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An American National Standard

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

This standard is issued under the fixed designation E119; 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 mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the 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] These test methods are under the jurisdiction of ASTM Committee E05 on Fire Standards and are the direct responsibility of Subcommittee E05.11 on Fire Resistance.

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These test methods, of which the present standard represents a revision, were prepared by Sectional Committee on Fire Tests of Materials and Construction, under the joint sponsorship of the National Bureau of Standards, the ANSI Fire Protection Group, and ASTM, functioning under the procedure of the American National Standards Institute. DOI: 10.1520/E0119-08A.

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:*[2]

C569 Method of Test for Indentation Hardness of Preformed Thermal Insulations[3]

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

E176 Terminology of Fire Standards

E814 Test Method for Fire Tests of Penetration Firestop Systems

E2226 Practice for Application of Hose Stream

3. Terminology

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

4. Significance and Use

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

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

4.3 The test standard provides for the following:

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

4.3.1.1 Measurement of the transmission of heat.

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

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

4.3.2 For individual load bearing members such as beams and columns:

4.3.2.1 Measurement of the load carrying ability under the test exposure with consideration for the end support conditions (that is, restrained or not restrained).

4.4 The test standard does not provide the following:

4.4.1 Information as to performance of specimens constructed with components or lengths other than those tested.

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

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

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

4.4.5 Measurement of flame spread over surface of specimen.

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

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 of instrumentation for recording the flow of fuel to the furnace burners. Fuel flow data may be useful for a furnace heat balance analysis, for measuring the effect of furnace or control changes, and for comparing the

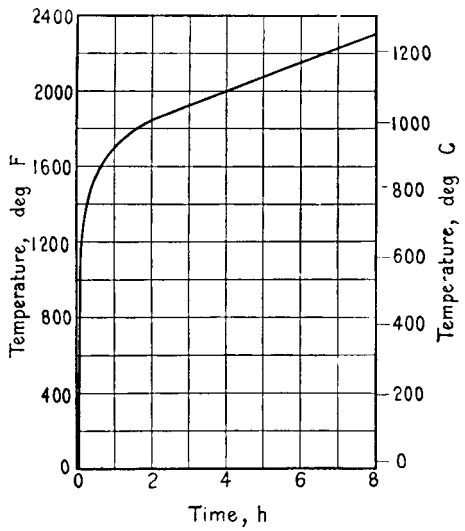

FIG. 1 Time-Temperature Curve

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

[3] Withdrawn.

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 ½ in. (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 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

[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.

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

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, a test shall be conducted to subject the test specimen described in 11.2 or 11.3 to the impact, erosion, and cooling effects of a hose stream. The hose stream shall be applied in accordance with Practice E2226. The water pressure and duration of application shall be as prescribed in Table 1.

11.1.1 *Exemption*—The hose stream test shall not be required in the case of test specimens having a resistance period, indicated in the fire-resistance test, of less than 1 h.

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

11.2.1 The duplicate test specimen shall be exposed to the effects of the hose stream immediately after being subjected to a fire-resistance test for a time period of one-half the fire-resistance classification period determined from the fire-resistance test on the initial test specimen.

11.2.2 The length of time that the duplicate test specimen is subjected to the fire-resistance 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-resistance test.

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.

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 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.

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

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 for which a restrained rating is desired shall be so restrained during the test exposure.

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), 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

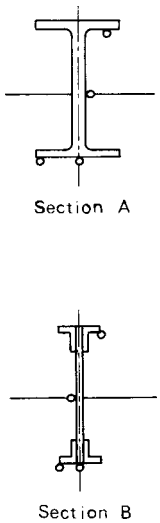

FIG. 2 Typical Thermocouple Distributions

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.

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.

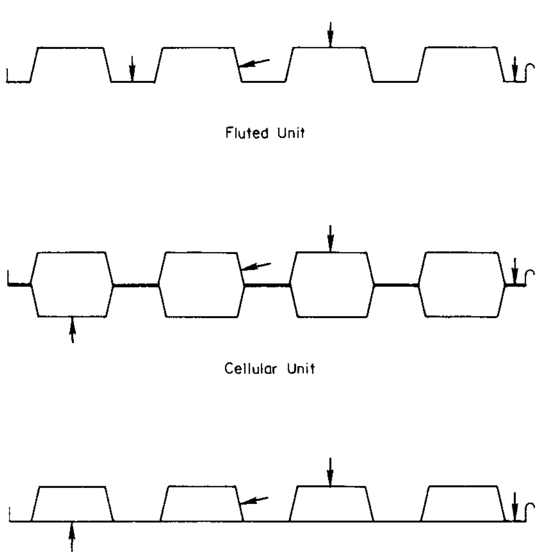

FIG. 3 Typical Location of Thermocouples

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 assembly, 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 and those portions of the floor or roof assembly that are integral to the structural design of the beam, against the potential effects from thermally induced longitudinal expansion. The restraint shall replicate the restraint expected to occur in building construction. Do not support or restrain portions of the perimeter of the floor or roof assembly that are not integral to the structural beam design.

NOTE 10—Composite steel construction and concrete construction that incorporate beams as an integral part of the structural design are examples where portions of the floor or roof assembly that are attached to the beam should be restrained against thermal expansion. Restraining the portion of the concrete slab that is integral to the structural design of the beam serves the intent of providing restraint against thermal rotation of the test specimen. It is not permitted to restrain portions of the perimeter of the test specimen other than that part that is integral to the structural design of the beam.

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; ceiling assemblies; columns; fire; fire endurance; fire-resistance; fire-resistance rating; fire-test-response standard; floor assembly; floors; restrained rating; restraint; roofs; roof assembly; truss; unrestrained rating; walls

ANNEX

(Mandatory Information)

A1. REQUIREMENTS FOR THERMOCOUPLE PADS

A1.1 *Thermocouple Pads*—Thermocouple pads used in measurement of temperature of unexposed surfaces of specimens shall be of a refractory fiber material placed with the softer surfaces in contact with the thermocouple. The pads shall not be used on surfaces subject to sharp distortions or discontinuities during the test unless the pads have been previously wetted, formed, and dried in accordance with A1.1.6. Properties of thermocouple pads shall be as follows:

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

A1.1.2 Thickness, 0.375 ± 0.063 in. (9.5 ± 1.6 mm). The thickness measurement shall be made using a ½-in. (13-mm) diameter, anvil head micrometer, without compression of the pad.

A1.1.3 Dry weight, 0.147 ± 0.053 lb (67 ± 24 g).

A1.1.4 Thermal conductivity (at 150°F (66°C)), 0.37 ± 0.03 Btu·in./h·ft^2·°F (0.053 ± 0.004 W/m·K).

A1.1.5 Density, 18.7 ± 0.2 lb/ft^3(300 ± 3.0 kg/m^3).

A1.1.6 The pads shall be shaped by wetting, forming, and then drying to constant weight to provide complete contact on sharply contoured surfaces.