# SLOVENSKI STANDARD
# SIST EN 13381-11:2026

**01-junij-2026**

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**Preskusne metode za ugotavljanje prispevka k požarni odpornosti konstrukcijskih elementov - 11. del: Reaktivna zaščita trdnih jeklenih palic v napetosti na podlagi požarnih preskusov z mehansko obremenitvijo**

Test methods for determining the contribution to the fire resistance of structural members - Part 11: Applied reactive protection to solid steel bars in tension based on mechanically loaded fire tests

Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden Bauteilen - Teil 11: Brandschutzmaßnahmen für Stahl-Vollstäbe unter Zugbeanspruchung basierend auf einer Brandprüfung unter mechanischer Belastung

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 11: Protection réactive appliquée aux barres d'acier pleines précontraintes (tirants) basé sur des essais de feu soumis à des contraintes mécaniques

**Ta slovenski standard je istoveten z:** **EN 13381-11:2026**

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**ICS:**

| | | |
|---|---|---|
| 13.220.50 | Požarna odpornost gradbenih materialov in elementov | Fire-resistance of building materials and elements |
| 91.080.13 | Jeklene konstrukcije | Steel structures |

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN 13381-11

April 2026

ICS 13.220.50

English Version

# Test methods for determining the contribution to the fire resistance of structural members - Part 11: Applied reactive protection to solid steel bars in tension based on mechanically loaded fire tests

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 11: Protection réactive appliquée aux barres d'acier pleines précontraintes (tirants) basé sur des essais de feu soumis à des contraintes mécaniques

Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden Bauteilen - Teil 11: Brandschutzmaßnahmen für Stahl-Vollstäbe unter Zugbeanspruchung basierend auf einer Brandprüfung unter mechanischer Belastung

This European Standard was approved by CEN on 13 March 2026.

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## European foreword

This document (EN 13381-11:2026) has been prepared by Working Group 1 ‘Structural and separating elements’ under 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 October 2026, and conflicting national standards shall be withdrawn at the latest by October 2026.

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 has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

This document 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 membranes.

— Part 2: Vertical protective membranes.

— Part 3: Applied protection to concrete members.

— Part 4: Applied passive protection to steel members.

— Part 5: Applied protection to concrete/profiled sheet steel 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.

— Part 10: Applied protection to solid steel bar in tension.

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# Introduction

The evaluation of a system's capability to provide fire protection performance to beams and/or columns with I- or H-section as well as hollow section is undertaken by test and assessment procedures detailed in EN 13381-8 for reactive (intumescent) fire protection systems. The scope of the above standard excludes the assessment of solid steel bars used as tension bars.

In general, it is not possible to use the results of fire protection systems tested according to EN 13381-8 on beams or columns with open or closed profile to steel tension bars with solid section. This has several reasons:

a) the profiles used for steel bars are usually much slenderer than the profiles used for beams or columns. Consequently, to achieve the same fire resistance usually higher dry film thicknesses of the reactive fire protection system are required;

b) due to the different profile shape, there is an altered foaming and cracking behaviour of reactive fire protection systems. On the predominantly flat surfaces of a beam with open profile, reactive fire protection systems behave differently than on highly convex curved surface of steel bars with circular solid section;

c) because the tensile stresses in a steel bar are equal along the entire bar length and within the cross-section, the failure occurs at the position, where the highest steel temperature is present. Therefore, tensile bars are vulnerable to local defects, e.g. cracks or ununiform foam thicknesses of reactive fire protection systems. Furthermore, beams have the possibility of cross-sectional plasticisation. Due to the resulting stress redistribution and the activation of additional load capacity reserves, in fire tests beams suffer lower strains compared to a bar in pure tension. This is also clear from the fact that the tests of a steel bar usually end with the breakage. In mechanically loaded beam tests such a high strain is usually not achieved;

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d) columns are not suitable for a comparison with steel bars, because the cross-sections are much bigger as well as the thermal and mechanical strains are acting in opposite direction;

e) in contrast to beams, which are generally used in a horizontal position, steel bars are used in different orientations. This can influence the thermal protection performance of the reactive fire protection system.

For reactive fire protection systems that have already been successfully tested and assessed according to EN 13381-8, the test standard EN 13381-10 offers under certain conditions the possibility to extend the scope of application to steel tension bars with solid sections. The fire tests in EN 13381-10 are based upon unloaded specimens. Because this approach contradicts to the German national safety level, where the fire resistance of structural members need to be tested under mechanical load, an A-Deviation was granted, meaning that it is not possible to apply EN 13381-10 in Germany. In addition, recent research and testing on loaded and unloaded steel bars protected with reactive fire protection coatings has shown the need for mechanically loaded fire testing.

This document provides a test and assessment procedure to cover a reactive fire protection system's scope of application to solid circular or rectangular steel bars used as tension bars based on mechanically loaded fire tests. This document is a stand-alone test standard and does not require a successful completion of the test procedure according to EN 13381-8. This document has been created to cover a testing and assessment procedure based primarily upon mechanically loaded fire tests. Across a range of solid circular and/or rectangular bars fire tests on mechanically loaded specimens are carried out. Unloaded specimens may be used to assess additional aspects, such as the influence of the bar orientation as well as smouldering fire behaviour. The assessment procedure described in this document aims to determine the reactive fire protection system's thermal protection performance.



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# 1 Scope

This document describes the test and assessment procedure for determining the contribution of reactive fire protection systems to the fire resistance of solid steel bars used as tension bars, when exposed to the standard temperature/time curve specified in EN 1363-1. In special circumstances, where specified in National Building Regulations, there can be a need to subject reactive fire protection systems to a slow heating curve (smouldering fire) as defined in EN 1363-2. The corresponding test and assessment procedure are described in Annex E. The fire protection performance is determined by mechanically loaded steel bars usually fire tested in horizontal orientation. Information regarding the testing of additional unloaded specimens is given to assess the influence of the bar orientation and smouldering fire behaviour.

The principles of the testing and assessment procedure can also be applied for other profile types. This document does not include steel bars used as reinforcement in concrete construction.

This document is applicable to steel bars up to a maximum diameter of 130 mm. In the case of rectangular bars, the maximum edge length is limited to 130 mm with a maximum aspect ratio of 2:1 against the shorter edge length.

The test programme and the assessment are designed to cover:

— a range of fire protection classification periods;

— a range of thickness of the applied reactive fire protection system;

— a range of steel bar dimensions and profiles;

— a range of specified design temperatures;

— a range of load utilization factors in case of fire;

— a range of bar orientation.

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This document also provides the assessment procedure, which prescribes how the analysis of the test data are made and gives guidance on the procedures by which interpolation is undertaken. The assessment procedure is used to establish:

a) on the basis of data derived from mechanically loaded testing steel bar, any practical constraints on the use of the reactive fire protection system under fire test conditions (the mechanical performance);

b) on the basis of the temperature data derived from testing steel bar the thermal properties of the reactive 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 grades, steel types and profile dimensions over the range of dry film thicknesses of the applied reactive fire protection system tested.



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## 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.

EAD 350402-00-1106, *Reactive coatings for fire protection of steel elements*

EN 1363-1:2020, *Fire resistance tests — Part 1: General requirements*

EN 1363-2, *Fire resistance tests — Part 2: Alternative and additional procedures*

EN 10025-1, *Hot rolled products of structural steels — Part 1: General technical delivery conditions*

EN 10204, *Metallic products — Types of inspection documents*

EN 60584-1, *Thermocouples - Part 1: EMF specifications and tolerances (IEC 60584-1)*

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

EN ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1)*

EN ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system (ISO 7500-1)*

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

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## 3 Terms, definitions, symbols and abbreviations

### 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 terminology databases for use in standardization at the following addresses:

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

— IEC Electropedia: available at https://www.electropedia.org/

**3.1.1**
**steel bar**
element of building construction, which is loadbearing, fabricated from steel and has a solid circular or rectangular (including square) cross-section composed entirely of steel with a consistent cross-sectional size throughout its length

**3.1.2**
**reactive fire protection material**
reactive materials which are specifically formulated to provide a chemical reaction upon heating such that their mechanical form changes and in doing so provide fire protection by thermal insulative and cooling effects



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**3.1.3**
**reactive fire protection system**
reactive fire protection material together with a specified primer and top coat if applicable

**3.1.4**
**fire protection**
protection afforded to the steel member by the reactive fire protection system such that the temperature of the steel member is limited throughout the period of exposure to fire

**3.1.5**
**test specimen**
steel bar plus the reactive fire protection system under test

**3.1.6**
**dry film thickness**
dried thickness of the reactive fire protection material excluding primer and top coat

**3.1.7**
**fire protection thickness**
mean dry film thickness of the reactive fire protection material excluding primer and top coat

**3.1.8**
**stickability**
ability of a reactive 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

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**3.1.9**
**steel temperature**
average temperature of the two measuring stations nearest the rupture point

**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

**3.1.11**
**mechanical load**
axial tensile force applied to the mechanically loaded specimen during the fire test (see 6.3)

**3.1.12**
**load utilisation in case of fire**
ratio of mechanical load to the tensile load carrying capacity of steel bar in case of fire (see 6.3)

**3.1.13**
**test programme**
describes the intended scope of application (see Clause 5)

**3.1.14**
**test set**
part of the test programme and consists of a group of mechanically loaded specimens (template see 5.3)



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**3.1.15**
**design steel temperature**
temperature of a steel bar to be used for the assessment of the mechanical and thermal performance

**3.1.16**
**deformation steel bar temperature**
temperature of a steel bar to be used by the structural engineer to check the deformation of the steel bar and the entire steel construction at elevated temperature

## 3.2 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

**Table 1 — Symbols and abbreviations**

| Symbol | Unit | Description |
|---|---|---|
| $\alpha$ | $K^{-1}$ | thermal expansion coefficient |
| $A_m/V$ | $m^{-1}$ | Section factor of the unprotected steel section |
| $A_{section}$ | $mm^2$ | Cross-sectional area of the steel section |
| $b$ | mm | Width of the rectangular solid steel section |
| $D$ | mm | Diameter of the circular solid steel section |
| $d_p$ | mm | Intended dry film thickness of reactive fire protection system |
| $d_{min}$ | mm | Intended minimum dry film thickness of the loaded or tall section tested according to EN 13381-8 |
| $d_{max}$ | mm | Intended maximum dry film thickness of the loaded or tall section tested according to EN 13381-8 |
| $D_{small}$ | mm | Diameter of the smallest tested tension bar from the test set |
| $D_{large}$ | mm | Diameter of the largest tested tension bar from the test set |
| $D_{select}$ | mm | Selected diameter of steel bar for which appropriate dry film thickness is calculated |
| $DFT_{mean}$ | mm | Mean value of all dry film thickness measurements of the reactive fire protection thickness at a steel bar |
| $DFT_{small}$ | mm | Dry film thickness of the smallest tested tension bar from the test set |
| $DFT_{large}$ | mm | Dry film thickness of the largest tested tension bar from the test set |
| $DFT_{ref}$ | mm | Dry film thickness of the unloaded steel bar used as reference specimen |
| $DFT_K$ | mm | $DFT_{mean}$ of the unloaded steel bar for which the correction time ($t_{corection,k,i}$) is calculated |
| $\dot{e}$ | $min^{-1}$ | Strain rate of steel |
| $F_{load}$ | kN | The mechanical tensile load applied to the specimen |
| $f_{y,20°C}$ | $N/mm^2$ | Yield strength at room temperature |
| $f_{p0.2,20°C}$ | $N/mm^2$ | 0,2 % proof stress at room temperature |

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| | | |
|---|---|---|
| $h$ | mm | Height of the rectangular steel section |
| $L_F$ | mm | Fire exposed length of the mechanically loaded specimen |
| $L_G$ | mm | Total length of the mechanically loaded specimen |
| $L_U$ | mm | Total length of unloaded steel bar |
| $r$ | mm | Radius of the circular solid steel section |
| $s$ | mm | Cross-sectional dimension of the specimen |
| $\theta_i$ | °C | Design steel temperature for the thermal and mechanical assessment |
| $\theta_{def}$ | °C | Steel temperature for the check of the total deformation of the steel bar and the entire steel construction at elevated temperature |
| $\theta_s$ | °C | Steel temperature at time $t_i$ |
| $\theta_{rupture}$ | °C | Steel temperature when the rupture occurred |
| $\theta_{select}$ | °C | Selected design temperature value for which the dry film thickness will be calculated |
| $\theta_{average,unloaded,i}$ | °C | Average temperature of unloaded steel bar for different orientation ($i$) |
| $\theta_{SH,average,unloaded,i}$ | °C | Average temperature of unloaded specimen in different orientation ($i$) for bars exposed to slow heating (SH) temperature/time curve |
| $\Delta\theta_k$ | °C | Temperature difference between steel bars with different orientation |
| $t$ | min | Fire performance period |
| $t_F$ | min | Fire resistance time |
| $t_C$ | min | The time when the load-bearing capacity ($t_C$) is reached |
| $t_{C,i}$ | min | Time for which the load utilization factor in case of fire is calculated for interpolation purposes |
| $t_{correction,k,i}$ | min | Corrected time, when unloaded steel bar reached design temperature $\theta_i$ |
| $t_{k,i}$ | min | Time for the reference specimen section to reach the design temperature |
| $t_{rupture}$ | min | Time when the steel bar rupture occurred |
| $\Delta T_{unloaded,i}$ | °C | Temperature difference between unloaded steel bars with different orientations |
| $\Delta T_{load,k}$ | °C | Temperature difference between loaded steel bars with different orientations |
| $U$ | mm | Deformation of the tension bar |
| $dU/dt$ | mm/min | Rate of deformation |
| $(dU/dt)_{limit}$ | mm/min | Limit value of the rate of deformation of the mechanically loaded steel bar |

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| | | |
|---|---|---|
| $\mu_{fi}$ | – | Load utilization factor in case of fire. The parameter is equivalent to the load utilization at the time $t = 0$ min ($\mu_0$ according to EN 1993-1-2) |
| $\mu_{fi,max}$ | – | Upper limit of load utilization factor in case of fire |
| $\mu_{fi,min}$ | – | Lower limit of load utilization factor in case of fire |
| $\mu_{fi,select}$ | – | Selected load utilization factor in case of fire used in the interpolation method |
| **Abbreviation** | | **Description** |
| DFT | | Dry film thickness of the reactive fire protection system |
| MS | | Measuring station |
| MP | | Measuring point |
| TC | | Thermocouple |
| ULS | | Ultimate limit state |

# 4 Test equipment

## 4.1 General

The furnace and test equipment shall conform to that specified in EN 1363-1. A number of steel bars are fire tested with a mechanical tensile load. These tension bars are first subjected to a tensile load, which is kept constant throughout the fire test, and then exposed to fire according to the protocol given in EN 1363-1. It is recommended that the tests be continued until the specimen reaches the maximum design steel temperature specified in the scope of testing or rupture of the specimen occurs. The description in this document refers to a fire test in horizontal position of the bar. However, it is also possible to conduct the fire test in vertical position. The load device and the furnace shall be changed accordingly. 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 specimens shall be chosen to suit the scope of testing.

## 4.2 Furnace

The furnace shall permit the dimensions of the specimens to be exposed to heating, as specified in Clause 5 and their installation within the test furnace to be as specified in Clause 6. A minimum distance of 300 mm shall be kept between the specimen surface and the edge of the burner outlet, the burner flame, other obstacles (except furnace plate thermocouples and specimen thermocouples) and furnace walls, floor and ceiling (see 6.1 and Figure 1). In addition, a direct impingement of the flame shall be avoided. In General, the furnace shall be able to create a uniform temperature distribution around the specimen. Furthermore, the required furnace temperature shall be reached at the plate thermocouples positioned near the specimen.



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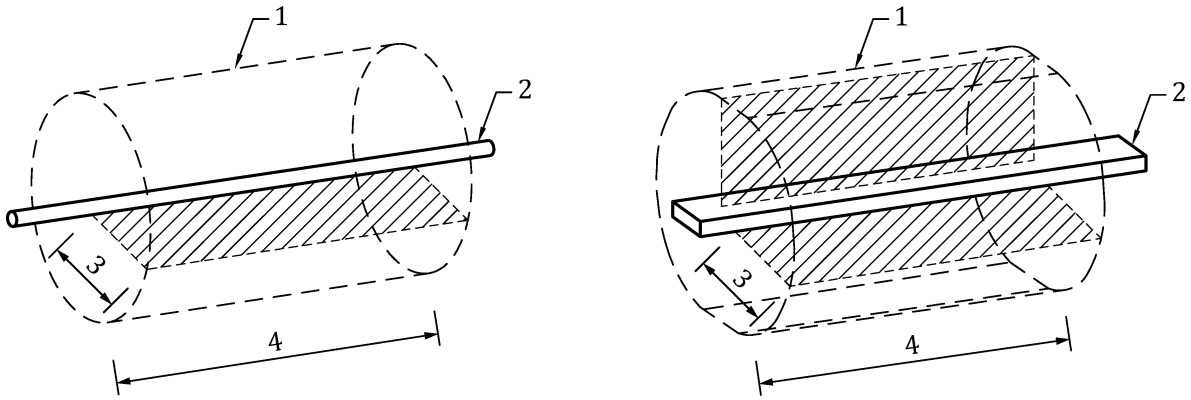


**Key**

1 undisturbed and obstacle free zone

2 specimen (tension bar)

3 ≥ 300 mm

4 fire exposed length of the specimen ($L_F$ ≥ 1 000 mm)

**Figure 1 — Undisturbed and obstacle free zone around the specimen in the furnace (the geometric limitations also apply to other bar orientations)**

### 4.3 Load frame and actuator

The loading equipment shall be capable of subjecting the specimens to the level of tensile load specified in the scope of testing (see 5.1). Furthermore, the loading equipment shall be able to generate conditions of uniform loading, which can maintain the test load at a constant value (±2 % of the required value, according to EN ISO 7500-1) until failure of the tension bar (maximum temperature or rupture).

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The load frame shall have room temperature over the entire duration of the fire test (a locally higher temperature of the load frame of not more than 50 K is allowed; it is recommended to locate the load frame outside of the furnace). A computer-based controlling of the loading system and deformation measurement is recommended.

## 5 Test programme

### 5.1 General

The manufacturer of the reactive fire protection system specifies the intended scope of application by defining the test programme. To develop the test programme the testing institute can be consulted. Based on the selected test programme the different test sets can be defined. The test programme contains at least one test set. If the general parameters selected in the test programme have more than one entry per line, several test sets shall be created. A subdivision into different test sets is required, because in the assessment only specimens with comparable parameters, i.e. identical entries for the general parameters, can be assessed together. In general, it is possible to include the data of one specimen for different test sets. A change or extension of a test set is possible by changing or adding new values for a variable parameter. For variable parameters a range can be specified. A change of the variable parameters does not require a new test set. Recommendations and details for the selection of the specimens of a test set are given in 5.3. The general structure of a test programme for mechanically loaded specimens is given in Table 2.



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