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Fire resistance tests — Elements of building construction —

Part 10: Specific requirements to determine the contribution of applied fire protection materials to structural steel elements

Essais de résistance au feu — Éléments de construction —

Partie 10: Exigences spécifiques pour déterminer la contribution des matériaux de protection appliqués aux éléments des structures en acier

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 92, *Fire safety*, Subcommittee SC 2, *Fire containment*.

ISO 834 consists of the following parts, under the general title *Fire resistance tests — Elements of building construction*:

— *Part 1: General requirements*

— *Part 2: Guidance on measuring uniformity of furnace exposure on test samples* [Technical Report]

— *Part 3: Commentary on test method and guide to the application of the outputs from the fire-resistance test* [Technical Report]

— *Part 4: Specific requirements for loadbearing vertical separating elements*

— *Part 5: Specific requirements for loadbearing horizontal separating elements*

— *Part 6: Specific requirements for beams*

— *Part 7: Specific requirements for columns*

— *Part 8: Specific requirements for non-loadbearing vertical separating elements*

— *Part 9: Specific requirements for non-loadbearing ceiling elements*

— *Part 10: Specific requirements to determine the contribution of applied fire protection materials to structural steel elements*

— *Part 11: Specific requirements for the assessment of fire protection to structural steel elements*

— *Part 12: Specific requirements for separating elements evaluated on less than full scale furnaces*

Introduction

This part of ISO 834 specifies a method for testing fire protection systems applied to structural steel members employed in buildings as beams, columns, or tension members. This part of ISO 834 is intended for use in conjunction with the assessment protocol described in ISO 834-11.

Fire resistance tests — Elements of building construction —

Part 10: Specific requirements to determine the contribution of applied fire protection materials to structural steel elements

1 Scope

This part of ISO 834 specifies a method for testing fire protection systems applied to structural steel members used in buildings as beams, columns, or tension members. This part of ISO 834 is intended for use in conjunction with the assessment protocol described in ISO 834-11. It applies to steel sections (including hollow sections) and only considers sections without openings in the web. Results from analysis of I or H sections are directly applicable to angles, channels, and T-sections for the same section factor, whether used as individual members, e.g. bracing, or part of a fabricated structural system such as a steel truss construction. This part of ISO 834 does not apply to solid bar, rod, or concrete-filled hollow sections.

This part of ISO 834 describes the fire test procedures that specify the tests which should be carried out to determine the ability of the fire protection system to remain sufficiently coherent and in position for a well-defined range of deformations, furnace, and steel temperatures, such that the efficacy of the fire protection system is not significantly impaired, and to provide data on the thermal characteristics of the fire protection system when exposed to the standard temperature/time curve specified in ISO 834-1.

In special circumstances, where specified in National Building Regulations, there can be a requirement to subject reactive fire protection materials to a smouldering curve. The test and the requirements for its use are described in Annex G.

This part of ISO 834 is applicable to both passive and reactive fire protection systems as defined in the terms and definitions, which are installed or applied in such a way that they remain in place for the intended duration of fire exposure.

The fire test methodology makes provision for the collection and presentation of data which is then used as direct input into ISO 834-11 to determine the limits of direct application to steel sections of various shapes, sizes, and fire resistance periods.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 834-1, *Fire-resistance tests — Elements of building construction — Part 1: General requirements*

ISO 834-6, *Fire-resistance tests — Elements of building construction — Part 6: Specific requirements for beams*

ISO 834-7, *Fire-resistance tests — Elements of building construction — Part 7: Specific requirements for columns*

ISO 1182:2010, *Reaction to fire tests for products — Non-combustibility test*

ISO 1716, *Reaction to fire tests for products — Determination of the gross heat of combustion (calorific value)*

ISO 8421-2, *Fire protection — Vocabulary — Part 2: Structural fire protection*

ISO 13943, *Fire safety — Vocabulary*

IEC 584-1, *Thermocouples – Part 1: Reference tables*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 834-1, ISO 13943, ISO 8421-2, and the following apply.

3.1
characteristic steel temperature
temperature of the structural steel member which is used for the determination of the correction factor for stickability calculated as (mean temperature + maximum temperature)/2

3.2
design temperature
temperature of the steel member for structural design purposes

3.3
fire protection
protection afforded to the steel member by the fire protection system such that the temperature of the steel member is limited throughout the period of fire exposure

3.4
fire protection system
fire protection material together with any supporting system including mesh reinforcement as tested

Note 1 to entry: The reactive fire protection materials system includes the primer and top coat if applicable.

3.5
fire protection thickness
dry thickness of a single-layer fire protection system or the combined thickness of all layers of a fire protection system

Note 1 to entry: The thickness of elements of the supporting system or joint cover strips are not included in the fire protection thickness.

Note 2 to entry: For reactive fire protection systems, the thickness is the mean dry film thickness of the coating excluding primer and top coat if applicable.

3.6
H section
steel member with wide flanges compared with the section depth whose main function is to carry axial loads parallel to its longitudinal axis which can be combined with bending and shear

3.7
I section
steel joist or girder with short flanges shaped like a letter “I” whose main function is to carry loads transverse to its longitudinal axis

Note 1 to entry: These loads usually cause bending of the beam member. The flanges may be parallel or tapered.

3.8
passive fire protection material
materials, which do not change their physical form on heating, providing protection by virtue of their physical or thermal properties

Note 1 to entry: They may include materials containing water or undergo endothermic reactions which, on heating, produce cooling effects. These may take the form of sprayed coatings, renderings, mat products, boards, or slabs.

3.9
reactive fire protection material
materials which are specifically formulated to provide a chemical reaction upon heating such that their physical form changes and in so doing provide fire protection by thermal insulative and cooling effects

3.10
reference section
steel section which is taken from the same length of steel as its equivalent loaded section

3.11
section factor (unprotected steel)
ratio of the fire exposed perimeter area of the structural steel member, per unit length, A_m, to its cross sectional volume per unit length, V

3.12
section factor (profiled fire protection systems):
ratio of the fire-exposed outer perimeter area of the steel structural member excluding the protection material, per unit length, A_m, to its cross-sectional volume per unit length, V

3.13
section factor (boxed fire protection systems)
ratio of the internal surface area of the smallest possible rectangle or square box encasement which can be measured around the steel structural member, A_m, to its volume per unit length, V

3.14
steel member
element of building construction, which is load bearing and fabricated from steel

Note 1 to entry: For the purpose of this part of ISO 834, the steel used in the testing must be of the same type.

3.15
steel temperature
overall mean temperature to be used as input data for the analysis which is calculated as follows:

— For I and H section beams, this refers to the mean of the upper flange temperatures plus the mean temperature of the web plus the mean temperature of the lower flange, divided by three.

— For I, H, and hollow section columns, this refers to the sum of the mean temperature of each measuring station divided by the number of measuring stations.

— For hollow section beams, this refers to the mean temperature of the sides of the section plus the mean temperature of the bottom face, divided by two

3.16
stickability
ability of a fire protection system to remain sufficiently coherent and in position for a well-defined range of deformations, furnace, and steel temperatures, such that its ability to provide fire protection is not significantly impaired

3.17
test package
set of steel sections which may include short or long specimens that is tested to demonstrate adequate stickability of the fire protection system and to provide thermal data over a range of protection thickness, steel section factor, and steel temperatures

3.18
test specimen
steel section plus the fire protection system under test

Note 1 to entry: The steel test section, representative of a steel member for the purposes of this test, comprises long and short steel columns or beams.

4 Symbols and abbreviated terms

Symbol	Unit	Description
A	m^2	area
A_m	m^2	exposed perimeter area of the structural steel member, per unit length
A_p	m^2	for profile protection: exposed outer perimeter area of the structural steel member excluding the protection material, per unit length for encased protection: the internal surface area of the smallest possible rectangle or square box encasement which can be measured around the structural steel member
b	m	breadth of the steel section
d	mm	thickness
d_{aver}	mm	average thickness
d_p	mm	thickness of fire protection material
$d_{p(max)}$	mm	maximum thickness of fire protection material
$d_{p(min)}$	mm	minimum thickness of fire protection material
h	mm	depth of the steel section
K_d	-	range factor for thickness
K_s	-	range factor for section factor
L_{exp}	mm	length of beam section exposed to heating
L_{spec}	mm	total length of specimen
L_{sup}	mm	length of beam section between supports
P	m	perimeter of the steel section exposed to fire
s_p	m^{-1}	section factor at factor K_s
s_{max}	m^{-1}	maximum section factor at K_s factor of 1
s_{min}	m^{-1}	minimum section factor at K_s factor of 0
t_f	mm	thickness of the flange of the steel section
t_w	mm	thickness of the wall of the hollow steel section or web thickness of an I section or H column
V	m^3/m	volume of the steel section per unit length
V_p	m^3/m	volume of the fire protection per unit length
LB	–	loaded beam
LC	–	loaded 3m column section
TC	–	unloaded tall (2 m) column section
LHB	–	loaded hollow beam
LHC	–	loaded hollow column
SIB	–	short I section beam

Symbol	Unit	Description
SIC	–	short I section column
TCHS	–	tall circular hollow beam
TRHS	–	tall rectangular hollow beam
SHB	–	short hollow beam
SHC	–	short hollow column
RB	–	reference beam

5 Test equipment

5.1 General

The furnace and test equipment shall conform to what is specified in ISO 834-1.

5.2 Furnace

The furnace shall be designed to accommodate the dimensions of the test specimens to be exposed to heating as specified in 7.2 and their installation either upon or within the test furnace as specified in Clause 8.

5.3 Loading equipment

Loading shall be applied according to ISO 834-1. The loading system shall permit loading to be applied to beams as specified in 6.2.2 and to columns as specified in 6.2.4.

6 Test conditions

6.1 General

The procedures given in ISO 834-1 shall be followed in the performance of the test unless specific contrary instructions are given.

A number of steel members "I", "H", and hollow test sections, protected by the fire protection system, are heated in a furnace according to the protocol given in ISO 834-1.

Loaded beams and loaded columns are heated to provide information on the ability of the fire protection system to remain intact and adhere to the steel members (stickability). Unloaded beams and unloaded columns are heated to provide information on the thermal characteristics of the fire protection system.

It is recommended that the tests be continued until the steel temperature reaches the maximum value commensurate with the application of the data.

The method of testing loaded beams in this part of the test method is designed to provide maximum deflection (span/30) under the influence of load and heating as defined in ISO 834-1. If this is not possible, then the rate of deflection exceeds what is given in ISO 834-1.

Where several test specimens are tested simultaneously, care shall be taken that each be similarly exposed to the specified test conditions.

6.2 Support and loading conditions

6.2.1 General

Details of the calculations made to define the test loads shall be included in the test report.

6.2.2 Loaded beams

For each loaded beam test specimen, provision shall be made for the proper support, positioning, and alignment in the furnace in accordance with ISO 834-6, subject to any amended requirements of this part of ISO 834.

The beam shall not be provided with additional torsional restraint except where deemed necessary as in 7.2.1. The simply supported span (L_{sup}) shall not be greater than the length exposed to heating by more than 400 mm at each end. The length of the specimen (L_{spec}) shall be the exposed length plus up to a maximum 500 mm at each end.

The loaded beam test specimens shall be subjected to a total load, which represents 60 % of the design moment resistance, calculated using the actual yield strength from the batch test certificate of conformity or the actual measured value.

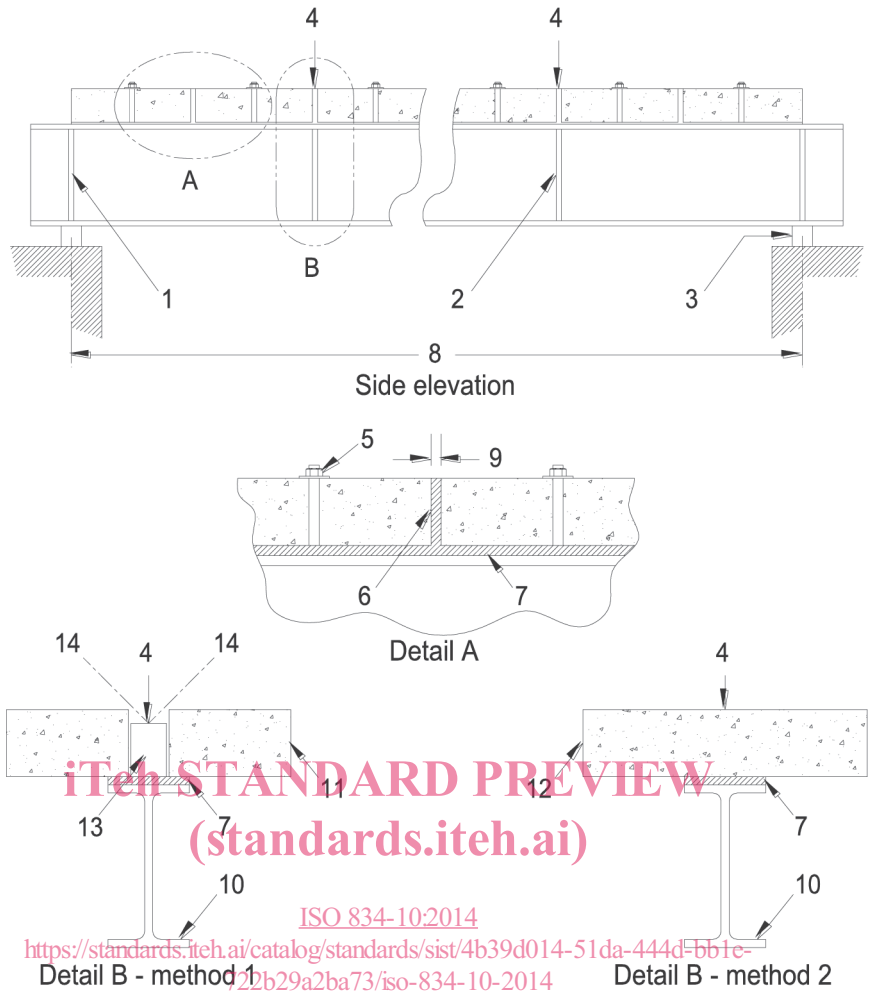
The actual load applied shall be the calculated total load less the dead weight of the beam, concrete topping, and fire protection system.

The method of loading shall be by a system which will produce a bending moment that is uniform over at least 20 % of the span of the beam around mid-span. The small increase in applied moment between jacks due to the cover slab may be ignored.

Loading shall be uniformly and symmetrically applied at two or more locations along its length.

The loading shall be applied using either of the two methods described in Figure 1.

The ends of loaded beams outside the furnace shall be insulated with a suitable insulation material.



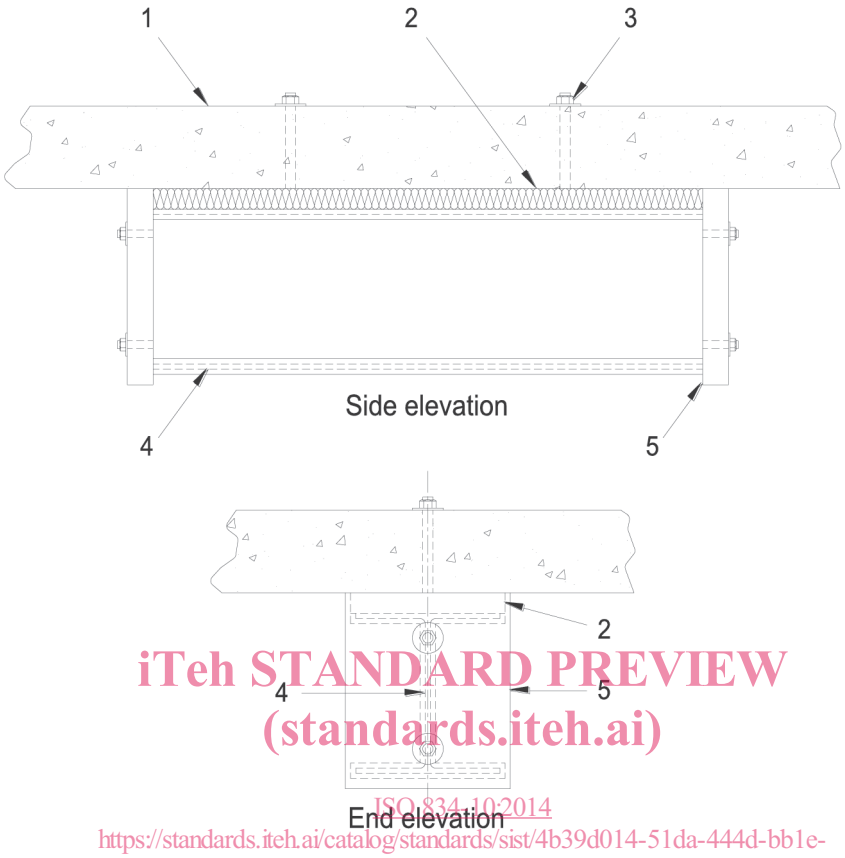
Key

A detail A - fixing of beam topping
B detail B – beam loading method 1 or 2
1 web stiffener at end bearing – I or H section
2 web stiffener at load points – I or H section
3 provide sufficient clearance to ensure furnace lining does not interfere with protection
4 load applied centrally to top of beam via load spacer 13 or to concrete slab 12
5 stud/plate/locking nut
6 fibre insulation or equivalent
7 compressible fibre insulation to width of beam (see 7.1)
8 span
9 gap to be sufficient to ensure beam is able to bend without being restricted by the slab
10 steel beam – I section shown, hollow beam similar
11 aerated concrete slab sections of nominal density 500 kg/m3 retained as in 7.1; nominal size of slabs 600 mm (±100 mm) width × 625 mm maximum length × 150 mm to 200 mm thick
12 lightweight concrete slab section of nominal density 1500 kg/m3 retained as in 7.1; nominal size of slabs as 11
13 load spacer
14 additional bracing to prevent rotation of beam if necessary

Figure 1 — Construction arrangement options for loaded beams

6.2.3 Unloaded beams

Each unloaded beam test specimen shall be supported as shown in Figure 2.



Key

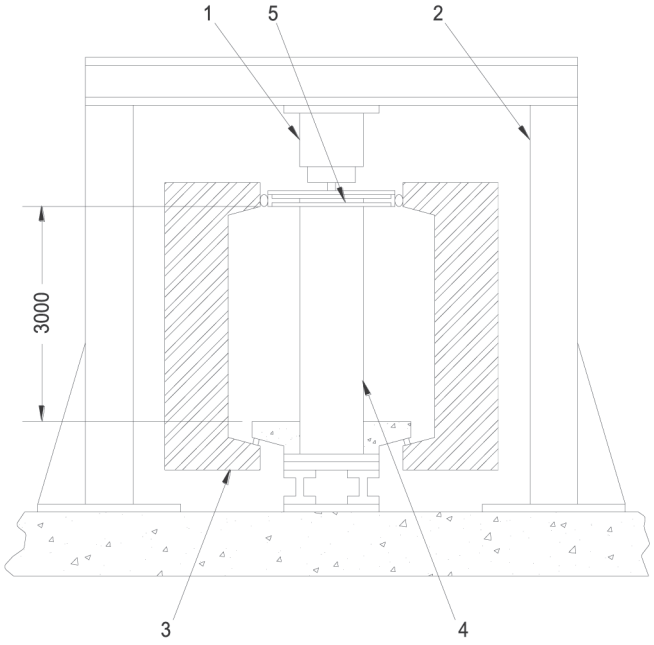
1 furnace cover
2 insulation board
3 stud/plate/locking nut
4 steel section
5 insulation board – end cap

Figure 2 — Support arrangement for unloaded beams

6.2.4 Loaded columns

For each loaded column, provision shall be made for the proper support, positioning, and alignment of the column test specimen in the furnace in accordance with ISO 834-7 subject to any amended or additional requirements of this part of ISO 834. An example of the test arrangement is given in Figure 3.

Dimensions in millimetres



Key

1 hydraulic jack
2 loading frame
3 furnace
4 loaded column
5 steel plate (only applies to reactive coatings)

Figure 3 — Loaded columns, example of general test arrangement

The loaded column shall be subjected to an applied test load which represents 60 % of the design buckling resistance calculated using the actual yield strength from the batch certificate of conformity or an actual measured value. Details of the calculation made to define the test load shall be included in the test report.

6.2.5 Unloaded columns

Unloaded column sections shall be supported vertically within the furnace; either installed to the soffit of the furnace cover slabs (see Figure 4) or stood directly on the furnace floor or on plinths (see Figure 5).