UL 1709

ISBN 0-7629-1074-7

Rapid Rise Fire Tests of Protection Materials for Structural Steel

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Rapid Rise Fire Tests of Protection Materials for Structural Steel, UL 1709

Third Edition, Dated March 23, 2005

Revisions: This Standard contains revisions through and including April 6, 2007.

Summary of Topics

Revision pages have been issued for UL 1709 to update the title page to indicate the latest approval date as an American National Standard and to incorporate the proposal dated December 22, 2006.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The following table lists the future effective dates with the corresponding item.

Future Effective Date	References
April 6, 2009	3.1

The new and revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated December 22, 2006.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: http://ulstandardsinfonet.ul.com/ulforeword.html

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

UL provides this Standard ″as is″ without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

UL will attempt to answer support requests concerning electronic versions of its Standards. However, this support service is offered on a reasonable efforts basis only, and UL may not be able to resolve every support request. UL supports the electronic versions of its Standards only if they are used under the conditions and operating systems for which it is intended. UL's support policies may change from time-to-time without notification.

UL reserves the right to change the format, presentation, file types and formats, delivery methods and formats, and the like of both its printed and electronic Standards without prior notice.

Purchasers of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgement (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

If a single-user version electronic Standard was purchased, one copy of this Standard may be stored on the hard disk of a single personal computer, or on a single LAN file-server or the permanent storage device of a multiple-user computer in such a manner that this Standard may only be accessed by one user at a time and for which there is no possibility of multiple concurrent access.

If a multiple-user version electronic Standard was purchased, one copy of the Standard may be stored on a single LAN file-server, or on the permanent storage device of a multiple-user computer, or on an Intranet server. The number of concurrent users shall not exceed the number of users authorized.

Electronic Standards are intended for on-line use, such as for viewing the requirements of a Standard, conducting a word search, and the like. Only one copy of the Standard may be printed from each single-user version of an electronic Standard. Only one copy of the Standard may be printed for each authorized user of a multiple-user version of an electronic Standard. Because of differences in the computer/software/printer setup used by UL and those of electronic Standards purchasers, the printed copy obtained by a purchaser may not look exactly like the on-line screen view or the printed Standard.

An employee of an organization purchasing a UL Standard can make a copy of the page or pages being viewed for their own fair and/or practical internal use.

The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if

the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Classification and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

This Standard consists of pages dated as shown in the following checklist:

No Text on This Page

MARCH 23, 2005
(Title Page Reprinted: April 6, 2007)

UL 1709

Standard for Rapid Rise Fire Tests of Protection Materials for Structural Steel

First Edition – February, 1989
Second Edition – February, 1994

Third Edition

March 23, 2005

The most recent designation of ANSI/UL 1709 as an American National Standard (ANSI) occurred on April 4, 2007. The ANSI approval for this standard does not include the Cover Page, Transmittal Pages, or Title Page.

This ANSI/UL Standard for Safety, which consists of the Third Edition, including revisions through April 6, 2007, is under continuous maintenance, whereby each revision is ANSI approved upon publication.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc. and is not part of the ANSI approved Standard.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements. 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 http://csds.ul.com.

ISBN 0-7629-1074-7

No Text on This Page

CONTENTS

INTRODUCTION

FULL-SCALE TEST METHOD

SMALL-SCALE TEST METHOD

APPENDIX A

INTRODUCTION

1 Scope

1.1 These requirements describe a test method measuring the resistance of protective materials to rapid-temperature-rise fires.

1.2 The test method covers a full-scale fire exposure, 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.

1.3 The test method also covers a small-scale fire exposure, intended to evaluate the ability of protective materials to withstand a variety of environmental conditions anticipated.

2 General

2.1 Units of measurement

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

2.2 Undated references

2.2.1 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.

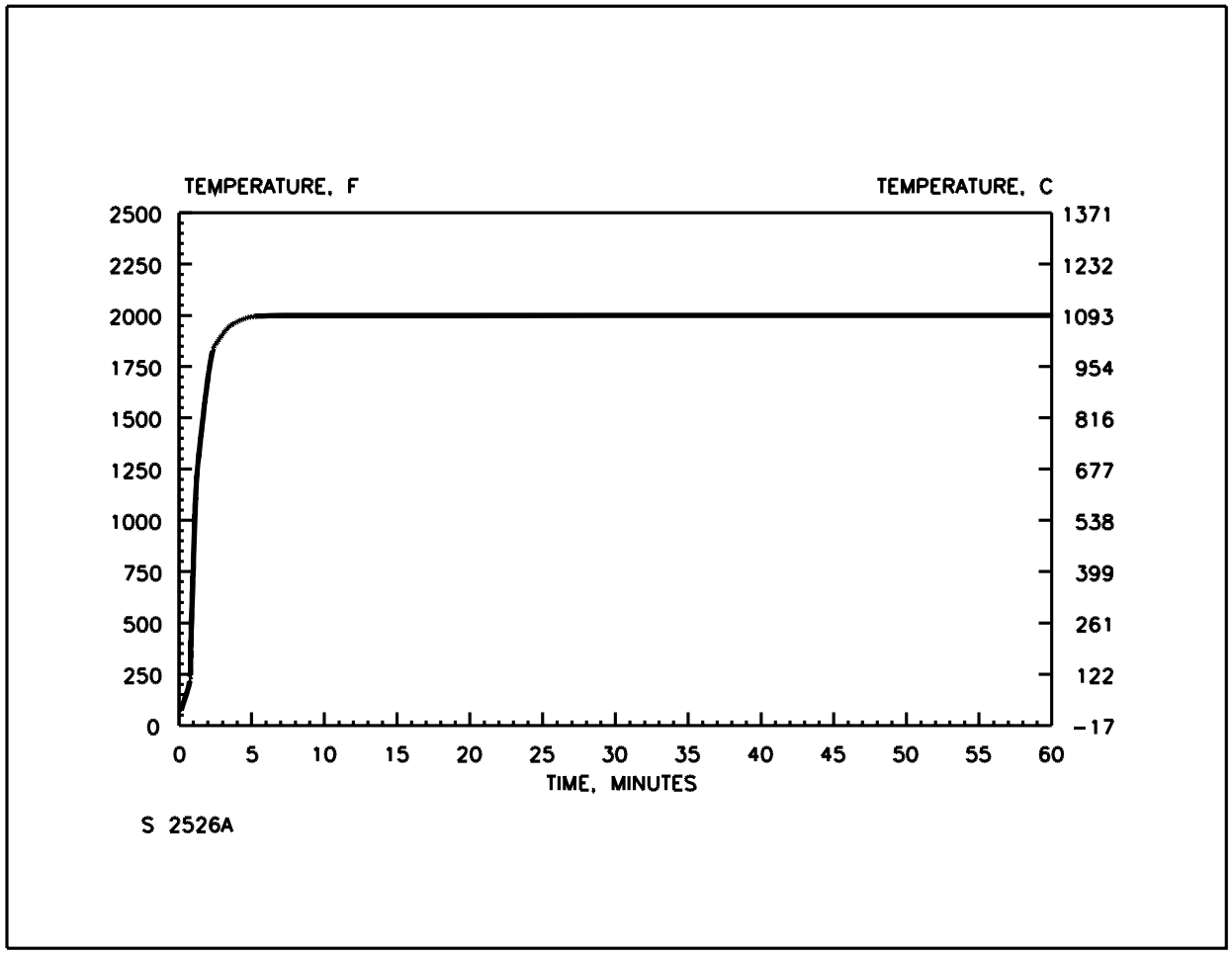
FULL-SCALE TEST METHOD

3 Furnace Control

3.1 The fire environment within the furnace is to develop a total heat flux of 65,000 ±5000 Btu/h·ft^2 (204 ±16 kW/m^2) 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 Furnace Calibration, Section 4. This temperature is to be maintained throughout the remainder of the fire test as shown in Figure 3.1.

Revised 3.1 effective April 6, 2009

Figure 3.1
Time-temperature curve



3.2 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 3.1 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.

3.3 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, and

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

3.4 The temperature fixed by the requirements of Furnace Calibration, Section 4, 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.

3.5 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.

3.6 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.

3.7 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.

4 Furnace Calibration

4.1 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.

4.2 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 Figures 4.1 and 4.2.

Figure 4.1
Calibration column I

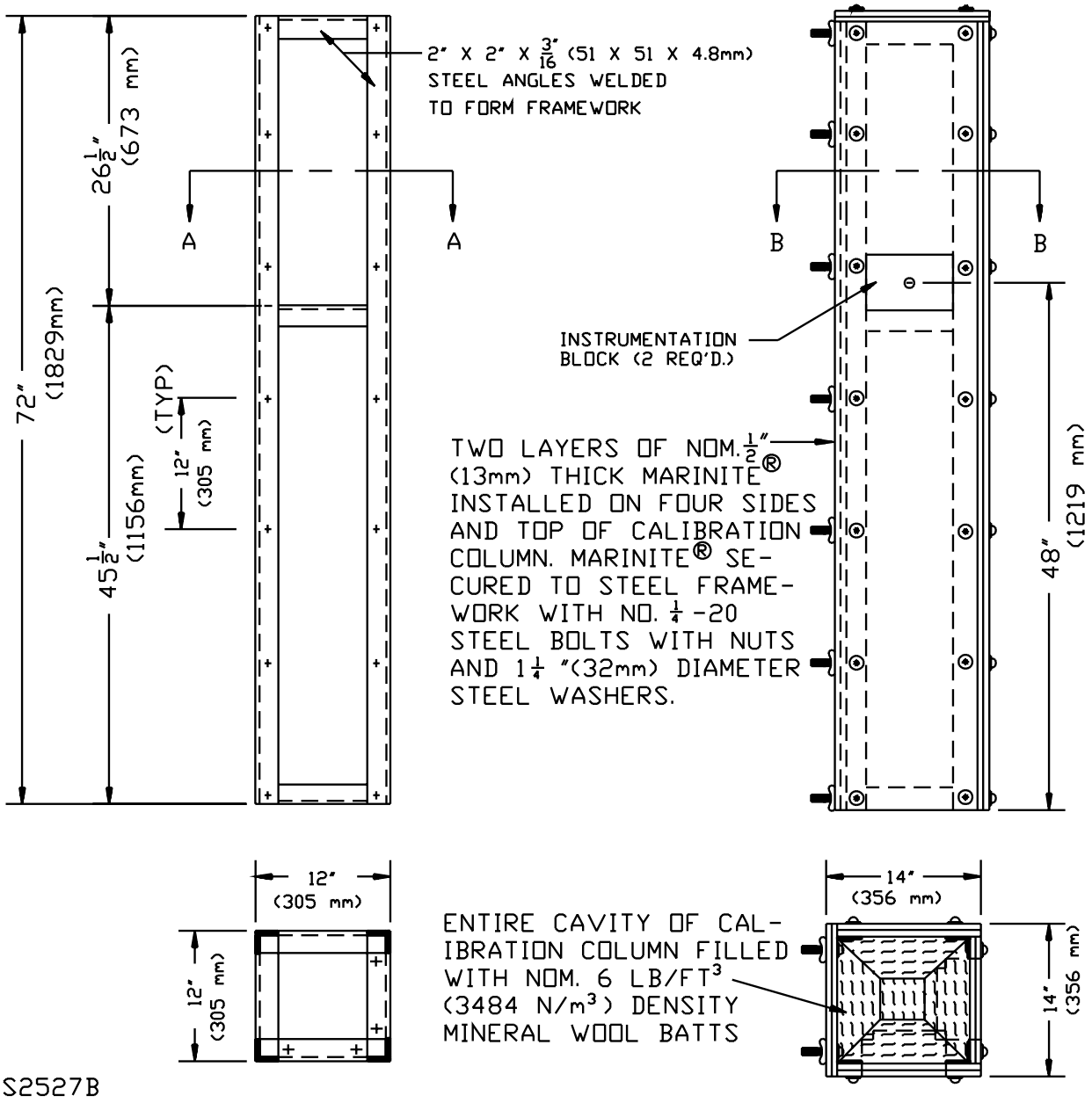
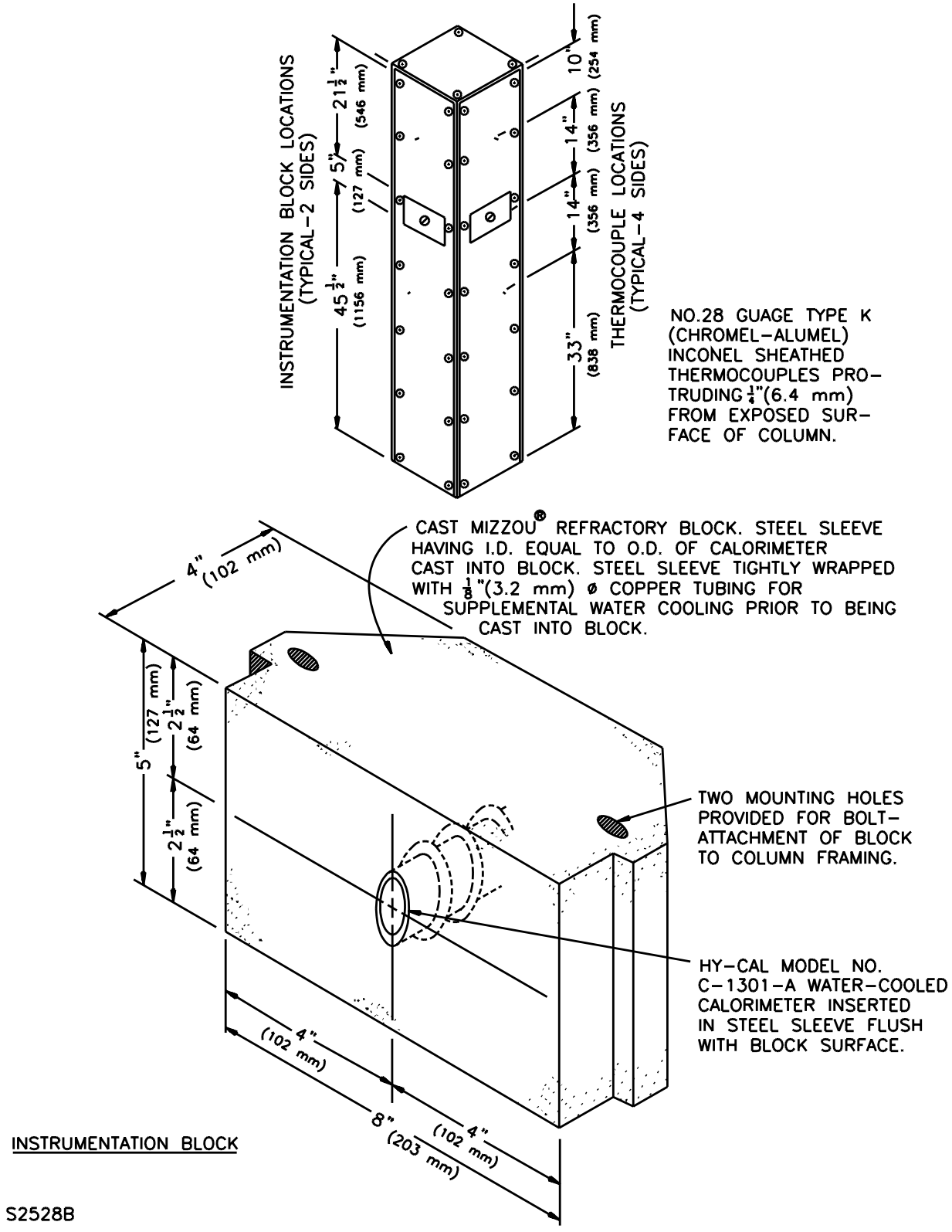


Figure 4.2
Calibration column II



4.3 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.

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

4.5 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.

4.6 The thermocouples used to measure the temperatures within the furnace are to be constructed as described in 3.5.

4.7 The calorimeters are to have a minimum range of 100,000 Btu/h·ft^2 (315 kW/m^2) and a 180° view angle.

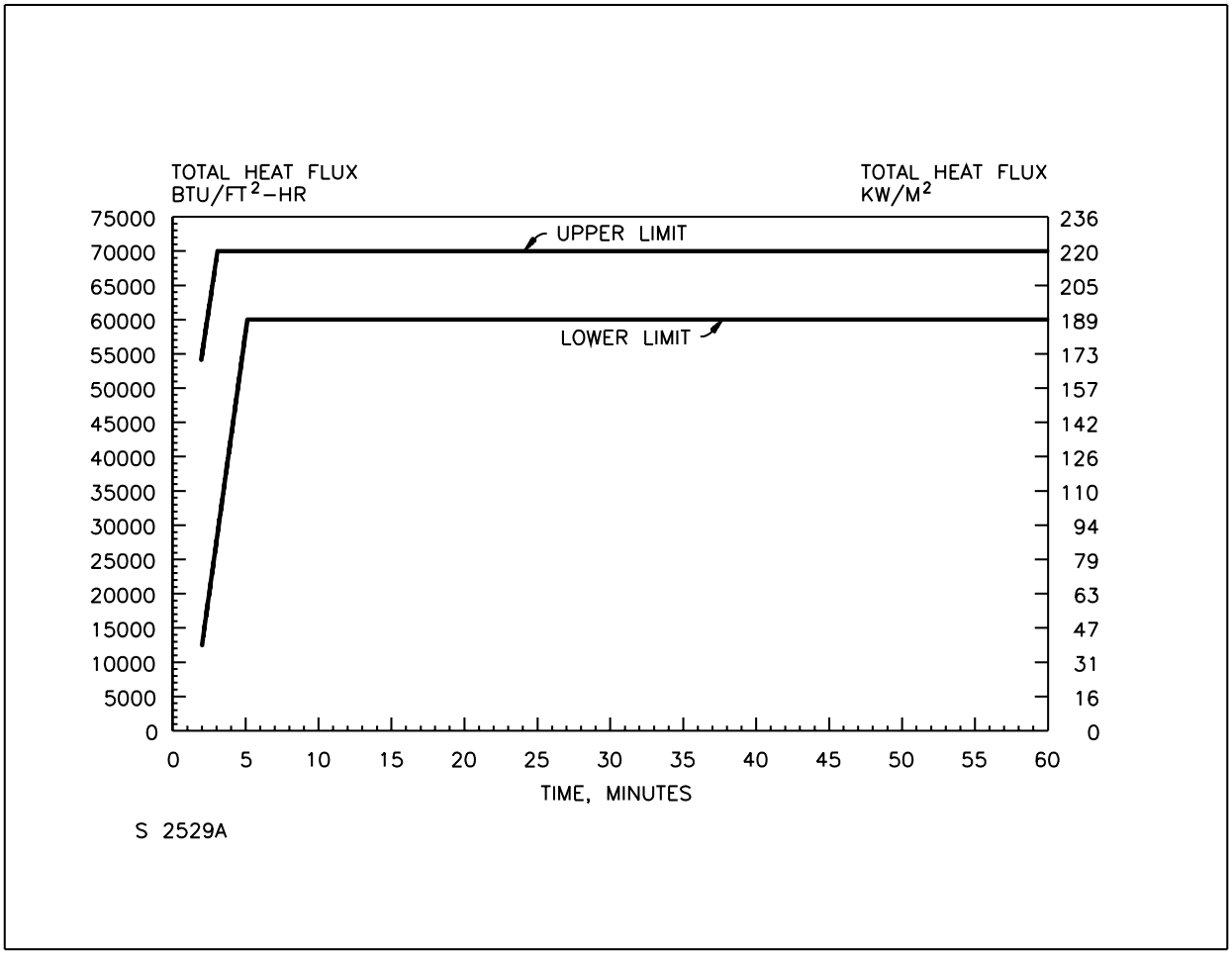
4.8 Combustion gas samples from within the furnace are to be obtained from a probe of stainless steel tubing having an outer diameter not less than 3/16 in (4.7 mm) and a wall thickness not less than 1/32 in (0.8 mm). The probe tip is to be positioned vertically at the midheight of the calibration column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

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

4.10 The fire environment during the calibration test is to comply with the requirements of 3.1. The length of the calibration test is to be 60 min.

4.11 Individual total heat flux measurements are to lie within the limits shown in Figure 4.3.

Figure 4.3
Time-total heat flux curve



4.12 Average furnace temperature is to be determined by averaging the temperatures recorded by the eight thermocouples placed 4 in (102 mm) from the column. The average shall be 2000 ±200°F (1093 ±111°C) and individual temperatures are to be 2000 ±400°F (1093 ±219°C) 5 min after the start of the test and until the end of the test.

4.13 The average furnace temperature curve shall be reproduced to maintain the furnace control described in Furnace Control, Section 3.

4.14 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.

5 Test Sample

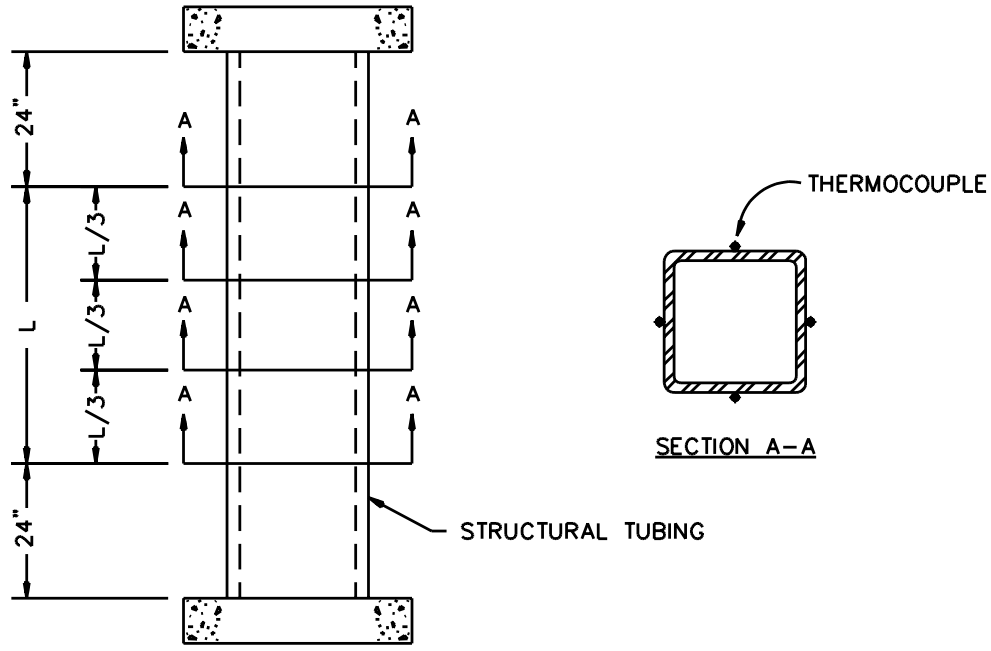
5.1 The size of the steel column used in the test sample shall be representative of the design, materials, and workmanship for which Classification is desired. The protection material shall be applied to the steel column in accordance with acceptable field practice. The length of the protected steel column shall be at least 8 ft (2.44 m). The steel column is to be supported vertically during application of protection material and during fire exposure.

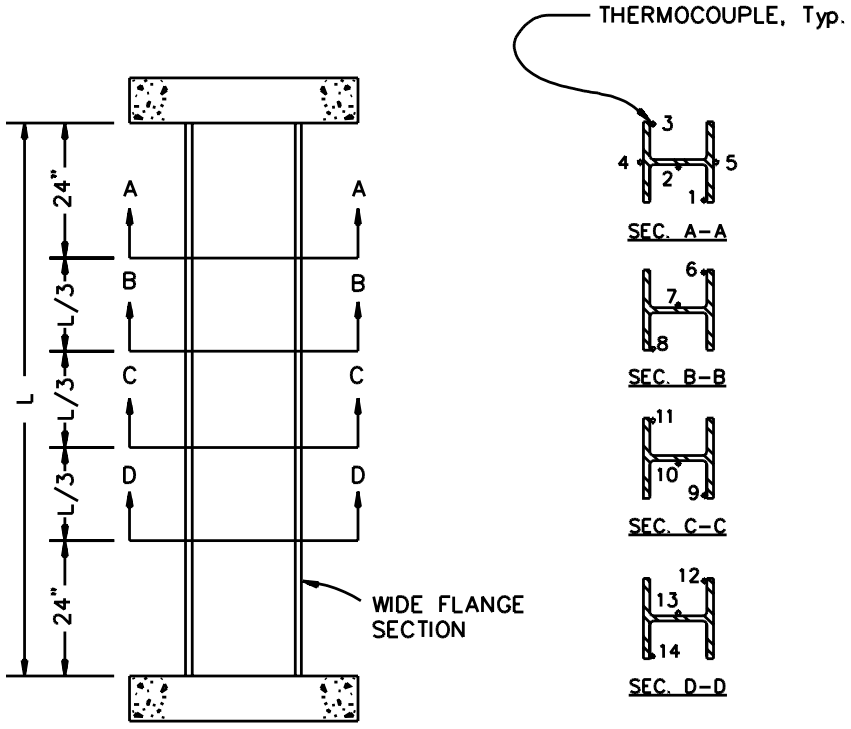
5.2 The temperature of the steel column is to be measured by no fewer than three thermocouples located at each of four levels (minimum of 12 thermocouples). The upper and lower levels are to be 2 ft (610 mm) from the ends of the steel column, and the other two intermediate levels are to be equally spaced 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 5.1 shows typical locations of thermocouples on wide flange and tubular steel columns. The thermocouples are to be fabricated from minimum 0.032 in (0.8 mm) diameter (No. 20 B & S gauge) chromel-alumel wires or equivalent having a time constant of 2 s or less.

5.3 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.

5.4 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 column from the furnace.

Figure 5.1
Thermocouple location





S2530B

5.5 Prior to test, the test sample is to be conditioned such that the dampest portion of the test sample 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).

6 Performance Criteria

6.1 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).

SMALL-SCALE TEST METHOD

7 Furnace Control During Fire Test

7.1 The average furnace temperature curve shall be reproduced to maintain the furnace control described in Furnace Control, Section 3.

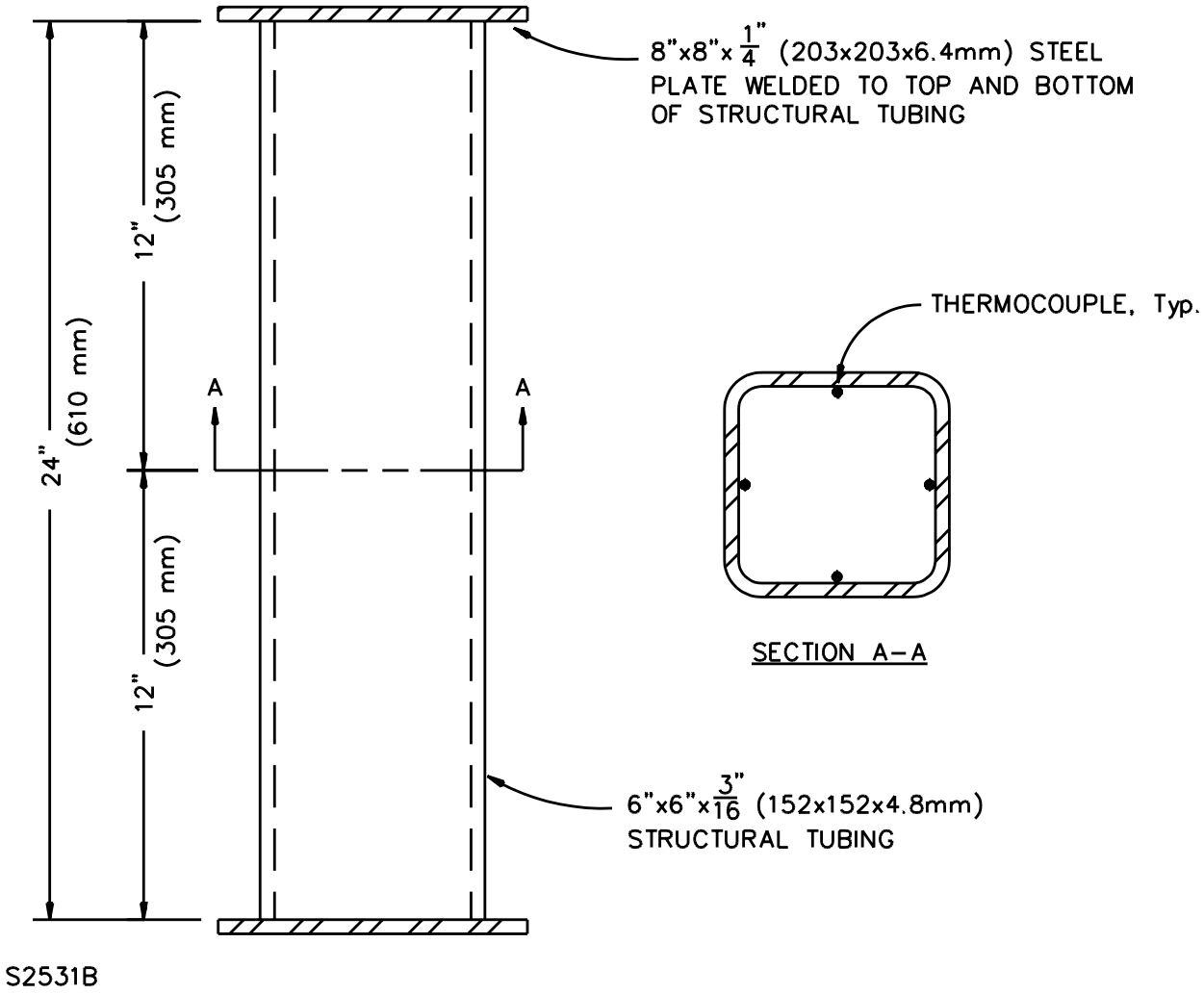
7.2 The temperature near all parts of the assembly, as obtained from the average of the readings of four thermocouples symmetrically disposed within the test furnace is to comply with the time-temperature curve of Figure 3.1.

7.3 The thermocouples are to be constructed as specified in 3.5.

8 Test Sample

8.1 The test sample is to be a 2 ft by 6 by 6 in (610 by 152 by 152 mm) structural steel tube with a 3/16 in (4.8 mm) wall thickness. The steel tube is to be provided with steel caps and covered with the protective material being investigated. Figure 8.1 shows the details of a test sample prior to application of the protective material.

Figure 8.1
Test sample



8.2 The temperatures of the test sample are to be measured with five Type K thermocouples having a time constant not greater than 2 s and located within the steel tube as shown in Figure 8.1.

8.3 The protective material shall be sufficient to provide at least a 50 min resistance, but not more than a 90 min resistance in compliance with the requirements of 9.1.

8.4 The test sample is to be conditioned in compliance with the requirements of 5.5 prior to the test.

8.5 After conditioning, and prior to test, the test sample is to be subjected to the selected environmental exposure simulations described in Appendix A to which it is anticipated that the protective material will be subjected to during its intended use. Other environmental exposures may be simulated in addition to those described in Appendix A.

9 Test Method

9.1 A test sample is to be conditioned as specified in 5.5, and subjected to the temperatures specified in 7.2. The thickness of the protective material shall be such that the time at which the test sample reaches an average temperature of 1000°F (538°C), and no thermocouple indicates an individual temperature greater than 1200°F (649°C), in no less than 50 min and no greater than 90 min after the beginning of the test. This time is to be defined as the control period. If necessary, the thickness of the protective material may be varied from one test sample to another to determine the thickness necessary for compliance with this requirement. This thickness, once determined, is to be the thickness applied to subsequent test samples.

9.2 Test samples after exposure to simulated environmental conditions described in 8.5 are to be fire tested in accordance with Furnace Control During Fire Test, Section 7.

10 Performance Criteria

10.1 The average temperature of the test samples shall not exceed 1000°F (538°C) and no thermocouple shall indicate a temperature greater than 1200°F (649°C) within a time equal to three quarters of the control period (see 9.1).

APPENDIX A

A1 Exposure Conditions

A1.1 The simulated exposure conditions described in A1.2 are intended to provide a basis for measuring the compatibility and permanence of the protective material with the conditions anticipated to be encountered during intended installation. Therefore, the selection of simulated exposures in addition to those described in A1.2 is to be based upon the environmental conditions at the site where the protective material is intended to be applied.

A1.2 Simulated exposure conditions may include, but are not limited to:

a) Aging – Accelerated aging of the protective material may be simulated by placing samples in a circulating air-oven at 158 ±5°F (70 ±2.7°C) for 270 days.

b) High Humidity – A high humidity condition may be simulated by placing samples in a controlled humidity of 97 – 100% at 95 ±3°F (35 ±1.5°C) for 180 days.

c) Industrial Atmosphere – The sulfur dioxide (SO_2) content and carbon dioxide (CO_2) content of an industrial atmosphere may be simulated by exposing the samples for 30 days to an amount of SO_2 equivalent to 1% of the volume of the test chamber, and an equal volume of CO_2. The test chamber is to be maintained at 95 ±3°F and a small amount of water is to be maintained at the bottom of the chamber.

d) Salt Spray – A corrosive atmosphere may be simulated by exposing samples to a salt spray for 90 days as described in the Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117.

e) Combination Wet, Freeze and Dry Cycling – The freeze-thaw action may be simulated by exposing samples to a cycle consisting of the equivalent of rainfall at the rate of 0.7 in/h (0.005 mm/s) of water for 72 h, followed by a temperature of minus 40 ±5°F (minus 40 ±2.7°C) for 24 h, and then a dry atmosphere of 140 ±5°F (60 ±2.7°C) for 72 h. This cycle is to be repeated twelve times.

f) Acid Spray – An acidic atmosphere may be simulated by exposing the samples for 5 days to a fog spray consisting of 2% by volume of hydrochloric acid (HCl) in water. The fog spray shall provide 1 to 2 mL of solution per hour for each 80 cm^2 of horizontal sample surface area.

g) Solvent Spray – Samples may be sprayed with reagent grade solvents at 70 ±5°F (21 ±2.7°C). Typical solvents are acetone and toluene. The solvent spray exposure may be applied with a typical paint spray gun until the entire surface area of the sample is completely covered with solvent that is not absorbed by the protective coating and excess solvent runs off the sample. An exposure cycle is to consist of application of the solvent, drying of the sample for 6 h, application of the solvent and drying of the sample for 18 h. The exposure cycle shall be repeated five times.

No Text on This Page

Superseded requirements for
the Standard for
Rapid Rise Fire Tests of Protection Materials for Structural Steel

UL 1709, Third Edition

The requirements shown are the current requirements that have been superseded by requirements in this edition. The numbers in parentheses refer to the new requirements with future effective dates that have superseded these requirements. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

3.1 The fire environment within the furnace is to develop a total heat flux of 65,000 ±5000 Btu/h·ft^2 (204 ±16 kW/m^2) and an average temperature of 2000 ±200°F (1093 ±111°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 Furnace Calibration, Section 4. This temperature is to be maintained throughout the remainder of the fire test as shown in Figure 3.1.

No Text on This Page