

**STANDARD METHODS OF FIRE ENDURANCE TESTS OF  
BUILDING CONSTRUCTION AND MATERIALS**

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# STANDARD METHODS OF FIRE ENDURANCE TESTS OF BUILDING CONSTRUCTION AND MATERIALS

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## STANDARD METHOD OF FIRE ENDURANCE TESTS OF BUILDING CONSTRUCTION AND MATERIALS

### PREFACE

This is the Fifth Edition of the Standard Method of Fire Endurance Tests of Building Construction and Materials, CAN/ULC-S101.

This Edition of the Standard was developed by the ULC Standards Task Group on Fire Endurance Tests and has been formally approved by the ULC Standards Committee on Fire Tests.

Appendices A, B, and C, identified as informative, are for informational purposes only.

Only metric SI units of measurement are used in this Standard. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

This Fifth Edition National Standard of Canada is based on, and now supersedes, the Fourth Edition.

Attention is drawn to the possibility that some of the elements of this Canadian standard may be the subject of patents rights. ULC Standards shall not be held responsible for identifying any or all such patents rights.

Requests for interpretation of this Standard should be sent to the Standards Department of ULC Standards. The requests should be worded in such a manner as to permit a “yes” or “no” answer based on the literal text of the requirement concerned.

The initiation of the review of this Standard will commence within 5 years of the date of publication, unless the Standard is identified as fitting within a stabilized category, whereby the review will commence within the appropriate time frame set out by ULC Standards.

This Standard is intended to be used for conformity assessment.



## 1. SCOPE

1.1 This Standard covers fire endurance tests applicable to walls, partitions, floors, roofs, ceilings, columns, beams, and girders, as well as to some components of these building sub-assemblies.

Note: The performance displayed by a component in one assembly would not necessarily be the same when such component is tested in a dissimilar assembly.

1.2 It is the intent that the fire endurance period established by this test method indicates performance only during the fire exposure period and shall not be construed as having determined suitability for use after fire exposure.

1.3 Separate fire endurance test methods are prescribed for various building constructions and materials, as follows:

|                                                                          |              |
|--------------------------------------------------------------------------|--------------|
| Walls and Partitions, Loadbearing                                        | (Section 7)  |
| Walls and Partitions, Non-Loadbearing                                    | (Section 8)  |
| Columns                                                                  | (Section 9)  |
| Columns, Structural Steel, Tests of Protection for                       | (Section 10) |
| Floor and Roof Assemblies                                                | (Section 11) |
| Beams or Joists, Loaded, Restrained                                      | (Section 12) |
| Beams or Joists, Loaded, Alternative Classification Procedure            | (Section 13) |
| Beams, Loaded, Unrestrained                                              | (Section 14) |
| Beams and Girders, Structural Steel, Alternative Tests of Protection for | (Section 15) |
| Framing and Facings, Combustible, Tests of Protection for                | (Section 16) |
| Ceiling Membranes                                                        | (Section 17) |

1.4 The fire exposure and hose stream tests are not intended to be representative of all fire conditions. It is likely that conditions will vary with changes in the amount, nature and distribution of fire, loading, ventilation, size and configuration of assembly installed. This fire endurance test Standard provides a relative measure of fire performance of comparable assemblies under specified fire exposure conditions.

## 2. REFERENCE PUBLICATIONS

2.1 The documents shown below are referenced in the text of this Standard. Unless otherwise stated elsewhere in this Standard such reference shall be considered to indicate the edition and/or revisions of the document available at the date on which the Committee approved this ULC Standard.

Documents Published by the CSA Group  
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- CAN/CSA-O86-09 Consolidated, Engineering Design in Wood
- CAN/CSA-S16-14, Design of Steel Structures
- CAN/CSA-S136-12, North American Specification for the Design of Cold-Formed Steel Structural Members
- CAN/CSA-A23.3-04 (R2010), Design of Concrete Structures

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- ISO/TR 834-2:2009, Fire-Resistance Tests – Elements of Building Construction – Part 2: Guidance on Measuring Uniformity of Furnace Exposure on Test Samples

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- ULC/ORD-C263E-88, Criteria for Use in Extension of Data from Fire Endurance Tests

### 3. TEST SPECIMEN

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

3.2 Where reference is made to the structural design of members, the design methods and loadings used shall be those required by the National Building Code of Canada. In cases where no applicable design standard exists, the design method and loadings used shall be clearly described in the test report.

3.3 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<sup>1</sup>, a proportionate reduction may be made in the dimensions of the test specimens for a test qualifying them for such restricted use.

3.4 When it is desired to include a built-up roof covering, the test specimen shall have a roof covering of 3 plies of No. 15 felt and not more than 5.8 kg/m<sup>2</sup> of hot-mopping asphalt without gravel surfacing. Tests of assemblies with this covering do not preclude the field use of other roof coverings with a larger number of plies of felt and additional asphalt or with gravel surfacing.

3.5 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.

### 4. PROTECTION AND CONDITIONING OF TEST SPECIMEN

4.1 Except as noted in Clause 4.3, the test specimen shall be protected during and after fabrication to assure normality of its quality and condition at the time of test. If it contains moisture, it shall not be tested until the specified strength has been attained and the excess moisture has been removed to achieve an air-dry condition.

4.2 The testing equipment and sample undergoing the fire endurance test shall be protected 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 10 to 32 °C. The speed of air across the unexposed surface of the test specimen, measured just before the test begins, shall not exceed 1.3 m/s as determined by an anemometer. If mechanical ventilation is employed during the test, an air stream shall not be directed across the unexposed surface of the test specimen.

4.3 Prior to the fire endurance test, constructions shall be conditioned with the objective of providing, within a reasonable time, a moisture condition within the test specimen approximately representative of that likely to exist in similar construction in buildings. For purposes of standardization, this condition shall be considered as that which would be established at equilibrium resulting from drying in an ambient atmosphere of 50 % relative humidity at 23 °C. However, with some constructions, it will be difficult or impossible to achieve such uniformity within a reasonable period of time. Accordingly, where this is the case, test

<sup>1</sup> For smaller assemblies, refer to ULC/ORD-C263e, Guide for Extension of Data for Fire Endurance Tests.

specimens shall be tested when the dampest portion of the structure, the portion at a 150 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  $23 \pm 3$  °C.

4.3.1 In the event that test 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 test specimen interior will be prevented by hermetic sealing, these requirements are permitted to be waived, except as to attainment of its design strength, the specimen tested in the condition in which it then exists and the fire endurance period corrected according to the method described in Subsection A2, Method of Correcting Fire Endurance Period Determined by Unexposed Surface Temperature Rise for Nonstandard Moisture Content.

4.3.2 If, during the conditioning of the test 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 test specimen or both from those produced as the result of drying in accordance with procedures given in Clause 4.3.

4.4 Within 72 h prior to the fire endurance test, information on the actual moisture content and distribution within the test specimen shall be obtained. This information shall be included in the test report.

4.4.1 If the moisture condition of the fire endurance test assembly is likely to change drastically within the 72 h sampling time, the sampling shall be made not later than 24 h prior to the test.

## 5. CONTROL OF FIRE ENDURANCE TESTS

### 5.1 STANDARD TIME-TEMPERATURE CURVE

5.1.1 The conduct of fire endurance tests of materials and construction shall be controlled by the standard time-temperature curve shown in Figure 1. The points on the curve that determine its character are given in Table 1.

### 5.2 FURNACE TEMPERATURES

5.2.1 The temperature fixed by the curve shall be deemed to be the average temperature from not fewer than nine thermocouples for a floor, roof, wall, or partition and not fewer than eight thermocouples for a structural column. The furnace thermocouples shall be constructed as described in Clause 5.2.1.1 and symmetrically disposed and distributed to measure the temperature near all parts of the test specimen. The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall not be less than 300 mm.

5.2.1.1 The thermocouple shall be fabricated from Chrome-Alumel thermocouple wire. The wire shall be 1.628 mm diameter (14 AWG) or 1.450 mm diameter (16 AWG) or 1.024 mm diameter (18 AWG). The thermocouple junction shall be formed by fusion-welding the wire ends to form a bead. Separate thermocouple wire lead shall be placed into one of the two holes

of the ceramic insulator pipe passing through the entire length. The ceramic insulator pipe shall have an outside diameter (O.D.) of 10 mm with two holes each having a diameter of 2 mm. The thermocouple wire and ceramic insulator pipe shall be inserted into a standard weight nominal 21.34 mm O.D. Inconel® 600 pipe (Schedule 40). Alternate black wrought steel or black wrought iron pipe of 21.34 mm O.D. is also permitted. The thermocouple bead shall be located  $7 \pm 1$  mm from the end of ceramic insulator pipe and  $13 \pm 1$  mm from the pipe end. The thermocouple assembly shall be as shown in Figure 2.

Note: The furnace thermocouple description in Clause 5.2.1.1 and shown in Figure 2 are not intended to invalidate the results of previous fire endurance tests conducted to the requirements in prior editions of this Standard.

5.2.2 For floors and columns, the junction of the thermocouples shall be placed  $300 \pm 10$  mm from the exposed face of the test specimen. In the case of walls and partitions, the thermocouples shall be placed  $150 \pm 10$  mm from the exposed face of the specimen. At no time during any test shall any thermocouple touch the test specimen as a result of the specimen's deflection. The quantity and distribution of furnace thermocouples shall be sufficient to ensure that one furnace thermocouple is provided for every  $1.5 \text{ m}^2$  of furnace cross-sectional area.

5.2.2.1 When testing columns, thermocouples shall be placed in pairs inside the furnace on opposite sides of the column at heights equal to one-third and two-thirds the height of the column.

5.2.3 The temperatures shall be read at intervals not exceeding 1 min during the first 2 h, and thereafter at intervals not exceeding 5 min.

5.2.4 For a valid test, the furnace control shall comply with the requirements in Clause 5.2.5.

5.2.5 The accuracy of the furnace control shall be such that the area under the standard time-temperature curve, obtained by averaging the results from the furnace thermocouple readings, shall be within  $\pm 10\%$  of the corresponding area under the standard time-temperature curve shown in Figure 1 for fire tests of 1 h or less duration,  $\pm 7.5\%$  for those over 1 h and not more than 2 h and  $\pm 5\%$  for tests exceeding 2 h in duration.

5.2.6 For specimens intended to be assigned a fire endurance period of  $\frac{1}{2}$  hour or greater, that is being determined on the basis of the average or maximum temperature rise on the unexposed surface or within the test specimen, or by failure under load, the equation shown below shall be used to determine the corrected fire endurance test period when the test will result in a total accumulative fire exposure that varies from the area under the standard time-temperature curve specified in Table 1. The uncorrected fire endurance test period shall be increased for fire exposure in the test higher than the standard time-temperature curve and be similarly decreased for fire exposure below the standard time-temperature curve.

The corrected fire endurance period can be determined by the following equation:

$$C = I + \frac{2(A - A_s)}{3(A_s + L)}$$

Where:

$C$  = corrected fire endurance period (in the same units as  $I$ ),

$I$  = fire endurance period obtained before correction, (h)

$A$  = area under the curve of indicated average furnace temperature for the first three quarters of the uncorrected fire endurance period obtained from the test, ( $^{\circ}\text{C}\cdot\text{h}$ )

$A_s$  = area under the standard curve for the same part of the period, ( $^{\circ}\text{C}\cdot\text{h}$ );  
and

$L$  = lag correction (in the same units as  $A$  and  $A_s$ ), ( $30^{\circ}\text{C}\cdot\text{h}$ ).

Note: The  $30^{\circ}\text{C}\cdot\text{h}$  is to compensate for the thermal lag of the furnace thermocouples during the first part of the test.

### 5.3 TEMPERATURE OF UNEXPOSED SURFACES OF FLOORS, ROOFS, WALLS AND PARTITIONS

5.3.1 Temperatures of unexposed surfaces shall be measured with thermocouples placed under dry, felted pads. The properties of these pads shall meet the requirements listed in Subsection 5.3.6, Thermocouple Pad Construction. The wire leads of the thermocouple shall have an immersion under the pad and be in contact with not less than 90 mm of the unexposed surface. The hot junction of the thermocouple shall be placed approximately under the centre of the pad. The outside diameter of protecting or insulating tubes shall not be more than 8 mm. The pad shall be held firmly against the unexposed surface for the duration of the test, and shall fit closely about the thermocouples. The wires for the thermocouple in the length covered by the pad shall not be greater than 1 mm in diameter and shall be electrically insulated with heat-resistant and moisture-resistant coatings.

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

5.3.2 Temperature readings shall be taken at not less than nine points on the unexposed surface. Five of these shall be symmetrically disposed, one to be approximately at the centre of the test specimen, and four at approximately the centre 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 300 mm, whichever is greater. Where there is an element of the construction nearer the edge that is not otherwise represented in the remainder of the test specimen, at least one of the thermocouples shall be located in the outer section. 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. When the aggregate area of any fasteners such as screws, nails, or staples, projected to the unexposed surface is less than 0.8 % of any 130 mm by 130 mm area, thermocouples shall neither be located opposite to nor on top of the fasteners.

5.3.3 Temperature readings shall be taken at intervals not exceeding 5 min, until a reading exceeding 100 °C has been obtained at any one point. Thereafter, if the readings are taken more frequently at the discretion of the testing organization, the intervals need not be less than 1 min.

### 5.3.4 Roving Thermocouple Construction

5.3.4.1 One or more roving thermocouples of the design shown in Figure 8, or alternative temperature measuring devices which can be shown to have at least the accuracy and a response time equal to or less than the design illustrated by Figure 8, shall be available to measure unexposed surface temperatures during a test in positions where higher temperatures are suspected. The measuring junction of the thermocouple assembly consists of 1.0 mm diameter thermocouple wires soldered or welded to a 12 mm diameter, 0.5 mm thick copper disc. The thermocouple assembly shall be provided with a handle so that it can be applied over any point on the unexposed surface of the test specimen.

### 5.3.5 Cotton Pad Construction

5.3.5.1 The cotton pad shall consist of new, undyed and soft cotton fibres without other added fibres, 20 mm thick x 100 mm square, and shall weigh between 3 g and 4 g. It shall be conditioned prior to use by placing it in a drying oven at  $100 \pm 5$  °C for at least 30 min. After drying, it may be stored in a desiccator for up to 24 h.

### 5.3.6 Thermocouple Pad Construction

5.3.6.1 The pads used in measurements of temperature of unexposed surfaces of specimens shall be of suitable refractory material and shall exhibit the following properties:

|                                |                                |
|--------------------------------|--------------------------------|
| Length and Width               | $150 \pm 3$ mm                 |
| Thickness                      | $10 \pm 1$ mm                  |
| Density                        | $500 \pm 10$ kg/m <sup>3</sup> |
| Thermal Conductivity (at 66°C) | $0.055 \pm 0.003$ W/(m·°C)     |

5.3.6.2 The thickness measurement shall be made under the light load of a 13 mm diameter pad of a dial micrometer gauge.

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

## 5.4 DIFFERENTIAL PRESSURE

5.4.1 The pressure differential between the exposed and unexposed surfaces of the test assembly shall be measured as described in Clauses 5.4.2 through 5.4.7.

5.4.2 The pressure sensing probes shall be as shown in either Figure 3 or 4.

5.4.3 The pressure shall be measured within a precision accuracy of  $\pm 1.2$  Pa using a differential pressure instrument capable of reading in increments no coarser than 0.2 Pa.

differential pressure measurement instrument(s) shall be located to minimize "stack" effects caused by vertical runs of pressure tubing between the furnace probe(s) and instrument locations.

5.4.4 The furnace pressure(s) shall be measured and recorded throughout the test at intervals not exceeding 1 min.

5.4.5 Control of the furnace pressure shall be established no later than 10 min after the start of the test and shall be maintained throughout the remainder of the test period.

5.4.6 Vertical Test Specimens - The vertical pressure distribution within the furnace shall be measured by at least two probes separated by a vertical distance of at least 1.8 m for furnaces greater than 2 m in height, and a minimum of 90 % of the furnace height for furnaces less than 2 m in height. Based on their vertical separation and their pressure differences, the location of the neutral plane (zero differential pressure) shall be calculated.

5.4.7 Horizontal Test Specimens - The pressure shall be measured by at least two probes located at the centre of the test specimen separated by a vertical distance of at least 1.8 m for furnaces greater than 2 m in height and a minimum of 90 % of the furnace height for furnaces less than 2 m in height.

## 6. FIRE ENDURANCE TESTS AND HOSE STREAM TESTS

### 6.1 FIRE ENDURANCE TEST

6.1.1 The fire endurance test on the test specimen with its applied load, if any, shall be continued until failure occurs, or until the test specimen has withstood the test conditions for a period equal to that herein specified in the determination of fire endurance period for the given type of construction.

6.1.2 Where a specific differential pressure is required, except for the first 10 min, the differential pressure between the exposed and unexposed surfaces of the test specimen shall be controlled within  $\pm 5$  % of the intended differential pressure.

#### 6.1.3 Deflection

6.1.3.1 Where appropriate, the deflection of the test specimen shall be recorded. In the case of loadbearing test specimens, measurements shall be made prior to and following application of the load. The accuracy of the measurement shall be within  $\pm 1$  mm.

6.1.3.2 For horizontal loadbearing test specimens, the measurements shall be made at the location where the maximum vertical deflections are expected to occur. The maximum vertical deflection is usually at mid-span for simply supported elements.

6.1.3.3 For vertical loadbearing test specimens, elongation, which represents an increased height of the test specimen, shall be expressed positively and, contraction, which represents a decreased height of the test specimen, shall be expressed negatively. In addition, measurements of horizontal deflection shall be made at the location where the maximum

deflections are expected to occur. Horizontal deflection of the vertical test specimens towards the fire shall be expressed positively, whereas deflection away from the fire shall be expressed negatively.

6.1.3.4 Deflection measurements of the test specimen shall be recorded at intervals not exceeding 1 min. The rate of deflection shall be calculated on the basis of this measurement.

6.1.4 With the consent of the testing organization, the fire test may be continued, for information purposes, beyond the fire endurance period of classification when no structural failure has occurred or no hazardous situation exists.

## **6.2 HOSE STREAM TEST**

### **6.2.1 Test Specimen**

6.2.1.1 Where required in the determination of a fire endurance period, a duplicate specimen shall be exposed to fire, for a period equal to one-half of that intended as the fire endurance period, but not for more than 1 h, immediately after which the test specimen shall be subjected to the impact, erosion, and cooling effects of a hose stream.

### **6.2.2 Procedure for Hose Stream Test**

6.2.2.1 Within 3.5 min of the termination of the fire test, the test specimen shall be positioned in such a manner as to be able to apply the hose stream to the entire surface exposed to the fire test furnace. Position the tip of the nozzle at the specified distance from the centre of the test specimen. Adjust the nozzle hose stream to the specified pressure. During adjustment, the hose stream shall not contact the test specimen. Photograph both the exposed and unexposed sides of the test specimen before the hose stream is applied. Verbally announce and record the duration of the hose stream exposure, water pressure and water delivery system being used. Position personnel to obtain an unobstructed view of both the exposed and unexposed sides of the test specimen during the hose stream test.

### **6.2.3 Application of the Hose Stream**

6.2.3.1 Commence the test by directing the hose stream at one corner of the test assembly first. Continue to direct the stream to the entire exposed face of the test assembly in accordance with this section. Pass the hose stream across the test assembly between 0.9 to 1.8 m/s. Movement from one side of the test assembly to the other constitutes one pass. When changing directions to make the return pass, change direction slowly and off of the test assembly but do not rest the hose stream off of the specimen during the test. Apply the hose stream horizontally, and then vertically covering the entire exposed face. The difference between the number of hose stream passes in the horizontal direction compared to the vertical direction, shall not exceed 10 % of the total. Take at least one photograph of both the exposed and unexposed sides of the test specimen during and after the hose stream test. Terminate the application of the hose stream upon completion of the required duration of exposure as specified in Table 2 or after a failure occurs, whichever happens first, or upon the request of the sponsor.

## **6.2.4 Exemption**

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

## **6.2.5 Optional Program**

6.2.5.1 Where the submittor elects, and with the advice and consent of the testing organization, to have the hose stream test made on the original specimen subjected to the fire endurance test, it shall be conducted in accordance with Subsection 6.2, Hose Stream Test.

## **6.2.6 Hose Stream Equipment and Details**

6.2.6.1 The stream shall be delivered through a 65 mm hose discharging through a National Standard Playpipe of corresponding size equipped with a 29 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 2.

## **6.2.7 Nozzle Distance**

6.2.7.1 The nozzle orifice shall be  $6 \pm 0.2$  m from the centre of the exposed surface of the test specimen if the nozzle is so located that, when directed at the centre, its axis is normal to the surface of the test specimen. If otherwise located, its distance from the centre shall be 6 m, reduced by an amount equal to 300 mm for each  $10^\circ$  of deviation from the normal ( $90^\circ$ ) with the maximum permissible deviation being  $30^\circ$ .

## **6.3 ROVING THERMOCOUPLE**

### **6.3.1 Application**

6.3.1.1 A roving thermocouple, constructed in accordance with Subsection 5.3.4, Roving Thermocouple Construction, shall be applied to any suspected hot spot that develops during the test. If a temperature of  $150^\circ\text{C}$  is not achieved within an application period of 20 s, the roving thermocouple shall be removed. Measurements with the roving thermocouple shall avoid fasteners such as screws, nails or staples that will be obviously higher or lower in temperature, as already specified for the unexposed surface thermocouple locations.

## **6.4 COTTON PADS**

### **6.4.1 Application**

6.4.1.1 A cotton pad, constructed in accordance with Subsection 5.3.5, Cotton Pad Construction, shall be applied to any crack, hole or fissure in the specimen through which the passage of flames or gases hot enough to ignite cotton pads is suspected.

## 6.5 FURNACE PERFORMANCE VERIFICATION

6.5.1 A furnace performance verification test in accordance with ISO/TR 834-2, Fire-resistance tests – Elements of building construction – Part 2: Guidance on measuring uniformity of furnace exposure on test samples, shall be conducted at least every five years and after any maintenance which potentially can have an impact on the test result of tests conducted with the furnace.

Note 1: Example of such maintenance is the resurfacing of the thermal insulation or repairs/replacement of the burners.

Note 2: The verification test is intended to measure the exposure imposed by the furnace onto the standardized test specimen.

6.5.1.1 Where ISO/TR 834-2, Fire-resistance tests – Elements of building construction – Part 2: Guidance on measuring uniformity of furnace exposure on test samples, conflicts with the requirements in Clause 6.5.2, the requirement in Clause 6.5.2 shall be met.

6.5.2 The furnace temperature measurements, control and instrumentation shall be in accordance with the requirements contained in Section 5, Control of Fire Endurance Tests, for a time period of 45 min.

## 7. TESTS OF LOADBEARING WALLS AND PARTITIONS

### 7.1 SIZE OF TEST SPECIMEN

7.1.1 The area exposed to fire shall not be less than 9.3 m<sup>2</sup>, with neither dimension less than 2750 mm. The test specimen shall not be restrained on its vertical edges.

### 7.2 LOADING

#### 7.2.1 Application of Loading

7.2.1.1 The superimposed load shall be gradually applied in four increments of 25 % allowing for stabilization of deflection after each increment. The full superimposed load shall have been applied at least 30 min before the start of the fire test. Maintain the superimposed load throughout the fire endurance test. The superimposed load shall represent a full specified load condition or a restricted load use condition.

#### 7.2.2 Full Specified Load Condition

7.2.2.1 To satisfy the full specified load condition, the test specimen shall be subjected to the specified gravity loads that produce a factored load effect as close as practicable to the factored resistance of the test specimen. The factored load effect and the factored resistance of the test specimen shall be determined in accordance with the appropriate limit states design standard published by the Canadian Standards Association.

### **7.2.3 Restricted Load Use Condition**

7.2.3.1 When a test is conducted with a load condition that is less severe than the full specified load condition, the restricted load use condition shall be identified and reported.

## **7.3 EXPOSURE TO FIRE**

7.3.1 Throughout the fire endurance test, the test specimen shall be exposed to fire on one side of the wall assembly.

7.3.2 Symmetrical walls or partitions shall be tested from one side only. Walls or partitions that are asymmetrical shall be tested from both sides. If an asymmetrical wall or partition is tested from one side only, the fire endurance period achieved by the assembly shall be reported for exposure on that side. When an asymmetrical wall or partition is tested from both sides, the fire endurance period achieved by the assembly when exposed on each side shall be reported.

## **7.4 DETERMINATION OF FIRE ENDURANCE PERIOD**

7.4.1 In obtaining the fire endurance period, the conditions specified in Clauses 7.4.2 through 7.4.4 shall be met.

7.4.2 Transmission of heat through the test specimen throughout the fire endurance period shall not raise the average temperature measured by the stationary thermocouples on its unexposed surface more than 140 °C above its initial average temperature; nor shall the temperature rise at any individual point exceed 180 °C including a temperature measured by the roving thermocouple.

7.4.3 The test specimen shall have sustained the applied load throughout the fire endurance test specified in Subsection 6.1, Fire Endurance Test, without passage of flame or passage of gases hot enough to ignite cotton pads.

7.4.4 The test specimen shall have sustained the applied load during the fire and hose stream tests as specified in Subsection 6.2, Hose Stream Test, without passage of flame, passage of gases hot enough to ignite cotton pads and passage 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 face during the time of the hose stream test.

## **8. TESTS OF NON-LOADBEARING WALLS AND PARTITIONS**

### **8.1 SIZE OF TEST SPECIMEN**

8.1.1 The area exposed to fire shall not be less than 9.3 m<sup>2</sup>, with neither dimension less than 2750 mm. The test specimen shall be restrained on all four edges.

## **8.2 EXPOSURE TO FIRE**

8.2.1 Throughout the fire endurance test, the test specimen shall be exposed to fire on one side of the wall assembly.

8.2.2 Non-loadbearing symmetrical walls or partitions shall be tested from one side only. Non-loadbearing walls or partitions that are asymmetrical shall be tested from both sides. If a non-loadbearing asymmetrical wall or partition is tested from one side only, the fire endurance period achieved by the assembly shall be reported for exposure on that side. When a non-loadbearing asymmetrical wall or partition is tested from both sides, the fire endurance period achieved by the assembly when exposed on each side shall be reported.

## **8.3 DETERMINATION OF FIRE ENDURANCE PERIOD**

8.3.1 In obtaining the fire endurance period, the conditions specified in Clauses 8.3.2 and 8.3.4 shall be met.

8.3.2 The wall or partition shall have withstood the fire exposure as specified in Subsection 6.1, Fire Endurance Test, without passage of flame or passage of gases hot enough to ignite cotton pads.

8.3.3 Transmission of heat through the test specimen throughout the fire endurance period shall not raise the average temperature measured by the stationary thermocouples on its unexposed surface more than 140 °C above its initial average temperature; nor shall the temperature rise at any individual point exceed 180 °C including a temperature measured by the roving thermocouple.

8.3.4 The wall or partition shall have withstood the fire and hose stream tests as specified in Subsection 6.2, Hose Stream Test, without passage of flame or passage of gases hot enough to ignite cotton pads and passage of 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 face during the time of the hose stream test.

# **9. TESTS OF COLUMNS**

## **9.1 SIZE OF TEST SPECIMEN**

9.1.1 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 not be less than 2750 mm of exposed length. Apply the contemplated details of connections and their protection, if any, according to the methods of acceptable field practice.

## **9.2 LOADING**

### **9.2.1 Application of Loading**

9.2.1.1 The superimposed load shall be gradually applied in four increments of 25 % allowing for stabilization of deflection after each increment. The full superimposed load shall have been applied at least 30 min before the start of the fire test. Maintain the superimposed load throughout the fire endurance test. The superimposed load shall represent a full specified load condition or a restricted load use condition.

9.2.1.2 Provision shall be made for transmitting the load to the column without unduly increasing the effective column length.

### **9.2.2 Full Specified Load Condition**

9.2.2.1 To satisfy the full specified load condition, the test specimen shall be subjected to the specified gravity load that produces a factored load effect as close as practicable to the factored resistance of the test specimen. The factored load effect and the factored resistance of the test specimen shall be determined in accordance with the appropriate limit states design standard published by the Canadian Standards Association.

### **9.2.3 Restricted Load Use Condition**

9.2.3.1 When a test is conducted with a load condition that is less severe than the full specified load condition, the restricted load use condition shall be identified and reported.

## **9.3 EXPOSURE TO FIRE**

9.3.1 Throughout the fire endurance test the specimen shall be exposed to fire on all sides.

## **9.4 DETERMINATION OF FIRE ENDURANCE PERIOD**

9.4.1 In obtaining the fire endurance period, the column shall sustain the applied load throughout the entire fire endurance period.

# **10. TESTS OF PROTECTION FOR STRUCTURAL STEEL COLUMNS**

## **10.1 APPLICATION**

10.1.1 This test procedure does not require column loading at any time and may be 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.

## 10.2 SIZE AND CHARACTERISTICS OF TEST SPECIMEN

10.2.1 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. The protection shall be applied according to the methods of acceptable field practice. The length of the protected column shall be at least 2450 mm. The column shall be vertical during application of the protection and during the fire exposure.

10.2.2 The applied protection shall be restrained 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.

10.2.3 The ends of the test specimen, including the means for restraint, shall be given sufficient thermal insulation to prevent appreciable direct heat transfer from the furnace.

## 10.3 TEMPERATURE MEASUREMENT

10.3.1 The temperature of the steel in the column shall be measured by at least three thermocouples located at each of four levels. The upper and lower levels shall be  $600 \pm 10$  mm from the ends of the exposed portion of the steel column. The two intermediate levels shall be equally spaced between the upper and lower levels. The thermocouples at each level shall be so placed as to measure significant temperatures of the component elements of the steel section. The recommended thermocouple distribution is shown in Figure 5.

10.3.2 When there are joints in the protection or when the thermal resistance of the protection is not uniform, additional measurements of the steel temperature shall be made by at least three thermocouples at cross-sections opposite to joints and any place with smaller thermal resistance.

## 10.4 EXPOSURE TO FIRE

10.4.1 Throughout the fire endurance test the specimen shall be exposed to fire on all sides.

## 10.5 DETERMINATION OF FIRE ENDURANCE PERIOD

10.5.1 In obtaining the fire endurance period, the transmission of heat through the protection during the period of fire exposure shall not raise the average temperature of the steel at any one of the levels specified by Clauses 10.3.1 and 10.3.2 above  $538^{\circ}\text{C}$  and shall not raise the temperature above  $649^{\circ}\text{C}$  at any one of the measured points.