



Standard Test Methods for Fire Tests of Building Construction and Materials¹

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This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which was adopted by 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,” “1/2-h,” etc.

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

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 performance during the period of exposure and shall not be construed as having determined suitability for use after fire exposure.

1.3 *This standard should be used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions and should not be used to describe or appraise the fire-hazard or fire-risk of materials, products, or assemblies under actual fire conditions. However, results of the test may be used as elements of a fire-hazard*

assessment or a fire-risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard or fire risk of a particular end use.

NOTE 1—A method of fire hazard classification based on rate of flame spread is covered in Test Method E 84.

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

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

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

2. Referenced Documents

2.1 ASTM Standards:

C 569 Test Method for Indentation Hardness of Pre-formed Thermal Insulations²

¹ These test methods are under the jurisdiction of ASTM Committee E-5 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 A2 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.

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

E 84 Test Method for Surface Burning Characteristics of Building Materials³
E 176 Terminology of Fire Standards³

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 will contain a fire, or retain their structural integrity or exhibit both properties dependent upon the type of assembly involved during a predetermined test exposure.

4.2 The test exposes a specimen to a *standard fire exposure* controlled to achieve specified temperatures throughout a specified time period. In some instances, the *fire exposure may be* followed by the application of a *specified standard* fire hose stream. The exposure, however, may not be representative of all fire conditions which may vary with changes in the amount, nature and distribution of fire loading, ventilation, compartment size and configuration, and heat sink characteristics of the compartment. It does, however, provide a relative measure of fire performance of comparable assemblies under these specified fire exposure conditions. Any variation from the construction or conditions (that is, size, method of assembly, and materials) that are tested may substantially change the performance characteristics of the assembly.

4.3 The test standard provides for the following:

4.3.1 In walls, partitions, and floor or roof assemblies:

4.3.1.1 Measurement of the transmission of heat.

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

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

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

4.4 The test standard does not provide the following:

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

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

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

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

4.4.5 Measurement of flame spread over surface of tested element.

4.4.6 The effect of fire endurance of conventional open-

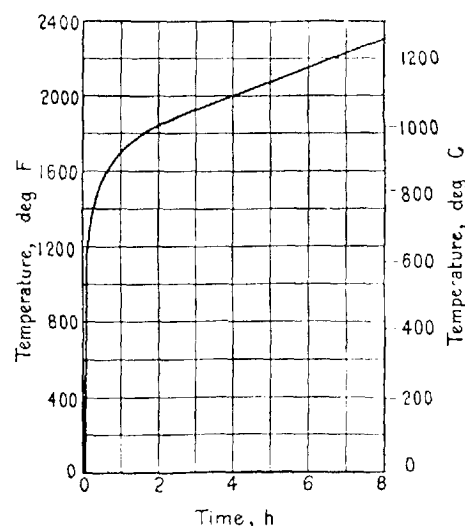


FIG. 1 Time-Temperature Curve

ings 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 2—*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 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 $\pm 5\%$.

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.

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."

³ Annual Book of ASTM Standards, Vol 04.07.

6. Furnace Temperatures

6.1 The temperature fixed by the curve shall be deemed to be the average temperature obtained from the readings of not less than nine thermocouples for a floor, roof, wall, or partition and not less than eight thermocouples for a structural column 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 3). The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall be not less than 12 in. (305 mm). Other types of protecting tubes or pyrometers may be used that, under test conditions, give the same indications as the above standard within the limit of accuracy that applies for furnace-temperature measurements. 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. In the case of 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 deflection.

NOTE 3—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 1/2 in. (25 mm) from the sealed end of a standard weight nominal 1/2-in. iron, steel, or Inconel⁵ pipe. The time constant for this and for several other thermocouple assemblies was measured in 1976. The time constant may also be calculated from knowledge of its physical and thermal properties.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 5) 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 3 1/2 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 4—For the purpose of testing roof assemblies, the unexposed surface shall be defined as the surface exposed to ambient air.

NOTE 5—Under certain conditions it may be unsafe or impracticable to use thermometers.

7.2 Temperature readings shall be taken at not less 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 at the discretion of the testing authority to obtain representative information on the performance of the construction under test. None of the thermocouples shall be located nearer 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 where there is an element of the construction that is not otherwise represented in the remainder of the test specimen. None of the thermocouples shall be located opposite or on top of beams, girders, pilasters, or other structural members if temperatures at such points will obviously be lower than at more representative locations. None of the thermocouples shall be located over fasteners such as screws, nails, or staples that will be obviously 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 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 significant details of the behavior of the material or construction during the test and after the furnace fire is cut off, including information on deformation, spalling, cracking, burning of the specimen or its component parts, continuance

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

⁶ Supporting data are available from ASTM Headquarters. Request RR: E05-1001.

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.

8.3 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 $\frac{1}{2}$ 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 6—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 are intended to apply for rating constructions of dimensions within the usual general range employed in buildings. If the conditions of use limit the construction to smaller dimensions, a proportionate reduction is permitted

to be made in the dimensions of the specimens for a test qualifying them for such restricted use.

9.3 When it is desired to include a built-up roof covering, the test specimen shall have a roof covering of 3-ply, 15-lb (6.8-kg) type felt not in excess of 120 lb (54 kg) per square (100 ft² (9 m²)) 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 and 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 For the purpose of obtaining additional performance data, the test may be continued beyond the time the fire endurance classification is determined.

11. Hose Stream Test

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

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

11.3 *Optional Program*—The submitter elects, with the advice and consent of the testing body, to have the hose stream test made on the specimen subjected to the fire endurance test and immediately following the expiration of the fire endurance test.

11.4 *Stream Equipment and Details*—The stream shall be delivered through a 2½-in. (64-mm) hose discharging through a National Standard Playpipe of corresponding size equipped with a 1⅞-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.

11.5 *Nozzle Distance*—The nozzle orifice shall be 20 ft (6 m) from the center of the exposed surface of the test specimen if the nozzle is so located that when directed at the

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)	

center its axis is normal to the surface of the test specimen. If otherwise located, its distance from the center shall be less than 20 ft by an amount equal to 1 ft (305 mm) for each 10 deg of deviation from the normal.

12. Protection and Conditioning of Test Specimen

12.1 Protect the test specimen during and after fabrication to assure normality of its quality and condition at the time of test. It shall not be tested until a large portion of its final strength has been attained, and, if it contains moisture, until the excess has been removed to achieve an air-dry condition 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 might lead to abnormal 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. If 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, within a reasonable time, a moisture condition within the specimen approximately representative of that likely to exist in similar construction in buildings. For purposes of standardization, this condition is to be considered as that which would be established at equilibrium resulting from drying in an ambient atmosphere of 50 % relative humidity at 73°F (Note 7). However, with some constructions, it is difficult or impossible to achieve such uniformity within a reasonable period of time. 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 will be prevented by hermetic sealing, these requirements are waived, except as to attainment of a large portion of final strength, and the specimen tested in the condition in which it then exists.

12.1.2 If, during the conditioning of the specimen it appears desirable or is necessary to use accelerated drying techniques, it is the responsibility of the laboratory conducting the test to avoid procedures which will significantly alter the structural or fire endurance characteristics of the specimen or both 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 8).

NOTE 7—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 8—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 Bias⁷

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 suggest 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 Sample

14.1 The area exposed to fire shall be not less than 100 ft² (9 m²), 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 fire and hose stream tests apply a constant superimposed load to simulate a maximum load condition. The applied load shall be as nearly as practicable the maximum load allowed by design under nationally recognized structural design criteria. The tests may also be conducted by applying to the specimen a load less than the maximum. Such tests shall be identified in the test report as having been conducted under restricted load conditions. The applied load, and the applied load expressed as a percentage of the maximum allowable design load, shall be included in the report. 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 9). The method used shall be reported.

NOTE 9—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.

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

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 Sample

17.1 The area exposed to fire shall be not less than 100 ft² (9 m²), 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 shall have withstood the fire and hose stream test as specified in Section 10, without passage of flame, of gases hot enough to ignite cotton waste, or of passage of water from the hose stream. The assembly shall be considered to have failed the hose stream test if an opening develops that permits a projection of water from the stream beyond the unexposed surface during the time of the hose stream test.

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

TESTS OF COLUMNS

19. Size of Sample

19.1 The length of the column exposed to fire shall, when practicable, approximate the maximum clear length contemplated by the design, and for building columns 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 acceptable field practice.

20. Loading

20.1 Throughout the fire endurance test expose the column to fire on all sides and load it in a manner calculated to develop theoretically, as nearly as practicable, the working stresses contemplated by the design. Make provision for transmitting the load to the exposed portion of the column without unduly increasing the effective column length.

20.2 If the submitter and the testing body jointly so decide, subject the column to 1¼ 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 test procedure does not require column loading at any time. The procedure is used at the discretion of the testing laboratory to evaluate steel column protections that are not required by design to carry any of the column load.

23. Size and Character of Sample

23.1 The size of the steel column used shall be such as to provide a test specimen that is truly representative of the design, materials, and workmanship for which classification is desired. Apply the protection according to the methods of acceptable field practice. The length of the protected column shall be at least 8 ft (2.4 m). The column shall be vertical during application of the protection and during the fire exposure.

23.2 Restrain the applied protection against longitudinal temperature expansion greater than that of the steel column by 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 be adequate to provide direct bearing for the entire transverse area of the protection.

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

24. Temperature Measurement

24.1 Measure the temperature of the steel in the column by at least three thermocouples located 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. So place the thermocouples at each level as to measure significant 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 for assemblies restrained against thermal expansion; a restrained assembly classification based upon the conditions of acceptance specified in 31.1.1 and 31.1.2 in addition to 31.1.3, 31.1.4, or 31.1.5; and an unrestrained assembly classification based upon the conditions of acceptance specified in 32.1.1 and 32.1.2 in addition to 32.1.3, 32.1.4, 32.1.5 or 32.1.6.

NOTE 10—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 classifications are permitted to be developed for beams tested in accordance with this test method using the conditions of acceptance specified in 40.1.1, 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 ft² (16 m²) 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 The specimen shall be installed in accordance with recommended fabrication procedures for the type of construction and shall be representative of the design for which classification is desired. Where a restrained classification is desired, specimens representing forms of construction in which restraint to thermal expansion occurs shall be reasonably 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. The maximum load condition shall be as nearly as practicable the maximum load allowed by the limiting condition of design under nationally recognized structural design criteria. A fire endurance test may be conducted applying a restricted load condition to the specimen which shall be identified for a specific load condition other than the maximum allowed load condition.

30. Temperature Measurement

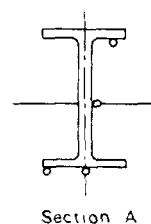
30.1 For specimens employing structural members (beams, open-web steel joists, etc.) spaced at more than 4 ft (1.2 m) on centers, measure the temperature of the steel in these structural members by thermocouples at three or more sections spaced along the length of the members with one section preferably located at midspan except that in cases where the cover 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 by four thermocouples placed on each member, except that no more than four members shall be so instrumented. Place the thermocouples at significant locations, such as at midspan, over joints in the ceiling, and over light fixtures, etc.

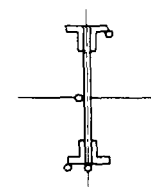
30.3 For steel structural members there shall be four thermocouples at each section except that where only four thermocouples are required on a member, the thermocouples may be distributed along the member at significant locations as provided for in 29.2; locate two on the bottom of the bottom flange or chord, one on the web at the center, and one on the top flange or chord. The recommended thermocouple distribution at each section is shown in Fig. 2.

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



Section A



Section B

FIG. 2 Recommended Thermocouple Distributions