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

This standard is issued under the fixed designation E 119; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the 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 nor 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," "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 bearing 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 for use under other conditions or 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 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*

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[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 Construction Assemblies.

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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.

responsibility of the user of this standard to establish appropriate safety and health 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.

2. Referenced Documents

2.1 *ASTM Standards:*

C 569 Test Method for Indentation Hardness of Preformed Thermal Insulations[2]

E 176 Terminology of Fire Standards[3]

3. Terminology

3.1 *Definitions*—For definitions of terms found in this test method, refer to Terminology E 176.

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 contain a fire, 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 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. The test provides a relative measure of the fire-test-response of comparable assemblies 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 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 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:

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 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, that is, electrical receptacle outlets, plumbing pipe, etc., unless specifically provided for in the construction tested.

CONTROL OF FIRE TESTS

5. Time-Temperature Curve

5.1 The conduct of fire tests of materials and construction shall be controlled by 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

5.2 For a closer definition of the time-temperature curve, see Appendix X1.

NOTE 1—*Recommendations for Recording Fuel Flow to Furnace Burners*—The following provides guidance on the desired characteristics

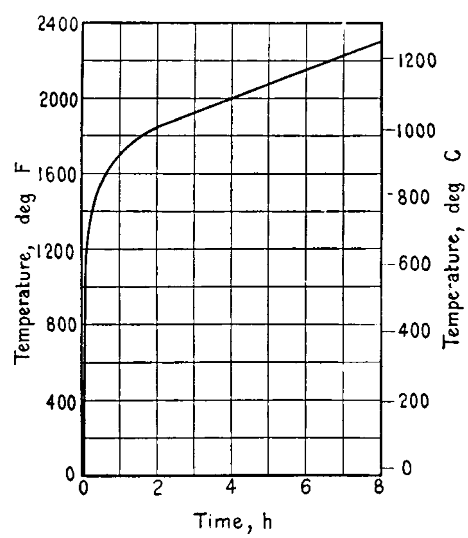

FIG. 1 Time-Temperature Curve

[2] *Discontinued*—See *1987 Annual Book of ASTM Standards*, Vol 04.06.

[3] *Annual Book of ASTM Standards*, Vol 04.07.

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 performance of assemblies of different properties in the fire endurance 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.

6. Furnace Temperatures

6.1 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 thermocouples being enclosed in protection tubes of such materials and dimensions that the time constant of the protected thermocouple assembly lies within the range from 5.0 to 7.2 min (Note 2). The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall be not less than 12 in. (305 mm). It is not prohibited to use other types of protecting tubes or pyrometers that, under test conditions, give the same indications as the above standard within the limit of accuracy that applies for furnace-temperature measurements.

6.1.1 For floors and columns, the junction of the thermocouples shall be placed 12 in. (305 mm) away from the exposed face of the sample at the beginning of the test and, during the test, shall not touch the sample as a result of its deflection.

6.1.2 For walls and partitions, the thermocouples shall be placed 6 in. (152 mm) away from the exposed face of the sample at the beginning of the test, and shall not touch the sample during the test, in the event of deflecton.

NOTE 2—A typical thermocouple assembly meeting these time constant requirements may be fabricated by fusion-welding the twisted ends of No. 18 gage Chromel-Alumel wires, mounting the leads in porcelain insulators and inserting the assembly so the thermocouple bead is ½in. (13 mm) from the sealed end of a standard weight nominal ½-in. iron, steel, or Inconel[5] pipe. The time constant is either measured or calculated from knowledge of its physical and thermal properties. The time constant for this and for several other thermocouple assemblies was measured in 1976.[6]

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

6.3 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 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. Temperatures of Unexposed Surfaces of Floors, Roofs, Walls, and Partitions

7.1 Temperatures of unexposed surfaces shall be measured with thermocouples or thermometers (Note 4) placed under dry, felted pads meeting the requirements listed in Annex A1. The wire leads of the thermocouple or the stem of the thermometer shall have an immersion under the pad and be in contact with the unexposed surface for not less than 3½ in. (89 mm). The hot junction of the thermocouple or the bulb of the thermometer shall be placed approximately under the center of the pad. The outside diameter of protecting or insulating tubes, and of thermometer stems, shall be not more than 5⁄16 in. (8 mm). The pad shall be held firmly against the surface, and shall fit closely about the thermocouples or thermometer stems. Thermometers shall be of the partial-immersion type, with a length of stem, between the end of the bulb and the immersion mark, of 3 in. (76 mm). 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 and moisture-resistant coatings.

NOTE 3—For the purpose of testing roof assemblies, the unexposed surface shall be defined as the surface exposed to ambient air.

NOTE 4—Under certain conditions it may be unsafe or impracticable to use thermometers.

7.2 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 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 construction under test. The thermocouples shall not be located closer to the edges of the test specimen than one and one-half times the thickness of the construction, 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 fasteners such as screws, nails, or staples that will be higher or lower in temperature than at a more representative location if the aggregate area of any part of such fasteners on the unexposed surface is less than 1 % of the area within any 6-in. (152-mm) diameter circle, unless the fasteners extend through the assembly.

7.3 Temperature readings shall be taken at intervals not exceeding 15 min until a reading exceeding 212°F (100°C) has

[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."

[5] Inconel is a registered tradename of INCO Alloys, Inc., 3800 Riverside Dr., P. O. Box 1958, Huntingdon, WV 25720.

[6] Supporting data are available from ASTM Headquarters. Request RR: E05–1001.

been obtained at any one point. Thereafter the readings may be taken more frequently at the discretion of the testing body, but the intervals need not be less than 5 min.

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 30 % 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.

CLASSIFICATION AS DETERMINED BY TEST

8. Report of Results

8.1 Results shall be reported in accordance with the performance in the tests prescribed in these test methods. They shall be expressed in time periods of resistance, to the nearest integral minute. Reports shall include observations of details of the behavior of the material or construction during the test and after the furnace fire is extinguished, including information on deformation, spalling, cracking, burning of the specimen or its component parts, continuance of flaming, and production of smoke.

8.2 Reports of tests involving wall, floor, beam, or ceiling constructions in which restraint is provided against expansion, contraction, or rotation of the construction shall describe the method used to provide this restraint.

8.2.1 Describe the physical details of the restraint system and provide information to define the longitudinal and rotational resistance of the test specimen by the restraint system.

8.2.2 Describe the restraint conditions with regard to the free movement of the test specimen prior to encountering resistance to expansion, contraction or rotation.

8.3 Reports of tests in which other than maximum load conditions are imposed shall fully define the conditions of loading used in the test and shall be designated in the title of the report of the test as a restricted load condition.

8.4 When the indicated resistance period is ½ h or over, determined by the average or maximum temperature rise on the unexposed surface or within the test sample, or by failure under load, a correction shall be applied for variation of the furnace exposure from that prescribed, where it will affect the classification, 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 54°F·h or 30°C·h (3240°F·min or 1800°C·min) to compensate for the thermal lag of the furnace thermocouples during the first part of the test. For fire exposure in the test higher than standard, the indicated resistance period shall be increased by the amount of the correction and be similarly decreased for fire exposure below standard.

NOTE 5—The correction can be expressed by the following equation:

$$C = 2I(A - A_s)/3(A_s + L)$$

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,
A_s = 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 A_s(54°F·h or 30°C·h (3240°F·min or 1800°C·min)).

8.5 Unsymmetrical wall assemblies are tested with either side exposed to the fire, and the report shall indicate the side so exposed. When both sides are tested, the report then shall so indicate the fire endurance classification applicable to each side.

TEST SPECIMEN

9. Test Specimen

9.1 The test specimen shall be truly representative of the construction for which classification is desired, as to materials, workmanship, and details such as dimensions of parts, and shall be built under conditions representative of those obtaining as practically applied in building construction and operation. The physical properties of the materials and ingredients used in the test specimen shall be determined and recorded.

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

9.3 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 of assemblies 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.

9.4 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.

CONDUCT OF FIRE TESTS

10. Fire Endurance Test

10.1 Continue the fire endurance test on the specimen with its applied load, if any, until failure occurs, or until the specimen has withstood the test conditions for a period equal to that herein specified in the conditions of acceptance for the given type of construction.

10.2 Continue the test beyond the time the fire endurance classification is determined when the purpose in doing so is to obtain additional data.

11. Hose Stream Test

11.1 Where required by the conditions of acceptance, the hose stream test shall be conducted to subject the specimen described in 11.2 or 11.3 to the impact, erosion, and cooling effects of a hose stream.

11.1.1 *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.

11.2 The hose stream test shall be conducted on a duplicate test specimen.

11.2.1 The duplicate specimen shall be exposed to the effects of the hose stream immediately after being 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.

11.2.2 The length of time that the duplicate specimen is subjected to the fire endurance test shall not exceed 1 h.

11.3 *Optional Program*—As an alternative procedure, conduct the hose stream test on the initially tested specimen immediately following its fire endurance test.

11.4 In conducting the hose stream test, direct the hose stream first at the middle and then at all parts of the exposed face of the specimen. Any changes in direction shall be made slowly.

11.5 *Stream Equipment and Details*—The stream shall be delivered through a 2½-in. (64-mm) hose discharging through a National Standard Playpipe of corresponding size equipped with a 1⅛-in. (28.5-mm) discharge tip of the standard-taper smooth-bore pattern without shoulder at the orifice. The water pressure and duration of application shall be as prescribed in Table 1.

11.6 *Nozzle Distance*—The distance between the tip of the nozzle and the center of the exposed surface shall be determined by the deviation from normal between the center of the nozzle axis and the center of the exposed surface of the specimen. The distance shall be 20 ft (6 m) when the axis through the center of the nozzle is normal to the center of the exposed surface. This distance shall be decreased by an amount equal to 1 ft (305 mm) for each 10° of deviation from the normal.

12. Protection and Conditioning of Test Specimen

12.1 Protect the test specimen during and after fabrication to assure its quality and condition at the time of test. It shall not be tested until its final strength has been attained, and, until an air-dry condition has been achieved in accordance with the requirements given in 12.1.1 through 12.1.3. Protect the testing equipment and sample undergoing the fire 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 sample, 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 specimen.

TABLE 1 Conditions For Hose Stream Test

Resistance Period	Water Pressure at Base of Nozzle, psi (kPa)	Duration of Application, min/100 ft^2(9 m^2) 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)	2½
1½ h and over if less than 2 h	30 (207)	1½
1 h and over if less than 1½ h	30 (207)	1
Less than 1 h, if desired	30 (207)	1

12.1.1 Prior to fire test, condition constructions with the objective of providing a moisture condition within the specimen representative of that in similar construction in buildings. For purposes of standardization, this condition is established at equilibrium resulting from drying in an ambient atmosphere of 50 % relative humidity at 73°F (Note 6). However, with some constructions, it is difficult or impossible to achieve such uniformity. Accordingly, where this is the case, specimens are tested when the dampest portion of the structure, the portion at 6-in. (152-mm) depth below the surface of massive constructions, has achieved a moisture content corresponding to drying to equilibrium with air in the range of 50 to 75 % relative humidity at 73 ± 5°F (23 ± 3°C). In the event that specimens dried in a heated building fail to meet these requirements after a 12-month conditioning period, or in the event that the nature of the construction is such that it is evident that drying of the specimen interior is prevented by hermetic sealing, these moisture condition requirements are waived, and the specimen tested when its strength is at least equal to its design strength.

12.1.2 Avoid drying procedures that will alter the structural or fire endurance characteristics of the specimen from those produced as the result of drying in accordance with procedures given in 12.1.1.

12.1.3 Within 72 h prior to the fire test information on the actual moisture content and distribution within the specimen shall be obtained. Include this information in the test report (Note 7).

NOTE 6—A recommended method for determining the relative humidity within a hardened concrete 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 fire 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 pages 320 and 321 of the 1955 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 by the graphs in Fig. 23 on p. 327. They indicate 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 7—If the moisture condition of the fire test assembly 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.

13. Precision and Bias [7]

13.1 No comprehensive test program has been conducted to develop data on which to derive statistical measures of repeatability (within-laboratory variability) and reproducibility (among-laboratory variability). The limited data indicate that there is a degree of repeatability and reproducibility for some types of assemblies. Results depend on factors such as the type

[7] Supporting data are available from ASTM Headquarters. Request RR: E05-1003.

of assembly and materials being tested, the characteristics of the furnace, the type and level of applied load, the nature of the boundary conditions (restraint and end fixity), and details of workmanship during assembly.

TESTS OF BEARING WALLS AND PARTITIONS

14. Size of Specimen

14.1 The area exposed to fire shall be not less than 100 ft^2(9 m^2), with neither dimension less than 9 ft (2.7 m). The test specimen shall not be restrained on its vertical edges.

15. Loading

15.1 Throughout the fire endurance and hose stream tests, apply a superimposed load to the specimen to simulate a maximum load condition. This load shall be the maximum load condition allowed under nationally recognized structural design criteria unless limited design criteria are specified and a corresponding reduced load is applied. A double wall assembly shall be loaded during the test to simulate field use conditions, with either side loaded separately or both sides together (Note 8). The method used shall be reported.

NOTE 8—The choice depends on the intended use, and whether the load on the exposed side, after it has failed, will be transferred to the unexposed side. If, in the intended use, the load from the structure above is supported by both walls as a unit and would be or is transferred to the unexposed side in case of collapse of the exposed side, both walls should be loaded in the test by a single unit. If, in the intended use the load from the structure above each wall is supported by each wall separately, the walls should be loaded separately in the test by separate load sources. If the intended use of the construction system being tested involved situations of both loading conditions described above, the walls should be loaded separately in the test by separate load sources. In tests conducted with the walls loaded separately the condition of acceptance requiring the walls to maintain the applied load shall be based on the time at which the first of either of the walls fail to sustain the load.

16. Conditions of Acceptance

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 temperature on its unexposed surface more than 250°F (139°C) above its initial temperature.

TESTS OF NONBEARING WALLS AND PARTITIONS

17. Size of Specimen

17.1 The area exposed to fire shall be not less than 100 ft^2(9 m^2), with neither dimension less than 9 ft (2.7 m). Restrain the test specimen on all four edges.

18. Conditions of Acceptance

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 has withstood the fire and hose stream test as specified in 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 temperature on its unexposed surface more than 250°F (139°C) above its initial temperature.

TESTS OF COLUMNS

19. Size of Specimen

19.1 The length of the column exposed to fire shall be not less than 9 ft (2.7 m). Apply the contemplated details of connections and their protection, if any, according to the methods of field practice. The column shall be vertical during the fire exposure.

20. Loading

20.1 Throughout the fire endurance test, expose the column to fire on all sides and load it with a superimposed load to simulate a maximum load condition. This load shall be the maximum load condition allowed under nationally recognized structural design criteria unless limited design criteria are specified and a corresponding reduced load is applied. Make provision for transmitting the load to the exposed portion of the column without increasing the effective column length.

20.2 As an optional procedure, subject the column to 1¾ times its designed working load before the fire endurance test is undertaken. The fact that such a test has been made shall not be construed as having had a deleterious effect on the fire endurance test performance.

21. Condition of Acceptance

21.1 Regard the test as successful if the column sustains the applied load during the fire endurance test for a period equal to that for which classification is desired.

ALTERNATIVE TEST OF PROTECTION FOR STRUCTURAL STEEL COLUMNS

22. Application

22.1 This alternative test procedure is used to evaluate the protection of steel columns without application of design load, provided that the protection material is not required by design to function structurally in resisting loads.

23. Size and Characteristics of Specimen

23.1 The length of the protected column shall be at least 8 ft (2.4 m). The column shall be vertical during the fire exposure.

23.2 Restrain the applied protection material against longitudinal temperature expansion greater than that of the steel column with rigid steel plates or reinforced concrete attached to the ends of the steel column before the protection is applied. The size of the plates or amount of concrete shall provide direct bearing for the entire transverse area of the protection material.

23.3 Provide the ends of the specimen, including the means for restraint, with thermal insulation to limit direct heat transfer from the furnace.

24. Temperature Measurement

24.1 Measure the temperature of the steel with not fewer than three thermocouples at each of four levels. The upper and lower levels shall be 2 ft (0.6 m) from the ends of the steel column, and the two intermediate levels shall be equally spaced. For situations in which the protection material thickness is not uniform along the specimen length, at least one of the levels at which temperatures are measured shall include the point of minimum cover. Place the thermocouples at each level to measure temperatures of the component elements of the steel section.

25. Exposure to Fire

25.1 Throughout the fire endurance test expose the specimen to fire on all sides for its full length.

26. Conditions of Acceptance

26.1 Regard the test as successful if the transmission of heat through the protection during the period of fire exposure for which classification is desired does not raise the average (arithmetical) temperature of the steel at any one of the four levels above 1000°F (538°C), or does not raise the temperature above 1200°F (649°C) at any one of the measured points.

TESTS OF FLOORS AND ROOFS

27. Application

27.1 This procedure is applicable to floor and roof assemblies with or without attached, furred, or suspended ceilings and requires application of fire exposure to the underside of the specimen under test.

27.2 Two fire endurance classifications shall be developed from tests of assemblies restrained against thermal expansion; a restrained assembly classification based upon the conditions of acceptance specified in 31.1.1 and 31.1.2 and where applicable, to the conditions in 31.1.3 through31.1.5; and an unrestrained assembly classification based upon the conditions of acceptance specified in 32.1.1 and 32.1.2 and where applicable, to the conditions in 32.1.3 through 32.1.6.

NOTE 9—See Appendix X3, which is intended as a guide for assisting the user of this test method in determining the conditions of thermal restraint applicable to floor and roof constructions and individual beams in actual building construction.

27.3 One fire endurance classification shall be developed from tests of assemblies not restrained against thermal expansion based upon the conditions of acceptance specified in 32.1.1 and 32.1.2.

27.4 Individual unrestrained beam classifications are developed for beams from restrained assembly tests and from unrestrained assembly tests, using the conditions of acceptance specified in 40.1.1 and 40.1.2, or 40.1.3.

28. Size and Characteristics of Specimen

28.1 The area exposed to fire shall be not less than 180 ft^2(16 m^2) with neither dimension less than 12 ft (3.7 m). Structural members, if a part of the construction under test, shall lie within the combustion chamber and have a side clearance of not less than 8 in. (203 mm) from its walls.

28.2 Specimens representing forms of construction in which restraint to thermal expansion occurs shall be so restrained in the furnace.

29. Loading

29.1 Throughout the fire endurance test, apply a superimposed load to the specimen to simulate a maximum load condition. This load shall be the maximum load condition allowed under nationally recognized structural design criteria unless limited design criteria are specified and a corresponding reduced load is applied.

30. Temperature Measurement

30.1 For specimens employing structural members (beams, open-web steel joists, etc.) spaced at more than 4 ft (1.2 m) on centers, measure the temperature of the steel in these structural members with four thermocouples at each of three or more sections equally spaced along the length of the members. For situations in which the protection material thickness is not uniform along the specimen length, at least one of the sections at which temperatures are measured shall include the point of minimum cover.

30.2 For specimens employing structural members (beams, open-web steel joists, etc.) spaced at 4 ft (1.2 m) on center or less, measure the temperature of the steel in these structural members with four thermocouples placed on each member. No more than four members shall be so instrumented. Place the thermocouples at locations, such as at midspan, over joints in the ceiling, and over light fixtures. It shall not be required that all four thermocouples be located at the same section.

30.3 Locate thermocouples as shown in Fig. 2: two on the bottom of the bottom flange or chord, one on the web at the center, and one on the top flange or chord.

30.4 For reinforced or prestressed concrete structural members, locate thermocouples on each of the tension reinforcing elements, unless there are more than eight such elements, in which case place thermocouples on eight elements selected in such a manner as to obtain representative temperatures of all the elements.

30.5 For steel floor or roof units locate four thermocouples on each section (a section to comprise the width of one unit),

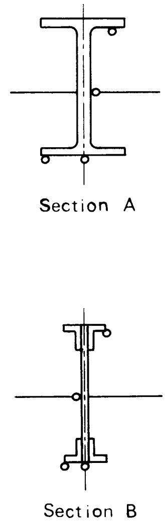

FIG. 2 Typical Thermocouple Distributions

one on the bottom plane of the unit at an edge joint, one on the bottom plane of the unit remote from the edge, one on a side wall of the unit, and one on the top plane of the unit. The thermocouples shall be applied, where practicable, to the surface of the units remote from fire and spaced across the width of the unit. No more than four nor less than two sections need be so instrumented in each representative span. Locate the groups of four thermocouples in representative locations. Typical thermocouple locations for a unit section are shown in Fig. 3.

31. Conditions of Acceptance—Restrained Assembly

31.1 In obtaining a restrained assembly classification, the following conditions shall be met:

31.1.1 The specimen shall have sustained the applied load during the classification period without developing unexposed surface conditions which will ignite cotton waste.

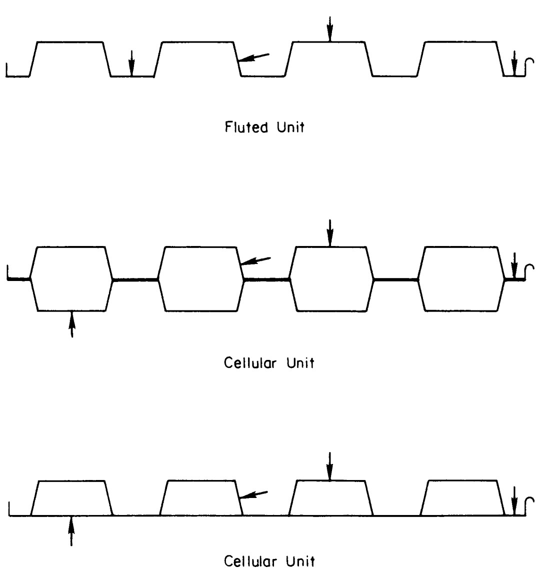

FIG. 3 Typical Location of Thermocouples

31.1.2 Transmission of heat through the specimen during the classification period 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.

31.1.3 For specimens employing steel structural members (beams, open-web steel joists, etc.) spaced more than 4 ft (1.2 m) on centers, the assembly shall achieve a fire endurance classification on the basis of the temperature criteria specified in 32.1.3 for assembly classifications up to and including 1 h. For classifications greater than 1 h, the above temperature criteria shall apply for a period of one half the classification of the assembly or 1 h, whichever is the greater.

31.1.4 For specimens employing steel structural members (beam, open-web steel joists, etc.) spaced 4 ft (1.2 m) or less on centers, the assembly shall achieve a fire endurance classification on the basis of the temperature criteria specified in 32.1.4 for assembly classifications up to and including 1 h. For classifications greater than 1 h, the above temperature criteria shall apply for a period of one half the classification of the assembly or 1 h, whichever is the greater.

31.1.5 For specimens employing conventionally designed concrete beams, spaced more than 4 ft (1.2 m) on centers, the assembly shall achieve a fire endurance classification on the basis of the temperature criteria specified in 32.1.5 for assembly classifications up to and including 1 h. For classifications greater than 1 h, the above temperature criteria shall apply for a period of one half the classification of the assembly or 1 h, whichever is the greater.

32. Conditions of Acceptance—Unrestrained Assembly

32.1 In obtaining an unrestrained assembly classification, the following conditions shall be met:

32.1.1 The specimen shall have sustained the applied load during the classification period without developing unexposed surface conditions which will ignite cotton waste.

32.1.2 The transmission of heat through the specimen during the classification period 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.

32.1.3 For specimens employing steel structural members (beams, open-web steel joists, etc.), spaced more than 4 ft (1.2 m) on centers, the temperature of the steel shall not have exceeded 1300°F (704°C) at any location during the classification period nor shall the average temperature recorded by four thermocouples at any section have exceeded 1100°F (593°C) during the classification period.

32.1.4 For specimens employing steel structural members (beams, open-web steel joists, etc.), spaced 4 ft (1.2 m) or less on center, the average temperature recorded by all joist or beam thermocouples shall not have exceeded 1100°F (593°C) during the classification period.

32.1.5 For specimens employing conventionally designed concrete structural members (excluding cast-in-place concrete roof or floor slabs having spans equal to or less than those tested), the average temperature of the tension steel at any section shall not have exceeded 800°F (427°C) for cold-drawn prestressing steel or 1100°F (593°C) for reinforcing steel during the classification period.

32.1.6 For specimens employing steel floor or roof units intended for use in spans greater than those tested, the average temperature recorded by all thermocouples located on any one span of the floor or roof units shall not have exceeded 1100°F (593°C) during the classification period.

33. Report of Results

33.1 The fire endurance classification of a restrained assembly shall be reported as that developed by applying the conditions of acceptance specified in 31.1.1 and 31.1.2, and where applicable, to the conditions in 31.1.3 through 31.1.5.

33.2 The fire endurance classification of an unrestrained assembly shall be reported as that developed by applying the conditions of acceptance specified in 32.1.1 and 32.1.2 and, where applicable, to the conditions in 32.1.3 through 32.1.6.

TESTS OF LOADED RESTRAINED BEAMS

34. Application

34.1 An individual restrained beam classification is obtained by this procedure for loaded restrained beams based upon the conditions of acceptance specified in 37. The fire endurance classification so derived shall be applicable to the beam when used with a floor or roof construction which has a comparable or greater capacity for heat dissipation from the beam than the floor or roof with which it was tested. The fire endurance classification developed by this method shall not be applicable to sizes of beams smaller than those tested.

35. Size and Characteristics of Specimen

35.1 The length of beam exposed to the fire shall be not less than 12 ft (3.7 m) and the member shall be tested in a horizontal position.

35.2 For specimens tested with a representative section of a floor or roof construction, such sections shall be not more than 7 ft (2.1 m) wide and symmetrically located with reference to the beam.

35.3 Restrain the beam including that part of the floor or roof element forming the complete beam as designed (such as composite steel or concrete construction) against longitudinal thermal expansion in a manner simulating the restraint in the construction represented. Do not support or restrain the perimeter of the floor or roof element of the specimen, except that part which forms part of a beam as designed.

36. Loading

36.1 Throughout the fire endurance test, apply a superimposed load to the specimen to simulate a maximum load condition. This load shall be the maximum load condition allowed under nationally recognized structural design criteria unless limited design criteria are specified and a corresponding reduced load is applied.

37. Conditions of Acceptance

37.1 The following conditions shall be met:

37.1.1 The specimen shall have sustained the applied load during the classification period.

37.1.2 The specimen shall have achieved a fire endurance classification on the basis of the temperature criteria specified in 32.1.3 of one half the classification of the assembly or 1 h, whichever is the greater.

ALTERNATIVE CLASSIFICATION PROCEDURE FOR LOADED BEAMS

38. Application

38.1 An individual unrestrained beam classification is developed for beams from tests as part of a floor or roof assembly as described in Sections 27-30 (except 27.3) and from tests for loaded restrained beams as described in Sections 34-36. The fire endurance classification so derived shall be applicable to beams when used with a floor or roof construction which has a comparable or greater capacity for heat dissipation from the beam than the floor or roof with which it was tested. The fire endurance classification developed by this test method shall not be applicable to sizes of beams smaller than those tested.

39. Temperature Measurement

39.1 Measure the temperature of the steel in structural members with four thermocouples at three or more sections equally spaced along the length of the members. For situations in which the protection material thickness is not uniform along the specimen length, at least one of the sections at which temperatures are measured shall include the point of minimum cover.

39.2 Locate the thermocouples as shown in Fig. 2: two on the bottom of the bottom flange or chord, one on the web at the center, and one on the bottom of the top flange or chord.

39.3 For reinforced or prestressed concrete structural members, locate thermocouples on each of the tension reinforcing elements unless there are more than eight such elements, in which case place thermocouples on eight elements selected in such a manner as to obtain representative temperatures of all the elements.

40. Conditions of Acceptance

40.1 In obtaining an unrestrained beam classification the following conditions shall be met:

40.1.1 The specimen shall have sustained the applied load during the classification period.

40.1.2 For steel beams the temperature of the steel shall not have exceeded 1300°F (704°C) at any location during the classification period nor shall the average temperature recorded by four thermocouples at any section have exceeded 1100°F (593°C) during this period.

40.1.3 For conventionally designed concrete beams, the average temperature of the tension steel at any section shall not have exceeded 800°F (427°C) for cold-drawn prestressing steel or 1100°F for reinforcing steel during the classification period.

ALTERNATIVE TEST OF PROTECTION FOR SOLID STRUCTURAL STEEL BEAMS AND GIRDERS

41. Application

41.1 This alternative test procedure is used to evaluate the protection of steel beams and girders without application of design load, provided that the protection is not required by design to function structurally in resisting applied loads. The fire endurance classification so derived shall be applicable to beams when used with a floor or roof construction which has a comparable or greater capacity for heat dissipation from the beam than the floor or roof with which it is tested. The fire endurance classification developed by this test method shall not be applicable to sizes of beams smaller than those tested.

42. Size and Characteristics of Specimen

42.1 The length of beam or girder exposed to the fire shall be not less than 12 ft (3.7 m) and the member shall be tested in a horizontal position. A section of a representative floor or roof construction not less than 5 ft (1.5 m) wide, symmetrically located with reference to the beam or girder and extending its full length, shall be included in the test specimen.

42.2 Restrain the applied protection material against longitudinal temperature expansion greater than that of the steel beam or girder with rigid steel plates or reinforced concrete attached to the ends of the steel beams before the protection material is applied. Provide the ends of the specimen, including the means for restraint, with thermal insulation to limit direct heat transfer from the furnace.

43. Temperature Measurement

43.1 Measure the temperature of the steel with not fewer than four thermocouples at each of four sections equally spaced along the length of the beam no nearer than 2 ft (0.6 m) from the inside face of the furnace. For situations in which the protection material thickness is not uniform along the specimen length, at least one of the sections at which temperatures are measured shall include the point of minimum cover. Place the thermocouples at each section to measure temperatures of the component elements of the steel section.

44. Conditions of Acceptance

44.1 Regard the test as successful if the transmission of heat through the protection during the period of fire exposure for which classification is desired does not raise the average (arithmetical) temperature of the steel at any one of the four sections above 1000°F (538°C), or does not raise the temperature above 1200°F (649°C) at any one of the measured points.

PERFORMANCE OF PROTECTIVE MEMBRANES IN WALL, PARTITION, FLOOR, OR ROOF ASSEMBLIES

45. Application

45.1 To determine the thermal protection afforded by membrane elements in wall, partition, floor, or roof assemblies, the nonstructural performance of protective membranes shall be obtained by this procedure. The performance of protective membranes is supplementary information only and is not a substitute for the fire endurance classification determined elsewhere in this fire-test-response standard.

46. Size of Specimen

46.1 The size of the specimen shall conform to 14.1 for bearing walls and partitions, 17.1 for nonbearing walls and partitions, or 28.1 for floors and roofs.

47. Temperature Performance of Protective Membranes

47.1 The temperature performance of protective membranes shall be measured with thermocouples, the measuring junctions of which are in intimate contact with the exposed surface of the elements being protected. The diameter of the wires used to form the thermo-junction shall not be greater than the thickness of sheet metal framing or panel members to which they are attached and in no case greater than No. 18 B&S gage (0.040 in.) (1.02 mm). The lead shall be electrically insulated with heat-resistant and moisture-resistant coatings.

47.2 For each class of elements being protected, temperature readings shall be taken at not fewer than five representative points. None of the thermocouples shall be located nearer to the edges of the test assembly than 12 in. (305 mm). An exception is made in those cases in which there is an element or feature of the construction that is not otherwise represented in the test assembly. None of the thermocouples shall be located opposite, on top of, or adjacent to fasteners such as screws, nails, or staples when such locations are excluded for thermocouple placement on the unexposed surface of the test assembly in 7.2.

47.3 Thermocouples shall be located to obtain information on the temperature at the interface between the exposed membrane and the substrate or element being protected.

47.4 Temperature readings shall be taken at intervals not exceeding 5 minutes.

48. Conditions of Performance

48.1 Unless otherwise specified, the performance of protective membranes shall be determined as the time at which the following conditions occur:

48.1.1 The average temperature rise of any set of thermocouples for each class of element being protected is more than 250°F (139°C) above the initial temperature, or

48.1.2 The temperature rise of any one thermocouple of the set for each class of element being protected is more than 325°F (181°C) above the initial temperature.

49. Report of Results

49.1 The protective membrane performance, for each class of element being protected, shall be reported to the nearest integral minute.

49.2 The test report shall identify each class of elements being protected and shall show the location of each thermocouple.

49.3 The test report shall show the time-temperature data recorded for each thermocouple and the average temperature for the set of thermocouples on each element being protected.

50. Keywords

50.1 beams; building construction; building materials; columns; fire; fire endurance; fire-rated assembly; fire-resistance; fire-test-response standard; floors; walls

ANNEX

(Mandatory Information)

A1. REQUIREMENTS FOR THERMOCOUPLE PADS

A1.1 *Asbestos Pads*—Asbestos pads used in measurements of temperature of unexposed surfaces of specimens shall be of felted amosite asbestos free of organic additives and shall exhibit the following properties:

A1.1.1 Length and width, 6 ± ⅛ in. (152 ± 3 mm).

A1.1.2 Thickness, 0.40 ± 0.05 in. (10.2 ± 1.3 mm). The thickness measurement shall be made under the light load of a ½-in. (13-mm) diameter pad of a dial micrometer gage.

A1.1.3 Dry weight, 0.260 ± 0.026 lb (0.12 ± 0.01 kg).

A1.1.4 Thermal conductivity (at 150°F (66°C)), 0.38 ± 0.027 Btu·in./h·ft^2·°F (0.055 ± 0.003 W/m·K).

A1.1.5 Hardness indentation shall be 0.157 ± 0.07 in. (4.0 ± 1.8 mm) or 10–25 (modified Brinell). Indentation shall be determined in accordance with Test Method C 569. Modified Brinell values of hardness are obtained by the relationship

$$\text{Hardness} = \frac{2.24}{y}$$

where y = the measured indentation in inches.

A1.1.6 The pads shall be sufficiently soft so that, without breaking, they may be shaped to contact over the whole surface against which they are placed.

A1.2 *Refractory Fiber Pads*—Comparative fire tests have demonstrated that a refractory fiber material designated Ceraform 126,[8] placed with the softer surfaces in contact with the thermocouple, may be substituted for the asbestos pad when distortion of the unexposed face of the sample is minimal. The pads are relatively rigid and shall not be used on surfaces subject to sharp distortions or discontinuities during the test.[9] Properties of Ceraform 126 material shall be as follows:

A1.2.1 Length and width, 6 ± ⅛ in. (152 ± 3 mm).

A1.2.2 Thickness, 0.375 ± 0.063 in. (9.5 ± 1.6 mm) (see A1.1.2).

A1.2.3 Dry weight, 0.147 ± 0.053 lb (67 ± 24 g)

A1.2.4 Thermal conductivity (at 150°F (66°C)), 0.37 ± 0.03 Btu·in./h·ft^2·°F (0.053 ± 0.004 W/m·K).

A1.2.5 Hardness (see A1.1.5) indentation on soft face shall be 0.075± 0.025 in. (1.9 ± 0.6 mm).

A1.2.6 The pads may be shaped by wetting, forming, and then drying to constant weight to provide complete contact on sharply contoured surfaces.

[8] Ceraform 126 is a registered tradename of Manville Specialty Products Group, P. O. Box 5108, Denver, CO 80217.

[9] Supporting data are available from ASTM Headquarters. Request RR: E05-1004.

APPENDIXES

(Nonmandatory Information)

X1. STANDARD TIME-TEMPERATURE CURVE FOR CONTROL OF FIRE TESTS

TABLE X1.1 STANDARD TIME-TEMPERATURE CURVE FOR CONTROL OF FIRE TESTS

Time	Temperature,° F	Area Above 68°F Base		Temperature, °C	Area Above 20°C Base	
h:min		°F-min	°F-h		°C-min	°C-h
0:00	68	00	0	20	00	0
0:05	1 000	2 330	39	538	1 290	22
0:10	1 300	7 740	129	704	4 300	72
0:15	1 399	14 150	236	760	7 860	131
0:20	1 462	20 970	350	795	11 650	194
0:25	1 510	28 050	468	821	15 590	260
0:30	1 550	35 360	589	843	19 650	328
0:35	1 584	42 860	714	862	23 810	397
0:40	1 613	50 510	842	878	28 060	468
0:45	1 638	58 300	971	892	32 390	540
0:50	1 661	66 200	1 103	905	36 780	613
0:55	1 681	74 220	1 237	916	41 230	687
1:00	1 700	82 330	1 372	927	45 740	762
1:05	1 718	90 540	1 509	937	50 300	838
1:10	1 735	98 830	1 647	946	54 910	915
1:15	1 750	107 200	1 787	955	59 560	993
1:20	1 765	115 650	1 928	963	64 250	1 071
1:25	1 779	124 180	2 070	971	68 990	1 150
1:30	1 792	132 760	2 213	978	73 760	1 229
1:35	1 804	141 420	2 357	985	78 560	1 309
1:40	1 815	150 120	2 502	991	83 400	1 390
1:45	1 826	158 890	2 648	996	88 280	1 471
1:50	1 835	167 700	2 795	1 001	93 170	1 553
1:55	1 843	176 550	2 942	1 006	98 080	1 635
2:00	1 850	185 440	3 091	1 010	103 020	1 717
2:10	1 862	203 330	3 389	1 017	112 960	1 882
2:20	1 875	221 330	3 689	1 024	122 960	2 049
2:30	1 888	239 470	3 991	1 031	133 040	2 217
2:40	1 900	257 720	4 295	1 038	143 180	2 386
2:50	1 912	276 110	4 602	1 045	153 390	2 556
3:00	1 925	294 610	4 910	1 052	163 670	2 728
3:10	1 938	313 250	5 221	1 059	174 030	2 900
3:20	1 950	332 000	5 533	1 066	184 450	3 074
3:30	1 962	350 890	5 848	1 072	194 940	3 249
3:40	1 975	369 890	6 165	1 079	205 500	3 425
3:50	1 988	389 030	6 484	1 086	216 130	3 602
4:00	2 000	408 280	6 805	1 093	226 820	3 780
4:10	2 012	427 670	7 128	1 100	237 590	3 960
4:20	2 025	447 180	7 453	1 107	248 430	4 140
4:30	2 038	466 810	7 780	1 114	259 340	4 322
4:40	2 050	486 560	8 110	1 121	270 310	4 505
4:50	2 062	506 450	8 441	1 128	281 360	4 689
5:00	2 075	526 450	8 774	1 135	292 470	4 874
5:10	2 088	546 580	9 110	1 142	303 660	5 061
5:20	2 100	566 840	9 447	1 149	314 910	5 248
5:30	2 112	587 220	79 787	1 156	326 240	5 437
5:40	2 125	607 730	10 129	1 163	337 630	5 627
5:50	2 138	628 360	10 473	1 170	349 909	5 818
6:00	2 150	649 120	10 819	1 177	360 620	6 010
6:10	2 162	670 000	11 167	1 184	372 230	6 204

TABLE X1.1 *Continued*

Time h:min	Temperature,° F	Area Above 68°F Base °F-min	Area Above 68°F Base °F-h	Temperature, °C	Area Above 20°C Base °C-min	Area Above 20°C Base °C-h
6:20	2 175	691 010	11 517	1 191	383 900	6 398
6:30	2 188	712 140	11 869	1 198	395 640	6 594
6:40	2 200	733 400	12 223	1 204	407 450	6 791
6:50	2 212	754 780	12 580	1 211	419 330	6 989
7:00	2 225	776 290	12 938	1 218	431 270	7 188
7:10	2 238	797 920	13 299	1 225	443 290	7 388
7:20	2 250	819 680	13 661	1 232	455 380	7 590
7:30	2 262	841 560	14 026	1 239	467 540	7 792
7:40	2 275	863 570	14 393	1 246	479 760	7 996
7:50	2 288	885 700	14 762	1 253	492 060	8 201
8:00	2 300	907 960	15 133	1 260	504 420	8 407

X2. SUGGESTED REPORT FORM

ASTM E119

TITLE PAGE

(Preferably Cover)

Laboratory ______________________________

Project Number ______________________________

ASTM E119 (Year)

STANDARD FIRE ENDURANCE TEST

Fire Endurance Time ______________________________

Construction ______________________________

Date Tested ______________________________

Sponsor ______________________________

Material ______________________________

Maximum Load Conditions, or Restricted Load Conditions (as the conditions of the test dictate) ______________________________

____

(Identify if test is part of a research program)

(Add—Table of Contents)

X2.1 *Description of Laboratory Test Facility*—Furnace, restraining frame, details of end conditions, including wedges, bearing, etc.

X2.1.1 If construction is to be tested under load indicate how the load is applied and controlled. (Give loading diagram.) Indicate whether the load is a maximum load condition or a restricted load condition and for either condition, report the specific loads and the basis for limitation, such as bending stress, shear, etc. A restricted load condition shall be reported as a percentage of the maximum load condition.

X2.1.2 If construction is to be tested as nonload bearing indicate whether frame is rigid or moves in test, or whether test is of temperature rise only.

X2.2 *Description of all Materials*—Type, size, class, strength, densities, trade name, and any additional data necessary to define materials. The testing laboratory should indicate whether materials meet ASTM Standards by markings, or by statement of sponsor, or by physical or chemical test by the testing laboratory.

X2.3 *Description of Test Assembly:*

X2.3.1 Give size of test specimen.

X2.3.2 Give details of structural design, including safety factors of all structural members in test assembly.

X2.3.3 Include plan, elevation, principal cross section, plus other sections as needed for clarity.

X2.3.4 Give details of attachment of test panel in frame.

X2.3.5 Location of thermocouples, deflection points, and other items for test.

X2.3.6 Describe general ambient conditions at:

X2.3.6.1 Time of construction,

X2.3.6.2 During curing (time from construction to test), and

X2.3.6.3 Time of test.

X2.4 *Description of Test:*

X2.4.1 Report temperature at beginning and every 5 min. If charts are included in report, clearly indicate time and temperature:

X2.4.1.1 In furnace space,

X2.4.1.2 On unexposed surface, and

X2.4.1.3 On protected framing members as stipulated in Standard.

NOTE X2.1—It is recommended that temperature observations not required by the standard, but useful, be reported in the Appendix to the report. These include temperatures on the face of framing members in back of protection and others that may be required by various Building Codes.

X2.4.2 Report deflections every 5 min for the first 15 min of test and the last hour. In between, every 10 min.

X2.4.3 Report appearance of exposed face:

X2.4.3.1 Every 15 min,

X2.4.3.2 At any noticeable development, give details and time, that is, cracks, buckling, flaming, smoke, loss of material, etc., and

X2.4.3.3 At end of the test include the amount of drop out, condition of fasteners, sag, etc.

X2.4.4 Report appearance of unexposed face:

X2.4.4.1 Every 15 min,

X2.4.4.2 At any noticeable development including cracking, smoking, buckling, give details and time, and

X2.4.4.3 At the end of test.

X2.4.5 Report time of failure by:

X2.4.5.1 Temperature rise,

X2.4.5.2 Failure to carry load, and

X2.4.5.3 Passage of flame-heat-smoke.

X2.4.6 If a hose stream test is required repeat necessary parts of X2.1 and X2.3. If failure occurs in hose stream test—describe!

X2.5 *Official Comments on:*

X2.5.1 Included shall be a statement to the effect that the construction truly represents field construction. If the construction does not represent typical field construction, then the deviations shall be noted.

X2.5.2 If construction is unsymmetrical (has different details on each face) be sure to indicate the face exposed to fire with comments on fire resistance from the opposite side.

X2.5.3 Fire test.

X2.6 *Summarize Results, include:*

X2.6.1 Endurance time,

X2.6.2 Nature of failure, and

X2.6.3 Hose stream test results.

X2.7 *List Official Observers*—Signatures of responsible persons.

X2.8 *Appendix*—Include all data not specifically required by test standard, but useful to better understanding of test results. Special observations for Building Code approvals should be in appendix.

X2.9 *Pictures*—All taken to show what cannot be covered in the report or to clarify.

X2.9.1 Assembly in construction.

X2.9.2 Exposed face prior to fire test.

X2.9.3 Unexposed face at start of endurance test; include recording equipment when possible.

X2.9.4 Unexposed face at end of fire endurance test.

X2.9.5 Exposed face at end of fire endurance test.

X2.9.6 Unexposed face at end of fire exposure before hose test.

X2.9.7 Exposed face at end of fire exposure before hose test.

X2.9.8 Exposed face after hose stream test.

X2.9.9 Unexposed face after hose stream test.

X2.10 It is essential to have the following:

X2.10.1 Detailed drawing of test assembly.

X2.10.2 Pictures (X2.9.1, X2.9.4X2.9.4, X2.9.8, and X2.9.9) for every test report.

X3. GUIDE FOR DETERMINING CONDITIONS OF RESTRAINT FOR FLOOR AND ROOF ASSEMBLIES AND FOR INDIVIDUAL BEAMS

X3.1 The revisions adopted in 1970 introduced the concept of fire endurance classifications based on two conditions of support: restrained and unrestrained. As a result, specimens can be fire tested in such a manner as to derive these two classifications.

X3.2 A restrained condition in fire tests, as used in this test method, is one in which expansion at the supports of a load carrying element resulting from the effects of the fire is resisted by forces external to the element. An unrestrained condition is one in which the load carrying element is free to expand and rotate at its supports.

X3.3 This guide is based on knowledge currently available and recommends that all constructions be classified as either restrained or unrestrained. This classification will enable the architect, engineer, or building official to correlate the fire endurance classification, based on conditions of restraint, with the construction type under consideration. While it has been shown that certain conditions of restraint will improve fire endurance, methodologies for establishing the presence of sufficient restraint in actual constructions have not been standardized.

X3.4 For the purpose of this guide, restraint in buildings is defined as follows: “Floor and roof assemblies and individual beams in buildings shall be considered restrained when the surrounding or supporting structure is capable of resisting substantial thermal expansion throughout the range of anticipated elevated temperatures. Construction not complying with this definition are assumed to be free to rotate and expand and shall therefore be considered as unrestrained.”

X3.5 This definition requires the exercise of engineering judgment to determine what constitutes restraint to “substantial thermal expansion.’’ Restraint may be provided by the lateral stiffness of supports for floor and roof assemblies and intermediate beams forming part of the assembly. In order to develop restraint, connections must adequately transfer thermal thrusts to such supports. The rigidity of adjoining panels or structures should be considered in assessing the capability of a structure to resist thermal expansion. Continuity, such as that occurring in beams acting continuously over more than two supports, will induce rotational restraint which will usually add to the fire resistance of structural members.

X3.6 In Table X3.1 only the common types of constructions are listed. Having these examples in mind as well as the philosophy expressed in the preamble, the user should be able to rationalize the less common types of construction.

TABLE X3.1 Construction Classification, Restrained and Unrestrained

I. Wall bearing:	
Single span and simply supported end spans of multiple bays:[A]	
(*1*) Open-web steel joists or steel beams, supporting concrete slab, precast units, or metal decking	unrestrained
(*2*) Concrete slabs, precast units, or metal decking	unrestrained
Interior spans of multiple bays:	
(*1*) Open-web steel joists, steel beams or metal decking, supporting continuous concrete slab	restrained
(*2*) Open-web steel joists or steel beams, supporting precast units or metal decking	unrestrained
(*3*) Cast-in-place concrete slab systems	restrained
(*4*) Precast concrete where the potential thermal expansion is resisted by adjacent construction[B]	restrained
II. Steel framing:	
(*1*) Steel beams welded, riveted, or bolted to the framing members	restrained
(*2*) All types of cast-in-place floor and roof systems (such as beam-and-slabs, flat slabs, pan joists, and waffle slabs) where the floor or roof system is secured to the framing members	restrained
(*3*) All types of prefabricated floor or roof systems where the structural members are secured to the framing members and the potential thermal expansion of the floor or roof system is resisted by the framing system or the adjoining floor or roof construction[B]	restrained
III. Concrete framing:	
(*1*) Beams securely fastened to the framing members	restrained
(*2*) All types of cast-in-place floor or roof systems (such as beam-and-slabs, flat slabs, pan joists, and waffle slabs) where the floor system is cast with the framing members	restrained
(*3*) Interior and exterior spans of precast systems with cast-in-place joints resulting in restraint equivalent to that which would exist in condition III (*1*)	restrained
(*4*) All types of prefabricated floor or roof systems where the structural members are secured to such systems and the potential thermal expansion of the floor or roof systems is resisted by the framing system or the adjoining floor or roof construction[B]	restrained
IV. Wood construction:	
All types	unrestrained

[A] Floor and roof systems can be considered restrained when they are tied into walls with or without tie beams, the walls being designed and detailed to resist thermal thrust from the floor or roof system.

[B] For example, resistance to potential thermal expansion is considered to be achieved when:

(*1*) Continuous structural concrete topping is used,

(*2*) The space between the ends of precast units or between the ends of units and the vertical face of supports is filled with concrete or mortar, or

(*3*) The space between the ends of precast units and the vertical faces of supports, or between the ends of solid or hollow core slab units does not exceed 0.25 % of the length for normal weight concrete members or 0.1 % of the length for structural lightweight concrete members.

X4. METHOD OF CORRECTING FIRE ENDURANCE FOR CONCRETE SLABS DETERMINED BY UNEXPOSED SURFACE TEMPERATURE RISE FOR NONSTANDARD MOISTURE CONTENT

X4.1 Scope

X4.1.1 The standard fire endurance is the time determined by unexposed surface temperature rise of a test specimen at a standard moisture level.

X4.1.2 This appendix gives a procedure to correct the fire endurance of unprotected vertical or horizontal slabs (solid or hollow), made from essentially inorganic building materials; and conditioned on both sides, when moisture content at the time of test is other than at a standard moisture level.

X4.1.3 From among the common inorganic building materials, only the hydrated portland cement products can hold (after due conditioning in accordance with 11) sufficient amount of moisture to affect noticeably the result of the fire test. Consequently, correcting the experimental fire endurance of constructions containing less than 5 volume % of portland cement paste is not necessary.

X4.2 Symbols

X4.2.1 The symbols used in this Appendix are defined as follows:

A = factor characterizing the drying conditions (see Table X4.1),
b = factor characterizing the permeability of the specimen (see Table X4.2),
FE = fire endurance of specimen, h,
RH = relative humidity,
m = moisture content, volume fraction ft^3/ft^3 or cm^3/cm^3,
m_a = average moisture content of test specimen,
m_c = average moisture content of cement paste,
m_e = nominal equilibrium moisture content of cement paste for a given *RH* (see Table X4.3).

m_{es}	=	equilibrium moisture content of cement paste at the standard *RH* level (see Table X4.3).
m_s	=	average moisture content of a standard conditioned concrete specimen of same concrete and cement paste volume as the test specimen, and
v	=	volume fraction of cement paste, ft^3/ft^3 or cm^3/cm^3.

X4.3 Calculation of Moisture Content

X4.3.1 The average moisture content, m_a, is the volume fraction of moisture (ft^3/ft^3 (or cm^3/cm^3)) in the material relative to its dry condition; where dry condition is defined as that resulting when the material is heated in an oven at 221 ± 1°F (105 ± 0.5°C) until no further weight loss occurs.

X4.3.2 The average moisture content of the cement paste can be estimated from the known value of *RH* at middepth (assuming the material has never been subject to rewetting) by calculating first the moisture content in the cement paste as follows:

$$m_c = A \cdot m_e$$

X4.3.3 The average moisture content of the test specimen is then calculated as follows:

$$m_a = v \cdot m_c$$

X4.3.4 Calculate the average moisture content of a standard conditioned specimen as follows:

$$m_s = v \cdot m_{es}$$

where m_{es} is the value of m_e in Table X4.1 pertaining to the standard *RH* level.

X4.4 Correction Procedure

X4.4.1 The correction procedure starts with the selection of an empirical factor to reflect the permeability of the material as suggested in Table X4.2. With known values of m_a and m_s calculate the products bm_a and bm_s. On the nomogram (Fig. X4.1) draw lines from point *R* to values of bm_a and bm_s on the right-hand scale. From the point representing the actual fire endurance time (*FE*) on the left-hand scale draw a line parallel to R-bm_a to intersect the curve. From this point on the curve draw a line parallel to R-bm_s and find the corrected fire endurance on the *FE* scale.

X4.5 Illustrative Example

X4.5.1 A wall made from normal weight concrete having 23.2 volume % of paste, was conditioned at 200°F (93°C) and 5 % *RH* until the *RH* at its middepth was reduced to 70 %. It had a 2.90-h fire endurance. Determine the adjusted fire endurance.

X4.5.1.1 *Step 1*—Calculate m_a as follows:
For 70 % *RH*,

$$m_e = 0.225$$

(see Table X4.1)

For 200°F (93°C) and 5 % *RH* conditioning, for normal weight concrete

$$A = 0.45$$

(see Table X4.3)

$$\therefore m_c = 0.45 \times 0.225 = 0.101$$

(see X4.3.1)

For $v = 0.232$

$$m_a = 0.232 \times 0.101 = 0.0234$$

(see X4.3.3)

that is, the concrete contains 2.34 volume % moisture at time of test.

X4.5.1.2 *Step 2*—Calculate m_s as follows:
As an example, if the standard moisture level is assumed to correspond to a middepth *RH* of 75 %, then $m_e = 0.24$

$$m_s = 0.232 \times 0.24 = 0.0557$$

(see X4.3.4)

that is, the standard moisture level is 5.57 volume %.

X4.5.1.3 *Step 3*—Calculate b_m as follows:

b	=	5.5 see Table X4.3
bm_a	=	$5.5 \times 0.0234 = 0.129$
bm_s	=	$5.5 \times 0.0557 = 0.306$

X4.5.1.4 *Step 4*—Draw lines on the nomogram from point *R* to bm_a and bm_s(see Fig. X4.1).

TABLE X4.1 Equilibrium Moisture Content (Desorption) of Cement Paste at Given Relative Humidity

RH at middepth, %	m_e
90	0.30
85	0.275
80	0.255
75	0.24
70	0.225
65	0.21
60	0.195
55	0.185
50	0.175
45	0.16
40	0.15

TABLE X4.2 Factor Characterizing Permeability of Test Specimen

Material	*b*
Normal weight and gun-applied concrete (dry unit weight greater than 135 lb/ft^3(2162 kg/m^3))	5.5
Lightweight concrete (dry unit weight between 85 and 115 lb/ft^3 (1361 and 1841 kg/m^3))	8.0
Lightweight insulating concrete (dry unit weight less than 50 lb/ft^3 (801 kg/m^3))	10.0

TABLE X4.3 Factor Characterizing Drying Conditions

Conditioning Environment	Middepth RH of Test Specimen, %	Factor *A* for Portland Cement	
		Normal Weight Concrete	Light-Weight Concrete
60 to 80°F (15.6 to 26.7°C) atmospheric conditions	any	1.0	1.0
120 to 160°F (48.9 to 71.1°C) 20 to 35 % RH	70 to 75	0.7	0.7
190 to 200°F (87.8 to 93.3°C) 0 to 5 % RH	70 to 75	0.45	0
120 to 200°F (48.9 to 93.3°C) 5 to 35 % RH	less than 70	0	0

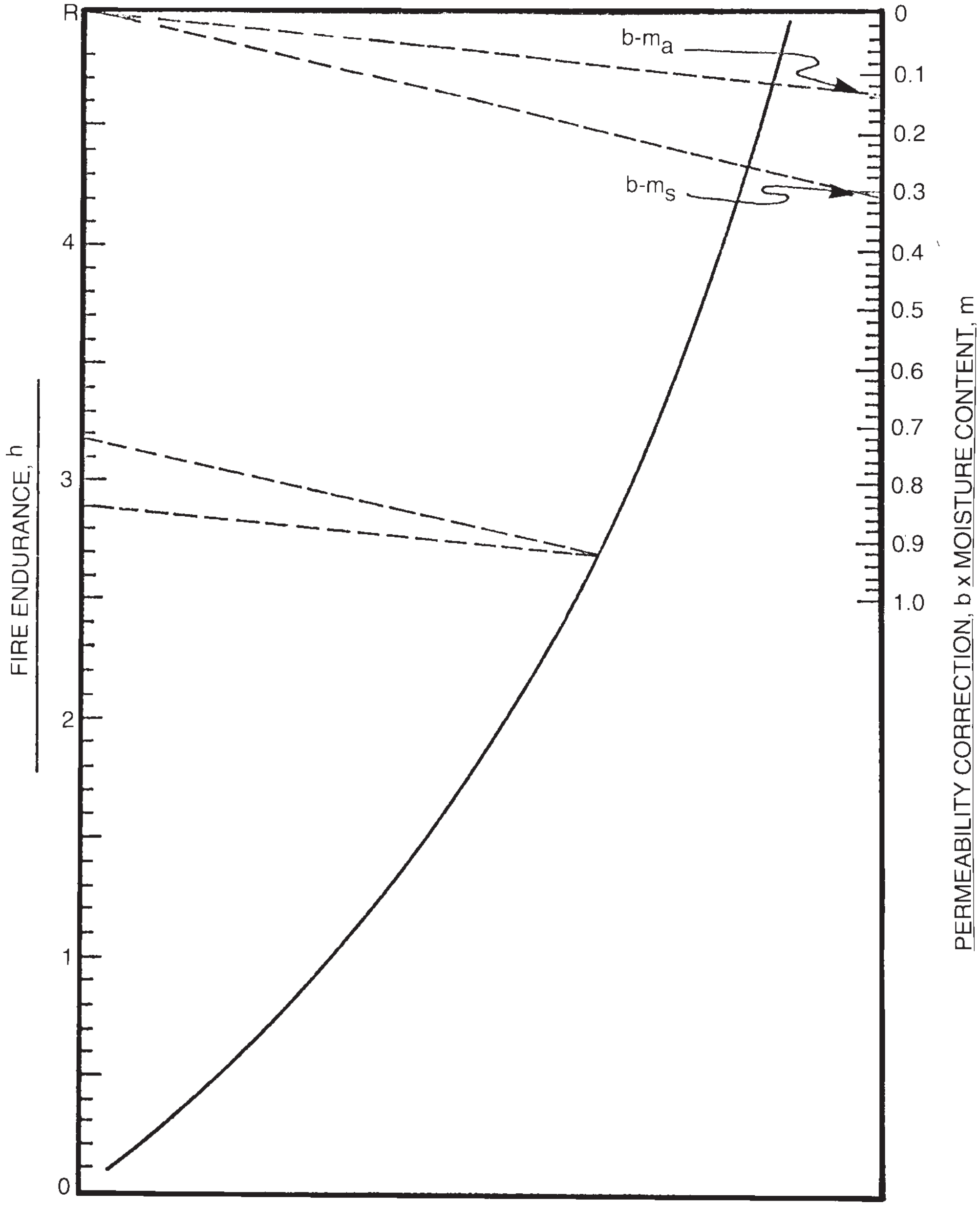

FIG. X4.1 Nomogram for Correcting Fire Endurance for Nonstandard Moisture Content

X4.5.1.5 *Step 5*—Draw a line from the *FE* ordinate, 2.90, parallel to line $R\text{-}bm_a$ to intersect the curve.

X4.5.1.6 *Step 6*—Draw a line parallel to $R\text{-}bm_s$ from a point on the curve, to intersect the *FE* ordinate scale. The value of *FE* = 3.19 is the adjusted fire endurance; that is, the fire endurance that would have resulted if the specimen had been tested at the standard moisture level, here assumed to correspond to 75 % RH at middepth.

X5. COMMENTARY

X5.1 Introduction

X5.1.1 This commentary has been prepared to provide the user of Test Methods E 119 with background information on the development of the standard and its application in fire protection of buildings. It also provides guidance in the planning and performance of fire tests and in the reporting of results. No attempt has been made to incorporate all the available information on fire testing in this commentary. The serious student of fire testing is strongly urged to peruse the referenced documents for a better appreciation of the history of fire-resistant design **(1, 2)**[10] and the intricate problems associated with testing and with interpretation of test results.

X5.1.2 Floors and walls designed as fire separations have been recognized for many years as efficient tools in restricting fires to the area of origin, or limiting their spread **(3, 4, 5, 6, 7, 8, 9, 10, 11)**. Prior to 1900, relative fire safety was achieved by mandating specific materials. By the year 1900, the appearance of a multitude of new materials and innovative designs and constructions accelerated the demand for performance standards. The British Fire Prevention Committee, established in 1894, was the first to produce tables listing fire resisting floors, ceilings, doors and partitions **(5)**. Test furnaces in the United States were constructed shortly after 1900 at the Underwriters Laboratories Inc., Columbia University, and the National Bureau of Standards (NBS) **(1, 12)**. These early furnaces eventually led to the development of Test Methods E 119.

X5.2 Historical Aspects

X5.2.1 Test Methods E 119 was first published by ASTM as C19 in 1918. A number of refinements have been made in the standard since that time, such as the classification of beams and of floor and roof assemblies based on conditions of support. Several provisions, including the temperature-time curve and the major apparatus, remain essentially unchanged. The roots of fire testing as we define it today can be traced back to about 1800. A comprehensive review of early fire testing has been published **(1)**.

X5.3 Fire-Load Concept

X5.3.1 Specifications for fire resistance in regulatory documents continue to be based largely on the fire-load concept developed by NBS in the 1920s and reported in the 1928 NFPA Quarterly by Ingberg. The concept incorporates the premise that the duration of a fire is proportional to the fire loading, that is, the mass of combustible materials per unit floor area. The relationship between the mass of combustible materials and fire duration was established on the basis of burnout tests in structures incorporating materials having calorific or potential heat values equivalent to wood and paper, that is, 7000 to 8000 BtU/lb (16.3 to 18.6 MJ/kg). The fire-load of noncellulosic materials such as oils, waxes, and flammable liquids were interpreted on the basis of their equivalent calorific content **(5, 13, 14, 15)**. In the simplest terms, the above premise states that 10 lb of combustible materials per square foot (50 kg/m^2) of floor area will produce a fire of 1 h duration.

X5.3.2 Increasing sophistication in the knowledge of materials and the fire process has resulted from numerous research activities **(9, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27)**. It is now generally conceded that fire severity as well as the temperature-time relationship of a fire depends on several factors, including;

1. Fire load—Amount and type.
2. Distribution of this fire load.
3. Specific surface characteristics of the fire load **(5, 27)**.
4. Ventilation, as determined by the size and shape of openings **(17, 18, 19, 21, 27, 28, 29)**.
5. Geometry of the fire compartment—Size and shape.
6. Thermal characteristics of the enclosure boundaries.
7. Relative humidity of the atmosphere.

For the purposes of this commentary, fire severity is defined as a measure of the fire intensity (temperature) and fire duration. It is expressed in terms of minutes or hours of fire exposure and in Test Methods E 119 is assumed to be equivalent to that defined by the standard temperature-time (*T-t*) Curve, that is, the area under the *T-t* curve **(27)**.

X5.4 Scope and Significance

X5.4.1 Test Methods E 119 is intended to evaluate in terms of endurance time, the ability of an assembly to contain a fire, or to retain its structural integrity, or both during the test conditions imposed by the standard. It also contains standard conditions for measuring heat transfer through membrane elements protecting combustible framing or surfaces.

X5.4.2 The end-point criteria by which the test result is assessed are related to:

1. Transmission of heat through the test assembly.
2. Ability of the test assembly to withstand the transmission of flames or gases hot enough to ignite combustible material.
3. Ability of the assembly to carry the load and withstand restraining forces during the fire test period.
4. Temperatures of the steel under some conditions.

X5.4.3 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 the exposure.

X5.4.4 The standard, although being specific about the assembly to be tested, enables the testing laboratory to determine whether the specimen is "truly representative" of the assembly intended for evaluation. This is necessary because of the wide variation in assemblies. For instance, wall test specimens generally do not contain electric switches and outlets, that in some designs may affect test results. Floor test specimens may or may not contain electrical raceways and outlets or pull boxes for power and communication wiring. Cover plates over trench headers are also present in some designs. The testing laboratory is in the best position to judge the effects of such items.

X5.5 Test Furnaces

X5.5.1 Test Methods E 119 does not provide specific construction details of the furnace. Readers are urged to consult reference documents for a more comprehensive review of furnace design and performance **(25)**.

X5.6 Temperature-Time Curve

X5.6.1 A specific temperature-time relationship for the test fire is defined in the standard and in Appendix X1. The actual recorded temperatures in the furnace is required to be within specified percentages of those of the standard curve. Accuracy in measuring temperature is generally easier to achieve after 1 h due to stabilizing of the furnace and the slope of the *T-t* curve. The number and type of temperature-measuring devices are

[10] The boldface numbers in parentheses refer to the list of references at the end of this test method.

outlined in the standard. Specific standard practices for location and use of these temperature-measuring devices are also outlined in the standard. However, no uniformity of the temperatures within the fire chamber is specified.

X5.6.2 The standard *T-t* curve used in Test Methods E 119 is considered to represent a severe building fire **(5)**. The curve was adopted in 1918 as a result of several conferences by eleven technical organizations, including testing laboratories, insurance underwriters, fire protection associations, and technical societies **(1, 16, 30)**. The *T-t* relationship of these test methods represents only one fire situation. Data are available to evaluate the performance of assemblies under fire exposure conditions that may be more representative of particular fire situations, that is, using different *T-t* relationships to simulate specific fire conditions **(9, 11, 16, 19, 22, 23, 27, 29, 31, 32)**.

X5.6.3 Furnace pressure is not specified and is generally slightly negative. The pressure may have an effect on the test results, and the test conditions should always be carefully controlled.

X5.7 Test Specimen

X5.7.1 The test specimen is required to represent as closely as possible the actual construction in the field, subject to the limits imposed by the test facilities.

X5.7.2 All specimens are required to be conditioned so as to attain a moisture content comparable to that in the field prior to testing. For uniformity, the standard moisture content is defined as that in equilibrium with an atmosphere of 50 % relative humidity at 73°F (23°C). Massive concrete units which may require unusually long drying periods may be fire tested after a 12-month conditioning period. Appendix X4 describes how the test result should be corrected to account for any variation from the standard moisture condition **(33)**.

X5.7.3 With few exceptions, only the interior face of exterior wall assemblies and the ceiling portion or underside of floor or roof assemblies are exposed to the standard fire **(24, 25)**. This practice is rationalized on the assumption that the outside face of exterior walls is not usually subjected to the same fire as the interior face and that the fire exposure of the upper side of a floor or roof assembly is seldom as intense as that of the underside.

X5.7.4 Although the standard does not contain specific criteria for judging the impact of through joints nor "poke-through" devices, such as electrical or telephone outlets, it should be recognized that these components should be evaluated with respect to structural-performance and temperature-rise criteria if they constitute a significant part of the tested assembly.

X5.7.5 For obvious reasons, symmetrical walls and partitions are tested only on one side. Assymmetrical walls and partitions may be required to be tested with either or both sides individually exposed to the fire. If both sides are exposed, the report should indicate the fire endurance classification for each case.

X5.8 Loading

X5.8.1 Floors and roofs are required to be loaded during test to provide a maximum load condition determined by the applicable nationally recognized design criteria. This practice allows for more confidence in extrapolating testing results. For instance, the maximum length of a floor specimen in most test facilities is 16 ft (4.9 m). It is, therefore, necessary to extrapolate developed fire-endurance ratings to much longer spans.

X5.8.2 When a floor or roof assembly is designed for a specific use, such as used in prefabricated housing units, the assembly may be tested with a restricted load condition. The loading condition used for such tests shall be defined in the test report. The standard does not require specific loading devices. Some laboratories use large containers of water; others use a system of hydraulic rams for floor and roof assemblies. When uniformly distributed load is simulated by point-loading (several, small-area loads), it is recommended that the load at any such area not exceed 25 % of the total load and that the individual point-loading have a width at least equal to the depth of the floor. Wall furnaces are generally equipped with hydraulic rams.

X5.8.3 The standard requires that load-bearing walls and partitions sustain the applied test load during the fire endurance and hose stream tests. A former requirement that load-bearing walls and partitions also sustain twice the specified superimposed test load after cooling but within 72 h of the test period has been deleted from the test method as being unrealistic. Non-bearing walls and partitions are not loaded during the test but are restrained on all sides. This restraint may impose more stress than a load on top. Committee E-5 has several times reviewed the loading procedures for framed walls and partitions. It was the committee's unanimous decision that such a wall be tested either with calculated maximum design load or with a load expected to occur in practice. The method used to compute the design loads must be reported.

X5.8.4 Some important stresses, such as those caused by creep and shrinkage in the wall itself and its supporting frame must be present, and the designer should recognize these stresses in his analysis. Committee E-5 has investigated the possibility of openings occurring at a joint at corners of non-load-bearing enclosures due to differential movement. While the possibility exists that this will occur, the committee has not found it feasible to amend the test based on data available.

X5.8.5 Double walls pose a unique problem as to load application. Which wall should be loaded? Or should both walls be loaded simultaneously? Committee E-5 has devoted considerable time to debating this problem, and recommends the decision be made by the user after an analysis of the loading conditions anticipated in service both before and after a fire. Such loading conditions are to be reported.

X5.9 Integrity

X5.9.1 All walls and partitions that qualify for a fire endurance classification of 1 h or more are required to be subjected to the cooling impact and erosion effects of a stream of water from a 2½-in. (63.5-mm) hose discharging through a standard play pipe equipped with a 1⅛-in. (28.5-mm) tip under specified pressures. In this hose stream test, the ability of the construction to resist disintegration under adverse conditions is examined. The requirement for a hose stream test was earlier removed from the test procedure for columns and floor or roof assemblies because of impracticality and the possibility of excessive damage to the furnace.

X5.10 Conditions of Tests

X5.10.1 Columns are generally tested with all four sides exposed to the test fire. However, it is possible to test a column with three sides exposed (fourth side against a wall). The standard requires that specimens be tested under conditions contemplated in the design. The former general practice of testing columns with pin connection at top and bottom to simulate the most critical condition is no longer a criterion.

X5.10.2 Columns are required to sustain successfully the design load during the test period. The standard also permits columns to be loaded up to 1-¾ times the design load prior to the fire test if desired by the submitter. Such loading, however, shall not be construed as having had a deleterious effect on the fire endurance test performance. Instead of loading, steel columns, whose protective covering does not carry load, may be assigned a fire-resistance classification on the basis of temperature of the steel only. With such columns, the protective cover shall be restrained against longitudinal expansion. Wood columns are tested for load-carrying ability only.

X5.10.3 From test results, it has been established that variations of restraint conditions can considerably influence the time of fire resistance for a structure or a structural element. Restraints are generally beneficial to fire resistance; however, there are conditions where restraint can have a detrimental effect on the performance of a specimen during a fire-resistance test **(34, 35)**. The users of test results are advised to study the reference documents as well as Appendix X3 and Table X3.1.

X5.10.4 An unrestrained classification for a steel beam or a reinforced concrete beam used as part of an assembly tested in restrained condition can be assessed from the temperature records obtained for the steel or the reinforcing steel respectively (Sections 38 through 40). It is also possible to evaluate the protective cover of steel beams by measuring the temperature of the steel that is protected (Sections 41 through 44). The fire endurance classification is only applicable to beams used with a floor or roof construction that has a comparable or greater capacity for heat dissipation from the beam than the floor or roof with which it is tested.

X5.11 Other Observations

X5.11.1 No limitation is imposed on the deformation of the specimen during or after the test period. It is assumed that the deflection or deformation of an assembly is limited only by its ability to stay in place (under load where specified) during the test period.

X5.11.2 A complete record of deformation during the endurance test may be helpful in the application of test results, and shall be reported.

X5.11.3 Other observations, such as the evolution of unusual quantities of visible smoke, vapors, or gases that may affect the proper decision regarding use of the test results, should be reported.

X5.12 Protective Membranes

X5.12.1 The standard provides criteria for evaluating the protection that membrane elements can offer to combustible framing and paneling, for example, joists, wall studs, and paneling or boards on the unexposed side of an assembly, and other combustible materials. The results of these tests are reported as protective membrane ratings.

X5.13 Future

X5.13.1 ASTM Committee E-5 on Fire Standards through Subcommittee E05.11 is continually striving to update Test Methods E 119. Users of the test method are encouraged to contact the committee for further information.

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