



SLOVENSKI STANDARD

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Preskusne metode za ugotavljanje prispevka k požarni odpornosti konstrukcijskih elementov - 4. del: Zaščita jeklenih elementov

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

Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden Bauteilen - Teil 4: Passive Brandschutzmaßnahmen für Stahlbauteile

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 4: Protection passive appliquée aux éléments en acier

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

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 4 :
Protection passive appliquée aux éléments en acier

Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden Bauteilen - Teil 4: Passive Brandschutzmaßnahmen für Stahlbauteile

This European Standard was approved by CEN on 10 February 2013.

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EN 13381-4:2013 (E)**Foreword**

This document (EN 13381-4:2013) 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of an identical text or by endorsement, at the latest by November 2013, and conflicting national standards shall be withdrawn at the latest by November 2013.

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

This document supersedes ENV 13381-4:2002.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

With respect to the previous version, the following changes have been made:

- A change has been made to the test method to introduce of a means allowing loaded beams to reach a deflection of $L/30$.
- In addition the graphical assessment method now includes a point to point method of constructing lines and a new virtual data point related to furnace temperature.

This document is compatible with EN 13381-8 and specifically deals with the testing and assessment of passive fire protection systems (sprays, renderings, mat products and boards) designed to protect structural steel.

This document is part of the EN 13381 series with the general title *Test methods for determining the contribution to the fire resistance of structural members*. Other parts of this series are:

- *Part 1: Horizontal protective membranes;*
- *Part 2: Vertical protective membranes;*
- *Part 3: Applied protection to concrete member;*
- *Part 4: Applied passive protection to steel members (the present document);*
- *Part 5: Applied protection to concrete/profile sheet steel and composite members;*
- *Part 6: Applied protection to concrete filled steel composite members;*
- *Part 7: Applied protection to timber members;*
- *Part 8: Applied reactive protection to steel members.*

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. 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 standard should be followed.

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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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EN 13381-4:2013 (E)**1 Scope**

This European Standard specifies a test method for determining the contribution made by applied passive fire protection systems to the fire resistance of structural steel members, which can be used as beams or columns. It considers only sections without openings in the web. It is not directly applicable to structural tension members without further evaluation. Results from analysis of I or H sections are directly applicable to angles, channels and T-sections for the same section factor, whether used as individual elements or as bracing. This European Standard does not apply to solid bar or rod.

This European Standard covers fire protection systems that involve only passive materials and not to reactive fire protection materials as defined in this document.

The evaluation is designed to cover a range of thicknesses of the applied fire protection material, a range of steel sections, characterised by their section factors, a range of design temperatures and a range of valid fire protection classification periods.

This European Standard contains the fire test procedures, which specifies the tests which should be carried out to determine the ability of the fire protection system to remain coherent and attached to the steelwork, and 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 fire test methodology makes provision for the collection and presentation of data, which can be used as direct input to the calculation of fire resistance of steel structural members in accordance with the procedures given in EN 1993-1-2 and EN 1994-1-2.

This European Standard also contains the assessment, which prescribes how the analysis of the test data shall be made and gives guidance on the procedures by which interpolation should be undertaken.

The assessment procedure is used to establish: [SIST EN 13381-4:2013](https://standards.iteh.ai/catalog/standards/sist/5ec83961-90ca-4ed8-96a2-919cc790ba07/sist-en-13381-4-2013)

- a) on the basis of temperature data derived from testing loaded and unloaded sections, a correction factor and 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 short steel sections, 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 sections and grades and to the fire protection system.

The results of the test and assessment obtained according to this European Standard are directly applicable to steel sections of I and H cross sectional shape and hollow sections.

2 Normative references

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

EN 12467, *Fibre cement flat sheets — Product specification and test methods*

EN 13162, *Thermal insulating products for buildings — Factory made mineral wool (MW) products — Specification*

EN 823, *Thermal insulating products for building applications — Determination of thickness*

EN 13501-1, *Fire classification of construction products and building elements — Part 1: Classification using data from reaction to fire tests*

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

EN 1365-3, *Fire resistance tests for loadbearing elements — Part 3: Beams*

EN 1365-4, *Fire resistance tests for loadbearing elements — Part 4: Columns*

EN 1993-1-1, *Eurocode 3: Design of steel structures — Part 1-1: General rules and rules for buildings*

EN 1993-1-2, *Eurocode 3: Design of steel structures — Part 1-2: General rules - Structural fire design*

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

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

ISO 8421-2:1987, *Fire protection — Vocabulary — Part 2: Structural fire protection*

ETAG 018-Part 3, *Guideline for European Technical Approval of Fire Protective Products — Part 3: Renderings and rendering kits intended for fire resisting applications*

ETAG 018-Part 4, *Guideline for European Technical Approval of Fire Protective Products — Part 4: Fire protective board, slab and mat products and kits*

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3 Terms and definitions, symbols and units

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3.1 Terms and definitions

SIST EN 13381-4:2013

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:

3.1.1

steel member

element of building construction which is loadbearing and fabricated from steel of the same type as is used in the testing

3.1.2

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

3.1.3

passive fire protection material

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

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

3.1.4

fire protection system

fire protection material together with any supporting system including mesh reinforcement as tested and with a specific primer and/or topcoat if applicable

EN 13381-4:2013 (E)**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 test section comprising columns and beams plus the fire protection system under test

3.1.7**fire protection thickness**

dry thickness of an applied protection material or a single layer fire protection system or the combined thickness of all layers of a multilayer fire protection system excluding the thickness of the supporting system or joint cover strips

3.1.8**stickability**

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

3.1.9**section factor****3.1.9.1****profiled fire protection systems**

ratio of the fire exposed outer perimeter area of the steel structural member itself excluding the protection material, per unit length, to its cross sectional volume per unit length

Note 1 to entry: See Figure 1.

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3.1.9.2**boxed fire protection systems**

ratio of the sum of the inside dimensions of the smallest possible rectangle or square encasement which can be measured round the steel structural member times unit length, to its volume per unit length

Note 1 to entry: See Figure 1.

3.1.10**design temperature**

temperature of a steel structural member for structural design purposes

3.1.11**characteristic steel temperature**

temperature of the steel structural member which is used for the determination of the correction factor for stickability calculated as $(\text{mean temperature} + \text{maximum temperature})/2$

3.1.12**steel temperature**

overall mean temperature to be used as input data for the analysis is calculated:

- for I and H section beams as the mean of the upper flange plus the mean of the web plus the mean of the lower flange divided by three;
- for I, H and hollow section columns as the sum of the means of each measuring station divided by the number of measuring stations;
- for hollow section beams as the mean of the sides plus the mean of the bottom face divided by two

3.2 Symbols and units

Symbol	Unit	Description
<i>LB</i>		loaded beam section
<i>UB</i>		unloaded short beam section
<i>LC</i>		loaded 3 m column section
<i>SC</i>		unloaded short column section
<i>p</i>		fire protection material
<i>a</i>		steel
<i>f</i>		furnace
<i>d</i>		thickness
ρ		density
t_i	min	time for the loaded section to reach the design temperature
t_1	min	time for the reference section to reach the design temperature
<i>S</i>	m^{-1}	section factor of the loaded section
S_1	m^{-1}	section factor of the reference section
<i>D</i>	mm	the protection thickness for the loaded section
D_1	mm	protection thickness for the reference section
d_{max}	mm	maximum protection thickness of the loaded section
d_{min}	mm	minimum protection thickness of the loaded section
d_i	mm	protection thickness of the short section
k_{imax}		stickability correction factor at maximum protection thickness
k_{imin}		stickability correction factor at minimum protection thickness
k_i		stickability correction factor for the short section at thickness d_i
A_m/V	m^{-1}	section factor of the unprotected steel section
A_p/V	m^{-1}	section factor of the protected steel section
<i>A</i>	m^2	cross sectional area of the steel section
<i>V</i>	m^3/m	volume of the steel section per unit length
V_v	m^3/m	volume of the fire protection material per unit length
<i>H</i>	mm	height of the steel column
<i>h</i>	mm	depth of the steel section
<i>B</i>	mm	breadth of the steel section
t_w	mm	thickness of the web of the steel section
t_f	mm	thickness of the flange of the steel section
<i>t</i>	mm	thickness of the wall of a hollow steel section
L_{exp}	mm	length of beam specimen exposed to heating
L_{sup}	mm	length of beam specimen between supports
L_{spec}	mm	length of beam specimen

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d_{UB}	mm	thickness of fire protection material on an unloaded beam section
d_{SC}	mm	thickness of fire protection material on an unloaded column section
d_p	mm	thickness of fire protection material concerned
$d_{p(max)}$	mm	maximum thickness of fire protection material used
$d_{p(min)}$	mm	minimum thickness of fire protection material used
$\rho_{protection}$	kg/m ³	density of fire protection material
ρ_{UB}	kg/m ³	density of fire protection material on an unloaded beam section
ρ_{SC}	kg/m ³	density of fire protection material on an unloaded column section
ρ_{LB}	kg/m ³	density of fire protection material on a loaded beam
ρ_a	kg/m ³	density of steel (normally 7 850 kg/m ³)
θ_{LB}	°C	characteristic steel temperature of a loaded beam
θ_{UB}	°C	characteristic steel temperature of a short unloaded reference beam
θ_{LC}	°C	characteristic steel temperature of a loaded column
θ_{SC}	°C	characteristic temperature of a short reference column.
$\theta_{c(UB)}$	°C	corrected mean temperature of an unloaded beam section
$\theta_{c(SC)}$	°C	corrected mean temperature of an unloaded column section
θ	°C	average temperature of the furnace at time t
θ_{at}	°C	average temperature of the steel at time t
$\Delta\theta$	°C	increase of furnace temperature during the time interval Δt
$\theta_{m(SC)}$	°C	modified steel temperature of an unloaded section
θ	°C	design temperature
K_d		range factor for thickness
K_s		range factor for section factor
c_a	J/(kgK)	temperature dependant specific heat capacity of steel as defined in EN 1993-1-2
c_p	J/(kgK)	temperature independent specific heat capacity of the fire protection material
μ		ratio of heat capacity of the fire protection material to that of the steel section
t	min	time from commencement of the start of the test
t_e	min	time for an unloaded section to reach an equivalent temperature to the loaded beam at time t
Δt	min	time interval
t_d	min	time required for a short section to reach the design temperature
λ_p	W/(mK)	effective thermal conductivity of the fire protection material
$\lambda_{char(p)}$	W/(mK)	characteristic value of effective conductivity of the fire protection material
$\lambda_{ave(p)}$	W/(mK)	mean value of λ_p calculated from all the short sections at a temperature θ
$\lambda_{\delta(p)}$		standard deviation of λ_p calculated from all the short sections at a temperature θ
K		constant applied to $\lambda_{\delta(p)}$

4 Test equipment

4.1 General

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

4.2 Furnace

The furnace shall permit the dimensions of the test specimens to be exposed to heating, as specified in Clause 6 and their installation upon or within the test furnace to be as specified in Clause 7.

4.3 Loading equipment

Loading shall be applied according to EN 1363-1. The loading system shall permit loading to be applied to beams as specified in 5.2.1 and to columns as specified in 5.2.3.

5 Test conditions

5.1 General

A number of short steel, I or H or hollow test sections, protected by the fire protection system, are heated in a furnace according to the protocol given in EN 1363-1.

Loaded and unloaded beams or columns that are likewise heated provide information on the ability of the fire protection system to remain intact and adhere to the steel test sections (stickability).

The method of testing loaded beams in this part of the test method is designed to provide maximum deflection (span/30) under the influence of load and heating. If the rate of deflection exceeds that given in EN 1363-1, then it may not be possible to reach span/30.

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

5.2 Support and loading conditions

5.2.1 Loaded beams

Each loaded beam test specimen shall be simply supported and allowance shall be made for free expansion and vertical deflection of the beam. The beam shall not be provided with additional torsional restraint except where deemed necessary as defined in 6.3.1. The simply supported span shall not be greater than the length exposed to heating by more than 400 mm at each end.

The loading shall be applied using either of the two methods described in Figure 2.

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

5.2.2 Unloaded beams

Each unloaded beam test specimen shall be supported as shown in Figure 3.

EN 13381-4:2013 (E)**5.2.3 Loaded columns**

For each loaded column, provision shall be made for the proper support, positioning and alignment of the column test specimen in the furnace in accordance with EN 1365-4 subject to any amended or additional requirements of this standard. An example is given in Figure 8.

5.2.4 Unloaded columns

Unloaded column sections shall be supported vertically within the furnace, either installed to the soffit of the furnace cover slabs, (see example in Figure 10), or stood on the furnace floor (directly or on plinths).

5.3 Loading

The loaded beam test specimens shall be subjected to a total load which represents 60 % of the design moment resistance, according to EN 1993-1-1, calculated using the actual steel yield strength from the batch certificate of conformity or an actual measured value.

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

The method of loading shall be by a system which will produce a bending moment which is uniform over at least 20 % of the span of the beam around mid-span.

The loaded column shall be subjected to an applied test load which represents 60 % of the design buckling resistance, according to EN 1993-1-1, calculated using the actual steel yield strength from the batch certificate of conformity or an actual measured value. Details of the calculation made to define the test loads shall be included in the test report.

Loaded steel test sections shall be tested in accordance with EN 1365-3 or EN 1365-4 subject to any amended or additional requirements of this standard.

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6 Test specimens**6.1 General**

The test sections shall be chosen to suit the scope of the assessment and will include both loaded and unloaded sections. The testing of loaded and reference sections provides the basis for the stickability correction to be applied to the thermal data generated from the unloaded short sections. Depending upon the scope of the assessment, the principle of selecting the loaded and unloaded sections shall be based on the details presented in 6.6. The test sections shall be chosen from the tables in Annex F.

For each test involving a loaded beam or column, an equivalent unloaded reference beam or column section respectively shall be included and tested in the furnace at the same time whenever possible. Where it is not possible to test a loaded column and a reference column together in the furnace then the reference section shall be tested separately in the same furnace in the same position as the loaded column.

For both the maximum and the minimum thickness of the fire protection system, a loaded beam shall be tested to examine stickability during maximum deflection of the steel section around 550 °C, up to a maximum anticipated steel temperature. The two loaded steel beams do not have to be the same size.

It will be necessary to consider loaded tests on both beams and columns if the protection systems are different.

The data from the loaded and equivalent unloaded reference sections shall be used to determine the correction factors for stickability across the range of thickness in accordance with Annex D.

If the assessment is to be confined to four sided protection of columns, the loaded beam tests shall be replaced by loaded column tests. In this case, the unloaded reference beam sections are replaced by unloaded reference column sections.

6.2 Size of test specimens

6.2.1 Loaded beams

Loaded beams shall have an I or H cross sectional shape, or hollow rectangular section.

Each beam shall have a total length, which shall provide for a length exposed to heating of not less than 4 000 mm.

The supported length and specimen length shall be specified as follows:

The span between the supports [L_{sup}] shall be the exposed length plus up to a maximum of 400 mm at each end. The length of the specimen [L_{spec}] shall be the exposed length plus up to a maximum of 500 mm at each end (see Figure 9).

The additional length, required for installation purposes, shall be kept as small as practically possible.

6.2.2 Reference sections

Where practical, each unloaded reference section shall be taken from the same length of steel as its equivalent loaded section, thereby ensuring that it is of the same dimensions and characteristics. If this cannot be achieved the test laboratory should ensure that the reference section is of similar dimensions and characteristics.

For board systems, the minimum length of short beams and columns used as reference sections shall be $(1\ 000 \pm 50)$ mm and joints in the board protection should not be included unless the maximum board length is less than 1 000 mm.

6.2.3 Loaded columns

All loaded columns shall have a minimum height, exposed to heating, of 3 000 mm.

6.2.4 Short sections

The short beams and columns shall have a length of $(1\ 000 \pm 50)$ mm.

6.3 Construction of steel test specimens

6.3.1 Loaded beams

Steel test sections used in loaded beam tests shall be constructed according to Figure 9.

Where the span of the beam is such that additional restraint is required then additional restraint can be provided by installation of web stiffeners as follows, subject to agreement with the sponsor.

To give web stiffness and torsional restraint, the beams may be provided with:

- a) Web stiffeners in the form of steel plates or triangular gussets, welded at each loading point. These shall be of thickness at least equal to the thickness of the web and of depth at least 10 mm less than the beam flange depth. Details are shown in Figure 9.