

SLOVENSKI STANDARD

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Preskusne metode za ugotavljanje prispevka k požarni odpornosti konstrukcijskih elementov - 5. del: Zaščita kompozitnih elementov iz betona in jeklene profilirane pločevine

Test methods for determining the contribution to the fire resistance of structural members - Part 5: Applied protection to concrete/profiled sheet steel composite member

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Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden Bauteilen - Teil 5: Brandschutzmaßnahmen für profilierte Stahlblech/Beton-Verbundkonstruktionen

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Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 5: Protection appliquée aux dalles mixtes béton/tôle d'acier profilée

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Test methods for determining the contribution to the fire resistance of structural members - Part 5: Applied protection to concrete/profiled sheet steel composite member

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 5 : Protection appliquée aux dalles mixtes béton/tôle d'acier profilée

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This European Standard was approved by CEN on 13 September 2014.

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Contents

Page

Foreword.....	4
1 Scope	5
2 Normative references	5
3 Terms and definitions, symbols and units.....	6
3.1 Terms and definitions	6
3.2 Symbols and units	8
4 Test equipment	9
4.1 General.....	9
4.2 Furnace	9
4.3 Loading equipment.....	9
5 Test conditions	9
5.1 General.....	9
5.2 Support and restraint conditions	10
5.3 Loading conditions.....	10
6 Test specimens	10
6.1 Number of test specimens	10
6.2 Size of test specimens	11
6.3 Construction of test specimens	11
6.4 Composition of test specimen component materials.....	13
6.5 Properties of test materials	14
6.6 Verification of the test specimen	15
7 Installation of the test construction.....	15
8 Conditioning of the test construction.....	15
9 Application of instrumentation.....	16
9.1 General.....	16
9.2 Instrumentation for measurement of furnace temperature	16
9.3 Instrumentation for measurement of test specimen temperature	16
9.4 Instrumentation for measurement of pressure.....	17
9.5 Instrumentation for measurement of deformation	17
9.6 Instrumentation for measurement of applied load	17
10 Test procedure	17
10.1 General.....	17
10.2 Furnace temperature and pressure	17
10.3 Application and control of load.....	17
10.4 Temperature of test specimen.....	17
10.5 Deformation	18
10.6 Observations	18
10.7 Termination of test.....	18
11 Test results	18
11.1 Acceptability of test results	18
11.2 Presentation of test results	19
12 Test report	19
13 Assessment.....	20

13.1	General	20
13.2	Profiled steel sheet temperature.....	21
13.3	Equivalent thickness of concrete	21
13.4	Limiting exposure time	22
13.5	Insulation.....	22
14	Report of the assessment	22
15	Limits of applicability of the results of the assessment	23
16	Additional limits of applicability of the results of the assessment for suspended ceilings used as protection system	25
16.1	Height of the cavity	25
16.2	Exposed width of test specimen.....	25
16.3	Properties of the horizontal protective membrane	25
16.4	Size of panels within the horizontal protective membrane.....	25
16.5	Fixtures and fittings	25
16.6	Gaps between grid members and test frame or walls	25
Annex A	(normative) Test method to the smouldering fire or slow heating curve.....	32
A.1	General	32
A.2	Test conditions	32
A.3	Termination of the test.....	32
A.4	Evaluation of the results.....	33
Annex B	(normative) Measurement of properties of fire protection materials.....	35
B.1	General	35
B.2	Thickness of fire protection materials	35
B.3	Density of applied fire protection materials	36
B.4	Moisture content of applied fire protection materials.....	36
Bibliography	38

EN 13381-5:2014 (E)**Foreword**

This document (EN 13381-5:2014) 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 May 2015 and conflicting national standards shall be withdrawn at the latest by May 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 supersedes ENV 13381-5:2002.

In comparison with the previous edition, the entire document has been revised.

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 standard are:

- *Part 1: Horizontal protective membranes;*
- *Part 2: Vertical protective membranes;*
- *Part 3: Applied protection to concrete members;*
- *Part 4: Applied passive protection products to steel 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.*

Caution

The attention of all persons concerned with managing and carrying out this fire resistance test, is drawn to 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 will be made and safety precautions will be identified and provided. Written safety instructions will be issued. Appropriate training will be given to relevant personnel. Laboratory personnel will ensure that they follow written safety instructions at all times.

The specific health and safety instructions contained within this standard will be followed.

According to the CEN-CENELEC Internal Regulations, the national standards organizations 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.

1 Scope

This European Standard specifies a test method for determining the contribution of fire protection systems to the fire resistance of structural concrete/profiled sheet steel composite members or slabs. The concrete can be lightweight, normal-weight or heavy-weight concrete and of strength classes 20/25 (LC/C/HC) to 50/60 (LC/C/HC).

The test method and its assessment procedure are designed to permit direct application of the results to cover a range of thicknesses of the applied fire protection material.

The test method is applicable to all fire protection materials used for the protection of concrete/steel composite members or slab and includes sprayed materials, coatings, cladding protection systems and multi-layer or composite fire protection materials, with or without a cavity between the fire protection material and the concrete/steel composite members or slab.

This European Standard contains the fire test which specifies the tests which will be carried out to determine the ability of the fire protection system to remain coherent and fixed to the composite member and to provide data on the temperatures of the steel sheet, throughout the depth of the concrete (for extended application purposes) and the unexposed surface of the concrete, when exposed to the standard temperature/time curve according to the procedures defined herein.

In special circumstances, where specified in national building regulations, there can be a need to subject reactive protection material to a smouldering curve. The test for this and the special circumstances for its use are detailed in Annex A.

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 concrete/steel composite members in accordance with the procedures given in EN 1994-1-2.

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

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/concrete composite structures, steel types and thicknesses, concrete densities, strengths, thicknesses and production techniques over the range of thicknesses of the applied fire protection system tested.

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 206, *Concrete - Specification, performance, production and conformity*

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

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

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

EN 1992-1-1, *Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings*

EN 13381-5:2014 (E)

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

EN 10346, *Continuously hot-dip coated steel flat products - Technical delivery conditions*

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

EN ISO 3251, *Paints, varnishes and plastics - Determination of non-volatile-matter content (ISO 3251)*

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, ISO 8421-2, EN 206 and the following apply.

3.1.1**concrete/steel composite member or slab (generally referred to as slab)**

element of building construction which is loadbearing and is fabricated from a profiled steel sheet lower surface and a concrete upper layer, which may contain steel reinforcing bars

Note 1 to entry: Profiled steel sheet is specified in EN 10346 and concrete according to EN 206.

3.1.2**fire protection material**

material or combination of materials applied directly or by means of fixing system to the surface of a concrete/steel composite slab for the purpose of increasing its fire resistance

3.1.3**passive fire protection materials**

materials which do not change their physical form on heating, providing fire protection by virtue of their physical or thermal properties and which may include materials containing water which, on heating, evaporates to produce cooling effects

3.1.4**reactive fire protection materials**

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

3.1.5**fire protection system**

fire protection material together with a prescribed method of attachment to the structural concrete/steel composite slab

3.1.6**fire protection**

protection afforded to the concrete/steel composite slab by the fire protection system such that the temperature throughout the depth of the structural slab and upon any steel reinforcing bars within it is limited throughout the period of exposure to fire

3.1.7**test specimen**

concrete/steel composite test slab plus the fire protection system under test

3.1.8**fire protection thickness**

thickness of a single layer fire protection material or combined thickness of all layers of a multilayer fire protection material

3.1.9**stickability**

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

3.1.10**equivalent thickness of concrete**

theoretical thickness of concrete which provides the same thermal insulation for a given period of test as does the given thickness of the applied fire protection system

3.1.11**limiting exposure time**

time at which the adherence of a fire protection system to the concrete/steel composite test slab can be no longer considered acceptable, as indicated by a defined, significant increase in maximum recorded temperature at any point on the steel surface

3.1.12**limiting temperature**

maximum value of temperature reached on the lower surface of the ribs of the profiled steel sheet when the limiting exposure time is reached

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3.1.13**profiled fire protection system**

material which is applied following the shape of the profiled steel sheet of the slab and directly in contact with the steel sheet

3.1.14**suspended fire protection system**

system which is not directly in contact with parts of the slab

3.1.15**boxed fire protection system**

system which is directly in contact with parts of the slab

3.1.16**characteristic temperature**

average of the mean temperature and the maximum individual temperature $[(\text{mean} + \text{maximum})/2]$ for a thermocouple group or location

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3.2 Symbols and units

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

Symbol	Unit	Designation
L_{exp}	mm	length of the test specimen exposed to the furnace
L_{sup}	mm	centre to centre distance between the supports of the test specimen
L_{spec}	mm	total length of the test specimen
W_{exp}	mm	width of test specimen exposed to the furnace
h_1	mm	thickness of concrete above the steel ribs
h_2	mm	thickness of concrete within the steel profile
h	mm	thickness of concrete in concrete/steel composite test specimen thickness $h = h_1 + h_2$
l_p	mm	length of the components of the trapezoidal or re-entrant profile of the steel sheet (l_{p1} , l_{p2} and l_{p3})
P	kN	loading applied to concrete/steel composite test specimen
θ	°C	characteristic temperature
$\theta_{m,l}$ ($\theta_{m,u}$)	°C	limiting temperature at the lower respectively upper part of the steel profile
h_{eff}	mm	the effective thickness of the concrete/steel composite test slab
h_e	mm	the equivalent effective thickness of the concrete/steel composite test slab
h_{eq}	mm	the equivalent thickness of concrete corresponding to the particular thickness of the fire protection system tested
t_r	min	the time at which an increase of the characteristic temperature of all thermocouples on the unexposed concrete surface of 140 K (or a maximum of 180 K from a single thermocouple) is recorded
f_y	N/mm ²	yield strength of steel
d_p	mm	thickness of fire protection material

4 Test equipment

4.1 General

The furnace and test equipment shall be as specified in EN 1363-1.

4.2 Furnace

The furnace shall be designed to permit the dimensions of the test specimen to be exposed to heating to be as specified in 6.2 and its installation to be as specified in Clause 7.

4.3 Loading equipment

Loading equipment shall conform to that specified in EN 1363-1. The loading system shall permit loading, of the magnitude defined in 5.3, to be applied along the length and width of the test specimen.

The loading equipment shall not inhibit the free movement of air above the test specimen and no part of the loading equipment, other than at the loading points, shall be closer than 60 mm to the unexposed surface of the test specimen.

5 Test conditions

5.1 General

Test specimens, subjected to predefined loading, are heated upon a furnace under specified temperature/time conditions, in horizontal orientation, with fire exposure applied from below.

Tests are carried out on a loaded large size test slab and an unloaded small size test slab to provide information on:

- the temperature of the profiled steel sheet behind the fire protection system;
- the behaviour of the fire protection system and its stickability;
- the temperature of the unexposed side of the test specimen;
- the temperature throughout the concrete (optional for extended application purposes).

It is recommended that the test be continued until the temperature of the exposed profiled steel surface reaches a mean value of at least 400 °C, (or any single maximum value of 500 °C is recorded), to give the necessary information on the stickability of the fire protection system. These temperatures may be modified if requested by the sponsor.

If the recommended termination temperatures are not reached after 6 h test duration the test shall normally be terminated.

The procedures given in EN 1363-1 and EN 1363-2 (if relevant) shall be followed in the performance of this test method unless specific contrary instruction is given.

EN 13381-5:2014 (E)**5.2 Support and restraint conditions****5.2.1 Standard conditions**

The concrete/steel composite slab test specimens shall be tested as a simply supported one way structure with two free edges and an exposed surface and span as specified in 6.3.

The concrete/steel composite slab test specimens shall be installed onto the furnace to allow freedom for longitudinal movement and deflection using at one side rolling support(s) and at the other hinge support(s).

The surface of the bearings shall be smooth concrete or steel plates. The width of the bearings shall be the minimum representative of practice.

5.2.2 Other support and restraint conditions

If the support and restraint conditions differ from the standard conditions specified in 5.2.1, these conditions shall be described in the test report and the validity of the test results will be restricted to those tested.

For example the concrete/steel composite slab can be installed on a steel H or I profile at each end of the furnace and fixed by means of nails shot in each bottom of waves.

5.3 Loading conditions

Loading shall be applied to the full size test specimens.

The load shall be designed in order to introduce, between the two loading lines, a bending moment equivalent to the maximal allowed load designed by the manufacturer of the profiled steel sheets for the tested concrete thickness and span.

The load shall be symmetrically applied to the test specimen along two transverse loading lines, each one at a distance ($L_{sup}/4$) from each of the supports. The proportion of the total load applied at each loading position shall be $P/2$, as specified in Figure 1. Point loads shall be transferred to the test specimen through load distribution beams or plates (see Figure 1a)).

The total contact area between these and the concrete surface of the test specimen shall be as specified in EN 1363-1, provided that the load distribution beam or plate chosen has a flexural rigidity large enough to give the required distribution of the load.

Load distribution beams, for safety reasons, shall have a height to width ratio of < 1 .

If the load distribution beams or plates are of steel or other high conductivity material, they shall be insulated from the concrete surface of the test specimen by a suitable thermal insulation material.

Unexposed surface thermocouples shall not be closer than 100 mm to any part of the load distribution system as shown in Figure 1a).

6 Test specimens**6.1 Number of test specimens**

Two full size loaded concrete/steel composite members shall be tested.

To one member the minimum thickness of the fire protection system shall be applied and to the other member the maximum thickness. If the fire protection system is only available in a single thickness, then one test on one type of member only shall be carried out at that thickness.

Additional small scale tests (one test per variable) may be carried out to provide further test data for the fire protection system when:

- it is to be applied to a concrete/steel composite member of composite thickness less than that specified in this test method;
- it is to be applied at intermediate fire protection thicknesses between maximum and minimum thickness;
- the test is carried out to the smouldering curve, in which case a small size test slab with both maximum and minimum thickness of applied fire protection material shall be tested, according to Annex A.

6.2 Size of test specimens

The size of the test specimens shall be as specified in Table 1 and exemplified in Figure 1.

6.3 Construction of test specimens

6.3.1 Construction of concrete/steel composite test slabs

The concrete/steel composite test slabs shall comprise a trapezoidal or re-entrant steel profile plus concrete of thickness h_1 , given in Table 1, over the upper ribs of the profiled steel sheet. The concrete shall contain prefabricated welded steel mesh.

The welded steel mesh, placed towards the unexposed surface in both small and large test slabs shall comprise 4,0 mm diameter ribbed bars such that the area of reinforcing steel bars is (70 to 100) mm² per metre of width of the concrete/steel composite test element.

The position of the welded steel mesh with respect to the unexposed concrete surfaces shall be ensured by the use of spacers, either plastic or concrete, such that the concrete cover obtained is (20,0 ± 2,0) mm.

The actual position of the welded steel mesh at the unexposed surface and the positions of the thermocouples specified under 9.3 shall be adjusted just before the casting of the concrete member.

Lifting hooks may be incorporated into the composite slab. These shall be of sufficient number and location to avoid longitudinal and transverse moments. Alternatively, the composite slabs shall be supported on steel beams for lifting purposes.

Fixtures to which hangers may be attached may be provided on the unexposed side in order to avoid the collapse of the test specimen during the test, especially where the test is continued beyond the recommended termination temperature of 400 °C. These fixtures shall not interfere with the applied load.