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**Preskusne metode za ugotavljanje prispevka k požarni odpornosti konstrukcijskih elementov - 10. del: Ukrepi za zaščito napetih polnih jeklenih palic**

Test methods for determining the contribution to the fire resistance of structural members - Part 10: Applied protection to solid steel bars in tension

Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden Bauteilen - Teil 10: Brandschutzmaßnahmen für Stahl-Vollstäbe unter Zugbeanspruchung

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 10 : Protection appliquée aux barres d'acier pleines précontraintes (tirants)

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## Test methods for determining the contribution to the fire resistance of structural members - Part 10: Applied protection to solid steel bars in tension

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 10 : Protection appliquée aux barres d'acier pleines précontraintes (tirants)

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This European Standard was approved by CEN on 14 March 2020.

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**EN 13381-10:2020 (E)****European foreword**

This document (EN 13381-10:2020) has been prepared by Technical Committee CEN/TC 127 “Fire safety in buildings”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2020, and conflicting national standards shall be withdrawn at the latest by November 2020.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document is complementary and supportive to EN 13381-4 and EN 13381-8.

It is one of a series of standards for evaluating the contribution to the fire resistance of structural members by applied fire protection materials. Other parts of this series are:

- *Part 1: Horizontal protective members*
- *Part 2: Vertical protective members*
- *Part 3: Applied protection to concrete members*
- *Part 4: Applied passive protection to steel members*
- *Part 5: Applied protection to concrete/profile sheet steel and composite members*
- *Part 6: Applied protection to concrete filled hollow steel columns*
- *Part 7: Applied protection to timber members*
- *Part 8: Applied reactive protection to steel members*
- *Part 9: Applied fire protection systems to steel beams with web openings*

All the above Standards were prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association. However, whilst this European Standard is complimentary and supportive to EN 13381-4 and EN 13381-8, it falls outside of the scope of that standardization request and its results cannot be used as a basis of any European Classification for Resistance to Fire. It does, however, provide a valuable common basis for the fire protection industry to evaluate products and for national authorities to determine a product’s suitability to provide an appropriate level of fire protection to steel members in tension.

Attention is drawn to the A-deviation, in accordance with Annex E of the CEN/CENELEC Internal Regulations Part 2:2017, granted to DIN by virtue of the evidence presented in Annex D that indicates the existence of a conflicting national methodology supporting existing regulatory requirements in Germany.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

## Introduction

The evaluation of a product's capability to provide fire protection performance to I or H section, or hollow section, columns and beams is undertaken by test and assessment procedures detailed in EN 13381-4 for passive (non-reactive) fire protection products and in EN 13381-8 for reactive (intumescent) fire protection products.

The scopes of both the above standards specifically exclude the evaluation of solid bars used as tension members. This document, therefore, provides supplementary test and assessment procedures to those given in EN 13381-4 and EN 13381-8 to extend a product's scope of application to cover solid circular or rectangular bars used as tension members. It is equally applicable to passive and reactive fire protection products.

The evaluation represents an assessment of a product's fire insulation performance across a range of solid circular and/or rectangular cross section bars on the basis of tests on unloaded specimens and where appropriate loaded specimens. At the point of failure the strain generated on the bottom flange of a loaded beam during testing to EN 13381-4 or EN 13381-8 is greater than that produced in circular or rectangular bars in tension. Also, the strain generated during loaded column testing is similar to that generated in circular or rectangular bars in tension.

In addition, recent testing of loaded and unloaded bars protected with reactive coatings has shown that the benefit of a loaded test is very much dependant on product thickness; increased thickness of product reduces the difference between loaded and unloaded testing. A minimum generic thickness cannot be specified, however, as this is product dependent. Within EN 13381-8, product stickability is determined from loaded beam and/or loaded column testing at intended maximum product thickness. Therefore, where the scope of testing in this document uses lower thicknesses, then loaded testing in accordance with Annex B should be carried out.

In all cases, the maximum protection thickness tested on unloaded bars should not be greater than the maximum from loaded beams, columns or hollow columns tested to EN 13381-4 for passive fire protection products or tested to EN 13381-8 for reactive fire protection products. If higher thicknesses are required to provide any level of fire protection performance, then this should be validated on the basis of testing loaded bars in accordance with Annex B of this document.

For passive fire protection products, similar loaded tests are only required when the system fixing details to a tension member are not considered to fairly represent those used in the products EN 13381-4 evaluation.

An appropriate supplementary loaded test is, therefore, included in this document as a Normative Annex B to be applied only when required as detailed above.

**Caution:** The attention of all persons concerned with managing and carrying out this fire resistance test, is drawn to the fact that fire testing can be hazardous and that there is a possibility that toxic and/or harmful smoke and gases can be evolved during the test. Mechanical and operational hazards can also arise during the construction of test elements or structures, their testing and the disposal of test residues.

An assessment of all potential hazards and risks to health should be made and safety precautions should be identified and provided. Written safety instructions should be issued with the manufacturer's health and safety product data sheet.

Appropriate training should be given to relevant personnel. Laboratory personnel should ensure that they follow written safety instructions at all times.

The specific health and safety instructions contained within this document should be followed.

**EN 13381-10:2020 (E)****1 Scope**

This document specifies a fire test method and an assessment procedure for determining the contribution of fire protection systems to the fire resistance performance of circular and rectangular steel bars used as tension members.

This document applies to fire protection materials that have already been tested and assessed in accordance with EN 13381-4 or EN 13381-8.

For other section shapes such as angles, channels and flats, reference can be made to EN 13381-4 and EN 13381-8. This document does not include steel or any other cold formed bar used as reinforcement in concrete construction.

For other solid bar geometries such as oval or triangular cross section, these are subject to a separate test package in accordance with the principles of Clause 5 of this document.

Fire protection performance is determined by testing of unloaded tension members, although additional loaded test evidence can be required for certain product types subject to certain conditions specified in the document.

The method is applicable to all fire protection systems used for the protection of solid bar up to a maximum diameter of 130 mm and includes sprayed fire protection, reactive coatings, cladding protection systems and multi-layer or composite fire protection materials. In the case of rectangular bar, the maximum side length is limited to 130 mm with a maximum aspect ratio of 2:1 against the shorter side length. For dimensions greater than 130 mm it is appropriate to use rectangular or circular hollow sections tested and assessed in accordance with EN 13381-4 and EN 13381-8 provided they have been tested in the same orientation.

The evaluation is designed to cover a range of thicknesses of the applied fire protection material, a range of steel bar dimensions, a range of specified temperatures and a range of valid fire protection periods.

The test method is applicable to fire protection systems which are intimately in contact with the bar, or which include an airspace between the bar and the protection system as given in EN 13381-4.

This document also provides the assessment procedure, which prescribes the analysis of the test data and gives guidance on the procedures to undertake interpolation.

This document caters for testing in both vertical and horizontal orientations. Results from horizontally orientated bar can be applied to any orientation, whilst results from vertically orientated bar are only used for horizontal bars when the data has been corrected in accordance with Annex C.

This document gives the fire test procedures, carried out to provide data on the thermal characteristics of the fire protection system, when exposed to the standard temperature/time curve specified in EN 1363-1.

The assessment procedure is used to establish:

- a) on the basis of data derived from testing steel bar, any practical constraints on the use of the fire protection system under fire test conditions (the physical performance);
- b) on the basis of the temperature data derived from testing steel bar 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 application of the results to different steel types and sizes over the range of thicknesses of the applied fire protection system tested.



## 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.

EN 1363-1, *Fire resistance tests - Part 1: General requirements*

EN 10025 (all parts), *Hot rolled products of structural steels*

EN 13381-4, *Test methods for determining the contribution to the fire resistance of structural members - Part 4: Applied passive protection to steel members*

EN 13381-8, *Test methods for determining the contribution to the fire resistance of structural members - Part 8: Applied reactive protection to steel members*

EN ISO 13943, *Fire safety - Vocabulary (ISO 13943)*

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

## 3 Terms and definitions, symbols and units

### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1363-1, EN ISO 13943 and ISO 8421-2, 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/>

#### 3.1.1

##### **steel bar**

circular or rectangular solid bar composed entirely of steel with a consistent cross sectional size throughout its length

#### 3.1.2

##### **reactive fire protection material**

reactive material which is specifically formulated to provide a chemical reaction upon heating such that its physical form changes and in so doing provides fire protection by thermal insulative and cooling effect

#### 3.1.3

##### **passive fire protection material**

material which does not change its physical form on heating, providing protection by virtue of its physical or thermal properties

Note 1 to entry: They may include materials containing water which, on heating evaporates to produce cooling effects.

#### 3.1.4

##### **fire protection system**

fire protection material together with any supporting system including mesh reinforcement and a specified primer and top coat if applicable

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## 3.1.5

**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

## 3.1.6

**test specimen**

steel bar plus the fire protection system under test

## 3.1.7

**fire protection thickness**

thickness of a single layer fire protection system; or combined thickness of all layers of a multilayer fire protection system; or mean dry film thickness of the fire protection coating excluding primer and top coat

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

## 3.1.8

**stickability**

ability of a fire protection material 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

## 3.1.9

**maximum steel temperature**

highest average temperature recorded at any measurement station

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## 3.1.10

**section factor**

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

## 3.2 Symbols and units

Symbol	Unit	Description
$d_{int}$	mm	intermediate protection thickness
$d_{max}$	mm	maximum protection thickness
$d_{min}$	mm	minimum protection thickness
$d_p$	mm	interpolated thickness of fire protection material for a fire performance period $t$
$t$	min	fire performance period
$t_{int}$	min	time for bar with the intermediate protection thickness to reach the required temperature
$t_{max}$	min	time for bar with the maximum protection thickness to reach the required temperature
$t_{min}$	min	time for bar with the minimum protection thickness to reach the required temperature
$S_p$	mm	required dimension

Symbol	Unit	Description
$S_{int}$	mm	intermediate dimension
$S_{max}$	mm	maximum dimension
$S_{min}$	mm	minimum dimension
$K_d$		protection thickness range factor
$K_s$		dimension range factor
$D$	mm	bar diameter
$D_{min}$	mm	minimum bar diameter
$D_{max}$	mm	maximum bar diameter
$D_{int}$	mm	intermediate bar diameter

## 4 Test equipment

### 4.1 General

The furnace and test equipment shall conform to that specified in EN 1363-1 where appropriate.

### 4.2 Furnace

The furnace shall permit the dimensions of the test specimens, their installation within the test furnace and their exposure to heating to be as specified in EN 1363-1.

## 5 Test procedures

### 5.1 General

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A number of steel bars, protected by the fire protection system, are heated in a furnace according to the protocol given in EN 1363-1.

The tests shall 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 EN 1363-1 shall be followed in the performance of this test unless specific contrary instructions are given in this document.

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

### 5.2 Support conditions

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

### 5.3 Number of test specimens

For unloaded tests, there shall 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 5.7. For loaded testing, there shall be one loaded and one unloaded bar.

**EN 13381-10:2020 (E)****5.4 Size of test specimens**

The steel bars for unloaded testing shall have a minimum exposed length of 1 000 mm. Steel bars tested under load shall have an exposed length of 2 000 mm.

**5.5 Construction of steel test specimens****5.5.1 Steel specification**

The grade of steel used shall be any structural grade (S designation except S185) according to the EN 10025 series.

The actual dimensions of the steel bar shall be measured.

**5.5.2 Surface treatment and 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 in accordance with the manufacturer's recommendations.

**5.6 Composition of fire protection materials****5.6.1 General**

The composition, dimensions, verification and properties of the fire protection materials shall be determined in accordance with the requirements of EN 13381-4 or EN 13381-8.

**5.6.2 Thickness of applied reactive protection materials**

A minimum number of 20 measurements shall be taken on each bar spread over the measuring stations indicated in Figure 2 to determine the average fire protection thickness and applying the tolerances given in EN 13381-4 and EN 13381-8.

In the case of reactive coatings where electrical measuring devices are used to determine the coating thickness, they shall be calibrated on a similar diameter curved surface, or any other method agreed with the test laboratory.

**5.7 Selection of test specimens**

The intended scope of the assessment will determine the selection of the test specimens. The matrix given in Table 1 shall be followed.

The minimum number of unloaded specimens shall be 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 as close as possible to mid-range value between minimum and maximum.

For loaded testing in accordance with Annex B, the short 1 000 mm and the long 2 000 mm bars shall be protected with the maximum required thickness of fire protection.

If the test specimens are tested in the horizontal orientation, then the data can be used for both vertical and horizontal orientated bars. If the test package is tested in the vertical orientation, then a comparison test shall be carried out in the vertical and horizontal orientation using the maximum thickness on minimum diameter or maximum section factor bar. The resulting K correction factor shall then be applied to the vertical data when used for horizontally orientated bars.

For circular bar, the diameter shall be used and for rectangular bar, the section factor shall be used to define the dimension range. Typical test packages are illustrated in Tables 2 and 3.