provided by the client and Omega Point Laboratories, Inc. accepts no responsibility for any inaccuracies therein. Omega Point did not select the specimen and has not verified the composition, manufacturing techniques or quality assurance procedures.

The test assembly consisted of a 48" x 48" steel stud wall spaced 24" o.c. and constructed of 3– /8" steel studs (20 GA) attached to 3–5/8" steel runners (20 GA) using 7/16" long pan framing screws at each location. The unexposed side of the wall was covered with a single piece of ½" thick Type X gypsum wallboard attached to the studs using 1–¼" long self tapping drywall screws spaced 12" o.c. The exposed side of the wall was clad with a single 3/8" thick FRP panel described as "multiple plies of woven roving fiberglass impregnated with a thermosetting polyester resin'. The panel was attached to the studs using 1–1/4" long self tapping drywall screws spaced 12" o.c. Another layer of ½" thick Type X gypsum wallboard was then placed over the panel and fastened to the studs using 1–7/8" long self-tapping drywall screws spaced 24" o.c. The completed assembly was then mounted against the front of our small-scale vertical furnace and the test was begun.

TEST RESULTS AND OBSERVATION

The wall assembly was placed in front of the Laboratory's test furnace on April 25, 2001. The ambient temperature at the start of the test was 80°F, with a relative humidity of 50%. Throughout the fire test, the pressure differential between the inside of the furnace (measured at a point 1/3 of the way down from the top center of the wall specimen) and the laboratory ambient air was

maintained at –0.03 inches of water column, which resulted in a neutral pressure at the top of the test article.

Observations made during the test are as follows:

Time (min : sec)	Observation
0:00	Furnace fired at 3:25 p.m.
0:35	Gypsum paper turning dark
0:50	Ignition of the paper
1:10	Paper ash flaking away from the exposed surface
8:00	Exposed surface turning light
15:00	No visible change
25:00	No visible change
35:00	No visible change
45:00	Light smoke issuing from the top of the unexposed surface
60:00	Furnace extinguished and assembly moved into position for the hose stream test
62:15	Hose stream test begins
62:25	Hose stream test ended. All of the gypsum wallboard was knocked off the exposed surface and a few of the outer layers of the FRP panel were hanging from the exposed surface. The hose stream did not penetrate the entire panel and did not allow passage of water through the unexposed layer of gypsum wallboard. Upon closer inspection, it appear that heat intense enough to scorch the fabric had penetrated through the outer five layers. There were a total of 16 or 17 layers of fabric in the panel.

A table showing the maximum temperatures reached on each of the unexposed side thermocouples during the 60-minute fire exposure is presented below:

TC #	1	2	3	4	5	Average
Max Temp (°F)	203	207	208	200	199	203
Max Allowable	404	404	404	403	403	329

The wall withstood the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for the 60-minute fire test.

Transmission of heat through the wall during the fire endurance test did not raise the average temperature on the unexposed surface more than 250° above the initial average temperature, or any individual temperature more than 325°F above each individual thermocouples initial reading.

Calculation of Time Correction

The E119 standard requires that a correction factor be applied for variation of the furnace exposure from that prescribed where it will affect the classification. This calculation has been determined, as indicated below, to be less than 30 seconds, and so will not affect the sixty-minute classification, which is reported to the nearest integral minute.

Correction to indicated time: **Where:**	**0.04** **3**	**Minutes** **Seconds**
Indicated fire resistance:	60	minutes
Area under first ¾ of test curve:	58338	(°F·min)
Area under first ¾ E119 curve:	58269	(°F·min)
Lab correction:	3240	(°F·min)

CONCLUSIONS

The test specimen identification is as provided by the client and Omega Point Laboratories, Inc. accepts no responsibility for any inaccuracies therein. Omega Point did not select the specimen and has not verified the composition, manufacturing techniques or quality assurance procedures.

The wall assembly constructed and tested as described herein, achieved a fire resistance rating of 60 minutes when tested with the fire against the interior surface only, when tested in accordance with ASTM Method E119-98 Fire Test of Building Construction and Materials as a nonbearing wall assembly.