SIST

SLOVENSKI STANDARD
SIST EN 13381-9:2015

01-september-2015

Preskusne metode za ugotavljanje prispevka k požarni odpornosti konstrukcijskih elementov - 9. del: Požarno zaščitni sistemi za jeklene nosilce z odprtinami v stojini

Test methods for determining the contribution to the fire resistance of structural members - Part 9: Applied fire protection systems to steel beams with web openings

Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden Bauteilen - Teil 9: Brandschutzmaßnahmen für Stahlträger mit Stegöffnungen

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 9: Systèmes de protection au feu appliqués aux poutres alvéolaires en acier

Ta slovenski standard je istoveten z: **EN 13381-9:2015**

ICS:

13.220.50	Požarna odpornost gradbenih materialov in elementov	Fire-resistance of building materials and elements

SIST EN 13381-9:2015 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13381-9

June 2015

ICS 13.220.50; 91.080.10

English Version

Test methods for determining the contribution to the fire resistance of structural members - Part 9: Applied fire protection systems to steel beams with web openings

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Ref. No. EN 13381-9:2015 E

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Foreword

This document (EN 13381-9:2015) 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of an identical text or by endorsement, at the latest by December 2015, and conflicting national standards shall be withdrawn at the latest by December 2015.

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

This European Standard 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 member*;

— *Part 6: Applied protection to concrete filled hollow steel columns*;

— *Part 7: Applied protection to timber members* [currently at Enquiry stage];

— *Part 8: Applied reactive protection to steel members*.

The document adopts the principle of establishing ratios of temperatures between and around openings in the web of a beam with the temperatures of a solid portion of that beam. This is with the intention that this data can be utilized within a structural model to derive the value and location of the associated limiting temperature of the beam at the fire limit state. This can then be used in conjunction with data for the fire protection material determined from either EN 13381-4 or EN 13381-8, as appropriate to determine the necessary thickness of fire protection.

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.

Introduction

The European Committee for Standardization (CEN) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning the method of designing a fire resistant structural beam.

CEN takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has ensured CEN that, through appropriate declaration, he/she agrees to publically disclose the relevant part of their patent in RT1356 or EN 13381-9 and renounce to challenge the same and all subsequent European standards on the basis of infringement of their patent. In this respect, the statement of the holder of this patent right is registered with CEN. Information may be obtained from:

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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.

1 Scope

This European Standard specifies a test and assessment method for determining the contribution made by fire protection systems to the fire resistance of structural steel beam I and H members in the horizontal plane containing openings in the web which may affect the structural performance of the beam. This European Standard applies to beams subject to 3 or 4 sided fire exposure.

For any beam with a single web opening or where the web openings are considered to be of small diameter in relation to the web depth the applicability of this European Standard needs to be determined by a structural engineer.

This European Standard applies to fire protection materials that have already been tested and assessed in accordance with EN 13381-4 or EN 13381-8. i.e. this European Standard cannot be used in isolation. Use of this European Standard requires the multi-temperature analysis (MTA) derived from EN 13381-4 or EN 13381-8 as the basis for determining thickness for beams with web openings. This MTA needs to be carried out on the web and bottom flange separately generating an elemental multi-temperature analysis (EMTA). The bottom flange EMTA may be used as the top flange EMTA when a beam is subject to 4 sided exposure.

This European Standard contains the fire test methodology, which specifies the tests which need to be 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.

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

The assessment procedure is used to establish:

a) on the basis of the temperature data derived from testing unloaded steel sections, the thermal response of the fire protection system on cellular beams (the thermal performance);

b) the temperature ratio between the web post and the web reference temperature, which will vary depending on the web post width;

c) the temperature ratio between points around the web openings and the web reference area;

d) the elemental multi temperature analysis from either EN 13381-4 or EN 13381-8 needs to be reassessed and reported against elemental A/V for each fire resistance period;

e) a structural model needs to be used to derive limiting temperatures for cellular beams using the data from b), c) and d) above.

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 1363-1, *Fire resistance tests - Part 1: General Requirements*

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 1994-1-1, *Eurocode 4: Design of composite steel and concrete structures - Part 1-1: General rules and rules for buildings*

EN 1994-1-2, *Eurocode 4 - Design of composite steel and concrete structures - Part 1-2: General rules - Structural fire design*

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

EN 13381-4:2013, *Test methods for determining the contribution to the fire resistance of structural members - Part 4: Applied passive protection to steel members*

EN 13381-8:2013, *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)*

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1)*

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.

3.1.1
cellular beam(s)
structural steel beams with web opening(s)

3.1.2
fire protection material

3.1.2.1
reactive materials
materials that 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

3.1.2.2
passive materials
materials that 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 which, on heating evaporates to produce cooling effects. These may take the form of sprayed coatings, renderings, mat products boards or slabs.

3.1.3
fire protection system
fire protection material together with any supporting system including mesh reinforcement as tested

3.1.4
test specimen
steel test section plus the fire protection system under test

3.1.5
fire protection thickness
total dry film thickness of the fire protection material

3.1.6
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

3.1.7
bottom flange temperature
bottom flange temperature is the overall average of the bottom flange

3.1.8
web post
area of web between two web openings

3.1.9
web post temperature
proportioned average temperature of the web post derived from thermocouples fixed across the web at mid-height

3.1.10
web reference temperature
mean temperature of a solid portion of the web without holes in close proximity, that is at least 250 mm from the edge of a hole

3.1.11
web post buckling
web post buckling occurs when the web separating two openings is unable to transfer the required horizontal shear force and the shear stress is greater than the shear strength of the web

3.1.12
vierendeel bending
mechanism by which shear is transferred across the web opening and causes bending in the top and bottom, left and right, parts of the beam surrounding the opening

3.1.13
limiting temperature
temperature at a point along the beam at which structural failure of the cellular beam will take place

3.1.14
elemental section factor
section factor of the web or bottom flange in isolation

3.1.15
plate girder dimensions
plate girder size which is stated as overall beam depth by flange width by flange thickness by web thickness given in millimetres

3.1.16
multi temperature analysis
outcome of an assessment carried out in accordance with either EN 13381-4 or EN 13381-8 based on a range of average temperatures of the whole steel section

3.1.17
elemental multi temperature analysis
outcome of an assessment carried out on data from EN 13381-4 or EN 13381-8 based on a range of average temperatures of the web and flanges separately

3.2 Symbols and units

Symbol	Unit	Designation
B	m	Width of beam flanges
D	m	Depth of beam
t_w	m	Thickness of web
t_f	m	Thickness of flanges

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 be designed to permit the dimensions of the test specimens to be exposed to heating, to be as specified in 6.2 and their installation within the test furnace to be as specified in Clause 6.

4.3 Test conditions

A number of short steel beams all containing web openings and protected by the fire protection system shall be heated in a furnace according to the protocol given in EN 1363-1 and Clause 7.

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.

5 Test specimens

5.1 General

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

There are specific test packages designed to suit a specified fire performance period as given in 5.4.4, Tables 1, 2, and 3.

5.2 Precautions against erroneous results

In the event that there should be a loss of valid results from the package of short steel sections tested, (through failure of thermocouples, abnormal behaviour of fire protection, etc), then the conditions given in 9.1 shall be applied and a further number of short steel sections may be required to be tested.

5.3 Construction of steel test specimens

5.3.1 Cellular beam test sections

The beam sections shall be fabricated from welded steel plate to ensure that flange and web steel thicknesses are consistent, however the thermal data may be applied to both steel plate and hot rolled section.

In each case the welding techniques shall be in accordance with EN ISO 15614-1.

The short beams shall have a length of (1 200 ± 50) mm and will have circular or rectangular openings cut out of the webs.

The short beams shall be constructed according to Figures 1, 2 and 3.

To minimize heat transfer at the ends of the beams, the ends shall be protected with insulation board or similar which at elevated temperatures is capable of providing equivalent or greater insulation than that of the fire protection material provided over the length of the test specimen, (see Figure 4).

The linear dimensions of the end protection shall be greater than the total overall dimensions measured over the fire protected steel member.

5.3.2 Application of the fire protection material to the test sections

The surface of the steel shall be prepared in accordance with the manufacturers recommendations and the fire protection system shall be applied to the beams in a manner representative of practice.

5.4 Composition of test specimen component materials

5.4.1 Steel sections

The grade of steel used shall be any structural grade (S designation) to EN 10025-1 (excluding S 185). Engineering grades (E designation) shall not be used.

The dimensions of the steel sections shall be measured and these values shall be used to determine the elemental section factors. The elemental section factors shall be calculated in accordance with Figure 7.

All the steel sections shall be fabricated from steel plate to ensure a consistent approach in determining the thermal data.

5.4.2 Fire protection materials

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

The thickness of panel or board type 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 it deviates by more than 15 % then the maximum thickness recorded shall be used in the assessment.

The thickness of fire protection material applied to the inside edge of an opening may be less than the thickness tested on the main body beams in the test packages in 5.4.4 provided it is not less than the minimum tested on a loaded beam in EN 13381-4 or EN 13381-8 and that it is the same material. Other materials or combinations of may not be used unless alternative fire test evidence is available that is not covered by this European Standard.

5.4.3 Fire protection thickness requirements for sprayed materials

Thickness measurements shall be evenly distributed and shall be taken in order to provide an overall mean for each section, each bottom flange and each web post as follows;

Ten thickness measurements shall be taken on each face of each web post within an area 125 mm above and below the web centreline in accordance with Figure 6.

The mean fire protection thickness on each web post is determined as the sum of the means of each web post side divided by two.

In the case of the 500 mm web post the thickness measurements are taken in an area within a 250 mm x 250 mm square around the four thermocouples (see Figure 6).

Twenty thickness measurements shall be taken on the underside bottom flange of each section and the mean thickness of fire protection material on the bottom flange is then determined.

The mean thickness of the fire protection material on each face of each web post and the underside of the bottom flange shall be within 15 % of each other and the overall mean i.e. the range of mean thicknesses shall not vary by more than 15 % from the minimum mean to the maximum mean.

If any area does not meet this requirement, physical adjustments shall be made to ensure compliance.

In the case of reactive coatings thickness measurements shall be taken at a minimum of 20 mm from the edge of any opening as electronic gauges are not reliable at less than this distance. Refer to gauge manufacturers for details.

5.4.4 Selection of test specimens

The scope of the assessment will determine the selection of the test specimens. Tables 1, 2 and 3 provide specific section details for fire performance periods up to and including 240 min. Where the scope of the assessment is required to include web posts narrower than those listed in Tables 1, 2 and 3 then additional sections shall be tested or the 130 mm web posts can be replaced by 100 mm web posts.