
**Fire-resistance tests — Elements of
building construction —**

**Part 14:
Requirements for the testing and
assessment of applied fire protection
to solid steel bar**

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Essais de résistance au feu — Éléments de construction —

*Partie 14: Exigences pour les essais et l'évaluation de la protection
contre l'incendie appliquée aux barres pleines en acier*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 2, *Fire containment*.

A list of all parts in the ISO 834 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In building construction, high strength solid steel bar is often used as hangars and ties for supporting other structural elements that are required to be fire resistant. As a result, these members are also required to provide the same level of fire performance which usually involves applying either passive or reactive fire protection materials to maintain their structural stability for a specified period of fire resistance.

Small scale tensile tests on loaded steel specimens and subjected to transient heating conditions representing typical heating rates in fire, have demonstrated that when tensile strains of around 1 % to 3 % are attained, the specimens enter the onset of 'runaway' whereby the strain rate accelerates resulting in failure within a further small rise in temperature. Similar strains are also experienced in the lower flange of protected steel floor beams at the limit of deflection (span/30) when tested in accordance with ISO 834-6 and in loaded column tests when specimens undergo thermal expansion with extensions approaching 1 % strain before the onset of structural instability.

A purpose of loaded fire resistance tests is to demonstrate the integrity (stickability) of the fire protection materials to the steel member. Since similar strains are experienced in tension members as experienced on beams and columns, the integrity performance of the fire protection on loaded beams and columns is considered to be representative of the ability of the fire protection materials to remain adhered to steel bars provided the methods of application/fixing are the same.

This document is therefore primarily concerned with the collection of thermal test data on unloaded protected solid steel bar from which an assessment is carried out to determine the thickness of the fire protection material to meet specific periods of fire resistance, or limiting temperature criteria for steel bar of different diameters or thicknesses. Research has shown that data on circular hollow sections cannot be used for determining the protection thickness for solid bar and therefore a separate test standard for unloaded solid sections is required.

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Fire-resistance tests — Elements of building construction —

Part 14:

Requirements for the testing and assessment of applied fire protection to solid steel bar

1 Scope

This document specifies a test and assessment method for determining the contribution of fire protection systems to the fire resistance of circular and rectangular solid steel bar. ISO 834-10 and ISO 834-11 cover other section shapes such as angles, channels and flats. This document is not intended to be used for twisted wire or for cold or hot rolled steel bar which is primarily used for the reinforcement of concrete.

This document is applicable for the protection of solid bar up to a maximum diameter of 130 mm and in the case of rectangular bar the maximum side length shall be limited to 130 mm with a maximum aspect ratio of 2:1 against the shorter length side. Beyond these limits, the solid steel bars are covered in ISO 834-10 and ISO 834-11.

This document is intended to be used with any applied fire protection system, including multi-layered systems, that have demonstrated their integrity/stickability when tested on floor beams and hollow sections under load, and assessed in accordance with ISO 834-11.

This document does not incorporate results from a loaded test on a tension member. Guidance for conducting a fire test on a steel bar under a tensile load is provided in [Annex C](#).

This document contains the fire test methodology 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. It also contains an assessment method for the analysis of the test data.

The limits of applicability of the results of the assessment arising from the fire test are defined together with permitted direct application of the results to different steel types and sizes over the range of thicknesses of the applied fire protection system tested.

The assessment procedure is used to establish:

- on the basis of temperature data derived from testing steel bars, any practical constraints on the use of the fire protection system under fire test conditions, (the physical performance);
- on the basis of the temperature data derived from testing steel bars, the thermal properties of the fire protection system, (the thermal performance).

The limits of applicability of the results of the assessment arising from the fire test are defined together with permitted direct application of the results to different steel types and sizes of steel bar over the range of thicknesses of the applied fire protection system tested.

This document describes testing in both the vertical and horizontal orientations at the discretion of the sponsor.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. 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 834-10, *Fire resistance tests — Elements of building construction — Part 10: Specific requirements to determine the contribution of applied fire protection materials to structural steel elements*

ISO 834-11, *Fire resistance tests — Elements of building construction — Part 11: Specific requirements for the assessment of fire protection to structural steel elements*

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

ISO 13943, *Fire safety — Vocabulary*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <http://www.electropedia.org/>

3.1
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 exposure to fire

3.2
fire protection system
fire protection material together with any supporting system including mesh reinforcement as tested

3.3
fire protection thickness
dry thickness of the fire protection system

Note 1 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.

3.4
maximum steel temperature
highest average temperature recorded at any measurement station

3.5
passive fire protection material
sprayed coatings or renderings formulated with ingredients enabling the retention of their physical form upon heating while providing insulation to the substrate

3.6
reactive fire protection material
reactive 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

3.7**section factor of the rectangular steel bar**

ratio of the fire exposed outer perimeter of the steel bar itself, per unit length, A_m to its cross sectional area per unit length

3.8**steel bar**

solid bar composed entirely of steel with a consistent cross-section without any re-entrant angle and excluding flat steel products

3.9**stickability**

ability of a fire protection material to remain in position for a defined range of deformations, furnace and steel temperatures, such that its ability of the material to provide fire protection is not significantly impaired

3.10**test specimen**

steel bar plus the fire protection system under test

4 Symbols and abbreviated terms

Symbol	Unit	Description
A_m	m ²	exposed perimeter area of the structural steel member, per unit length
D	mm	required diameter
D_{int}	mm	intermediate diameter
D_{min}	mm	minimum diameter
D_{max}	mm	maximum diameter
d	mm	thickness
d_{int}	mm	intermediate protection thickness
d_{max}	mm	maximum protection thickness
d_{min}	mm	minimum protection thickness
d_p	mm	interploated thickness of fire protection material for time t
d_{pw}	mm	interploated thickness of fire protection material for diameter D
s_p	mm	required dimension
s_{int}	mm	intermediate dimension
s_{max}	mm	maximum dimension
s_{min}	mm	minimum dimension
t	min	time from the commencement of the test
t_{min}	min	time to reach the specified temperature for the bar with the minimum protection thickness
t_{int}	min	time to reach the specified temperature for the bar with the intermediate protection thickness
t_{max}	min	time to reach the specified temperature for the bar with the maximum protection thickness
V	m ³ /m	volume of the steel section per unit length

5 Test equipment**5.1 General**

The furnace and test equipment shall conform to that 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 [9.2](#) and the installation of test specimens within the furnace as specified in [Clause 7](#).

5.3 Loading equipment

The test specimens are unloaded.

6 Test conditions

6.1 General

A number of short and long steel bars, protected by the fire protection system, are heated in a furnace according to the protocol given in ISO 834-1.

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

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

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

The testing of loaded and unloaded beams and/or columns in accordance with ISO 834-10 and ISO 834-11 provides the basis for the stickability correction at minimum and maximum protection thickness to be applied to the thermal data generated from the short steel bars.

The test sections shall be chosen to suit the scope of the assessment.

6.2 Support conditions

Unloaded steel bars shall be supported horizontally or vertically within the furnace such that they are allowed to expand unrestrained.

When the test specimens are supported vertically, the results are only applicable to members used in the vertical orientation. When specimens are tested in the horizontal plane, the results apply to members in any orientation.

6.3 Number of test specimens

There will be 9 bars with dimensions to suit the scope of the assessment. The principle of selecting the specimens shall be based on the details presented in [6.7](#).

6.4 Size of test specimens

The steel bars shall have a minimum exposed length of 1 000 mm.

6.5 Construction of steel test specimens

6.5.1 Protected steel bars

Where specimens are tested in the horizontal position they shall be supported on plinths on the floor, or suspended horizontally from the furnace roof.

NOTE [Figures A.1](#) and [A.2](#) illustrate how the specimens are suspended from the furnace roof.

Where specimens are supported horizontally, they shall be perpendicular to the roof within $\pm 10\%$ of the horizontal plane.

To minimize heat transfer to the ends of the steel bar, the support attachments shall be insulated, which at elevated temperatures, is capable of providing equivalent or greater insulation performance than that of the protection material provided over the length of the bar.

Where specimens are tested in the vertical plane, they shall be supported on plinths on the furnace floor.

6.5.2 Application of the fire protection material

The surface of the steel shall be prepared and the fire protection system shall be applied to the bars in a manner representative of practice and shall be substantially similar to that used in preparing test specimens in accordance with ISO 834-10.

6.6 Composition of test specimen component materials

6.6.1 Steel specification

The grade of steel used shall be any plain carbon hot finished or heat treated structural grade used in building construction with a minimum elongation of 20 % at ambient temperature. It shall not be cold worked.

The actual size of the steel bars shall be measured.

6.6.2 Fire protection materials

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6.6.2.1 General

The composition, expected nominal density and moisture content of the fire protection system shall be specified by the sponsor. The heat capacity of the fire protection system shall be specified by the sponsor when required for the assessment.

For reactive coatings, the dry film thickness of the coating shall be measured at the time of the test. The appropriate procedures and verification process are given in ISO 834-10:2014, Annex B.

For passive fire protection materials, the actual thickness, density and moisture content of the material shall be measured at the time of test for each specimen. The procedures appropriate to different types of fire protection material are given in ISO 834-10:2014, Annex A.

The dimension for preformed casings, boards and slabs shall be determined in accordance with national standards and be within the tolerances defined in these standards.

Similarly the thickness for spray applied materials shall be determined in accordance with national standards and be within the tolerances defined in these standards.

6.6.2.2 Thickness of applied fire protection material

The maximum thickness of the material shall not be greater than the thickness of the material as previously tested in accordance with ISO 834-10 either as a floor beam or a column on a steel member of either an open section or hollow section.

6.6.2.2.1 Preformed casings, slabs and boards

The thickness of the fire protection materials should not deviate by more than 15 % of the mean value over the whole of its surface. The mean value shall be used in the assessment of the results and in the limits of applicability of the assessment. If the thickness varies by more than 15 %, then the maximum thickness recorded shall be used in the assessment.

The mean shall be the mean of all measurements in accordance with ISO 834-10:2014, Annex A.

6.6.2.2.2 Spray passive coatings

The thickness of sprayed passive protection materials shall be measured at the locations specified in ISO 834-10:2014, Annex A.

The measurement shall be taken between 50 mm and 100 mm away from each thermocouple position.

The thickness of spray applied fire protection coatings should not deviate by more than 20 % of the mean value. The mean value shall be used in the assessment of the results and in the limits of applicability of the assessment. If it deviates by more than 20 % then the maximum thickness shall be used in the assessment.

6.6.2.2.3 Reactive coatings

For reactive fire protection materials, the average primer thickness shall be measured first and subtracted from the total average primer and reactive coating thickness. The resulting permitted thickness tolerances excluding primer and topcoat (assuming normal distribution of measured thickness) shall be as follows:

a) at the temperature measurement stations:

- A minimum of 68 % of readings shall be within ± 20 % of the mean.
- A minimum of 95 % of readings shall be within ± 30 % of the mean.
- All readings shall be within ± 45 % of the mean.

b) overall:

- A minimum of 68 % of readings shall be within ± 20 % of the mean at the temperature measurement stations.
- A minimum of 95 % of readings shall be within ± 30 % of the mean at the temperature measurement stations.
- All readings shall be within ± 45 % of the mean at the temperature measurement stations.

If the thickness is outside these limits the test specimens shall be adjusted to comply with above requirements.

In the case of reactive coatings where electrical measuring devices are used they shall be calibrated on a similar diameter curved surface.

6.6.2.3 Density of passive fire protection materials

The density of the fire protection material (where appropriate) applied shall be measured according to ISO 834-10:2014, Annex A and recorded.

At each thickness of fire protection material, the density of each should not deviate by more than 15 % of the mean value. The mean value shall be used in the assessment of the results and in the limits of applicability of the assessment. If it deviates by more than 15 % then the maximum density recorded shall be used.

6.6.2.4 Verification of the test specimen

An examination and verification of the test specimen for conformity to specification shall be carried out as described in ISO 834-1.