



UL 1709

STANDARD FOR SAFETY

Rapid Rise Fire Tests of Protection
Materials for Structural Steel

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UL Standard for Safety for Rapid Rise Fire Tests of Protection Materials for Structural Steel, UL 1709
Sixth Edition, Dated August 8, 2022

Summary of Topics

This Sixth Edition of ANSI/UL 1709 dated August 8, 2022 includes a restructure of the standard into two parts.

The requirements are substantially in accordance with Proposal(s) on this subject dated February 18, 2022.

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UL 1709

Standard for Rapid Rise Fire Tests of Protection Materials for Structural

Steel

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Sixth Edition

August 8, 2022

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The most recent designation of ANSI/UL 1709 as an American National Standard (ANSI) occurred on August 8, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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PART 1 – GENERAL REQUIREMENTS

INTRODUCTION

1 Scope

1.1 This Standard describes a full-scale test method for measuring the thermal resistance of protective materials, systems, or constructions to rapid-temperature-rise fires.

1.2 Part 1 of this Standard describes the furnace calibration and furnace control requirements.

2 Units of Measurement

2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3 Referenced Publications

3.1 Any undated reference to a code or standard appearing in the requirements of this Standard shall be interpreted as referring to the latest edition of that code or standard.

3.2 The following publications are referenced in this Standard:

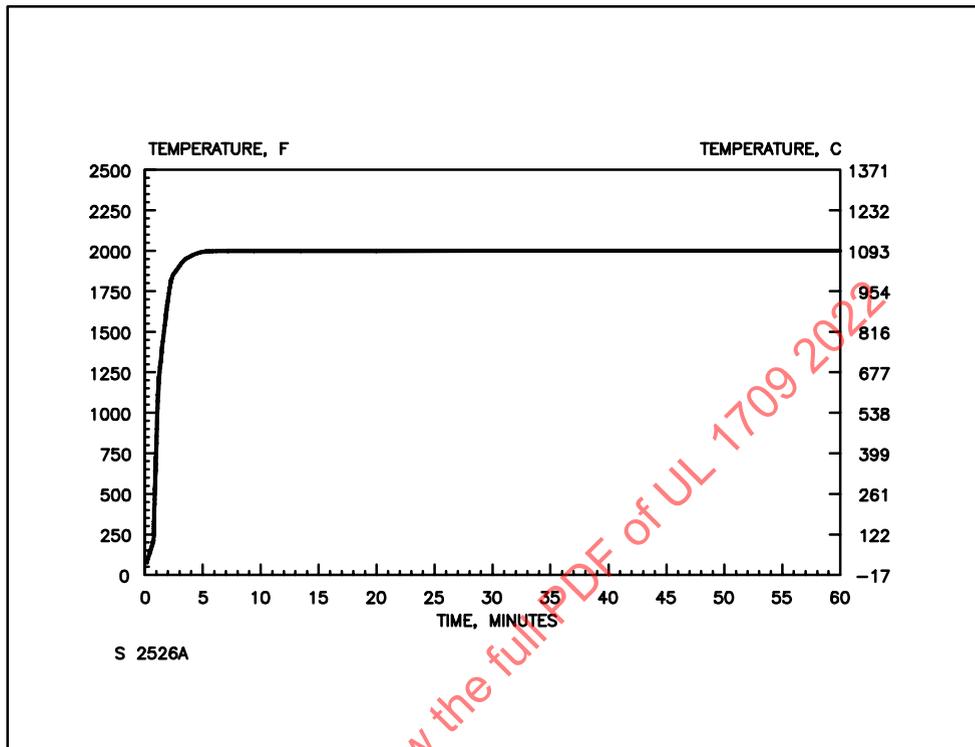
UL 2431, *Durability of Fire Resistive Coatings and Materials*

FULL-SCALE TEST METHOD

4 Furnace Control

4.1 The fire environment within the furnace is to develop a total heat flux of $65,000 \pm 5000$ Btu/h · ft² (204 ± 16 kW/m²) and an average temperature of 2000 ± 100 °F (1093 ± 56 °C) within 5 min from the start of the test. The fire environment is to be controlled by reproducing the furnace temperatures recorded during the furnace calibration method specified in the Furnace Calibration section of the relevant Part of this Standard. This temperature is to be maintained throughout the remainder of the fire test as shown in [Figure 4.1](#).

Figure 4.1
Time-Temperature Curve



4.2 The furnace is to be controlled to maintain the area under the time-temperature curve to within 10 % of the corresponding area under the standard time-temperature curve shown in [Figure 4.1](#) for fire tests of 60 min or less duration; to within 7.5 % for tests longer than 60 min but not longer than 120 min; and to within 5 % for tests exceeding 120 min in duration. The area under the time-temperature curve is to be obtained by averaging the results from the pyrometer or thermocouple readings.

4.3 A correction is to be applied for variation of the furnace exposure from the prescribed, where such variation will affect the test results, by multiplying the indicated time period by two-thirds of the value obtained by dividing the difference in area between the curve of average furnace temperature and the standard curve for the first three-fourths of the period by the area between the standard curve above a base line of 68 °F (20 °C) for the same part of the indicated period during the first part of the test. For fire exposure times longer than standard, the indicated rating period is to be increased by the amount of the correction and for fire exposure times less than standard, the indicated rating period is to be similarly decreased. The correction can be expressed by the following formula:

$$C = \frac{2I(A - A_S)}{3(A_S)}$$

In which:

C is the correction in the same units as I

I is the indicated fire-resistance period

A is the area under the curve of indicated average furnace temperature for the first three-fourths of the indicated period

A_s is area under the standard furnace curve for the same part of the indicated period

4.4 The temperature fixed by the requirements of the Furnace Calibration section of the relevant Part of this Standard, is to be the average temperature obtained from the readings of eight thermocouples symmetrically disposed and distributed within the test furnace to show the temperature near all parts of the assembly or assemblies.

4.5 The thermocouples are to be fabricated by fusion-welding the twisted ends of 0.064 in (1.6 mm) diameter (No. 14 B & S gauge) chromel-alumel wires having a time constant of 2 min or less, and mounting the wires in porcelain insulators. The thermocouple assembly is to be inserted through a standard weight, nominal 1/2-in iron, steel or inconel pipe, and the end of the pipe from which the welded junction protrudes is to be open. The thermocouple junction is to protrude 1/2 in (12.7 mm) from the open end of the pipe.

4.6 The junction of the thermocouples is to be placed 4 in (102 mm) away from the exposed face of the test specimen and located at the 1/3 and 2/3 heights of the test specimen. The junction of the thermocouples is not to touch the specimen during the test, as a result of specimen deflection.

4.7 Each thermocouple within the furnace shall be read at intervals not exceeding 1 min during the first 30 min of the test and at intervals not exceeding 5 min during the remainder of the test.

5 Furnace Calibration

5.1 A furnace calibration record is to be maintained and the furnace is to be recalibrated after completion of any repair that could alter the heat generation, retention or flow characteristics of the furnace. The calibration shall be conducted at a frequency not to exceed 10 years.

5.2 The exposure of the furnace is to be measured with thermocouples and calorimeters as described by the relevant subsequent Part of this Standard.

5.3 The measured values of all thermocouples and calorimeters are to be recorded at intervals not exceeding 1 min.

5.4 The thermocouples used to measure the temperatures within the furnace are to be constructed as described in [4.5](#).

5.5 Calorimeters are to have a minimum range of 100,000 Btu/h · ft² (315 kW/m²) and a 180° view angle

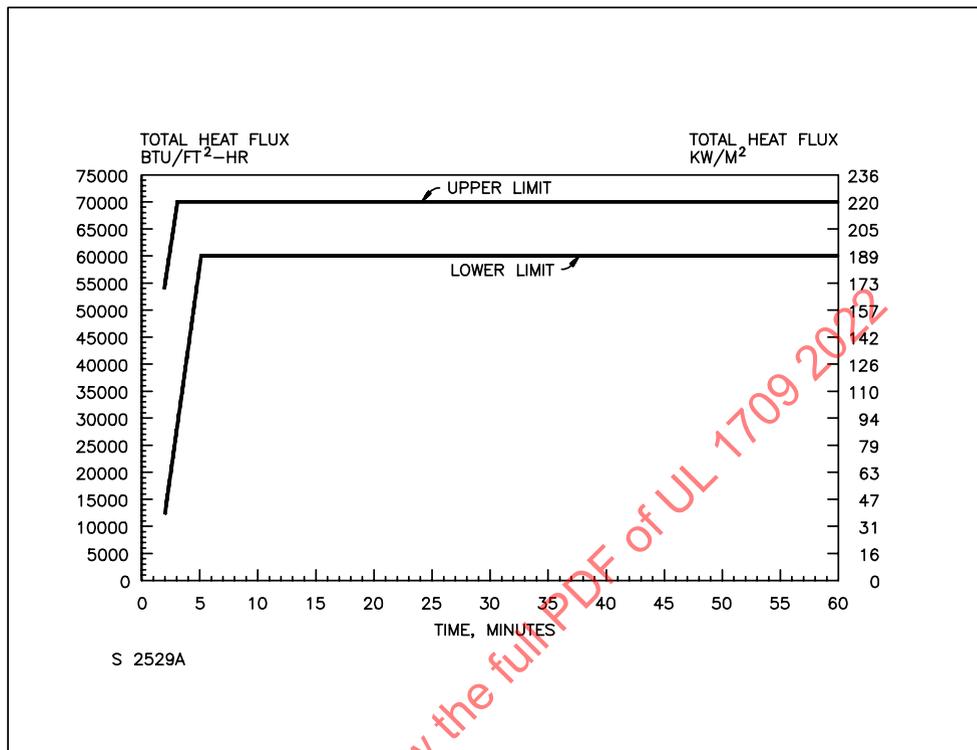
5.6 Combustion gas samples from within the furnace are to be obtained as described by the relevant subsequent Part of this Standard.

5.7 The combustion gas samples are to be obtained continuously by use of a vacuum pump and the oxygen content measured by an oxygen analyzer.

5.8 The fire environment during the calibration test is to comply with the requirements of [4.1](#). The length of the calibration test is to be 60 min.

5.9 Individual total heat flux measurements are to lie within the limits shown in [Figure 5.1](#).

Figure 5.1
Time-total Heat Flux Curve



5.10 The average furnace temperature is to be determined by averaging the temperatures recorded by the furnace control thermocouples. The average shall be 2000 ± 100 °F (1093 ± 56 °C) and individual temperatures are to be 2000 ± 200 °F (1093 ± 111 °C) 5 min after the start of the test and until the end of the test.

6 Test Specimen

6.1 The size of the test specimen shall be representative of the design, materials, and workmanship for which classification is desired.

6.2 All thermocouples for the purpose of recording specimen temperature are to be fabricated from minimum 0.032 in (0.8 mm) diameter (No. 20 B & S gauge) chromel-alumel, inconel sheathed wires or equivalent having a time constant of 2 s or less.

PART 2 – STRUCTURAL STEEL

INTRODUCTION

7 General

7.1 Unless specifically stated otherwise, the requirements in Part 1 of this Standard are applicable.

7.2 Part 2 of this Standard covers additional procedures for use in conjunction with Part 1 of this Standard, intended to evaluate the thermal resistance of protective material applied to structural members and the ability of the protective material to withstand the fire exposure.

7.3 Part 2 of this Standard describes the minimum testing requirements for classification, the limits of applicability of test results and acceptable methodology to determine the classification achieved.

7.4 The test method includes a supplementary test method for beams, intended to evaluate the ability of protective materials to perform when subject to significant deflections, for use in conjunction with the full-scale exposure test and applicable for beams and other sections subject to bending. Information published in accordance with this test method may also include product design tables for beams and sections subject to bending derived from the supplementary test method and accompanying methodology.

7.5 Information published in accordance with this test method may also include product design tables for alternate limiting temperatures derived from a multi-temperature analysis. Such tables are provided to aid in conditions where a performance-based-design approach is implemented.

8 Glossary

8.1 For the purpose of the requirements in Part 2 of this Standard, the following definitions apply.

8.2 CONFIGURATION OF SECTION – The type of section, defined by reference to its shape and structural use. For example: open column, open beam, hollow column, hollow beam.

8.3 HOLLOW SECTION – A tube or pipe or similar shape that has a cross-section containing enclosed space.

8.4 OPEN SECTION – A wide flange or similar shape section that has a cross-section containing no enclosed space.

9 Terms of Abbreviation

9.1 For the purpose of the requirements in Part 2 of this Standard, the following terms of abbreviation are used.

D or D_{FT} thickness of fire protection material (in)

D_{min} minimum thickness of fire protective coating (in)

D_{max} maximum thickness of fire protection coating (in)

D_{mid} an intermediate thickness of fire protection coating lying within the mid third between D_{min} and D_{max} (in)

t the period or duration of classification (minutes)

T the temperature (°F or °C) used as the criteria in an engineering assessment (engineering analysis or study) intended to provide supplementary information to the classification

W/D where W is the weight of the open steel section per lineal foot and D is the perimeter of protection material at the interface between the open steel section and the protection material

A/P where A is the cross-sectional area of the hollow section and P is the perimeter of protection material at the interface between the hollow steel section and the protection material

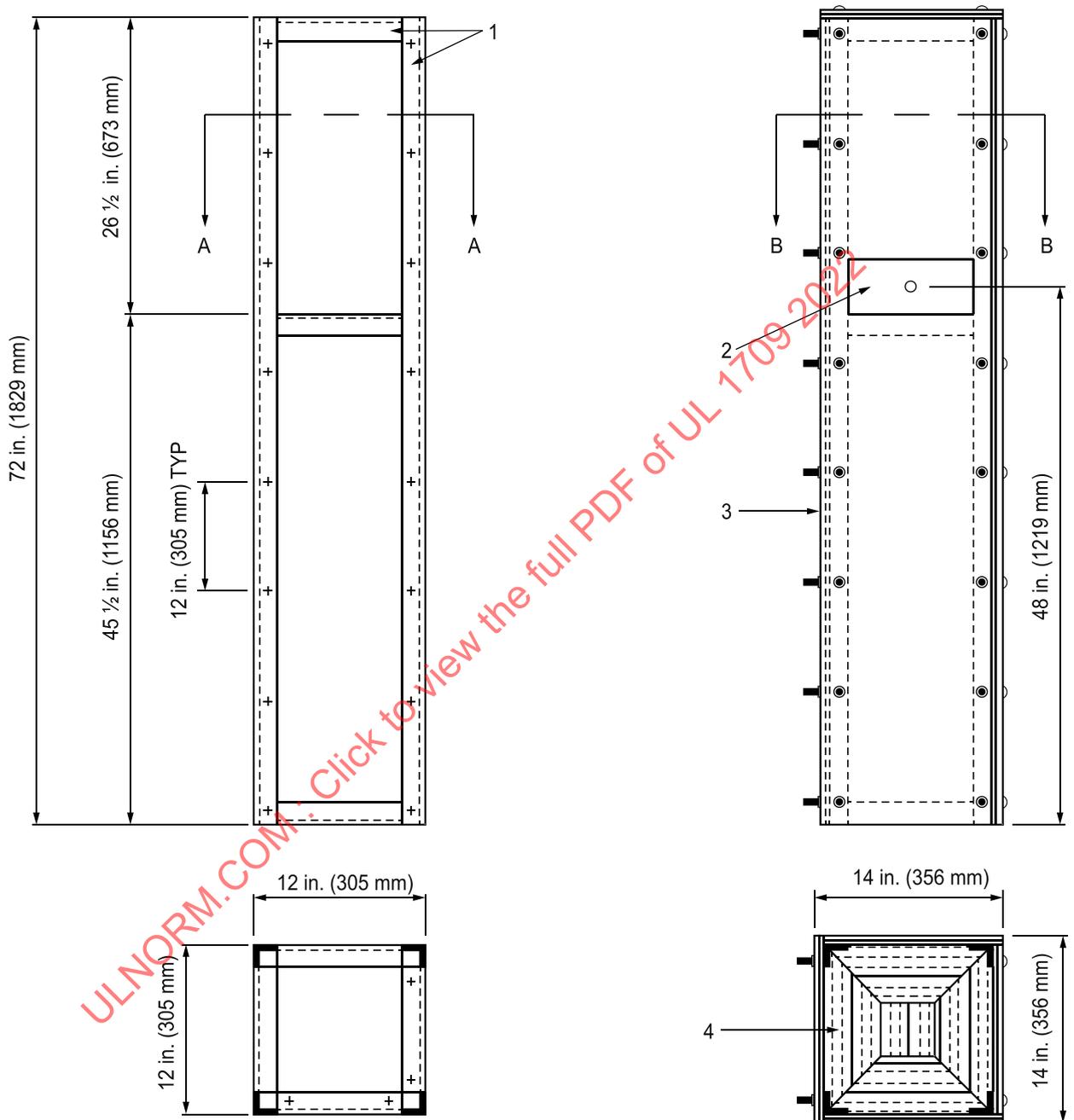
FULL-SCALE TEST METHOD

10 Furnace Calibration

10.1 The exposure of the furnace is to be measured with thermocouples and calorimeters mounted within a nominal 14 by 14 in by 6 ft high (357 by 357 by 1829 mm) vertical calibration column centered within the furnace chamber. The calibration column is to be fabricated from noncombustible materials, constructed and instrumented as shown in [Figure 10.1](#) and [Figure 10.2](#).

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Figure 10.1
Calibration Column I

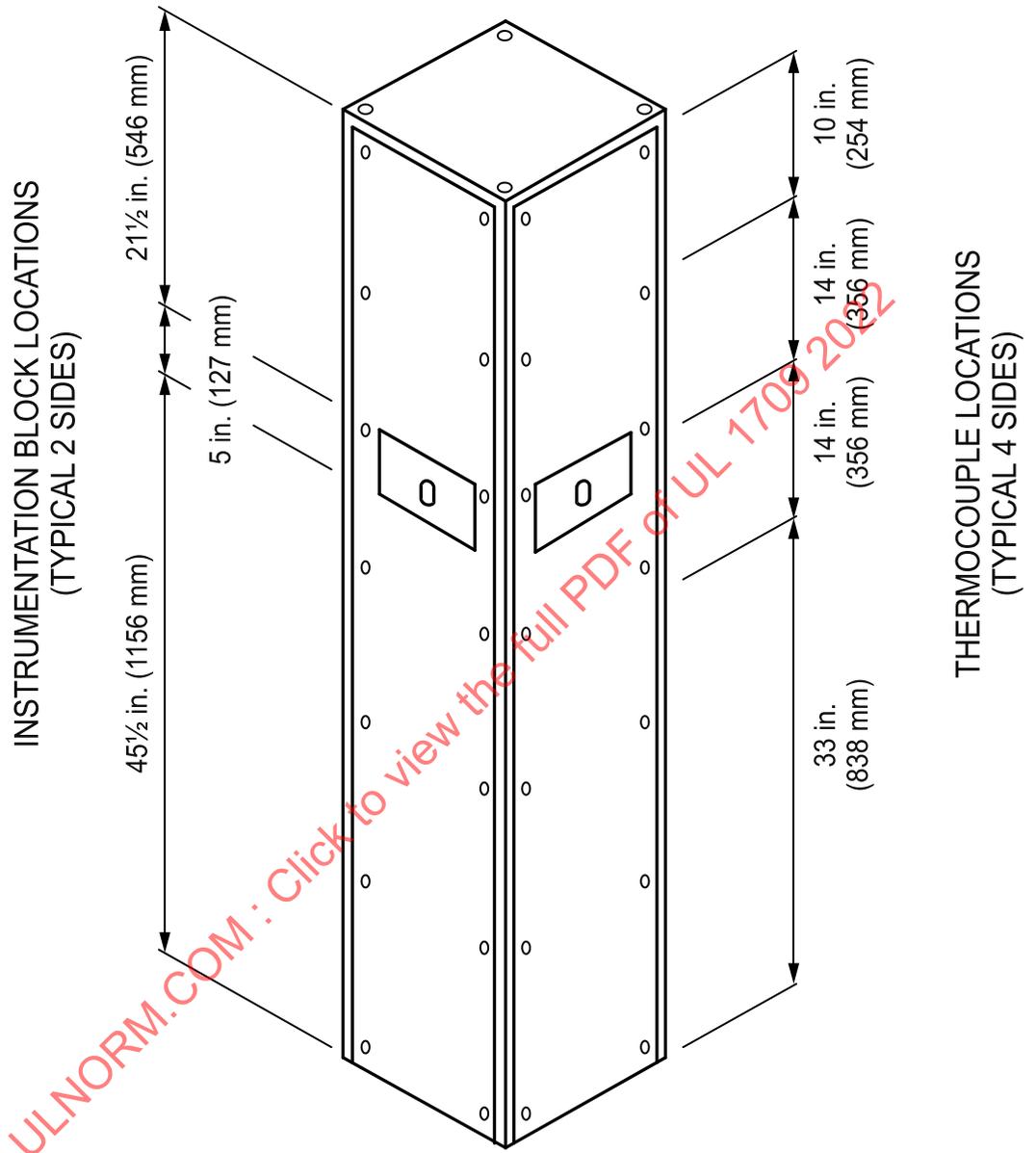


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KEY

- 1 2" x 2" x 3/16" (51 x 51 x 4.8 mm) steel angles welded to form framework
- 2 Instrumentation block (2 required)
- 3 Two layers of nom. 1.2" (13 mm) Marinite or equivalent inorganic insulation boards installed on four sides and top of calibration column, secured to framework with No. 1/4 – 20 steel bolts with nuts and 1-1/4 (32 mm) diameter steel washers
- 4 Entire cavity of calibration column filled with nom. 6 lb/ft³ (3484 kg/m³) density mineral wool batts

Figure 10.2
Calibration Column II



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10.2 The temperature of the furnace is to be measured by eight thermocouples, each located 4 in (102 mm) from the exposed face of the calibration column and at the 1/3 and 2/3 heights.

10.3 The measured values of all thermocouples and calorimeters are to be recorded at intervals not exceeding 1 min.

10.4 The thermocouples used to measure the temperatures on the face of the calibration column are to be No. 28 gauge, Type K inconel sheathed thermocouples having a time constant of 0.5 s or less. The thermocouple junction is to be located 1/4 in (6.3 mm) from the face of the calibration column.

10.5 The thermocouples used to measure the temperatures within the furnace are to be constructed as described in Section 4, Furnace Control, in Part 1 of this Standard.

10.6 The calorimeters are to have a minimum range of 100,000 Btu/h · ft² (315 kW/m²) and a 180° view angle.

10.7 Combustion gas samples from within the furnace are to be obtained from a probe of stainless steel tubing having an outer diameter not less than 3/16 in (4.7 mm) and a wall thickness not less than 1/32 in (0.8 mm). The probe tip is to be positioned vertically at the mid-height of the calibration column and horizontally located 4 in (102 mm) from the face of the calibration column.

10.8 The combustion gas samples are to be obtained continuously by use of a vacuum pump and the oxygen content measured by an oxygen analyzer.

10.9 The individual total heat flux measurements and average furnace temperature during the calibration test is to comply with conditions given in Part 1 of this Standard. The length of the calibration test is to be 60 min.

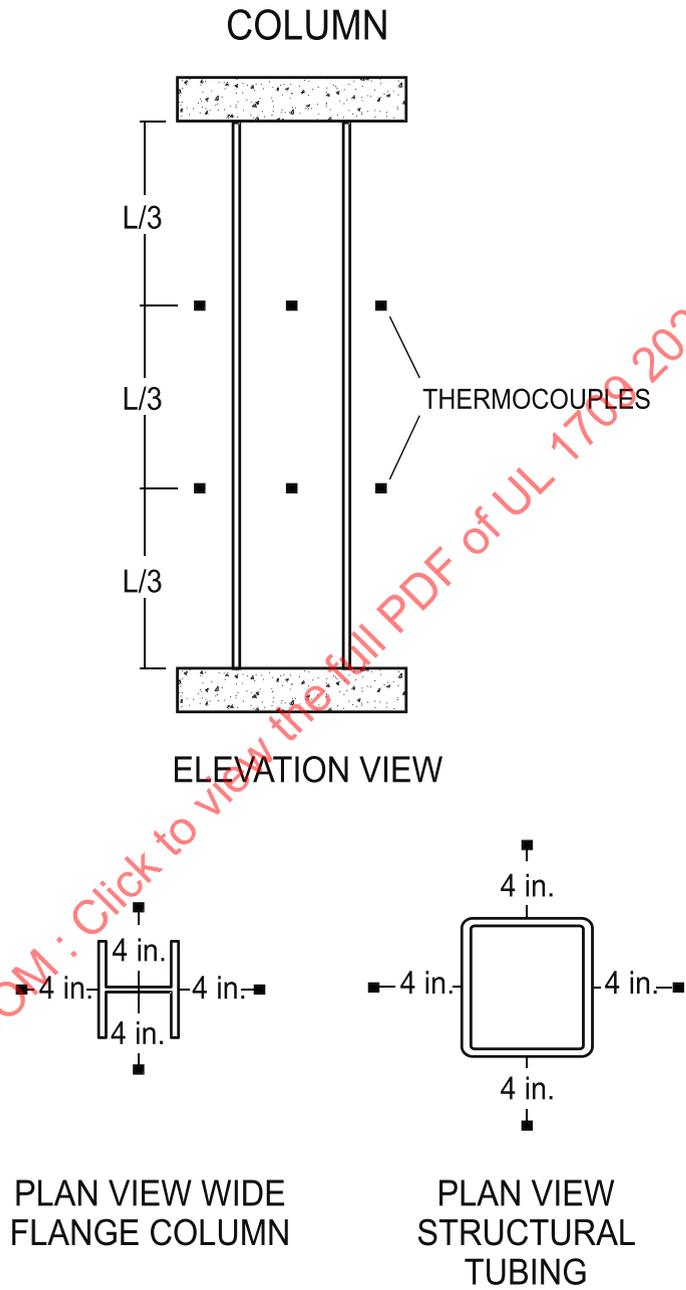
10.10 A record of the temperatures measured near the face of the column and the oxygen content are to be retained on file for a period of 10 years.

11 Furnace Control

11.1 Tests shall be conducted in accordance with Part 1 of this Standard.

11.2 The average furnace temperature is to be determined by averaging the temperatures recorded by the eight thermocouples placed 4 in (102 mm) from the column as shown in [Figure 11.1](#). The average shall be 2000 ±100 °F (1093 ±56 °C) and individual temperatures are to be 2000 ±200 °F (1093 ±111 °C) 5 min after the start of the test and until the end of the test.

Figure 11.1
Furnace Control Thermocouple Location – Column



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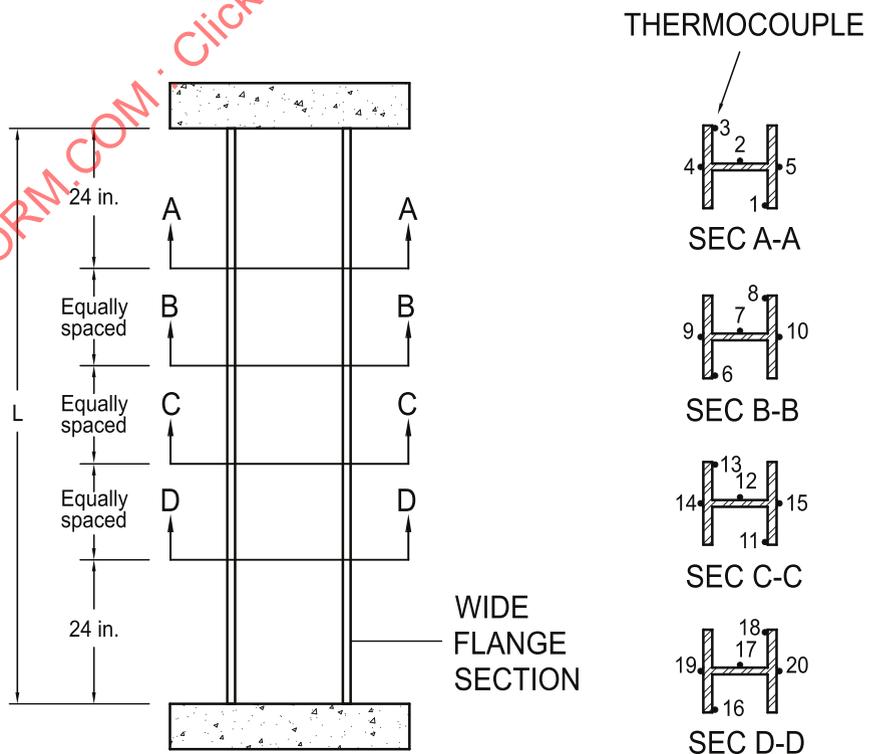
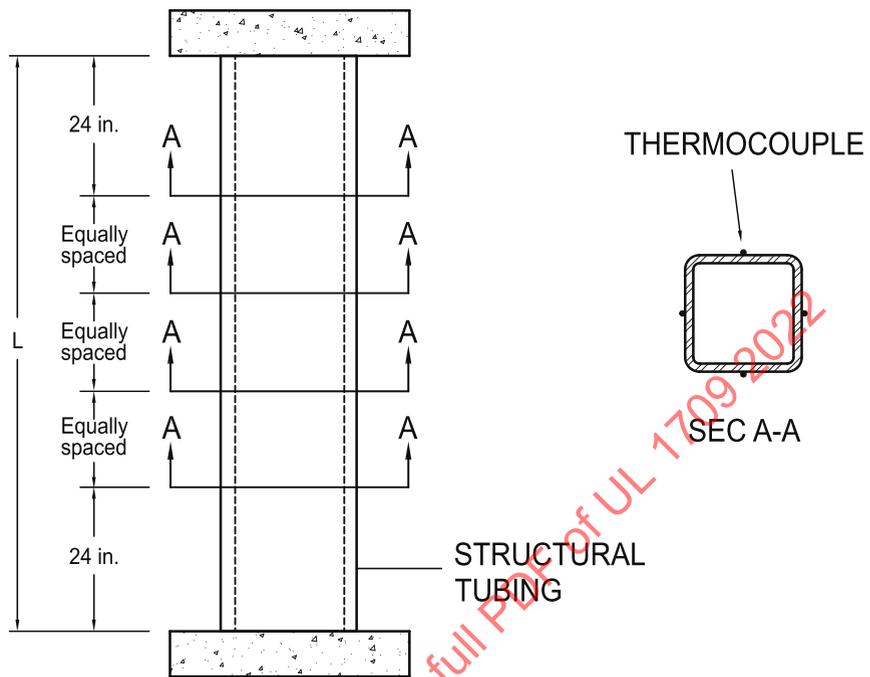
12 Test Specimen

12.1 The size of the steel section used in the test specimen shall be representative of the design, materials, and workmanship for which classification is desired. In cases where classification is required across a range of steel sizes and shapes the procedures in Annex A shall be followed, indicating the number of specimens required to be tested. Open sections (e.g. wide flange columns) and hollow sections (e.g. pipes, tubes) shall be considered separately for classification.

12.2 The protection material shall be applied to the steel specimen in accordance with acceptable field practice. The length of protected open or hollow steel column exposed to flame (L in [Figure 12.1](#)) shall be at least 8 ft (2.44 m). Steel columns are to be supported vertically during application of protection material and during fire exposure.

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Figure 12.1
Thermocouple Location Columns



12.3 The temperature of the open steel column is to be measured by no fewer than five thermocouples located at each of four levels (minimum of 20 thermocouples). The upper and lower levels are to be 2 ft (610 mm) from the ends of the steel column, and the other two intermediate levels are to be equally spaced between the upper and lower levels. The thermocouples at each level are to be placed to measure significant temperatures of the component elements of the steel column. [Figure 12.1](#) shows required locations of thermocouples on wide flange and tubular steel columns.

12.4 The temperature of the hollow steel column is to be measured by no fewer than four thermocouples located at each of four levels (minimum of 16 thermocouples). The upper and lower levels are to be 2 ft (610 mm) from the ends of the steel column, and the other two intermediate levels are to be equally spaced between the upper and lower levels. The thermocouples at each level are to be placed to measure significant temperatures of the component elements of the steel column. [Figure 12.1](#) shows required locations of thermocouples on tubular steel columns.

12.5 The applied protection material is to be restrained against longitudinal thermal expansion greater than that of the steel column by attaching rigid steel plates or reinforced concrete to the ends of the steel column prior to application of the protection material. The plates or concrete are to be sized to provide direct bearing over the entire transverse area of the protection material.

12.6 The ends of the test sample, including the means for restraint, are to have sufficient thermal insulation to prevent significant direct heat transfer through to the ends of the steel section from the furnace.

12.7 Prior to test, the test specimen is to be conditioned such that the dampest portion of the test specimen 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 (22.8 ± 2.8 °C). If the protection product requires a different moisture content to perform as intended, such moisture content may be allowed provided the moisture content and justification of acceptance are documented in the report, and the moisture content is included in the classification.

12.8 Moisture content equilibrium with air shall be determined to have been reached when successive weekly weighings of a representative specimen, prepared at the same time as the test specimen, indicate that the representative specimen has stopped losing weight.

13 Performance Criteria

13.1 The transmission of heat through the protection material during the period of fire exposure for which classification is desired shall not raise the average temperature at any of the four levels of the steel column above 1000 °F (538 °C) and no thermocouple shall indicate a temperature greater than 1200 °F (649 °C).

14 Report

14.1 The following shall be included in the test report:

- a) Full details of the test specimens including surface preparation, anti-corrosive treatment or coating systems, any fixing methods and application methods appropriate to the protection material;
- b) A generic description and accurate details of the fire protection system and any reinforcement, sealer coats, or retention methods present;
- c) Description of the conditioning of the test specimens and their installation within the test furnace;
- d) The measured dimensions of the fire protection system together;

- e) If relevant, the load utilization along with the calculation method and standard used in the derivation of this value;
- f) Individual furnace temperature measurements and the average of all individual furnace temperature measurements, taken as specified in Section [11](#), Furnace Control.
- g) If relevant, measured longitudinal deformations, rates of deformation and the times at which they occur;
- h) Observations made and times at which they occur; and
- i) Individual temperature measurements and the average temperature of each measuring station.

15 Environmental Performance

15.1 Products evaluated for fire endurance under the requirements of this Part of the Standard shall also comply with the applicable performance requirements in UL 2431 for Material Classification Category I-A: Outdoor, Heavy Industrial.

16 Applicability of Results and Classification

16.1 An individual classification of an open or hollow column may be obtained by the tests described within this document and based upon the performance criteria specified in Section [13](#). The fire endurance classification is applicable to the type of construction representative of the design that the test is intended to examine.

16.2 Classification is applicable only to steel columns and only in the configuration (either open sections such as wide flange columns or hollow sections such as tubes and pipes) of the steel tested.

16.3 Supplementary product design tables for the same configuration of steel tested as a column can be generated for beams by following the procedure in Annex [B](#), on the basis of the supplementary test procedure in Section [17](#), Additional Procedures for Beams.

16.4 Classification of multiple steel column sections, covering a range of W/D or A/P values, and durations may be accomplished by following the procedures outlined in Annex [A](#), Sections [A1](#), [A2](#) and [A3](#).

16.5 Classification is applicable to steel columns exposed on 4 sides, or less than all four sides. When the steel column is exposed on less than all four sides, the sides that are not exposed (and that cannot be coated by fire protection material) must be in direct contact with material of substantial heat sink such as concrete.

16.6 Classification may be extended to sections of identical configuration with a value of W/D or A/P greater than that tested. The fire protection thickness D for the maximum W/D or A/P classified at the same duration shall be applied in these cases. Classification may not be extended to sections with a value of W/D or A/P lower than that tested.

17 Supplementary Test Method for Beams

17.1 Furnace control

17.1.1 The supplementary test method results are used to generate supplementary product design tables for beams, and is not used to directly generate column classification. Comparative testing between a loaded and non-loaded beam is performed to establish the effect of deflection on the performance of the protection system, and to calculate a correction factor, which is applied as per Annex [B](#).

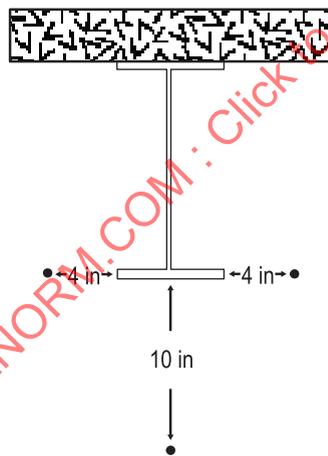
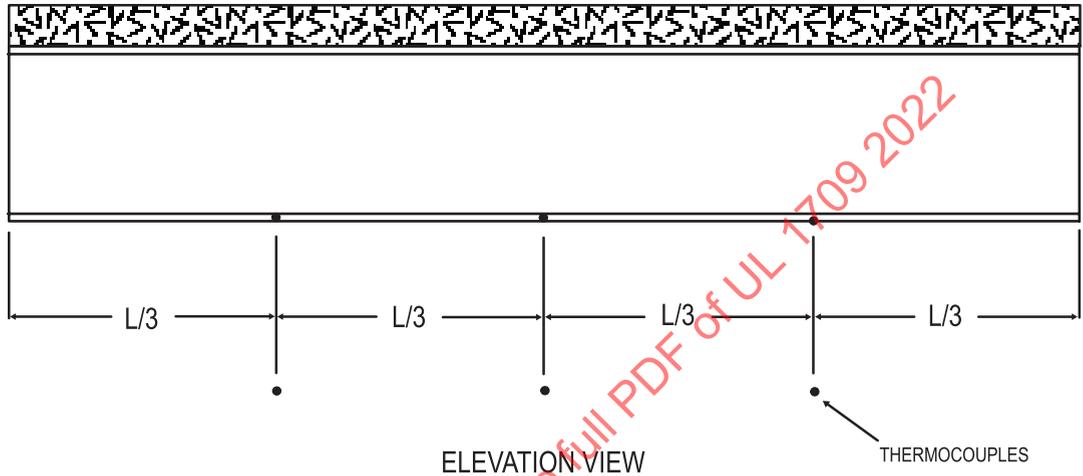
17.1.2 The supplementary test method is not subject to calibration requirements as per the full-scale column exposure test. It is subject to furnace control requirements as specified in [17.1.3](#) and [4.2](#), [4.3](#) and [4.7](#) in Part 1 of this Standard.

17.1.3 The average furnace temperature is to be determined by averaging the temperatures recorded by the nine thermocouples placed 4 in (102 mm) away from the exposed face of the specimen at the beginning of the test, or 10 in (254 mm) away from the underside, as shown in [Figure 17.1](#). The thermocouples shall not touch the specimen during the test as a result of specimen deflection. The average temperature shall be 2000 ± 100 °F (1093 ± 56 °C) and individual temperatures are to be 2000 ± 200 °F (1093 ± 111 °C) 5 min after the start of the test and until the end of the test.

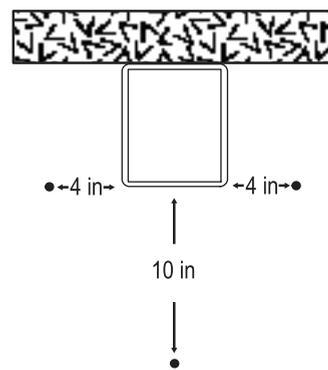
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Figure 17.1
Furnace Control Thermocouple Location – Beam

BEAM



SECTION VIEW WIDE
FLANGE BEAM



SECTION VIEW
STRUCTURAL
TUBING

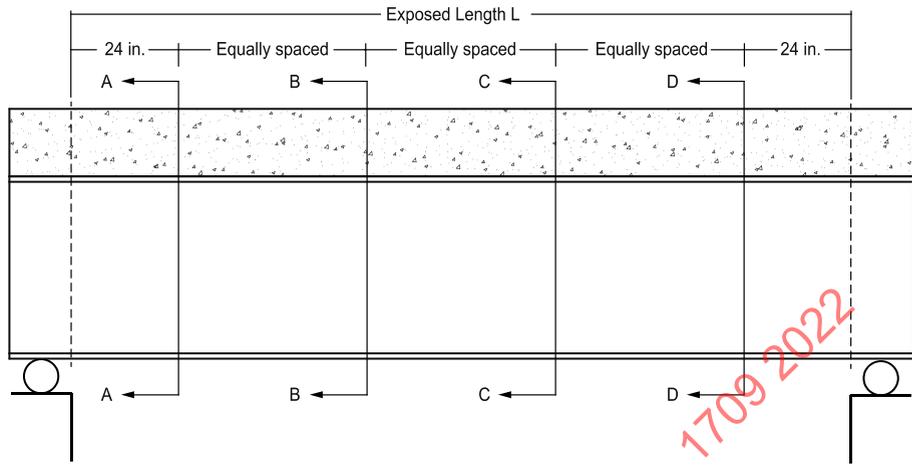
17.2 Test specimen

17.2.1 The protection material shall be applied to the steel beam specimen in accordance with acceptable field practice.

17.2.2 The length of the loaded open or hollow steel beams exposed to flame (L in [Figure 17.2](#)) shall be at least 12 ft (3.66 m).

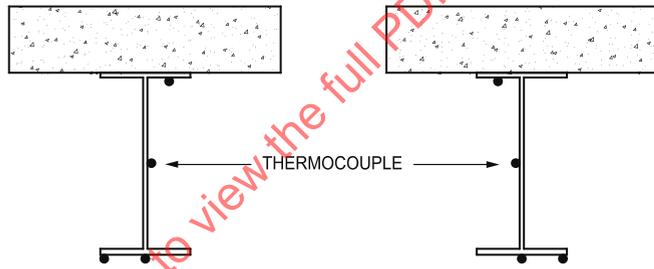
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Figure 17.2
Thermocouple Location Beams

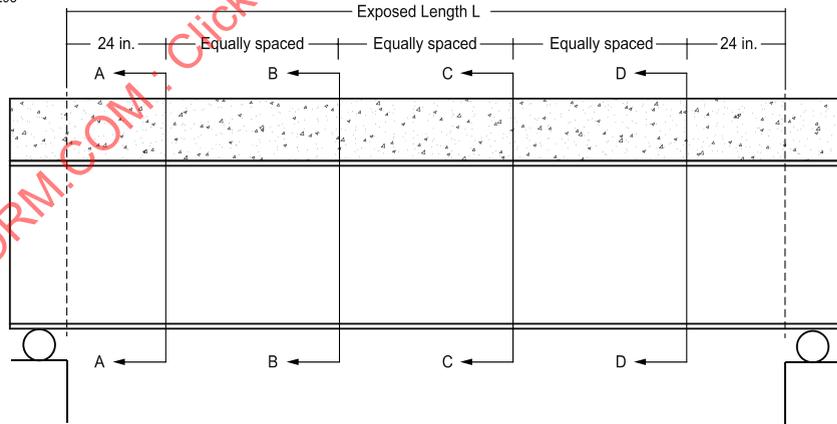


SEC. A - A, C - C

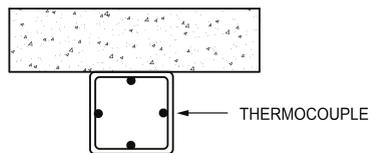
SEC. B - B, D - D



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SEC. A - A, B - B, C - C, D - D



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17.2.3 An unloaded reference section shall be tested at the same time, positioned parallel with the loaded section.

17.2.4 The length of the unloaded reference section exposed to flame shall be at either 4 ft (1.22 m) or 12 ft (3.66 m).

17.2.5 The temperature of the loaded steel beam is to be measured by no fewer than four thermocouples located at each of four stations (minimum of 16 thermocouples). The end stations are to be 2 ft (610 mm) from the ends of the steel beam, and the two intermediate stations are to be equally spaced between the end stations. The thermocouples at each level are to be placed to measure significant temperatures of the component elements of the steel beam. [Figure 17.2](#) shows required locations of the thermocouples on wide flange and tubular steel beams.

17.2.6 The temperature of the unloaded steel beam is to be measured by the same thermocouple arrangement as described in [17.2.5](#) in the case of 12 ft (3.66 m) beams, or no fewer than four thermocouples centrally located at one station in accordance with [Figure 17.2](#) Sec A-A for 4 ft (1.22 m) beams.

17.2.7 All thermocouples for the purpose of recording specimen temperature are to be fabricated from minimum 0.032 in (0.8 mm) diameter (No. 20 B & S gauge) chromel-alumel, inconel sheathed wires or equivalent having a time constant of 2 s or less.

17.2.8 Concrete toppings for the loaded beam shall be made of normal weight concrete with a nominal density of 140 – 150 pcf (2240 – 2400 kg/m³). The concrete slab shall be sized, fixed to the steel beam in a non-composite manner, and any gaps sealed, in a manner appropriate to laboratory practice. No insulation material is permitted between the concrete and the steel beam.

17.3 Performance criteria

17.3.1 Loaded beam tests shall be loaded prior to commencing the test. This load is to be the maximum load condition allowed under nationally recognized structural design criteria. This load shall be maintained until both of the following limits are exceeded:

a) A maximum total deflection of:

$$(L^2) / (400 d)$$

b) And after the deflection limit has been exceeded, a maximum rate of deflection per minute as determined over one-minute intervals of:

$$(L^2) / (9000 d)$$

Where:

L = the clear span of the beam

d = the distance between the extreme fiber of the beam in the compression zone and the extreme fiber of the beam in the tensile zone

17.3.2 With reference to [17.3.1](#), the units of deflection, L and d must be expressed in the same units such as inches or millimeters.

17.3.3 On exceeding both of the limits in [17.3.1](#), the load shall be removed or reduced.