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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

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 adheared 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.

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 ±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

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.

The sponsor shall be responsible for verifying that the fire protection material has been applied correctly and in the case of sprayed or coated materials, to ensure, by methods appropriate to the material that it is of design composition and specification.

6.7 Selection of test specimens

6.7.1 Principle of selection

The intended scope of the assessment will determine the selection of the test specimens.

The minimum number of specimens is 9 bars representing a range of protection thicknesses and bar dimensions. The ranges shall include maximum, intermediate and minimum values for protection thickness and bar dimensions. Intermediate values shall be a close as possible to mid-range value between minimum and maximum.

The matrix given in Table 1 shall be followed, and the resulting assessment shall be multi-temperature as the critical temperature of bars will vary substantially according to the structural design.

Table 1 — Matrix of fire protection thickness required for a range of section factors

Steel bar dimension range	Protection thickness range		
	Minimum	Intermediate	Maximum
Minimum 0,0(S_{min})	✓	✓	✓
Intermediate 0,4 to 0,6(S_{int})	✓	✓	✓
Maximum 1,0(S_{max})	✓	✓	✓

The intermediate dimension (S_{int}) is subject to a tolerance of ±10 %.

The actual values of the range factor shall be derived from the Formulae (1) and (2).

For thickness:

$$d_p = K_d (d_{max} - d_{min}) + d_{min} \quad (1)$$

where

d_p is the thickness at factor K_d;

d_{max} is the maximum thickness at K_d factor of 1;

d_{min} is the minimum thickness at K_d factor of 0.

For dimension factor:

$$s_p = K_s (s_{max} - s_{min}) + s_{min} \quad (2)$$

where

s_p is the dimension factor at factor K_s;

s_{max} is the maximum dimension factor at K_s factor of 1;

s_{min} is the minimum dimension factor K_s factor of 0.

The dimension range shall be determined by the sponsor within the limits given in this document.

For circular bar, the diameter shall be used and for other shapes the section factor shall be used to define the dimension range.

A typical test package for circular bars is illustrated in Table 2.

Table 2 — Typical test package

Circular bar diameter mm	Rectangular bar section factor m^{-1}	Protection thickness
25	120	maximum
25	67	intermediate
25	33	minimum
63	120	maximum
63	67	intermediate
63	33	minimum
100	120	maximum
100	67	intermediate
100	33	minimum

Additional test specimens may be tested to increase the scope of the assessment by introducing further bars with different dimensions and protection thicknesses. However the principle of testing minimum, maximum and intermediate values larger or smaller shall be followed. Intermediate values shall be equally spaced as practicably possible between the minimum and maximum values.

7 Installation of the test specimens

7.1 Test specimen installation patterns

The bars shall be positioned within the furnace to ensure the bars are not shielded or affected by furnace walls, other test specimens and other obstacles. A minimum distance of separation of 300 mm in the horizontal plane is required.

7.2 Installation of the test specimens

The specimens may be installed vertically or horizonatlly in the furnace or plinths on the furnace floor. They may also be supported horizontally by suspending from the furnace roof as illustrated in the informative Figures A.1 and A.2.

The ends of the bar shall be insulated with a material and appropriate thickness capable of providing equivalent or greater insulation than that of the fire protection material provided over the length of the bar.

7.3 Furnace load

In order to ensure that the specified furnace temperature/time relationship is complied with it may be necessary to control the amount of steel bars within the furnace and their location.

For example a typical furnace of size 4 m by 3 m by about 2 m deep can accommodate up to 45 kg of steel bars per m^3 of furnace volume without adverse effect.

8 Conditioning of the test specimens

All test specimens, their components and any test samples taken for determination of material properties shall be conditioned in accordance with ISO 834-1, or for a period specified by the manufacturer for adequate curing.

9 Application of instrumentation

9.1 General

The instrumentation for measurement of temperature, furnace pressure, shall comply with the requirements of ISO 834-1.

9.2 Instrumentation for measurement and control of furnace temperature

9.2.1 General

Plate thermometers, of the type specified in ISO 834-1, shall be provided to measure and control the temperature of the furnace and shall be uniformly distributed, to give a reliable indication of the temperature in the region of the test specimens. They shall not be placed in positions where they are unable to measure the furnace temperature correctly because they are obstructed by test specimens.

9.2.2 Furnace temperature in the region of test specimens

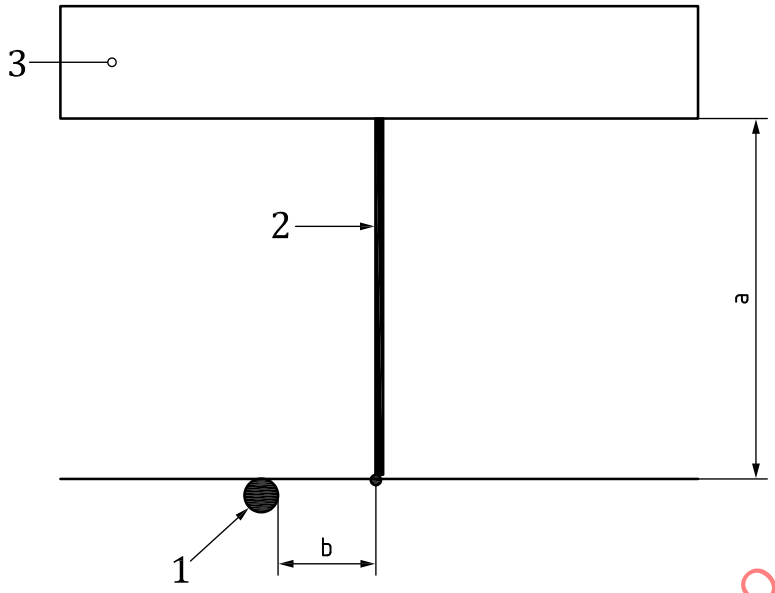
In the case where 9 bars are tested horizontally at the same time the furnace temperature shall be measured by 8 plate thermometers evenly distributed over a plane area that encloses all bars, e.g. if the bars are contained within an area of 4 m by 3 m or 12 m^2 a plate thermometer shall be placed within each 1,5 m^2 of this area.

In the case where 9 bars are tested vertically at the same time the furnace temperature shall be measured by 4 plate thermometers evenly distributed over a plane area that encloses all bars, e.g. if the bars are contained within an area of 2 m by 2 m or 4 m^2 a plate thermometer shall be placed within each 1,0 m^2 of this area.

In the case of isolated bars the furnace temperature shall be measured by 1 plate thermometer located on each side of the bar, i.e. 2 per bar.

For horizontal specimens suspended from the furnace roof, the plate thermometers shall be positioned at a distance of 100 mm from the bar and 500 mm from the furnace roof slab (see Figure 1).

The plate thermometers shall be positioned such that there are equal numbers where side 'A' faces a side wall of the furnace and the floor of the furnace. Figure 1 shows a typical arrangement of plate thermometers for horizontal bars.



Key

1 bars
2 plate thermometer support with plate located opposite the centre of the bar
3 furnace roof slab
a 500 mm.
b 100 mm.

Figure 1 — Location of plate thermometers — Vertical cross-section of furnace

9.2.3 Instrumentation for the measurement of steel temperatures

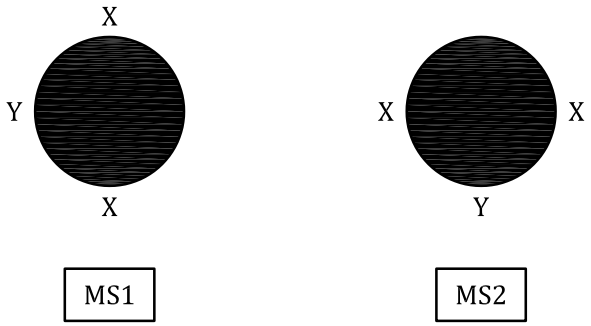
Thermocouples for measurement and recording of steel temperatures shall be of the type, fixing method and location as given in ISO 834-10.

There shall be 2 measurement stations and the thermocouples shall be positioned at 1/3 and 2/3 (333 mm and 667 mm from 1 end) along the exposed length of each bar. The thermocouples shall be attached to the steel surface and may be installed after the application of a reactive coating by peening into the surface of the rods.

Table 3 — Number of thermocouples

Bar diameter or length of shorter side	Number of thermocouples at each station	Total number of thermocouples
≥80 mm	3	6
<80 mm	2	4

A test sponsor may elect to add additional thermocouples to a test specimen. Any additional thermocouples shall be added in a way that does not prevent the specimen complying with this clause and Figure 2 or the specimen results will be invalid.



Key

MS1 measurement station 1 at 0,333 m along bar
MS2 measurement station 2 at 0,666 m along bar
X thermocouple positions for bars <80 mm
X, Y thermocouple positions for bars ≥80 mm

Figure 2 — Locations of thermocouples for different bar diameters

9.3 Instrumentation for the measurement of pressure

Equipment for measuring pressure within the furnace shall be provided, located and used as specified in ISO 834-1.

10 Test procedure

10.1 General

Assemble the required number of unloaded steel bars forming the testing package appropriate to the scope of the assessment as detailed in 6.7.1.

Carry out checks for thermocouple consistency and establish data points for temperature as specified in ISO 834-1 before commencement of the test and the procedures defined in 10.2 to 10.7.

10.2 Furnace temperature and pressure

Control the furnace and measure and record the furnace temperature in the region of the test specimens using the plate thermometers defined in 9.2.1 and the furnace pressure in accordance with ISO 834-1. The plate thermometers as specified in 9.2.2 will be used to control the furnace to the criteria of ISO 834-1.

The location of plate thermometers to be used to control the furnace temperature is dependent upon the specimens incorporated within the furnace (see 9.2.2).

10.3 Steelwork temperature

Measure and record the temperature of the steel bars using the thermocouples attached to the steelwork as specified in 9.2.3 at intervals not exceeding 1 min.

10.4 Observations

Monitor the general behaviour of each of the specimens throughout the test and record the occurrence of cracking, fissuring, delamination or detachment of the fire protection material and similar phenomena as described in ISO 834-1.

10.5 Termination of test

All tests should provide thermal data up to the maximum temperature required for the scope of the assessment.

The duration of the test is subject to agreement between the manufacturer and the test laboratory.

11 Test results

11.1 Acceptability of test results

It is possible that within any test package apparently erroneous results may occur through failure of thermocouples, abnormal behaviour of the fire protection, incorrect assembly of the test specimen etc. If any results are to be disregarded, i.e. become invalid. The laboratory, in consultation with the sponsor, shall justify this and apply the following rules:

a) At least 1 valid thermocouple per measuring station (and minimum of 50 % of the original number of thermocouples) shall be valid.

11.2 Presentation of test results

The test report shall include the following statement:

"This report provides the constructional details, the test conditions, the results obtained when the specified fire protection system described herein was tested following the procedures of ISO 834-14. Any deviation with respect to thickness of fire protection material and constructional details, other than those allowed under the field of application could invalidate the test result".

In addition to the items required by ISO 834-1 the following shall also be included in the test report:

a) the generic description and accurate details of the fire protection system;

b) full details of the test specimens including fixing methods and application methods appropriate to the protection material;

c) description of the fabrication of the test construction. Description of the conditioning of the test construction and its installation onto the test furnace;

d) the results of measured dimensions especially the thickness of the fire protection together with those values to be used in the assessment, e.g. section factor;

e) individual furnace temperature and pressure measurements and the mean of all individual furnace temperature and pressure measurements, taken as specified in ISO 834-1, graphically presented and compared with the specified requirements and tolerances given in ISO 834-1;

f) observations made and times at which they occur shall be reported;

g) individual temperature measurements and the maximum average temperature of the two measuring stations of each test specimen as defined in 3.4.

These results may be presented as a selection of the measured data sufficient to give a history of the performance of the test specimen according to ISO 834-1.

These results may also be prepared and printed in tabular form and/or presented on computer media. In the latter case this should be prepared in an appropriate, secure "read only" format to prevent alteration. Only data maintained in the laboratory files shall be used in the assessment.

12 Assessment

12.1 General

The temperature data obtained from the unloaded bars are used as a basis for relating the time to reach a specified steel temperature, the thickness of fire protection material and the bar dimensions.

12.2 Assessment procedure for thermal performance

Assessment of thermal performance shall be carried out as follows:

a) Use the temperatures measured at the measuring points indicated in 9.2.3 and in Figure 2 as the input to start the thermal performance analysis.

b) For each steel bar test specimen, determine the highest average temperature recorded at any measuring station as defined in 3.4 as a function of the heating time.

c) For each steel bar test specimen, determine the time to reach a specified temperature of interest, e.g. 350 °C, 400 °C, 450 °C, 500 °C, 550 °C, 600 °C, 650 °C and 700 °C.

d) Use the temperature dependent factors for stickability, obtained from loaded beam and/or loaded column tests to ISO 834-10 and analysis to ISO 834-11.

e) For each steel bar test specimen, multiply the time to reach the specified temperature of interest with the correction factor for stickability, obtained from the loaded beam and/or loaded column stickability analysis to ISO 834-11.

f) Use the corrected times as input for the analysis of thermal performance of the solid steel bars.

g) The assessment of thermal performance of the solid steel bar test specimens protected with fire protection materials, shall be performed in accordance with the linear interpolation method presented in Annex B of this document.

13 Assesment report

The assessment report shall include the following:

a) the name/address of the body providing the assessment and the date it was carried out. Reference to the name/address of the test laboratory, the unique test reference number and report number(s);

b) the name(s) and address(es) of the sponsor(s). The name of the manufacturer of the product or products and the manufacturer or manufacturers of the construction;

c) the generic description of the product or products, particularly the fire protection system and any component parts (where known). If unknown this shall be stated;

d) general description of the test specimens forming the basis of the assessment including the dimensions of the test specimens;

e) reason for the omission of any test data;

f) the composition and measured properties, of test specimen components required to be determined from 6.6;

g) the thermal analysis shall produce a table of protection thicknesses for each design temperature, fire performance period and section factor. An example of the presentation of such tabulated information is given in Table 4;

h) a statement regarding the limits of direct application of the assessment procedure.

Table 4 — Example of tabulated data for circular bars

Fire performance period — 30 min								
Specifiedtemperature °C	350	400	450	500	550	600	650	700
Bar diameter mm	Thickness of fire protection material to maintain steel temperature below specified temperature							
20								
30								
40								
50								
60								
70								
80								
90								
100								
110								
120								
130								
140								
150								
160								
170								
180[a]								

[a] Temperature range and diameter range for illustration only; actual range to be determined by the scope of the assessment.

14 Limits of the applicability of the results of the assessment

The results from this test method and the assessment procedure are applicable to fire protection systems over the range of fire protection thicknesses tested in this document and in any case no greater than those tested in ISO 834-10 and to the limits of applicability assessed in ISO 834-11.

The maximum temperatures established during the test shall be no greater than the range established in ISO 834-10.

The fire protection period resulting from the test and assessment is limited to the maximum period of testing or some shorter period for which the sponsor requires approval.

Results from bar tested horizontally may be applied to any orientation, whilst results from vertically tested bar shall only relate to that orientation.

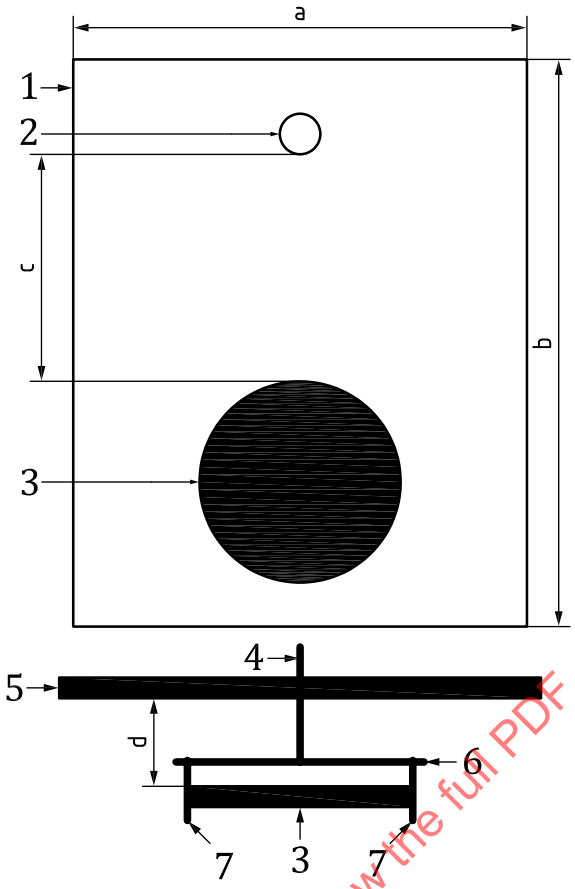
The results of the assessment for circular bar and rectangular bar may not be applied to other shapes.

Annex A
(informative)

Support to specimens suspended from the furnace roof

A.1 Support to specimens

Where the solid bar is supported from the furnace roof, Figures A.1 and A.2 provide guidance in how this may be achieved.



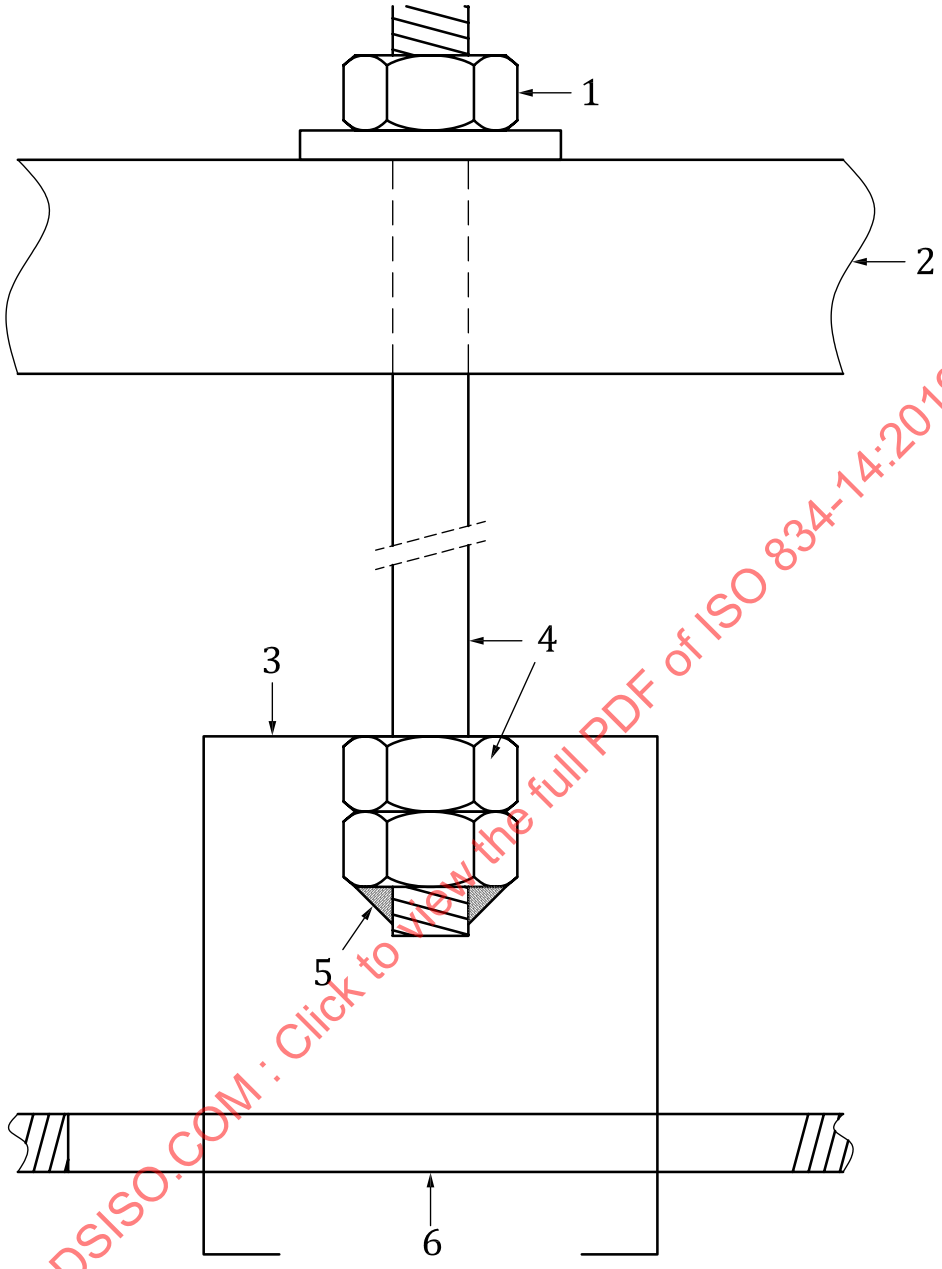
Key

1 steel plate
2 hole of 18 mm diameter
3 test piece
4 M20mm threaded bar
5 furnace roof
6 M15 mm diameter bar passing through end plates with threaded endsto attach retaining nuts
7 end plates
a Minimum 150 mm.
b Minimum 250 mm.
c Minimum 100 mm.
d 500 mm.

NOTE 1 Plates would be welded (or otherwise attached) to both ends of each test piece with the holes aligned. After application, a single 15 mm diameter bar approximately 100 mm longer than the test piece and with threaded ends is passed through the holes from the inside of the plates, and then held in place by retaining nuts. End plate to be minimum 8 mm thick.

NOTE 2 Not to scale.

Figure A.1 — Mounting of specimen from the furnace roof



Key

1 nut and plate secured on top of furnace slab
2 furnace cover slab
3 100 mm × 200 mm × 10 mm hollow section 100 mm deep
4 M20 diameter bar with double nut secured with weld
5 weld
6 M15 diameter bar spanning between end plates

Figure A.2 — Connection between solid bar and the hangar from the furnace roof

Annex B
(normative)

Linear interpolation and extension analysis

B.1 General

The linear interpolation analysis shall be conducted in accordance with the following steps.

B.1.1 Step 1 — Input data

B.1.1.1 The input data shall consist of the following:

The specified temperatures as defined in Table 4.

The corrected time for the maximum average temperature of each bar to reach the specified temperatures. (See 12.2).

The diameter of circular bars or the section factor for rectangular bars.

The average protection mean thickness of the fire protection. (See 6.6.2.2.1, 6.6.2.2.2 and 6.6.2.2.3).

B.1.2 Step 2 — Determine time of maximum average temperatures

B.1.2.1 Determine the time when the maximum average temperature [see 11.2 g)] of each bar is reached for each specified temperature and protection thickness band. The average protection thickness is calculated as the average of the mean protection thickness of each individual bar in each nominal thickness band (see 6.7.1).

An example of the required data for a test matrix for round bars is given in Table B.1.

Table B.1 — Time to reach specified temperature

Specified temperature 550 °C		Bar diameter (mm)		
		minimum	intermediate	maximum
		25	75	130
Protection thickness band	mm	Time for bar to reach specified temperature (min)		
Minimum	2,045	41,8	49,3	58
Intermediate	4,100	77,3	96,9	112,9
Maximum	5,900 0	98,7	123,4	143,8

B.1.3 Step 3 — Determine protection thicknesses for specified temperature and rating period

For each section factor or diameter determine, by linear interpolation, the protection thickness for each of the specified temperatures and fire performance periods using Formula (B.1).