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English Version

Test methods for determining the contribution to the fire resistance of structural members - Part 1: Horizontal protective membranes

Méthodes d'essai pour déterminer la contribution à la
résistance au feu des éléments de construction - Partie 1:
Membranes de protection horizontales

Prüfverfahren zur Bestimmung des Beitrages zum
Feuerwiderstand von tragenden Bauteilen - Teil 1:
Horizontal angeordnete Brandschutzbekleidungen

This draft European Standard is submitted to CEN members for formal vote. It has been drawn up by the Technical Committee CEN/TC 127.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (FprEN 13381-1:2014) has been prepared by Technical Committee CEN/TC 127 "Fire safety in buildings", the secretariat of which is held by BSI.

This document is currently submitted to the Formal Vote.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of 89/106/EEC.

This document will supersede CEN/TS 13381-1:2005.

This 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 2: Vertical protective membranes,*
- *Part 3: Applied protection to concrete members,*
- *Part 4: Applied passive protection products 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.*

The fire protection capacity of the horizontal protective membrane can be nullified by the presence of combustible materials in the cavity above the membrane. The applicability of the results of the assessment is limited according to the quantity and position of such combustible materials within that cavity. The amount of combustible material permissible in the cavity should be given in national regulations.

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 shall be made and safety precautions shall be identified and provided. Written safety instructions shall be issued. Appropriate training shall be given to relevant personnel. Laboratory personnel shall ensure that they follow written safety instructions at all times.

The specific health and safety instructions contained within this European Standard shall be followed.

WARNING: When performing this test method, laboratories shall expect that there may be significant quantities of smoke released. This smoke release is expected to be very significant where the fire test involves timber and timber based components. Laboratories shall ensure that appropriate smoke extraction facilities are provided.

1 Scope

This European Standard specifies a test method for determining the ability of a horizontal protective membrane, when used as a fire resistant barrier, to contribute to the fire resistance of standard horizontal structural building members as defined in 6.4.2.

Test of horizontal protective membrane installed under a specific non-standard floor should be tested according to EN 1365-2.

This European Standard contains the fire test which specifies the tests which are carried out whereby the horizontal protective membrane, together with the structural member to be protected, is exposed to a fire test according to the procedures defined herein. The fire exposure, to the temperature/time curve given in EN 1363-1, is applied from below the membrane itself.

The test method makes provision, through specified optional additional procedures, for the collection of data which can be used as direct input to the calculation of fire resistance according to the processes given within EN 1992-1-2, EN 1993-1-2, EN 1994-1-2 and EN 1995-1-2.

This European Standard also contains the assessment which provides information relative to the analysis of the test data and gives guidance for the interpretation of the results of the fire test, in terms of loadbearing capacity criteria of the protected horizontal structural member.

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

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 structures, membranes and fittings.

This European Standard applies only where there is a gap and a cavity between the horizontal protective membrane and the structural building member. Otherwise, the test methods in prEN 13381-3, EN 13381-4 or prEN 13381-5, as appropriate, apply.

Tests should be carried out without additional combustible materials in the cavity.

Annex A gives details of assessing the performance of the ceiling when exposed to a semi-natural fire.

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 1363-1:2012, *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 1992-1-2:2004, *Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design*

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 1995-1-1, *Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings*

EN 1995-1-2:2004, *Eurocode 5: Design of timber structures - Part 1-2: General - Structural fire design*

EN 312, *Particleboards - Specifications*

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

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

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

prEN 13381-5, *Test methods for determining the contribution to the fire resistance of structural members - Part 5: Applied protection to concrete/profiled sheet steel composite members*

prEN 13381-7, *Test methods for determining the contribution to the fire resistance of structural members - Part 7: Applied protection to timber members*

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

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

3 Terms and definitions, symbols and units

3.1 Terms and definitions

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

3.1.1

horizontal structural building member

horizontal structural element of building construction which is loadbearing, separating and which is fabricated from concrete, steel, steel/concrete composite or timber

3.1.2

horizontal protective membrane

any horizontal membrane or ceiling lining that does not form any part of any loadbearing part of the structure and can comprise multiple layers of materials, together with any supporting framework, hangers, fixings and any insulation materials which is either suspended from or attached directly to a structural building member, or is self supporting and fixed beneath a structural building member, and which is intended to give additional fire resistance to that structural building member, as for example ceiling tiles resting on a light supporting frame, ceiling boards, metal trays, plastered and similar ceilings not directly applied to the underside of the structural member

3.1.3

separating gap

distance between the non exposed surface of the horizontal protective membrane and the lowest surface of the exposed side of the structural building member

3.1.4

cavity

whole void or voids between the non exposed surface of the horizontal protective membrane and the highest surface of the exposed side of the structural building member

3.1.5

horizontal protective membrane test specimen

full horizontal protective membrane assembly submitted for test, including typical fixing equipment and methods and typical features such as insulating materials, light fittings, ventilation ducts and access panels

3.1.6

fire protection

protection afforded to the structural building member by the horizontal protective membrane system such that the temperature on the surface of the structural building member and within the cavity is limited throughout the period of exposure to fire

3.1.7

characteristic temperature

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

3.2 Symbols and units

Symbol	Unit	Designation
L_{exp}	mm	Exposed length of the structural building member.
L_{sup}	mm	Centre to centre distance between the supports of the structural building member tested.
L_{spec}	mm	Total length of the main beams or members of the structural building member.
$A_{m/V}$	m^{-1}	Section factor of unprotected steel beam (see EN 13381-4).

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 6.4.1 and its installation to be as described in Clause 7.

4.3 Loading equipment

Loading shall be applied according to EN 1363-1. The loading system shall permit loading, of the magnitude defined in 5.3, to be uniformly applied along the length and width of the test specimen at loading points positioned as defined in 5.3.

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

A horizontal structural building member, including any supporting construction, which carries a horizontal protective membrane, to be used as a fire resistant barrier against fire from below, is subjected to predefined loading and to the fire test defined herein.

The temperature within the cavity and the surface temperature of the structural building member are measured throughout the test.

Any leakage through the structural floor slab and at the sides of the structure shall be minimized. The gap between the floor slab and the furnace shall be made tight by e.g. mineral wool pads or similar in such a way that the slab can deflect vertically.

It is recommended that the test is continued until the characteristic temperature recorded by all thermocouples within the cavity reaches the appropriate limiting temperature of the structural building members used or until any individual temperature recorded within the cavity rises to 750 °C for concrete, steel, or concrete/profiled steel composite members and 500 °C for timber structural members.

The procedures given in EN 1363-1 and, if applicable, in EN 1363-2, shall be followed in the performance of this test method unless specific contrary instruction is given. Where required, the semi-natural fire test shall be performed in accordance with Annex A.

5.2 Support and restraint conditions

5.2.1 Standard conditions

The test specimen shall be tested as a simply supported one way structure with two free edges and an exposed surface and span as specified in 6.4.1.

It shall be installed to allow freedom for longitudinal movement and deflection using at one side rolling support(s) and at the other hinge support(s) as shown in Figure 1.

The surface of the bearings shall be smooth concrete or steel plates. The width of the bearings shall be at least as wide as the beam.

5.2.2 Other support and restraint conditions

Support and restraint conditions differing from the standard conditions specified in 5.2.1 shall be described in the test report and the validity of the results restricted to that tested.

5.3 Loading conditions

The test specimen shall be subjected to loads determined in accordance with EN 1363-1. The means of determination of the load shall be clearly indicated in the test report.

The applied load shall be calculated such that the maximum bending moment equals 60 % of the ultimate cold condition limit state value of the design moment resistance specified in the appropriate structural Eurocodes (EN 1992-1-1, EN 1993-1-1, EN 1994-1-1 and EN 1995-1-1).

The design moment resistance shall be calculated using either the actual or nominal material properties, derived according to 6.5, of the loadbearing member with a material safety factor (γ_m) equal to 1,0.

The load shall be symmetrically applied to the test specimen either along two transverse loading lines, applied at $\frac{1}{4} L_{sup}$ and $\frac{3}{4} L_{sup}$ and separated from each other by a distance of $L_{sup}/2$, see Figure 2, or by the use of dead weights. In both cases the loading shall produce stresses approximating to a uniformly distributed load.

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.

Point loads shall be transferred to the test specimen, along the two transverse loading lines, through load distribution beams or plates, see Figures 1 and 3, the total contact area between these and the test specimen shall be as specified in EN 1363-1.

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

If the load distribution plates are of steel or any other high conductivity material, they shall be insulated from the 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.

6 Test specimens

6.1 General

One test specimen shall normally be required.

The structural building member to be used in the test shall be as given in 6.4.1 and be chosen from the standard elements described in 6.4.2 and be representative of that to be used in practice.

Where a horizontal protective membrane is manufactured with elements or components of variable size or may be installed by different procedures, then separate tests shall be carried out on elements or components at maximum and minimum sizes (the components which are cut to finish the ceiling extremities shall not be considered as smaller size components). The installation procedures for which the sponsor requires approval shall be deemed as being represented by the fire test.

The horizontal protective membrane to be used in the test shall be constructed as described in 6.3 and shall be installed according to practice, by the procedures given in the installation manual or other written instruction provided by the sponsor. It shall include all thermal insulating layers or materials to be used in practice within the cavity.

6.2 Fixtures and fittings

All fixtures and fittings, such as light fittings, ventilation openings and access panels expected to be installed, shall be tested in a separate full size test. The installation and frequency of use of these shall then if possible be representative of practice. Such fixtures and fittings shall not be installed within the test specimen at a distance of less than 250 mm from any of its edges.

6.3 Horizontal protective membranes

The test specimen shall reproduce the conditions of use, including junctions between membrane and walls and edge panels, joints and jointing materials and be installed from below by the same method and procedures as given in the installation manual, or in written instructions, which shall be provided by the sponsor.

It shall be fitted with all the components for hanging, expansion and abutting, plus any other fixtures which are to be defined by the sponsor, with a frequency representative of practice.

For horizontal protective membranes which are suspended from the structural building member by hangers, the suspension system and the length of the hangers shall be representative of practice.

The profiles bearing the various panels shall be installed against each other without any gap, unless a gap (or gaps) is required for design purposes. In this case the gap (or gaps) at the junctions of main runners shall be representative of that to be used in practice and shall be installed within the main runners and not at their ends.

The profiles within the test specimen shall include a joint representative of joints to be used in practice in both longitudinal and transverse directions.

The horizontal protective membrane shall be fixed according to normal practice on all four edges, either directly to the furnace walls or to a test frame. A test frame, where used, shall be fixed directly to the horizontal structural building member being protected, or to the furnace walls.

If the construction or properties of the horizontal protective membrane are different in the longitudinal and transverse directions, the performance of the specimen may vary depending upon which components are aligned with the longitudinal axis. If known from experience, the specimen shall be installed so as to represent the most onerous condition by arranging the more critical components parallel to the longitudinal axis. If the more onerous condition cannot be identified, two separate tests shall be carried out with the components arranged both parallel and perpendicular to the longitudinal axis.

6.4 Structural building members supporting horizontal protective membranes

6.4.1 General principles

The dimensions of the structural building member supporting the horizontal protective membrane and which is exposed to the furnace shall be:

- a) exposed length (L_{exp}) : at least 4 000 mm
- b) span (L_{sup}) : L_{exp} plus up to 400 mm maximum at each end
- c) length (L_{spec}) : L_{exp} plus up to 500 mm at each end
- d) exposed width : at least 3 000 mm

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

Test specimens of exposed width less than 3 000 mm may be tested according to this method. However, application of the result shall be restricted to constructions of equal or less width than that tested.

The gap between the structural building member and the longitudinal furnace walls or simulated furnace walls shall not exceed 30 mm and shall be sealed with compressed mineral fibres or ceramic fibres of adequate fire performance (or comparable materials of equivalent performance) to allow both deflection of the member under heating conditions and prevention of leakage of hot gases during the test.

6.4.2 Standard horizontal structural building members

The following structural building members are considered to be standard for this test method.

a) Reinforced aerated concrete slabs on steel beams

The structural member shall comprise hot rolled steel 'I' section beams of profiles with section factor A_m/V equal to $(275 \pm 25) \text{ m}^{-1}$ (for three sided exposure) and with a section depth of typically $(160 \pm 20) \text{ mm}$. The grade of steel used shall be any structural grade (S designation) according to the specification given in EN 13381-4. Engineering grades (E designation) shall not be used.

These beams shall be spaced at $(700 \pm 100) \text{ mm}$ centres resting on the bearing surface of the furnace test frame. The beams may be assembled incorporating cross members welded at the ends.

The centre of either of the outer steel beams shall not be placed less than 275 mm from the furnace wall in order that the edge of the horizontal protective membrane rests only on the peripheral support. The centre of either of the outer steel beams shall not be placed more than 450 mm from the furnace wall.

The reinforced aerated concrete slabs shall be of density not more than 650 kg/m^3 and minimum thickness 100 mm and maximum width 650 mm. They shall be placed transversely on the profiles of the steel beams and separated from each other by gaps of 5 mm to 10 mm which shall be sealed with ceramic fibre or equivalent material and silicone flexible sealant. New, unused, reinforced aerated concrete slabs shall be used for each test.

The aerated concrete slabs shall rest on the steel beam framework without mechanical connection so that there is no gain in mechanical strength of the structure with increasing deformation.

b) Reinforced dense aggregate concrete slabs on steel beams

All the principles given in a) for reinforced aerated concrete slabs on steel beams apply except that the concrete slabs shall comprise dense aggregate concrete of density $(2\,350 \pm 150) \text{ kg/m}^3$ and shall have a thickness of between 60 mm to 120 mm. See prEN 13381-3 for the aggregates of the concrete

c) Timber floors (or roofs)

The standard structural building member from which a horizontal membrane is suspended for the protection of a timber structural building member shall comprise equally spaced softwood joists, of nominal density $(450 \pm 75) \text{ kg/m}^3$ and cross-section $(220 \pm 10) \text{ mm} \times (75 \pm 5) \text{ mm}$ at 530 mm to 600 mm centres, see Figure 4. The number of joists (preferably six) and their spacing shall be appropriate to the exposed width, which shall be from 3 000 mm to 3 300 mm.

The joists shall be connected by cross members of the same material and cross-section, located in the area of the furnace support. They shall also be connected by cross members of the same material but with cross-section $(175 \pm 10) \text{ mm} \times (40 \pm 5) \text{ mm}$, located around mid span, see Figure 4. The wooden floor shall be made from particle board sheets of thickness $(21 \pm 3) \text{ mm}$ and density $(600 \pm 50) \text{ kg/m}^3$ according to EN 312, laid perpendicular to the joists, with tongue and groove joints and nailed down.

d) Concrete/profiled steel sheet composite slabs

The standard concrete/profiled steel sheet composite test slab shall be prepared according to the specification given in prEN 13381-5. The grade of steel and the concrete type, composition and strength shall be as specified in prEN 13381-5.

The standard concrete/profiled steel sheet composite slab shall be fixed to and supported on steel beams with a representative span as specified in 6.4.1.

Safety suspensions may be provided on the unexposed side of the slab, without contributing to the loadbearing capacity of the structural member, in order to avoid collapse of the structural member under test during the test.

6.5 Properties of test materials

Where appropriate, the actual properties of materials used in the structural building member tested (e.g. concrete strength) shall be determined according to EN 1363-1 or using an appropriate product test standard, e.g. concrete strength. Otherwise nominal values, e.g. for steel or wood based materials, may be used. The dimensions of the structural building member used shall be measured.

The material composition of the horizontal protective membrane shall be specified by the sponsor. For confidentiality reasons the sponsor may not wish detailed formulation of composition details to be reported in the test report. Such data shall, however, be provided and maintained in confidence in laboratory files.

The actual thickness, density and moisture content of the components of the horizontal protective membrane shall be measured and recorded, just prior to the time of test, on the components themselves or on special test samples taken from the test component. These shall be conditioned as defined in Clause 8. The procedures appropriate to different types of material are given in Annex B.

The thickness of slab 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 the board thickness varies by more than 15 % then the maximum thickness recorded shall be used in the assessment.

The thickness of sprayed or coated, passive or reactive type fire protection materials when used as component parts of horizontal protective membranes shall be measured according to Annex B. The thickness shall not deviate by more than 20 % of the mean value over the whole of its surface. The mean value shall be used in the assessment of the results and the limits of applicability of the assessment. If it deviates by more than 20 %, the maximum thickness recorded shall be used in the assessment.

The density of the horizontal protective membrane and its components, at minimum and maximum thickness, shall be measured according to Annex B and recorded. The density shall not deviate by more than 15 % of the mean value. The mean value of density shall be used in the assessment of the results and the limits of applicability of the assessment. If it deviates by more than 15 %, the maximum density recorded shall be used in the assessment.

6.6 Verification of the test specimen

An examination and verification of the test specimen for conformity to specification shall be carried out as described in EN 1363-1.

The properties of the materials used in the preparation of the test specimen shall be measured using representative samples, where necessary, as described in 6.5 using the methods given in Annex B.

The sponsor shall verify materials contained within the test specimen which are applied by spray or coating for compliance to design composition and specification using tests appropriate to the material under test.

6.7 Optional and additional plate thermometers within the cavity

At the request of the sponsor, where there is a need to obtain test data for use as direct input to the calculation of fire resistance according to the procedures given in EN 1992-1-2, EN 1993-1-2, EN 1994-1-2 and EN 1995-1-2 or other calculation methods, additional plate thermometers shall be used within the cavity.

7 Installation of the test construction

The test construction, comprising the structural building member, any supporting construction or test frame and the horizontal protective membrane, shall be installed onto the furnace to allow freedom for longitudinal movement and deformation, using at one side rolling support(s) and at the other side hinge support(s). Special attention shall be taken to insulate the supports from the influence of heat.

The order in which the test construction is installed upon the furnace shall be appropriate to practice.

8 Conditioning

The test construction and test samples taken for the determination of material properties, as specified in 6.5, shall be conditioned according to EN 1363-1.

Material properties (specified in 6.5) shall be determined according to Annex B and EN 1363-1.

Steps shall be taken to ensure that all the component materials of the test construction are conditioned according to EN 1363-1 and will not influence the test result.

9 Application of instrumentation

9.1 General

The instrumentation for the measurement of temperature, furnace pressure, applied load and deformation shall comply with the requirements of EN 1363-1.

9.2 Instrumentation for measurement of furnace temperature

Plate thermometers of the type specified in EN 1363-1 shall be provided to measure the temperature of the furnace. They shall be uniformly distributed, with at least one centrally placed within every 1,5 m² of the exposed test specimen surface area, the exposed area being the nominal area measured in the plane of the specimen.

The plate thermometers shall be oriented so that side 'A' faces the floor of the furnace. For test specimens with less than 6 m² exposed area, a minimum of four plate thermometers shall be used.

9.3 Instrumentation for measurement of specimen temperature

9.3.1 General

Instrumentation shall be provided for the measurement and recording of cavity temperature, surface temperature of the test specimen and the temperature at other optional locations.

9.3.2 Instrumentation for measuring cavity temperature

A total of nine thermocouples shall be used for measuring cavity temperatures, in sets of three, in each of three cross sectional areas (T1 -T9 in Figure 5). Each thermocouple in a set shall be separated horizontally from the next by (750 ± 100) mm:

Area 1: central section, located halfway along the span of the building member,

Area 2: (1 000 ± 100) mm from one side of the central section,

Area 3: (1 000 ± 100) mm from the other side of the central section.

These nine thermocouples shall be positioned half way up the plenum within the cavity.

An additional three cavity temperature measurement thermocouples shall be used when testing flammable timber test constructions, for safety reasons. These additional thermocouples (T10 -T12) shall be distributed according to Figure 5.

All cavity temperature measurement thermocouples shall be of a nominal thickness of 1 mm in accordance with EN 1363-1:2012, 4.5.1.4

Plate thermometers in accordance with EN 1363-1:2012, 4.5.1.1 directed with the steel surface downwards may be used to get effective cavity temperatures for calculating the thermal exposure of the beams.

9.3.3 Instrumentation for measuring surface temperatures

a) Standard test construction – reinforced concrete slabs on steel beams

Twelve thermocouples shall be provided for measurement of surface temperature on the steel beams. There shall be three thermocouples fixed to each steel beam used in the test construction described in 6.4.2(a) and 6.4.2(b). These shall be separated from the loading points and loading plates by at least 100 mm. They shall be located on the underside of the lower flange of the beam (thermocouples a1 to a4 exemplified in Figure 6), in each of the three cross sectional areas specified in 9.3.2.

Thermocouples for measuring surface temperature of the steel test beams shall be of the double glass fibre insulated bare wire type specified in EN 1363-1. They shall be positioned and fixed as specified in EN 1363-1.

b) Standard test construction - steel/concrete composite slabs

Twelve thermocouples shall be provided for measurement of surface temperature on the (exposed) steel surface of the steel/concrete composite test construction described in 6.4.2(d).

Four thermocouples shall be distributed, on the lower profiles of the steel at (700 ± 100) mm centres across the width of the furnace, with the outer temperature measurement points being between 300 mm and 450 mm from the furnace wall, i.e. in similar positions to those exemplified for steel beams given in Figure 6. Sets of these four thermocouples shall be located in each of the three cross sectional areas specified in 9.3.2. They shall be separated from loading points/loading plates by at least 100 mm.

Thermocouples for measuring surface temperature of the steel/concrete test slabs shall be of the double glass fibre insulated bare wire type specified in EN 1363-1. They shall be positioned and fixed as specified in EN 1363-1.

9.3.4 Optional and supplementary instrumentation for measuring temperature

a) To generate data for use in calculation of fire resistance

Where the sponsor requires temperature data for use as direct input to the calculation of fire resistance according to the procedures given in EN 1992-1-2, EN 1993-1-2, EN 1994-1-2 and EN 1995-1-2, two plate thermometers shall be placed 100 mm below each of the beams as indicated in Figure 5 (PT1 to PT4 as defined in EN 1363-1). They shall be oriented so that side 'A' faces vertically downwards towards the horizontal protective membrane. If the separating gap is lower than 100 mm place the plate thermometer at the mid-height of the cavity.

b) To generate other optional data

Other thermocouples may be used to generate optional data at the request of the sponsor. These shall all be of the appropriate type and fixing as specified in EN 1363-1. These include:

- Five thermocouples located on the unexposed surface of the structural building member, when standard building members are used (thermocouples c1 to c5 given in Figure 6). These shall be as defined in EN 1363-1 and shall be separated from the loading points and loading plates by at least 100 mm.
- Five thermocouples located on the highest surface of the underside of the structural building member (thermocouples b1 to b5 given in Figure 6), i.e. upon:
 - i) the surface of the concrete slabs supported by steel beams,
 - ii) within the steel profile of trapezoidal or re-entrant steel/concrete composite slabs,
 - iii) the timber floor.
- Four thermocouples located on the unexposed face of the horizontal protective membrane and below any insulation material (thermocouples d1 to d4 given in Figure 6). These shall be located:
 - iv) one thermocouple in the centre of the horizontal protective membrane. If the horizontal protective membrane is made up of panels then this thermocouple shall be placed at the centre of a panel;
 - v) one thermocouple at a membrane joint if included;
 - vi) one thermocouple on each type of edge and internal profile bearing the membrane panel, in both longitudinal and transverse directions.
- Five thermocouples located on top of any insulation included in the test specimen (thermocouples e1 to e5 given in Figure 6). These shall be as defined in EN 1363-1.

9.4 Instrumentation for measurement of pressure

Equipment for measuring pressure within the furnace shall be provided, located and used as specified in EN 1363-1.

9.5 Instrumentation for measurement of deflection

A suitable means of measuring the vertical deformation at mid span of the test specimen, relative to its supports, shall be provided, located and used as specified in EN 1363-1.

9.6 Instrumentation for measurement of applied load

Instrumentation for measurement of applied load shall be provided and used as specified in EN 1363-1.

10 Test procedure

10.1 General

Carry out checks for thermocouple consistency and establish data points for temperature as specified in EN 1363-1 before commencement of the test and the procedures defined in 10.2 to 10.7.

10.2 Furnace temperature and pressure

Measure and record the furnace temperature using the thermocouples defined in 9.2 and the furnace pressure in accordance with the procedures and frequency specified in EN 1363-1.

Control the furnace temperature according to the data received from the furnace temperature measurement thermocouples to the criteria of EN 1363-1.

Control the furnace pressure to the criteria of EN 1363-1.

10.3 Application and control of load

Using the procedures of EN 1363-1, apply a constant load to the test specimen, of magnitude in accordance with 5.3, throughout the test period until a deformation of $L_{sup}/30$ is reached or when the rate of deflection exceeds that given in EN 1363-1, at which point the load shall be removed.

10.4 Temperatures of test specimen

Measure and record the temperature within the cavity and upon the surface of the test construction using the thermocouples specified in 9.3.2 and 9.3.3, at intervals not exceeding one minute. Where any of the supplementary and optional thermocouples specified in 9.3.4 are used, measure and record the temperatures from these at intervals not exceeding one minute.

10.5 Deflection

Using the procedures of EN 1363-1, identify an initial deformation datum point, relative to the supports, before application of the load. Then apply the test load and measure the zero point for deformation after applying the load and before commencement of heating. Monitor the deformation continuously throughout the test and record the results at intervals not exceeding 1 min. Control during the test the rate of deflection.

10.6 Observations

Wherever practical, monitor the general behaviour of the test specimen, especially the horizontal protective membrane, throughout the test and record the occurrence of cracking, fissuring, deterioration, delamination or similar behaviour as described in EN 1363-1.

10.7 Termination of the test

Terminate the test when one or more of the reasons for termination specified in EN 1363-1 occurs and/or when all limit surface/cavity temperatures are reached.

11 Test results

11.1 Acceptability of test results

It is possible that within any test apparently erroneous results occur through failure of thermocouples, abnormal behaviour of the test specimen etc. The criteria for acceptability of temperature data given in EN 1363-1 shall be observed.

11.2 Presentation of test results

The following shall be reported within the test report:

- a) the results of measured dimensions and actual material properties, especially the thickness, density and moisture contents of the test specimen and its components, together with those values to be used in the assessment, as defined in 6.4;
- b) the individual results of all furnace temperature measurements and the mean of all individual furnace temperature measurements, taken as specified in EN 1363-1, graphically presented and compared with the specified requirements and tolerances given in EN 1363-1;
- c) The furnace pressure measurements, taken as specified in EN 1363-1, graphically presented and compared with the specified requirements and tolerances given in EN 1363-1;
- d) the individual results and the mean of all individual results of all the cavity temperature measurement thermocouples specified in 9.3.2 taken as specified in 10.4, all graphically presented. Evidence of compliance with the validity criteria of 11.1;
- e) the individual results and the mean of all individual results of all the surface temperature measurement thermocouples specified in 9.3.3, taken as specified in 10.4, all graphically presented. Evidence of compliance with the validity criteria of 11.1;
- f) the individual results and the mean of all individual results of all optional and supplementary temperature measurement thermocouples specified in 9.3.4, taken as specified in 10.4, all graphically presented. Evidence of compliance with the validity criteria of 11.1;
- g) the results of deformation and rate of change of deformation measurements, taken as specified in EN 1363-1 and graphically presented. If the load is removed, the time at which this occurred.

These results (b) to (f) may be presented as a selection of the measured data sufficient to give a history of the performance of the test specimen according to EN 1363-1;

- h) the results of observations made and the times at which they occur.

12 Test report

The test report shall include the following statement:

"This report provides the constructional details, the test conditions and the results obtained when a specific horizontal protective membrane was tested whilst protecting a specific type of test construction following the procedures of test method EN 13381-1. Any deviation with respect to size, constructional details, edge combinations or fixtures and fittings of the horizontal protective membrane from that tested may invalidate the test result."

In addition to the items required by EN 1363-1, the following shall also be included in the test report:

- a) the generic description and fixing details of the horizontal protective membrane;
- b) full details of the test specimens including assembly and preparation details including surface preparation especially the depth of the cavity used;
- c) description of the fabrication of the test construction. Description of the conditioning of the test construction and its installation onto the test furnace;
- d) the results of the measurements obtained using the measurement devices in 11.2 a) to f) during the tests presented in graphical format (and any other optional format), as required in 11.2;

- e) if possible a description of significant behaviour of the test specimen observed during the test period, including observations of the time(s) and magnitude of any deterioration or detachment of the horizontal protective membrane;
- f) the magnitude of the load applied to the test specimen, as a function of time, and if removed, the time at which this occurred;
- g) the reason, on the basis of 10.7 of this test method, for the termination of the test and the time elapsed when the test was terminated;
- h) details of the calculations used to determine the test load.

13 Assessment

13.1 General

Requirements given in Clauses 13, 14 and 15 are meant for extended application. For direct application, these clauses do not apply.

The assessment method details how the contribution of the horizontal protective membrane to the fire protection of the structural member is established using temperatures measured within the cavity by thermocouples or plate thermometers, upon the exposed surface of the structural building member and, when a practical non-standard horizontal structural building member is tested, upon the unexposed surface of the furnace closure.

13.2 Assessment of loadbearing capacity

13.2.1 General

For the purposes of this test method, assessment of loadbearing capacity is made by determination from the characteristic temperature curves obtained under 13.2.2 and 13.2.3, the time elapsed to the last completed minute, from the commencement of the test, to the time when specified limiting cavity and surface temperatures, each appropriate to the type of material contained within the structural building member tested, are reached.

13.2.2 Characteristic temperature curve: cavity temperatures

From the temperature data collected and reported in 11.2 the following shall be identified:

- the graph of the mean of all nine individual cavity temperatures (12 individual cavity temperatures for timber based building members),
- the graph of the individual thermocouple giving rise to the highest individual cavity temperature.

The characteristic temperature from the nine (twelve) cavity thermocouples shall be calculated and similarly presented, as defined in 11.2. This curve shall be used as the characteristic curve for cavity temperature and used in the assessment.

13.2.3 Characteristic temperature curve: surface temperatures (steel beams or steel/concrete slabs)

From the temperature data collected and reported in 11.2 the following shall be identified:

- the graph of the mean of all twelve individual surface temperatures;
- the graph of the individual thermocouple giving rise to the highest individual cavity temperature.

The characteristic temperature shall be calculated and similarly presented, as defined in 11.2. This curve shall be used as the characteristic curve for surface temperature and used in the assessment.

13.2.4 Application of method of limiting temperatures

Limiting temperatures are the temperatures (defined for both cavity and surface) at which the specific material of construction used within the structural building member will be unable to continue to support its load.

Limiting temperatures for each specific type of material of construction, from which loadbearing capacity is obtained from measurement of cavity temperature (Subject to the criteria of 15 Table 3) are:

- 600 °C all reinforced concrete building members;
- 530 °C building members containing steel beams plus reinforced concrete slabs;
- 450 °C all reinforced concrete building members containing pre-stressed rebars/wires or strands;
- 400 °C building members containing steel/concrete composites;
- 370 °C cold formed steel building members;

NOTE According to EN 1992-1-2:2004, 5.2, the steel critical temperature at pre-stressed bars is 400 °C and 350 °C at pre-stressed wires and strands.

— 300 °C building members containing timber joists or structures with wooden floor boards. The limiting temperature given for timber members does not permit and takes no account of charring of that timber, contrary to 3-1(8) of EN 1995-1-2:2004. For assessment of charring behaviour the test procedure of prEN 13381-7 shall be followed.

Limiting temperatures, for each specific type of material of construction, from which loadbearing capacity is obtained from measurement of surface temperature (Subject to the criteria of 15 Table 3) are:

- 510 °C building members containing steel beams plus reinforced normal or aerated concrete slabs (temperature measured on the steel beam);
- 350 °C cold formed steel building members (temperature measured on the steel element);
- 350 °C building members containing steel/concrete composites (temperature measured on the profiled steel sheet of the composite slab).

If the limiting value of temperature is not reached before the test is terminated then the loadbearing capacity, as defined for both cavity and surface temperature cases, shall be the test duration.

13.3 Assessment of data for calculation purposes

From the temperature data collected and reported in 11.2 the following shall be identified:

- the graph of the mean of all four individual plate thermometers (plate thermometers PT1 to PT4 given in Figure 5);
- the graph of the individual plate thermometer (plate thermometers PT1 to PT4 given in Figure 5) giving rise to the highest individual temperature.

The assessment and use of these temperature data, measured by plate thermometers, to give the amount of heat transfer etc. required to calculate fire resistance according to EN 1992-1-2, EN 1993-1-2, EN 1994-1-2 and EN 1995-1-2, is not considered herein. Users shall consult the relevant EN "Eurocode" standard.

14 Report of the assessment

The report of the assessment shall include the following:

- a) the name/address of the body providing the assessment and the date it was carried out. Reference to the name/address of the test laboratory, the unique test reference number and report number(s);
- b) the name(s) and address(es) of the sponsor(s). The name of the manufacturer of the product or products and the manufacturer or manufacturers of the construction;
- c) the generic description of the product or products, particularly the horizontal protective membrane and any component parts (where known). If unknown this shall be stated;
- d) full details of the test construction with drawings, including dimensions of components, photographs, where appropriate, and if available the installation manual or written instructions provided by the sponsor. The details of the assembly of the test specimen, especially the depth of the cavity used. Details of its conditioning;
- e) reason for the omission of any test data;
- f) general description of the test specimens forming the basis of the assessment including the dimensions of the test specimens, the composition and measured properties of the components required to be determined from 6.5 and their method of determination;
- g) the results of the loadbearing capacity, determined from the characteristic temperature curves specified in 13.2, being the time elapsed to the last completed minute, from the commencement of the test, to the time when either a specified cavity or surface temperature, appropriate to each type of material of construction, is reached, whichever is earliest.

The results of the loadbearing capacity shall be presented according to Table 3;

- h) The report shall also include a statement regarding the limits of direct application of the assessment procedure in accordance with Clause 15;
- i) any specific temperature data obtained from the use of plate thermometers within the cavity, as specified in 13.3.

The insulation and integrity for the slabs of the standard test structure are deemed to be of the same value as that of loadbearing capacity of the test structure.

Table 1 - Presentation of loadbearing capacity results

For application to the following construction materials	Limiting cavity temperature	Loadbearing capacity from elapsed time
Concrete	600 °C	min
Steel beams/concrete slabs	530 °C	min
Pre-stressed concrete	450 °C	min
Steel concrete composite slabs	400 °C	min
Cold formed steel building members	370 °C	min
Timber	300 °C	min
For application to the following construction materials	Limiting surface temperature	Loadbearing capacity from elapsed time
Steel beams/concrete slabs	510 °C	min
Steel concrete composite slabs	350 °C	min
Cold formed steel members	350 °C	min

15 Limits of applicability of the results of the assessment

15.1 Type of structural building member

When the procedure described in this test method is carried out on standard constructions according to 6.4.2, the results obtained may be applied to other combinations of beams or joists and floors in accordance with Table 2.

Table 2 - Application of results from tests to other materials

Standard structural building member tested	Results applicable to structural building members comprising, slabs constructed from alternative material types, provided from 15.2 to 15.5 are satisfied			
[see 6.4.2]	Aerated concrete	Normal concrete	Steel/concrete composite	Timber
Aerated concrete slabs on steel beams [see 6.4.2 a)]	YES	YES	YES	YES
Normal concrete slabs on steel beams [see 6.4.2 b)]	NO	YES	YES	NO
Steel/concrete composite members on steel beams [see 6.4.2 d)]	NO	YES ^{b)}	YES	NO
Timber boards on timber beams [see 6.4.2 c)]	YES ^{a)}	YES ^{a)}	YES ^{a)}	YES
^{a)} only for the duration to get 300 °C inside the cavity during the fire test of the timber floor protected by the same horizontal membrane. ^{b)} only for the duration to get 400 °C inside the cavity during the fire test of the steel/concrete composite slab protected by the same horizontal membrane.				

Tables 3 to 6 provide the limiting temperature criteria by which the results are applied to other combinations of beams or joists, slabs and floors according to the materials from which they are constructed depending on the tested combination.

Where building members contain a combination of the material types then the lowest limiting temperature value appropriate to those materials shall be chosen. The results of the assessment may also be presented according to Table 3.

Table 3 - Limiting temperature values and presentation of results for aerated concrete slab on steel beams has been tested (see 6.4.2.a)

Type of beam or joist	Type of slab or floor	Specified limiting temperature value (cavity) [°C]	Specified limiting temperature value (surface) [°C]	Time to specified temperature value (cavity) [minutes]	Time to specified temperature value (surface) [minutes]	Loadbearing capacity [minutes] (Note)
Pre-stressed Concrete	Aerated concrete	450	-		-	
Concrete	Aerated concrete	600	-		-	
Pre-stressed Concrete	Pre-stressed concrete	450	-		-	
Concrete	Pre-stressed concrete	450	-		-	
Pre-stressed Concrete	concrete	450	-		-	
Concrete	concrete	600	-		-	
Steel	Aerated concrete	530	510			
Steel	Pre-stressed concrete	450	-		-	
Steel	concrete	530	510			
Pre-stressed Concrete	Steel/ concrete composites	400	350			
Concrete	Steel/ concrete composites	400	350			
Steel	Steel/ concrete composites	400	350			
Cold formed Steel	Steel/ concrete composites	370	350			

Type of beam or joist	Type of slab or floor	Specified limiting temperature value (cavity) [°C]	Specified limiting temperature value (surface) [°C]	Time to specified temperature value (cavity) [minutes]	Time to specified temperature value (surface) [minutes]	Loadbearing capacity [minutes] (Note)
Cold formed steel	Pre-stressed Concrete	370	350			
Cold formed steel	Concrete	370	350			
Cold formed steel	aerated Concrete	370	350			
Cold formed steel	Timber	300	-			
Timber	Aerated concrete	300	-		-	
Timber	Pre-stressed concrete	300	-		-	
Timber	concrete	300	-		-	
Timber	Steel/ concrete composite	300	-		-	
Concrete	Timber	300	-		-	
Steel	Timber	300	-		-	
Timber	Timber	300	-		-	

NOTE Loadbearing capacity performance is the lowest value of time to reach the specified limiting temperature in either the cavity or at the surface or the time to reach the specified limiting temperature within the cavity if no surface limiting temperature is given in this table.

Table 4 - Limiting temperature values and presentation of results for concrete slab on steel beams has been tested (see 6.4.2.b))

Type of beam or joist	Type of slab or floor	Specified limiting temperature value (cavity) [°C]	Specified limiting temperature value (surface) [°C]	Time to specified temperature value (cavity) [minutes]	Time to specified temperature value (surface) [minutes]	Loadbearing capacity [minutes] (Note)
Pre-stressed Concrete	Pre-stressed concrete	450	-		-	
Concrete	Pre-stressed concrete	450	-		-	
Pre-stressed Concrete	concrete	450	-		-	
Concrete	concrete	600	-		-	
Steel	Pre-stressed concrete	450	-			
Steel	concrete	530	510			
Pre-stressed Concrete	Steel/ concrete composites	400	350			
Concrete	Steel/ concrete composites	400	350			
Steel	Steel/ concrete composites	400	350			
Cold formed Steel	Steel/ concrete composites	370	350			
Cold formed steel	Pre-stressed Concrete	370	350			
Cold formed steel	Concrete	370	350			

NOTE Loadbearing capacity measured from the time to reach the specified limiting temperature within the cavity or lowest value of time to reach the specified limiting temperature in either the cavity or at the surface where such limiting temperatures are allowed.

Table 5 - Limiting temperature values and presentation of results for steel/concrete composite member slab has been tested (see 6.4.2.d)

Type of beam or joist	Type of slab or floor	Specified limiting temperature value (cavity) [°C]	Specified limiting temperature value (surface) [°C]	Time to specified temperature value (cavity) [minutes]	Time to specified temperature value (surface) [minutes]	Loadbearing capacity [minutes] (Note)
Steel	Steel/ concrete composites	400	350			
Pre-stressed Concrete	Steel/ concrete composites	400	350			
Concrete	Steel/ concrete composites	400	350			
Cold formed Steel	Steel/ concrete composites	370	350			
Steel	Concrete	400	-			
Pre-stressed Concrete	Concrete	400	-			
Concrete	Concrete	400	-			
Cold formed Steel	Concrete	370	350			

NOTE Loadbearing capacity measured from the time to reach the specified limiting temperature within the cavity or lowest value of time to reach the specified limiting temperature in either the cavity or at the surface where such limiting temperatures are allowed.

Table 6 - Limiting temperature values and presentation of results for timber boards on timber beams has been tested (see 6.4.2.c))

Type of beam or joist	Type of slab or floor	Specified limiting temperature value (cavity) [°C]	Specified limiting temperature value (surface) [°C]	Time to specified temperature value (cavity) [minutes]	Time to specified temperature value (surface) [minutes]	Loadbearing capacity [minutes] (Note)
Pre-stressed Concrete	Aerated concrete	300	-		-	
Concrete	Aerated concrete	300	-		-	
Pre-stressed Concrete	Pre-stressed concrete	300	-		-	
Concrete	Pre-stressed concrete	300	-		-	
Pre-stressed Concrete	concrete	300	-		-	
Concrete	concrete	300	-		-	
Steel	Aerated concrete	300	-			
Steel	Pre-stressed concrete	300	-			
Steel	concrete	300	-			
Pre-stressed Concrete	Steel/ concrete composites	300	-			
Concrete	Steel/ concrete composites	300	-			
Steel	Steel/ concrete composites	300	-			
Cold formed Steel	Steel/ concrete composites	300	-			
Cold formed steel	Pre-stressed Concrete	300	-			

Type of beam or joist	Type of slab or floor	Specified limiting temperature value (cavity) [°C]	Specified limiting temperature value (surface) [°C]	Time to specified temperature value (cavity) [minutes]	Time to specified temperature value (surface) [minutes]	Loadbearing capacity [minutes] (Note)
Cold formed steel	Concrete	300	-			
Cold formed steel	aerated Concrete	300	-			
Cold formed steel	Timber	300	-			
Timber	Aerated concrete	300	-		-	
Timber	Pre-stressed concrete	300	-		-	
Timber	concrete	300	-		-	
Timber	Steel/ concrete composite	300	-		-	
Concrete	Timber	300	-		-	
Steel	Timber	300	-		-	
Timber	Timber	300	-		-	

NOTE Loadbearing capacity measured from the time to reach the specified limiting temperature within the cavity or lowest value of time to reach the specified limiting temperature in either the cavity or at the surface where such limiting temperatures are allowed.

15.2 Type of concrete

Fire resistance obtained from a tested structural building member containing aerated concrete slabs shall be applicable to any structural building member containing aerated concrete with the same or greater thickness than that tested, and with the permitted application with respect to the cavity specified in 15.6.

Fire resistance obtained from a tested structural building member containing aerated concrete slabs shall be applicable to any structural building member containing normal concrete with 60 mm or greater and with the permitted application with respect to the cavity specified in 15.6.

Fire resistance obtained from a tested structural building member containing normal density concrete slabs shall be applicable to any structural building member containing normal concrete with the same or greater thickness than that tested, and with the permitted application with respect to the cavity specified in 15.6.

Fire resistance obtained from a tested standard timber floor shall be applicable to any structural building member containing normal concrete with 60 mm or greater and with the permitted application with respect to the cavity specified in 15.6.

Fire resistance obtained from a tested standard timber floor shall be applicable to any structural building member containing aerated concrete with 100 mm or greater and with the permitted application with respect to the cavity specified in 15.6.

15.3 Type of steel beam

Fire resistance obtained from the testing of a test specimen containing steel beams shall be applicable to structural building members containing:

- a) steel beams having any section factor when the fire resistance is that derived by measurement of cavity temperature,
- b) steel beams having a section factor lower than that tested when the fire resistance is that derived by measurement of the surface temperature upon the lower flange of the steel beam.

Fire resistance obtained from a tested standard timber floor shall be applicable to structural building members containing steel beams having any section factor,

The permitted application with respect to the cavity defined in 15.6 shall be allowed in both cases.

15.4 Type of steel/concrete composite structures

Fire resistance obtained from a tested standard timber floor or a standard aerated concrete floor shall be applicable to structural building member designed as following:

The standard concrete/profiled steel sheet composite test slab shall be prepared according to the specification given in prEN 13381-5. The grade of steel and the concrete type, composition and strength shall be as specified in prEN 13381-5.

The standard concrete/profiled steel sheet composite slab shall be fixed to and supported on two equally spaced steel beams with a representative span as specified in 6.4.1.

Safety suspensions may be provided on the unexposed side of the slab, without contributing to the loadbearing capacity of the structural member, in order to avoid collapse of the structural member under test during the test.

Fire resistance obtained from testing a test specimen containing a composite steel/concrete building member shall be directly applicable to other steel/concrete composite members provided that:

- a) the steel sheet is of equal or greater thickness than that tested and of the same type of corrugation profile (e.g. trapezoid for trapezoid, dovetail for dovetail),
- b) the concrete is of the same or greater thickness and of the same or greater density than that tested.

The permitted application with respect to the cavity defined in 15.6 shall be allowed in all cases.

15.5 Type of timber structure

Fire resistance obtained from the testing of a timber structural building member or the standard aerated concrete floor shall be directly applicable to timber building members provided that:

- the thickness of timber particle board/cover is equal or greater than 21 mm;

- the particle board which are laid perpendicular to the joists, shall be connected with tongue and groove joints;
- the butt joints shall only be located above the joist ;
- the requirements of EN 1995-1-1 and the provisions with respect to the cavity specified in 15.6 are both maintained.

15.6 Height of the cavity

Fire resistance obtained by direct application shall be applicable to cavities with equal or greater height than that tested.

15.7 Exposed width of test specimen

Where the exposed width in the test is less than 3 000 mm the results shall not be applicable to structures of width greater than that tested.

15.8 Properties of the horizontal protective membrane

The result of the assessment is only applicable to the horizontal protective membrane construction tested and at the density and thickness tested $\pm 5\%$.

Components of supporting steel frame and installation conditions shall be the same as those tested.

15.9 Size of panels within the horizontal protective membrane

Where panels are produced in a range of sizes and if the minimum and maximum sizes are tested, in separate tests, then the results giving the lowest values are directly applicable to all intermediate sizes.

15.10 Fixtures and fittings

If the test was performed without fittings and fixtures, the result is not applicable to membranes with fittings and fixtures. A separate test including the fixtures and fittings as defined in 6.2 shall be required. Fixtures and fittings at intermediate spacings may be directly applied as a result of this additional test.

Test results on membranes containing fittings and fixtures with their own suspension devices may be applied to membranes containing such suspension devices provided the distribution does not exceed those tested.

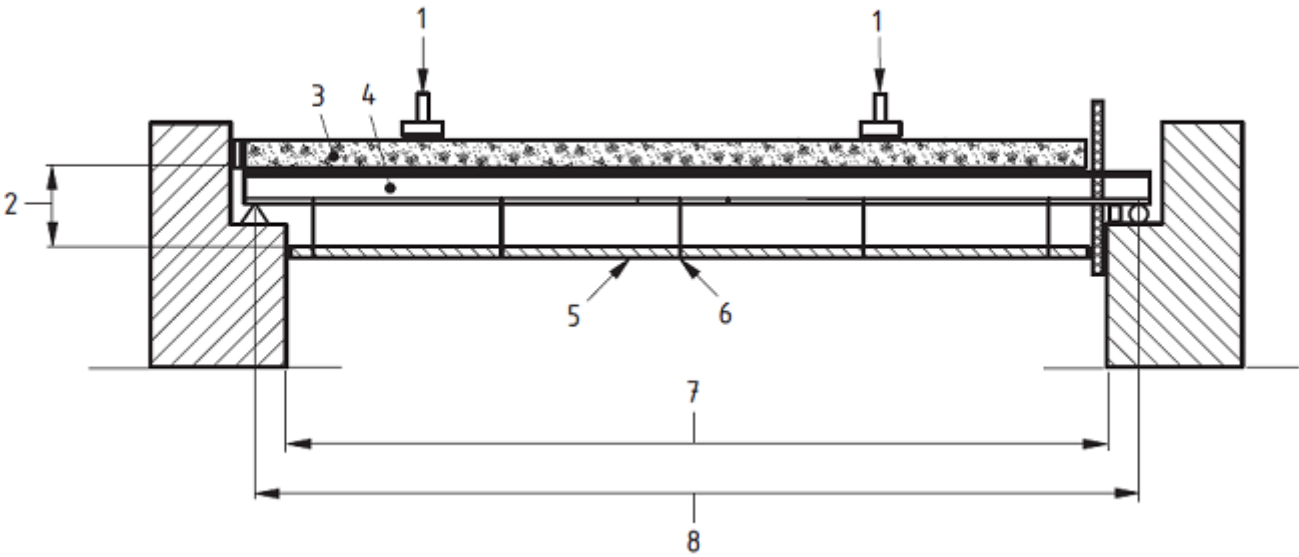
The total area occupied by fixtures and fittings related to the area of the membrane lining is not increased and the maximum tested opening area in the lining is not exceeded.

If the test was performed with fittings and fixtures, the result is not applicable to membranes without fittings and fixtures.

15.11 Gaps between grid members and test frame or walls

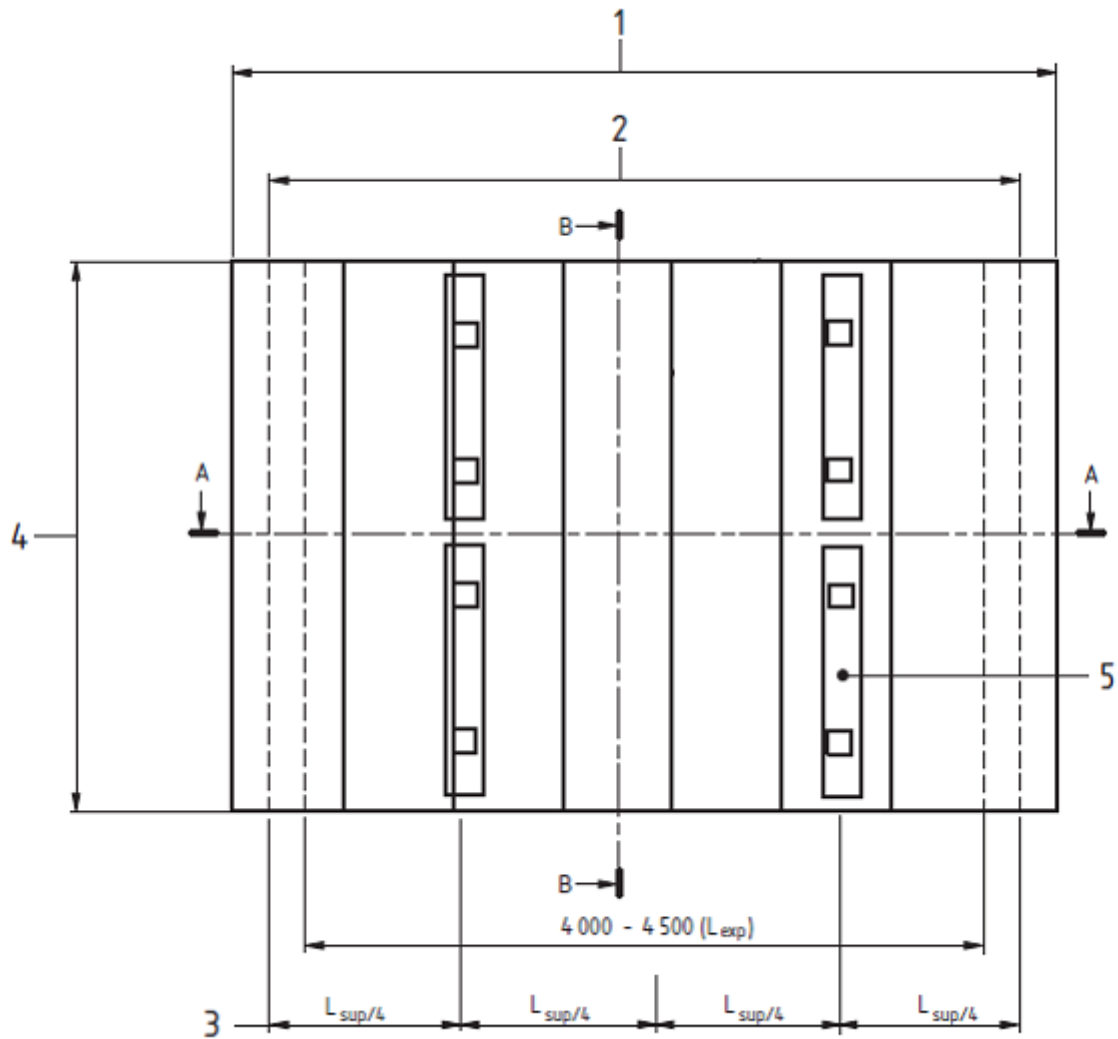
Test results obtained with no expansion gap between grid members and the test frame or furnace walls shall be applicable to practical situations where such gaps are used, providing these are no greater than 5 mm in size.

Dimensions in millimetres



- Key**
- 1 appropriate load distributive device
 - 2 cavity
 - 3 concrete slab
 - 4 steel beam
 - 5 ceiling lining (with or without insulation)
 - 6 supporting framework
 - 7 $L_{exp} \geq 4\ 000\ \text{mm}$
 - 8 L_{sup}

Figure 1 - Construction of test specimen (steel beam/concrete slab): Section A-A

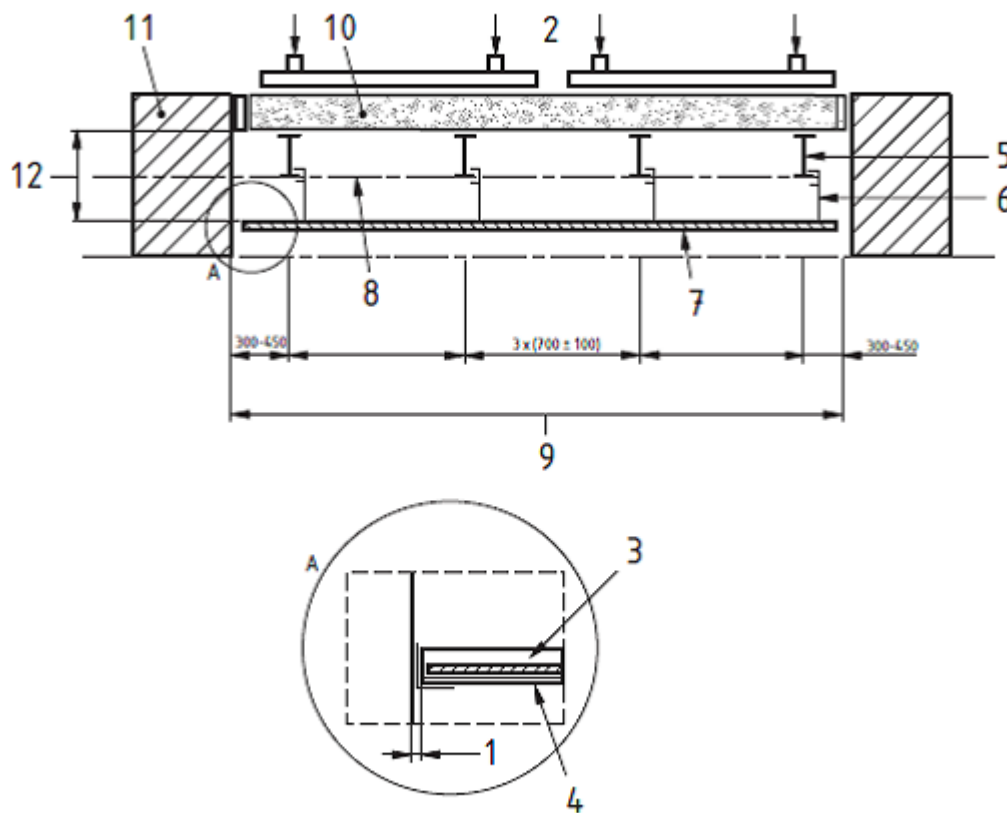


Key

- | | | | |
|---|--------------------------|---|--------------------------------------|
| 1 | length of the steel beam | 4 | width of exposed concrete slabs |
| 2 | L_{sup} | 5 | appropriate load distribution device |
| 3 | application of the load | | |

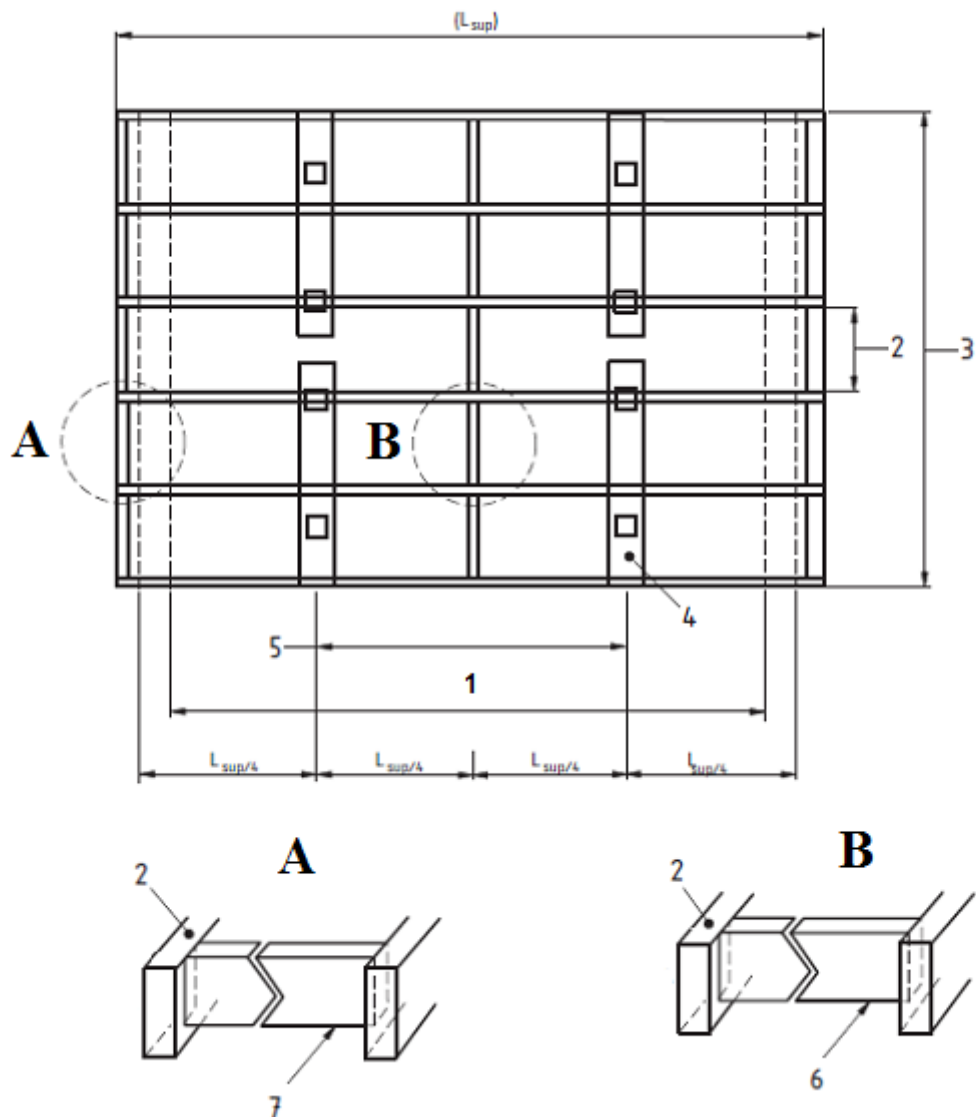
Figure 2 - Overview of test specimen (steel beam/concrete slab)

Dimensions in millimetres

**Key**

- | | | | |
|---|--------------------------------------|----|---|
| 1 | no gap | 7 | horizontal protective membrane |
| 2 | appropriate load distribution device | 8 | plan of reference for the thermocouples |
| 3 | ceiling lining | 9 | width of exposed concrete slab $\geq 3\,000$ mm |
| 4 | grid member | 10 | concrete slab |
| 5 | steel beams | 11 | furnace wall |
| 6 | hangers | 12 | cavity |

Figure 3 - Construction of test specimen (steel beam/concrete slab): Section B-B

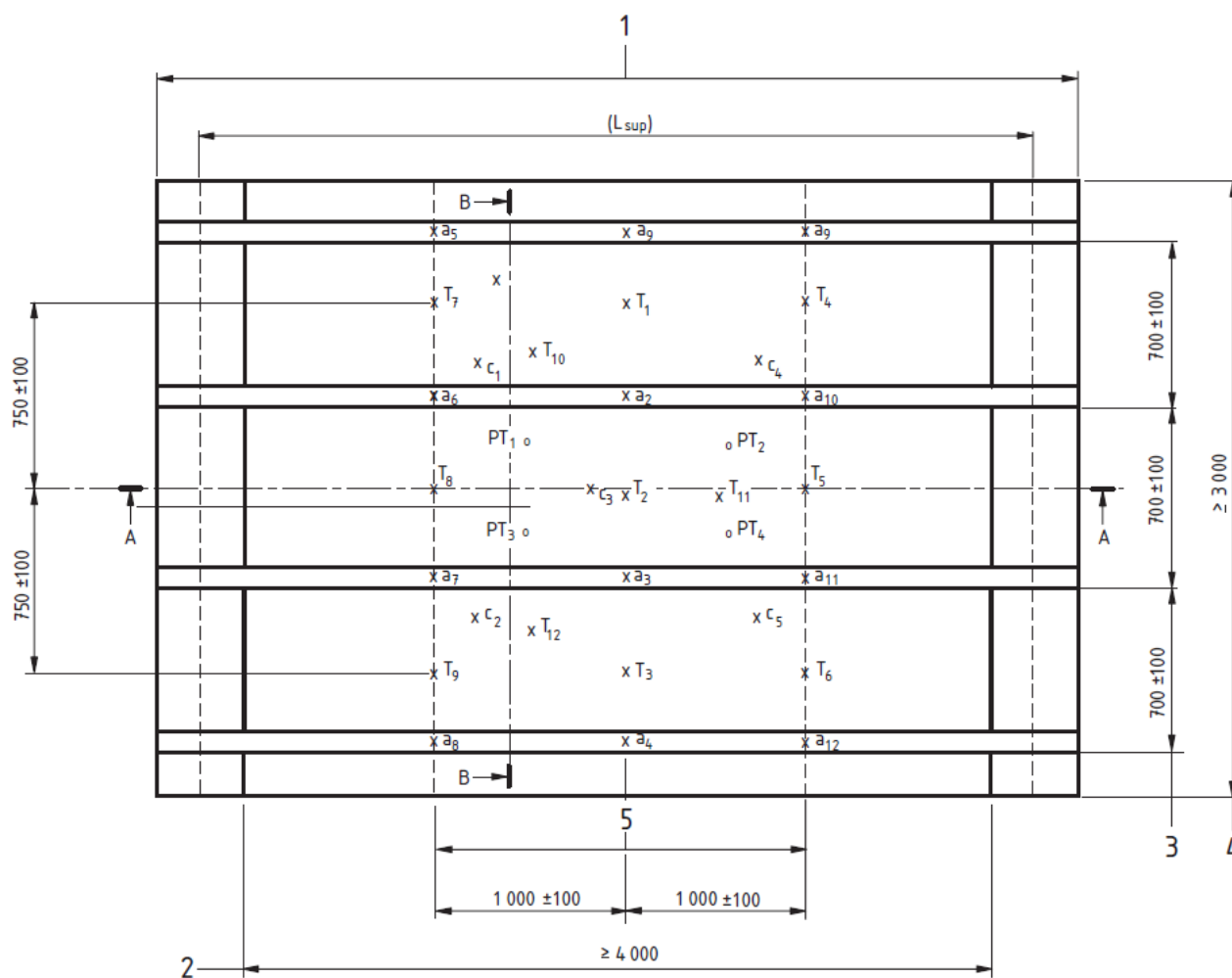


Key

- | | | | |
|---|---|---|--|
| 1 | L_{exp} | 5 | application of the load |
| 2 | joists $(220 \pm 10) \times (75 \pm 5)$ at 530 to 600 centres | 6 | cross beam (mid span) $(175 \pm 10) \times (40 \pm 5)$ |
| 3 | exposed width $\geq 3\ 000$ | 7 | cross beam (supports) $(220 \pm 10) \times (75 \pm 5)$ |
| 4 | appropriate load distribution device | | |

Figure 4 - Construction and overview of timber test specimen

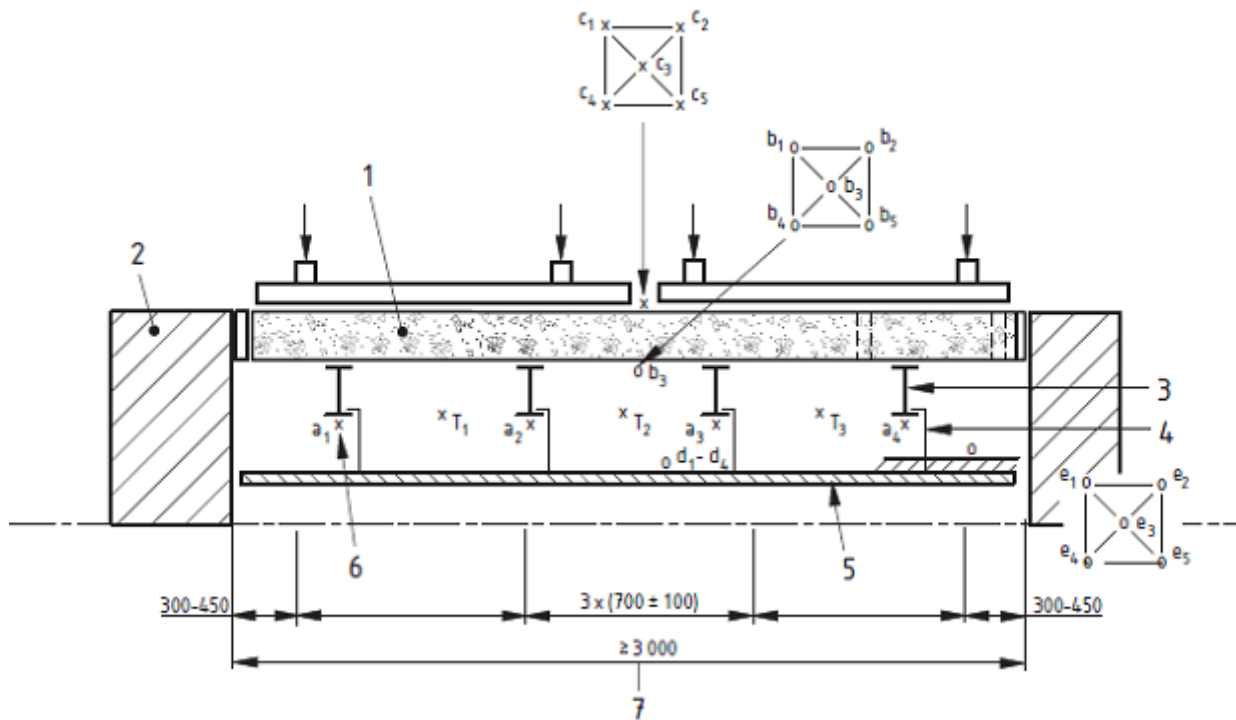
Dimensions in millimetres



Key

- 1 L_{spec}
 - 2 exposed length
 - 3 spacing steel beams
 - 4 width of exposed concrete slab
 - 5 loading lines
- Mandatory thermocouples [designated x] – see 9.3.2 and 9.3.3
- Optional thermocouples [designated o] – see 9.3.4
- T1 to T9 (T12) cavity temperature measurement
- PT1 to PT4 plate thermometers
- a1 to a12 surface temperature measurement
- c1 to c5 unexposed surface temperature measurement (see 9.3.2c)

Figure 5 - Overview of mandatory thermocouples and thermocouples used in support of Eurocodes



Key

- 1 concrete slab
- 2 furnace wall
- 3 steel beams
- 4 hangers
- 5 horizontal protection membrane
- 6 plan of reference for thermocouples
- 7 width of the exposed concrete slab

Mandatory thermocouples (x) Optional thermocouples (o)

T1 to T9 (T12) - cavity temperature

b1 to b5 - surface temperature on underside of building membrane

a1 to a12 - surface temperature

d1 to d4 - surface temperature on unexposed face of horizontal protective membrane

c1 to c5 - unexposed surface temperature

e1 to e5 - surface temperature on top of any insulation within cavity

Figure 6 - Temperature measurement locations

Annex A (normative)

Exposure to a semi-natural fire

A.1 General

Suspended ceilings may be required to be subjected to the semi-natural fire. This exposure which is from the underside is used only in special circumstances and is not intended to be compulsory for all suspended ceilings.

A.2 Semi-natural fire source

EN 1363-1 defines the heating conditions in terms of a specified standard temperature/time relationship to be used for the determination of the fire resistance of structural building elements.

It is acknowledged that the standard heating condition cannot reflect the full spectrum of real life fire scenarios. There shall also not be too large a discrepancy between the fire performance assessed by the use of the standard curve and that to be expected in building fires. Generally, this is achieved through the wide ranging classification system and the appropriate choice of failure criteria.

Experience has shown that some lightweight component systems having a very low thermal inertia can behave unsatisfactorily when subjected to a rapidly developing fire. A method is proposed whereby the response of elements to a rapidly growing fire can be evaluated.

Because of the difficulties in achieving a very rapid rate of rise of temperature and flame impingement in a gas fired furnace, wooden cribs are used to provide the heating regime.

A.3 Test equipment

A.3.1 The furnace

The test shall be carried out in a four-sided chamber or furnace with the characteristics specified in EN 1363-1. The dimensions of the chamber or furnace shall be at least (3 × 3 × 3 (height)) m. One wall of the furnace shall be provided with a free opening of 1,5 m height such that the opening factor calculated as:

$$A_w h^{1/2}/A_t = (0,06 \text{ m}^{1/2} \pm 0,005) \text{ m}$$

where

A_w is the area of the opening, in square metres,

h is the height of the opening, in metres,

A_t is the total surface area of the walls, floor & ceiling of the furnace, in square metres,

The sill of the opening shall be (1,25 ± 0,25) m above the floor of the furnace.

The top of the opening shall be (0,4 ± 0,1) m below the horizontal protective membrane.

A.3.2 Preparation of fire source and heating conditions

The cribs shall be fabricated from softwood, *pinus silvestris*, having a moisture content of $(12 \pm 3) \%$. The wood shall be cut into lathes or sticks having a length of (660 ± 5) mm, a width of (70 ± 2) mm and a thickness of (44 ± 2) mm. The sticks shall be assembled into cribs of 13 layers, each layer consisting of three sticks. The sticks in alternate layers shall be at right angles to each adjacent layer (see Figure A.1). The centre stick from the bottom layer shall be removed to leave space for an ignition tray.

Dimensions in millimetres

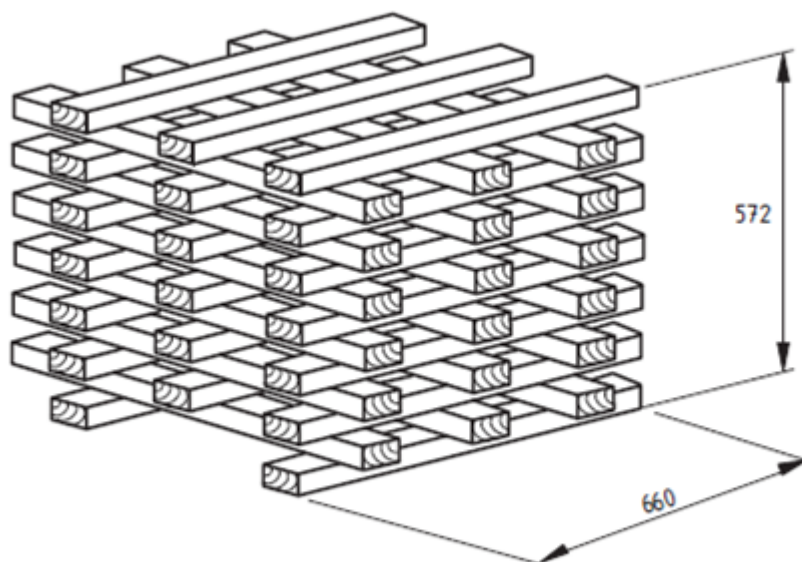


Figure A.1 - A typical wooden crib for the semi-natural fire exposure test

Wooden cribs, as described above, shall be distributed evenly within the test chamber to give a total fire loading of (40 ± 2) kg per square metre of floor area.

A metal tray, measuring (250 ± 5) mm x (250 ± 5) mm x (20 ± 5) [depth] mm containing $(0,75 \pm 0,1)$ litres of n heptane shall be placed under each wooden crib.

The test is commenced by igniting the fuel in the trays. This shall be completed within 30 s. Observations shall commence from time zero, when the ignition process is started.

A.4 Test conditions

The loading and support conditions shall be as described in 5.2 and 5.3

A temperature of not less than $1\ 000$ °C shall be achieved between 10 min and 20 min from the commencement of the test. This temperature shall be the mean temperature as measured by thermocouples relevant to the element being tested installed.

A.5 Test specimen

The test specimen, together with any associated construction, shall be as described in Clause 6, except the dimensions of the specimen which shall be adapted to the furnace dimensions.

A.6 Installation of the test specimen

The test specimen shall be installed as described in Clause 7.

A.7 Conditioning

The test construction shall be conditioned as described in Clause 8.

A.8 Application of instrumentation

The instrumentation used in the test shall be as described in 9.2 and 9.3.

A.9 Test procedure

Measure and record the temperatures within the furnace, using the thermocouples specified in 9.2 at intervals not exceeding one minute.

Monitor the test specimen throughout the test and observe such general behaviour as described in EN 1363-1 at regular intervals, including cracking, fissuring, the occurrence of gaps between the components, delamination or detachment of the horizontal protective membrane and similar phenomena.

Optionally measure and record the temperature upon the structural building member and the horizontal protective membrane, using the thermocouples specified in 9.3, at intervals not exceeding one minute.

Allow the test to continue until the fire source decays naturally, unless terminated by extinguishment.

A.10 Test results

The results of temperature measurements shall be presented according to Clause 11.

A.11 Test report

The test report shall be as given in Clause 12.

A.12 The assessment

The stability of the horizontal protective membrane shall be expressed according to there being no visible openings or deterioration of the membrane during the time when the temperature is increasing within the test chamber. Such openings or deterioration shall be defined as being where an element or a component of the horizontal protective membrane has fallen down or where an edge of such elements or components has left its supporting profile element.

A.13 The assessment report

The assessment report shall contain:

- a) items a) to e) from Clause 14,

FprEN 13381-1:2014 (E)

b) the time elapsed to the completed minute, from the commencement of the test to the time when the appearance of openings, detachment or deterioration in the horizontal protective membrane were observed and if these occurred before maximum furnace temperature was reached,

c) a pass/fail statement.

Fire resistance classification should only be obtained by testing according to the standard temperature/time heating curve.

Annex B (normative)

Measurement of properties of horizontal protective membranes and components

B.1 General

Determination of the thickness, density and moisture content of horizontal protective membranes, components thereof and other materials used in this fire resistance test is important to the accurate prediction of fire protection performance from the test result. The methods used to establish these properties shall, therefore, be consistent and this annex gives guidance on appropriate procedures to be used.

Any special test samples used to determine thickness, density and moisture content shall be conditioned as described in Clause 8.

Any specific product standard existing for the measurement of such properties shall be followed.

The procedures given in EN 1363-1 shall be followed together with the provisions of B.2 to B.4.

B.2 Thickness of horizontal protective membrane and its components

B.2.1 For horizontal protective membranes containing board or panel materials, the nominal thickness of each material shall be measured using suitable gauges or callipers in accordance with EN 12467 or EN 823.

The measurement shall be carried out either on the actual materials during assembly of the test specimen or on a representative special test sample, the minimum linear dimensions of which shall be 300 mm by 300 mm. At least nine measurements shall be made including measurements around the perimeter and over the surface of the material.

The design thickness used in the assessment and test reports shall be as described in 6.5.

B.2.2 For horizontal protective membranes containing sprayed passive fire protection materials, the thickness of this component shall be measured using a 1 mm diameter probe or drill, which shall be inserted into the material at each measurement position until the tip of the probe or drill touches the surface of the building element. The probe or drill shall carry a circular steel plate of diameter 50 mm upon it, for accurate determination of the surface level.

Thickness measurement points shall be located on the horizontal protective membrane at points corresponding to each of the main cavity temperature measuring locations, T1 to T9 (T12). They shall be regarded as the minimum number of thickness measurement points.

For horizontal protective membranes containing sprayed fire protection materials, the design thickness used in the assessment and test reports shall be as specified in 6.5.

In case where there is a gap between the membrane and the structural member and it is not possible to use the probe, then use additional standard steel plate, of size (300 x 300) mm as explained in B.2.3 b).

B.2.3 For horizontal protective membranes containing reactive fire protection coating materials, the dry film thickness of that component shall be determined by at least two of the following methods. In all cases the designations used in the assessment and test reports shall be as described in 6.5.

- a) Interpolation from that measured on a standard steel plate, of size (300 × 300) mm, to which the coating is applied at the same time and by the same method as it is applied to the horizontal protective membrane structure (i.e. placed in horizontal position and applied from beneath). Measurements shall be made at nine points over the steel plate at least, including measurements around the perimeter and over the surface of the material.

The dry film thickness of reactive fire protection coatings over steel plates (methods a) or b)) shall be measured using an instrument employing either the Electro-magnetic Induction principle or the Eddy Current principle. Reactive fire protection materials applied as coatings typically range from 0,25 mm to 4 mm thickness and the choice of instrument will be appropriate to the thickness of coating used.

- b) Interpolation by examination of the wet film applied at the same time and by the same method to a standard steel plate, of size (300 × 300) mm, as it is applied to the horizontal protective membrane (i.e. placed in horizontal position and applied from beneath). Dry film thickness shall be measured by:
- 1) determining mass of material applied per unit area and hence applied wet film thickness. Interpolation to dry film thickness using expected mass loss/thickness loss specified by sponsor.
 - 2) use of wet film thickness combs to give wet film thickness. Interpolation of this using expected thickness loss to dry film thickness.
- c) Other verifiable methods proposed by the sponsor.

B.3 Density of horizontal protective membranes and components thereof

The density of each component of the horizontal protective membrane shall be determined from measurements of mass and dimensions using the following:

- a) For horizontal protective membranes containing board or panel materials, the density can be obtained from values of mass, mean thickness (from nine measurements) and area measured either on the actual materials during assembly or on a representative special test sample, the minimum linear dimensions of which shall be (300 × 300) mm. The mass of the board shall be obtained using a balance having an accuracy equivalent to 0,1 % of the total mass of the sample being weighed or 0,1 g (the sample size shall be sufficient such that the minimum mass is 100 g) whichever is the greater.

The density of fibrous or compressible fire protection material shall be related to nominal thickness.

- b) For horizontal protective membranes containing spray applied fire protection materials, the density of these materials shall be determined from samples of the material sprayed from beneath, into two (300 × 300) mm metal trays, made from 1 mm thick steel plate. The depth of the trays shall be the same as the design thickness of the spray applied protection.

They shall be prepared in the same manner, orientation and at the same time, as that applied to the horizontal protective membrane system. Two such trays shall be prepared. One of these trays is dried to provide a reference for dry density and moisture content. The second tray shall be used to determine the density at the time of test.

The thickness of the specimen within the trays shall be determined at nine points over the surface of the trays using:

- one at the centre (one in total),
- two along each centre to corner axis, equidistant from each other, the centre and the corner (eight in total).

The mass of the fire protection within the tray shall be obtained using a balance having an accuracy equivalent to 0,1 % of the total mass of the sample being weighed or 0,1 g (the sample size shall be sufficient such that the minimum mass is 100 g) whichever is the greater.

c) The design density used in the assessment and test reports in all cases shall be as defined in 6.5.

It is inappropriate to measure the density of thin coatings and intumescent paint.

B.4 Moisture content of horizontal protective membrane and components thereof

B.4.1 The samples and materials used to measure moisture content shall be stored together with and under the same conditions as the test specimens. The measurement of final moisture content shall be made on the day that fire testing takes place.

B.4.2 For horizontal protective membranes containing board or panel materials, special test samples shall be taken measuring a minimum (300 × 300) mm.

They shall be weighed and dried in a ventilated oven, using the temperatures and techniques specified in EN 1363-1. The moisture content of the specimen shall be calculated as a percentage of its moisture equilibrium weight.

If the product contains, or is based on, gypsum and similar materials, drying shall take place at (40 ± 5) °C.

B.4.3 For horizontal protective membranes containing spray applied passive fire protection materials, the moisture content of the material shall be calculated from repeated weighing/heating/ weighing of one of the sample trays referred to in B.3b),.

They shall be weighed and dried in a ventilated oven, using the temperatures and techniques specified in EN 1363-1. The moisture content of the specimen shall be calculated as a percentage of its moisture equilibrium weight.

If the product contains, or is based on, gypsum and similar materials, drying shall take place at (40 ± 5) °C.

It is inappropriate to measure the moisture of thin coatings and intumescent paint.

Annex C (normative)

Test method to the smouldering fire (slow heating curve)

C.1 Introduction

Fire protection products activated by the heat flux of the fire may be required to be subjected to a test to a smouldering curve (slow heating curve as defined in EN 1363-2), with a rate of temperature increase less than that of the standard temperature/time curve.

NOTE See Council Directive 89/106/EEC, ID No. 2: Safety in case of fire, Clauses 3.2.4 and 4.3.1.3.4 (b).

This exposure, applicable to reactive fire protection materials, is used only in special circumstances, where it might be expected that the performance of the product when exposed to a smouldering fire might be substantially less than when it is exposed to the standard temperature/time curve, and where such a test is specified in the national building regulations of the Member State of destination.

It is not intended to be mandatory for all fire protection materials applied to structural steel members.

C.2 Test equipment

The furnace and test equipment shall be designed to permit the test specimens to be exposed to heating as specified within C.5.

The smouldering curve (slow heating curve) shall be as specified in EN 1363-2, where it provides a heating regime wherein during the period $t = 0$ min to 20 min the furnace temperature (T) follows the relationship

$$T = 154 \sqrt[4]{t} + 20$$

After $t = 20$ min and for the remainder of the test, the furnace temperature (T) follows the temperature/time relationship:

$$T = 345 \log_{10}[8(t-20) + 1] + 21$$

This heating protocol is shown graphically in Figure C.1.

C.3 Test specimens

The test specimen, together with any associated construction, shall be as described in Clause 6.

C.4 Termination of test

Terminate the test after 40 min or if it becomes unsafe to continue according to EN 1363-1.

C.5 Evaluation of the results

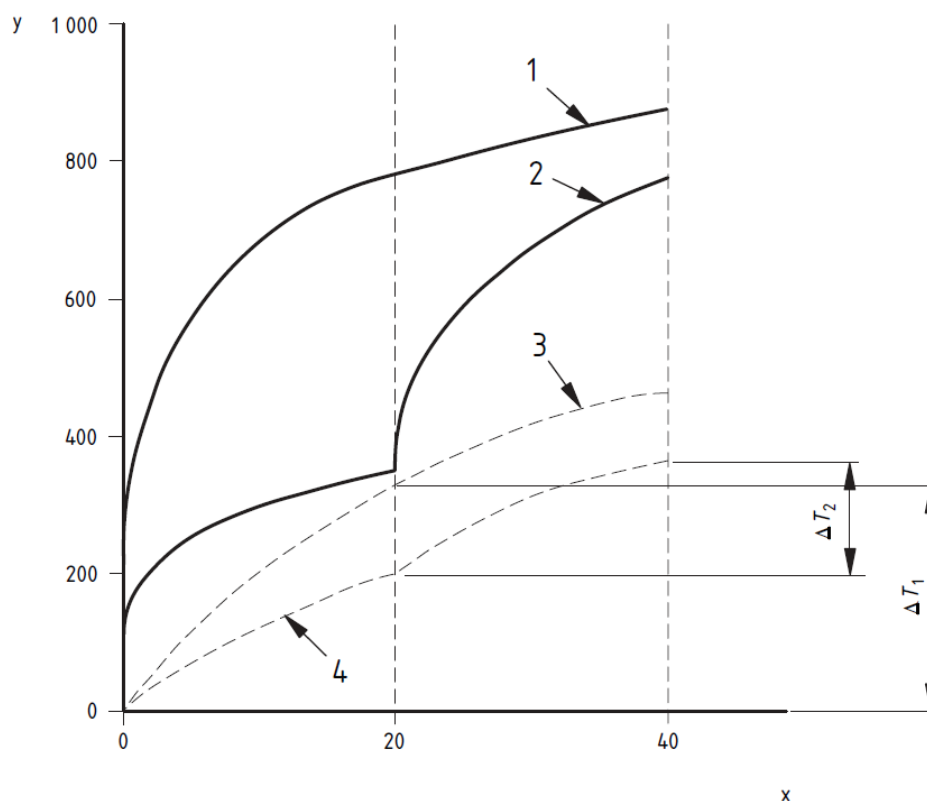
The characteristic temperature of the cavity when subjected to both the standard temperature/time curve (according to the principal test) and the smouldering curve (this test) shall be compared each with the other.

The results from the characteristic temperature in the cavity shall be examined and recorded by tabulation.

The results shall be presented graphically, in a manner similar to that given in Figure C.1, and the performance of the fire protection material to the two fire sources compared and recorded.

The values of ΔT_1 and ΔT_2 shall be measured and recorded.

The results of tests carried out according to the standard temperature/time curve for the particular reactive fire protection material under test shall only be valid and applicable if $\Delta T_1 > \Delta T_2$.



Key

- Y temperature °C
- X time (min)
- 1 standard temperature curve
- 2 smouldering (slow heating) curve
- 3 test element temperature to standard temperature/time curve
- 4 test element temperature to smouldering (slow heating) curve

Figure C.1 – Comparison of performance to the standard and smouldering fire curves

Bibliography

EN 1365-2, *Fire resistance tests for loadbearing elements - Part 2: Floors and roofs*

prEN 13381-2, *Test methods for determining the contribution to the fire resistance of structural members - Part 2: Vertical protective membranes*

prEN 13381-3, *Test methods for determining the contribution to the fire resistance of structural members - Part 3: applied protection to concrete members*