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# Standard Test Methods for Fire Tests of Building Construction and Materials[1]

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*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 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 test 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 test methods may be cited as the "Standard Fire Tests," and the performance or exposure shall be expressed as "2-h," "6-h," "½-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.

## 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 loadbearing and other walls and partitions, columns, girders, beams, slabs, and composite 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 comparative performance to specific fire-test conditions during the period of exposure and shall not be construed as having determined suitability under other conditions or for use after fire exposure.

1.3 *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.*

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

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the*

[1] These test methods are under the jurisdiction of ASTM Committee E05 on Fire Standards and are the direct responsibility of Subcommittee E05.11 on Fire Resistance.

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These test methods, of which the present standard represents a revision, were prepared by Sectional Committee on Fire Tests of Materials and Construction, under the joint sponsorship of the National Bureau of Standards, the ANSI Fire Protection Group, and ASTM, functioning under the procedure of the American National Standards Institute.

*A Summary of Changes section appears at the end of this standard *responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

C569 Test Method for Indentation Hardness of Preformed Thermal Insulations (Withdrawn 1988)[3]

D6513 Practice for Calculating the Superimposed Load on Wood-frame Walls for Standard Fire-Resistance Tests

E176 Terminology of Fire Standards

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E814 Test Method for Fire Tests of Penetration Firestop Systems

E2226 Practice for Application of Hose Stream

## 3. Terminology

3.1 *Definitions*—For definitions of terms found in this test method, refer to Terminology E176.

## 4. Significance and Use

4.1 These test methods are intended to evaluate the duration for which the types of building elements noted in 1.1 contain a fire, retain their structural integrity, or exhibit both properties during a predetermined test exposure.

4.2 The test exposes a test specimen to a standard fire controlled to achieve specified temperatures throughout a specified time period. When required, the fire exposure is followed by the application of a specified standard fire hose stream applied in accordance with Practice E2226. The test provides a relative measure of the fire-test-response of comparable building elements under these fire exposure conditions. The exposure is not representative of all fire conditions because conditions vary with changes in the amount, nature and distribution of fire loading, ventilation, compartment size and configuration, and heat sink characteristics of the compartment. Variation from the test conditions or test specimen construction, such as size, materials, method of assembly, also affects the fire-test-response. For these reasons, evaluation of the variation is required for application to construction in the field.

4.3 The test standard provides for the following:

4.3.1 For walls, partitions, and floor or roof test specimens:

4.3.1.1 Measurement of the transmission of heat.

4.3.1.2 Measurement of the transmission of hot gases through the test specimen.

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

4.3.2 For individual loadbearing members such as beams and columns:

4.3.2.1 Measurement of the load carrying ability under the test exposure with 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 Information as to performance of test specimens constructed with components or lengths other than those tested.

4.4.2 Evaluation of the degree by which the test specimen 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 test specimen.

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 the surface of test specimens.

4.4.6 The effect on fire-resistance of conventional openings in the test specimen, that is, electrical receptacle outlets, plumbing pipe, etc., unless specifically provided for in the construction tested. Also see Test Method E814 for testing of fire stops.

## 5. Test Specimen

5.1 The test specimen shall be representative of the construction that the test is intended to assess, as to materials, workmanship, and details such as dimensions of parts, and shall be built under conditions representative of those applied in building construction and operation. The physical properties of the materials and ingredients used in the test specimen shall be determined and recorded.

5.2 The size and dimensions of the test specimen specified herein shall apply for classifying constructions of dimensions within the range employed in buildings. When the conditions of use limit the construction to smaller dimensions, the dimensions of the test specimen shall be reduced proportionately for a test qualifying them for such restricted use.

5.3 Test specimens designed with a built-up roof shall be tested with a roof covering of 3 ply, 15 lb (6.8 kg) type felt, with not more than 120 lb (54 kg) per square 100 $ft^2$ (9 $m^2$) of hot mopping asphalt without gravel surfacing. Tests with this covering do not preclude the field use of other coverings with a larger number of plys of felt, with a greater amount of asphalt or with gravel surfacing.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

5.4 Roofing systems designed for other than the use of built-up roof coverings shall be tested using materials and details of construction representative of field application.

## 6. Protection and Conditioning of Test Specimen

6.1 Protect the test specimen during and after fabrication to ensure its quality and condition at the time of test. The test specimen shall not be tested until its required strength has been attained, and, until an air-dry condition has been achieved in accordance with the requirements given in 6.2 – 6.4. Protect the testing equipment and test specimen undergoing the fire-resistance test from any condition of wind or weather that is capable of affecting results. The ambient air temperature at the beginning of the test shall be within the range of 50 to 90°F (10 to 32°C). The velocity of air across the unexposed surface of the test specimen, measured just before the test begins, shall not exceed 4.4 ft (1.3 m/s), as determined by an anemometer placed at right angles to the unexposed surface. When mechanical ventilation is employed during the test, an air stream shall not be directed across the surface of the test specimen.

6.2 Prior to the fire-resistance test, condition test specimens with the objective of providing moisture condition within the test specimen representative of that in similar construction in buildings. For purposes of standardization, this condition is established at equilibrium resulting from conditioning in an ambient atmosphere of 50 % relative humidity at 73°F (Note 1).

6.2.1 With some constructions it is difficult or impossible to achieve such uniformity. Where this is the case, test specimens are tested when the dampest portion of the test specimen, or the portion at 6-in. (152-mm) depth below the surface of massive constructions, has achieved a moisture content corresponding to conditioning to equilibrium with air in the range of 50 to 75 % relative humidity at 73 ± 5°F (23 ± 3°C).

6.2.2 When evidence is shown that test specimens conditioned in a heated building will fail to meet the requirements of 6.2 after a 12-month conditioning period, or in the event that the nature of the construction is such that it is evident that conditioning of the test specimen interior is prevented by hermetic sealing, the moisture condition requirements of 6.2 are permitted to be waived, and either 6.2.2.1 or 6.2.2.2 shall apply.

6.2.2.1 Alternative conditioning methods are permitted to be used to achieve test specimen equilibrium prescribed in 6.2 (Note 2), or

6.2.2.2 The specimen tested when its strength is at least equal to its design strength after a minimum 28 day conditioning period.

6.3 Avoid conditioning procedures that will alter the structural or fire-resistance characteristics of the test specimen from those produced as the result of conditiong in accordance with procedures given in 6.2.

6.4 Information on the actual moisture content and distribution within the test specimen shall be obtained within 72 h prior to the fire. Include this information in the test report (Note 3).

NOTE 1—A recommended method for determining the relative humidity within a hardened concrete test specimen with electric sensing elements is described in Appendix I of the paper by Menzel, C. A., "A Method for Determining the Moisture Condition of Hardened Concrete in Terms of Relative Humidity," *Proceedings*, ASTM, Vol 55, 1955, p. 1085. A similar procedure with electric sensing elements is permitted to be used to determine the relative humidity within test specimens made with other materials.

With wood constructions, the moisture meter based on the electrical resistance method can be used, when appropriate, as an alternative to the relative humidity method to indicate when wood has attained the proper moisture content. Electrical methods are described on page 12-2 of the 1999 edition of the *Wood Handbook of the Forest Products Laboratory*, U.S. Department of Agriculture. The relationships between relative humidity and moisture content are given in Table 3-4 on p. 3-7. This indicates that wood has a moisture content of 13 % at a relative humidity of 70 % for a temperature of 70 to 80°F (21 to 27°C).

NOTE 2—An example where alternative conditioning may be employed is where concrete specimens are conditioned at elevated temperatures in a "heated building" to more rapidly obtain the conditions described in 6.2. In such cases, temperatures other than 73°F are used to reach a maximum 50 % relative humidity.

NOTE 3—If the moisture condition of the test specimen is likely to change drastically from the 72-h sampling time prior to test, the sampling should be made not later than 24 h prior to the test.

## 7. Control

7.1 *Fire-Resistance Test:*

7.1.1 *Time-Temperature Curve:*

7.1.1.1 The furnace temperatures shall be controlled to follow the standard time-temperature curve shown in Fig. 1. The points on the curve that determine its character are:

| | |
|---|---|
| 1000°F (538°C) | at 5 min |
| 1300°F (704°C) | at 10 min |
| 1550°F (843°C) | at 30 min |
| 1700°F (927°C) | at 1 h |
| 1850°F (1010°C) | at 2 h |
| 2000°F (1093°C) | at 4 h |
| 2300°F (1260°C) | at 8 h or over |

7.1.1.2 For a more detailed definition of the time-temperature curve, see Appendix X1.

NOTE 4—*Recommendations for Recording Fuel Flow to Furnace Burners*— The following provides guidance on the desired characteristics of instrumentation for recording the flow of fuel to the furnace burners. Fuel flow data may be useful for a furnace heat balance analysis, for measuring the effect of furnace or control changes, and for comparing the

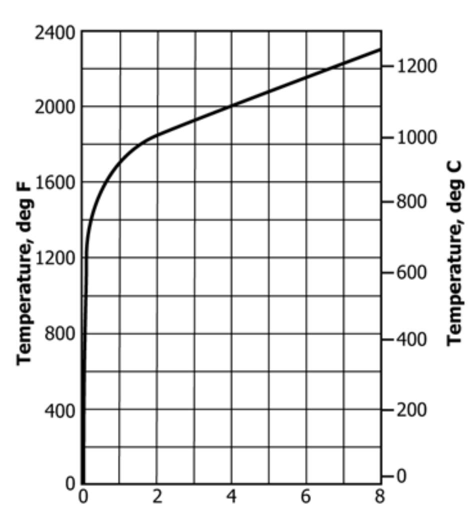


FIG. 1 Time-Temperature Curve

performance of test specimens of different properties in the fire-resistance test.[4]

Record the integrated (cumulative) flow of gas (or other fuel) to the furnace burners at 10 min, 20 min, 30 min, and every 30 min thereafter or more frequently. Total gas consumed during the total test period is also to be determined. A recording flow meter has advantages over periodic readings on an instantaneous or totalizing flow meter. Select a measuring and recording system to provide flow rate readings accurate to within ±5 %.

Report the type of fuel, its higher (gross) heating value, and the fuel flow (corrected to standard conditions of 60°F (16°C) and 30.0 in. Hg) as a function of time.

7.2 *Furnace Temperatures:*

7.2.1 The temperature fixed by the curve shall be the average temperature from not fewer than nine thermocouples for a floor, roof, wall, or partition and not fewer than eight thermocouples for a structural column. Furnace thermocouples shall be symmetrically disposed and distributed to show the temperature near all parts of the sample. The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall be not less than 12 in. (305 mm).

7.2.1.1 The thermocouple shall be fabricated from Chromel-Alumel thermocouple wire. The wire shall be 14 AWG (0.0642 in. diameter, 1.628 mm diameter) or 16 AWG (0.0508 in. diameter1.450 mm diameter) or 18 AWG (0.0403 in. diameter, 1.024 mm diameter). The thermocouple junction shall be formed by fusion-welding the wire ends to form a bead.

Each thermocouple wire lead shall be placed into one of the two holes of the ceramic insulators. The ceramic insulators shall have an outside diameter of 0.40 in. (10 mm) with two holes each having an outside diameter of 0.08 in. (2 mm). The thermocouple wire and ceramic insulators shall be inserted into a standard weight nominal 0.50 in. (12.7 mm) Inconel® 600 pipe (Schedule 40). The thermocouple bead shall be located 0.25 ± 0.04 in. (6.35 ± 1 mm) from the end of ceramic insulators and 0.50 ± 0.04 in. (12.7 ± 1 mm) from the pipe end. The thermocouple assembly is shown in Fig. 2.

7.2.1.2 For walls and partitions, the furnace thermocouples shall be placed 6 in. (152 mm) away from the exposed face of the test specimen at the beginning of the test. For all other test specimens, the furnace thermocouples shall be placed 12 in. (305 mm) from the exposed face of the test specimen at the beginning of the test. During the test, furnace thermocouples shall not touch the test specimen in the event of the test specimen's deflection.

7.2.2 The furnace temperatures shall be read at intervals not exceeding 5 min during the first 2 h, and thereafter the intervals shall not exceed 10 min.

7.2.3 The accuracy of the furnace control shall be such that the area under the time-temperature curve, obtained by averaging the results from the pyrometer readings, is within 10 % of the corresponding area under the standard time-temperature curve shown in Fig. 1 for fire-resistance tests of 1 h or less duration, within 7.5 % for those over 1 h and not more than 2 h, and within 5 % for tests exceeding 2 h in duration.

7.3 *Test Specimen Temperatures:*

7.3.1 *Temperatures Measurement of the Unexposed Surfaces of Floors, Roofs, Walls, and Partitions:*

7.3.1.1 Temperatures of unexposed test specimen surfaces shall be measured with thermocouples placed under dry, felted pads meeting the requirements listed in Annex A1. The wire leads of the thermocouple shall be positioned under the pad and be in contact with the unexposed test specimen surface for not less than 3½ in. (89 mm). The hot junction of the thermocouple shall be placed approximately under the center of the pad. The pad shall be held firmly against the surface, and shall cover the thermocouple. The wires for the thermocouple in the length covered by the pad shall be not heavier than No. 18 B&S gage (0.04 in.) (1.02 mm) and shall be electrically insulated with heat-resistant or moisture-resistant coatings, or both.

NOTE 5—For the purpose of testing roof assemblies, the unexposed surface shall be defined as the surface exposed to ambient air.

7.3.1.2 Temperatures shall be recorded at not fewer than nine points on the surface. Five of these shall be symmetrically disposed, one to be approximately at the center of the test specimen, and four at approximately the center of its quarter sections. The other four shall be located to obtain representative information on the performance of the test specimen. The thermocouples shall not be located closer to the edges of the test specimen than one and one-half times the thickness of the test specimen, or 12 in. (305 mm). Exception: those cases in which there is an element of the construction that is not otherwise represented in the remainder of the test specimen. The thermocouples shall not be located opposite or on top of beams, girders, pilasters, or other structural members if temperatures at such points will be lower than at more representative locations. The thermocouples shall not be located over

[4] Harmathy, T. Z., "Design of Fire Test Furnaces," *Fire Technology*, Vol. 5, No. 2, May 1969, pp. 146–150; Seigel, L. G., "Effects of Furnace Design on Fire Endurance Test Results," *Fire Test Performance, ASTM STP 464*, ASTM, 1970, pp. 57–67; and Williamson, R. B., and Buchanan, A. H., "A Heat Balance Analysis of the Standard Fire Endurance Test."

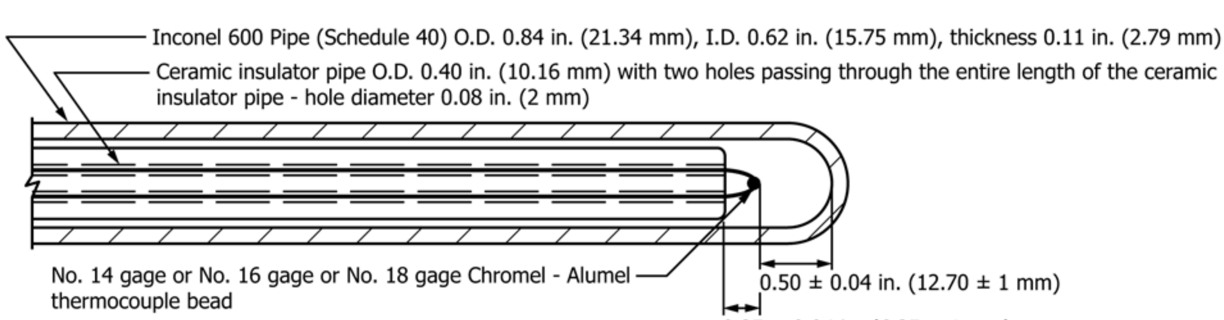


**FIG. 2 Thermocouple Assembly**