



BSI Standards Publication

Test methods for determining the contribution to the fire resistance of structural members

Part 7: Applied protection to timber members

National foreword

This British Standard is the UK implementation of EN 13381-7:2019. It supersedes DD ENV 13381-7:2002, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee FSH/22/-/12, Fire resistance tests For Protection Systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

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

Méthodes d'essai pour déterminer la contribution à la résistance au feu des éléments de construction - Partie 7: Protection appliquée aux éléments en bois

Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden Bauteilen - Brandschutzmaßnahmen für Holzbauteile

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European foreword

This document (EN 13381-7:2019) has been prepared by Technical Committee CEN/TC 127 “Fire safety in buildings”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2019, and conflicting national standards shall be withdrawn at the latest by March 2021.

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

This document supersedes ENV 13381-7:2002.

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 protection to steel members.

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

Part 6: Applied protection to concrete filled hollow steel columns.

Part 8: Applied reactive protection to steel members.

Part 9: Applied fire protection systems to steel beams with web openings.

Part 10: Applied protection to solid steel rods.

The main changes compared to ENV 13381-7:2002 are:

- a) New test procedures have been introduced to address the different fields of applications of fire protection systems on solid timber products and timber frame assemblies in horizontal and vertical position and the design models available in EN 1995-1-2.
- b) Loaded tests are performed using large-scale test specimens depending on their intended use on walls or ceilings.
- c) The start of charring and the stickability is measured with thermocouples on the timber member(s) surface of a beam specimen or a timber frame specimen.
- d) Charring behind a fire protection system is measured using charring specimens embedded in the cavity insulation of a timber frame specimen.
- e) Interpolation of results for different thicknesses of fire protection system is not allowed.

- f) The use of test results for different orientations obtained in tests in one orientation is specified.

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

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

This document has been prepared under a standardization request given to CEN/CENELEC by the European Commission and the European Free Trade Association.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This document specifies test methods for determining the contribution of fire protection kits to the fire resistance of structural timber members.

Such fire protection kits include claddings, sprayed fire protection and reactive coatings.

The method is applicable to all fire protection kits used for the protection of timber members. These can be fixed directly, totally or in part, to the timber member and can include an air gap between the fire protection kit and the timber member, as an integral part of its design.

Evaluation of timber constructions protected by horizontal or vertical protective membranes are the subject of EN 13381-1 or EN 13381-2 respectively.

The test method is applicable to the determination of the contribution of fire protection kits to the fire resistance of loadbearing timber structural members including floors, roofs, walls, beams and columns.

This document contains the fire test which specifies the test to be carried out to determine the ability of the fire protection kit at a specified thickness to delay the temperature rise throughout the timber member, to determine the ability of the fire protection kit at a specified thickness to remain coherent and fixed to the timber member and to provide data for determining the charring rate of the protected test member, when exposed to the standard temperature/time curve according to the procedures defined herein. This document is not appropriated to classify the tested assembly according to EN 13501-2.

The test to subject reactive protection material to a smouldering temperature time fire curve and the special circumstances for this are detailed in Annex G.

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 timber members in accordance with the procedures given in EN 1995-1-2.

A description of the relationship of this test method and the assessment of the results obtained therefrom to EN 1995-1-2 and guidelines for the use of this test method in accordance with that standard are given in Annex B.

This document also contains the assessment which indicates how the analysis of the test data should be made and gives guidance to the procedures by which interpolation should be undertaken.

The limits of applicability of the results of the assessment arising from the fire test are defined, together with the direct application of the results to different timber constructions with the specified thickness and fixation of the applied fire protection kit tested.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 301, *Adhesives, phenolic and aminoplastic, for load-bearing timber structures — Classification and performance requirements*

EN 338, *Structural timber — Strength classes*

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

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

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

EN 1365-1, *Fire resistance tests for loadbearing elements — Part 1: Walls*

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

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

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

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

EN 13381-1, *Test methods for determining the contribution to the fire resistance of structural members — Part 1: Horizontal protective membranes*

EN 13381-8, *Test methods for determining the contribution to the fire resistance of structural members — Part 8: Applied reactive protection to steel members*

EN 14080, *Timber structures - Glued laminated timber and glued solid timber — Requirements*

EN 14081-1, *Timber structures — Strength graded structural timber with rectangular cross section — Part 1: General requirements*

EN 15425, *Adhesives — One component polyurethane (PUR) for load-bearing timber structures — Classification and performance requirements*

EN ISO 2808, *Paints and varnishes — Determination of film thickness (ISO 2808)*

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

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

ISO 834-12, *Fire resistance tests — Elements of building construction — Part 12: Specific requirements for separating elements evaluated on less than full scale furnaces*

3 Terms, 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, together with the following, apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1.1

board

part of a building assembly of typically not reactive material, used as a part or as fire protection material

3.1.2

cavity insulation

stone wool insulation in batts of reaction to fire class A1 and a density of 30 kg/m³ (± 5 kg/m³) to be placed between timber joists or studs over their full depth in timber frame assemblies tested according this standard to achieve a loading of and heat accumulation in the fire exposed fire protection kit

3.1.3

char line

border-line between char layer and the residual cross section assumed to be equal with the position of the 300 degree Celsius isotherm

3.1.4

charring depth

distance from the original surface of the timber member to the char line

3.1.5

charring specimen

non-load bearing, instrumented, laminated timber specimen containing one temperature measurement station incorporated into a large scale test specimen, into a large scale test or a model scale test specimen to follow the charring behind a fire protection kit

3.1.6

failure time

time at which failure of the fire protection kit occurs, due to detachment of a significant area or sudden significant temperature rise upon the initially protected timber surface

3.1.7

fire protection material

material or combination of materials applied to the surface of a timber structural member for the purpose of increasing its fire resistance

3.1.8**fire protection kit**

fire protection material together with a prescribed method of attachment to a timber structural member for which the fire protection kit may include multiple layers of materials and multiple combinations of materials

3.1.9**model scale test**

test to determine the charring rate during the protected charring phase on a furnace of full scale or less than full scale depending on the dimension of the model scale test specimen

3.1.10**passive fire protection materials**

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

3.1.11**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 provide fire protection by thermal insulative and cooling effects

3.1.12**timber structural member**

element of building construction which may be loadbearing or non-loadbearing and which is mainly constructed from solid timber and/or other wood based products

3.1.13**fire protection**

protection afforded to the timber member by the fire protection kit such that the rise of temperature of the timber and fixings is limited or delayed throughout the period of exposure to fire

3.1.14**stickability**

ability of a fire protection material to remain sufficiently coherent and in position without failure due to detachment of a significant area or sudden significant temperature rise upon the initially protected timber surface

3.1.15**temperature measurement station**

number of thermocouples in different depths which are installed within the charring specimen and are representative for a limited area

3.1.16**test specimen**

assembly of the timber or wood based test member with its fire protection kit

3.1.17**spreader beam**

stiff beam with a height width ratio of equal or less than 1,0 used in large scale tests to distribute the load uniformly placed on the top of the large scale floor test specimen or the large scale wall test specimen over the whole width of the specimen

3.1.18**start of charring**

point in time when the temperature measurement at an initially fire protected timber surface reaches or exceeds 300 °C

3.1.19**wood defect**

knot, bark pocket, resin pocket, pith or crack

3.1.20**large scale test**

loaded test to determine the start of charring behind the fire protection kit and the stickability of a fire protection kit (applied to a horizontal or vertical timber framed assembly or to a timber beam) on a full scale furnace

3.2 Symbols and units

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

Symbol	Unit	Description
A	mm ²	Area
$E_{0.05}$	N/mm ²	Fifth percentile value of modulus of elasticity
I_z	mm ⁴	Second Moment of area about the z-axis
L_{exp}	mm	Length of the specimen exposed to the heating
L_{sup}	mm	Length of the specimen between centres of supports
T	°C	Temperature
TC		Thermocouple
b	mm	Width of the large scale test specimen
c	mm	Centre distance of loaded joists
d	mm	Vertical distance between horizontal joints
d_{char}	mm	Charring depth
d_{TC}	mm	Distance of the thermocouple from the exposed side of the timber member
$f_{c,0,d}$	N/mm ²	Design compressive strength along the grain
$f_{c,0,k}$	N/mm ²	Characteristic compressive strength along the grain
h	mm	Depth of the timber member; The height of a large scale test specimen; The depth of the model scale test specimen; The height of the joists in a large scale wall test
h_c	mm	Depth of the aerated concrete member
h_D	mm	Thickness of the decking of the large floor element
h_p	mm	Thickness of the fire protection kit. In the case of two or more layers of fire protection material h_p is the sum of the thicknesses.
h_D	mm	Thickness of the decking at the non-exposed side for large scale wall test specimens and large scale floor test specimens

Symbol	Unit	Description
i_z	mm	Radius of inertia about the z-axis
k_{mod}		Modification factor for duration of load and moisture content
k_2		Protection coefficient
l	mm	Length of the large scale wall specimen
l_c	mm	Length of the aerated concrete members
l_a	mm	Length of the mechanical fixation penetrating in the virgin wood
$l_{a,0}$	mm	Anchorage length of the mechanical fixation in the wood at $t = 0$
l_m	mm	Measurement length. Length where thermocouples are distributed
$l_{m,i}$	mm	Measurement length where thermocouples of one temperature measurement station are distributed; i from 1 to 3
l_s	mm	Length of the model scale test specimen
s	mm	Distance between thermocouples
s_f	mm	Minimum distance to the furnace walls
t	min	Time
t_{ch}	min	Start of charring at the surface of a timber member
$t_{ch,model}$	min	Time when the average temperature of the surface TC attached to the model scale specimen reaches 300 °C
$t_{ch,1}$	min	Assumed start of charring based to calculate the charring depth specimen depth and the number of thermocouples needed
t_{300}	min	Time at which the temperature indicated by a thermocouple placed at the surface of the timber test member or at a specified point within a protected timber test member, reaches 300 °C
t_f	min	Failure time of the protection for stickability
t_{test}	min	Time of termination of test
w_c	mm	Width of the aerated concrete members
w_f	mm	Width of the opening to which the tested element is mounted
w_s	mm	Width of the charring specimen
x	mm	Centre distance between first 2 outer joists or studs of a large scale wall test specimen or a large scale floor test specimen Length of a defect
β	mm/min	charring rate
β_o	mm/min	One-dimensional charring rate according to EN 1995-1-2
β_n	mm/min	Notional charring rate according to EN 1995-1-2
β_2	mm/min	Charring rate behind a fire protection kit according to EN 1995-1-2
γ_M		Partial factor for material properties, also accounting for model uncertainties and dimensional variations

Symbol	Unit	Description
λ_D	W/mK	Declared thermal conductivity according to EN 13162
λ_y		Slenderness ratio corresponding to bending about the y-axis
$\lambda_{rel,y}$		Relative slenderness ratio corresponding to bending about the y-axis
λ_z		Slenderness ratio corresponding to bending about the z-axis

4 Test equipment

4.1 General

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

4.2 Furnace

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

4.3 Loading equipment

Loading 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.

5 Test conditions

5.1 Test procedure

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

Large scale tests shall be performed on timber walls or timber floors or on timber beams.

The charring behind a fire protection system shall be determined by incorporating minimum 3 charring specimens in the large scale test specimen or in the model scale test specimen (see Annex A).

The EN 1365-1, EN 1365-2 or EN 1365-3 test method(s) and test specimen(s) appropriate to the use of the fire protection material, specified by the sponsor, shall be followed with the following additional provisions:

- the surface temperature of the timber members;
- the temperature throughout the depth of the charring specimens;
- the general behaviour of the fire protection system; and
- its failure, under fire load in conjunction with deflection during the test

shall be examined by additional instrumentation described in this standard.

5.2 Support and restraint conditions

All supports shall not counteract the deformation under load and shall be capable to rotate sufficiently. The restraint conditions have to ensure the side stability of any cellular concrete coverage.

- The wall test specimen shall be tested with two free vertical edges as shown in Figure 5. The top and bottom ends should be supported as given in Figure 6 or Figure 7.
- The floor test specimen shall have one articulated on one side and a support with rollers on the other side, so as to allow the movement and the longitudinal deformation. The floor test specimen shall not be restrained parallel to the joists. For that purpose, the test piece is submitted to test as a structure unidirectional simply supported, with two free edges as shown in Figure 8.
- The beam test specimen shall have one articulated on one side and a support with rollers on the other side, so as to allow the movement and the longitudinal deformation as shown in Figure 16.
- The model scale test specimen shall be placed on a furnace frame.

5.3 Loading conditions

Load shall be applied to all test specimens except the model scale test specimen.

For calculating the buckling resistance or bending resistance of the large scale test specimens the resistance of the timber joist only or the timber beam(s) only shall be taken into account. Any composite action shall be disregarded.

- If the spreader beam(s) used are of steel or other high conductivity material, they shall be insulated from the surface of the floor test specimen by a suitable thermal insulation material. Loading conditions for large scale wall test: the magnitude and distribution of the load applied to the specimen shall be calculated taking into account the weight of the loading system. The maximum effect produced by the total applied load shall be 30 % of the buckling resistance at normal temperature according to EN 1995-1-1 using $\gamma_m = 1,25$ and $k_{mod} = 1,0$.
- Loading conditions for large scale floor test: the magnitude and distribution of the load applied to the specimen shall be calculated taking into account the dead weight of the specimen (measured or derived by calculation from samples of the components) and the weight of the loading system. The line load shall be symmetrically applied to the test specimen along two transverse loading lines, each one at a distance ($l/4$) from each of the supports. The proportion of the total load (P) applied at each loading position shall be as specified in Figures 8 and 16. The load shall produce stresses approximating to a uniformly distributed load on the transverse loading lines.

The total surface of contact between the spreader beam and the contact plate and the decking of the large scale floor test specimen has to be as specified in EN 1363-1, provided that the spreader beam has a flexural rigidity large enough to give the required distribution of the load.

The maximum effect produced by the total applied load (P) at mid-span of the specimens shall be 60 % of the bending resistance at normal temperature according to EN 1995-1-1 using $\gamma_m = 1,25$ and $k_{mod} = 1,0$.

- Loading conditions for beams: the magnitude and distribution of the load applied to the specimen shall be calculated taking into account the dead weight of the specimen (measured or derived by calculation from samples of the components), dead weight of the cellular concrete coverage and the weight of the loading system. The load shall be symmetrically applied to the test specimen by a two point loading system, each one at a distance ($l/4$) from each of the supports. The proportion of the total load (P) applied at each

loading position shall be as specified in Figure 16. The load shall produce stresses approximating to a uniformly distributed load on the transverse loading line. Point loads shall be transferred to the test specimen through load distribution beams or plates (Figures 16 to 18).

The maximum effect produced by the total applied load (P) at mid-span of the specimens shall be 60 % of the bending resistance at normal temperature according to EN 1995-1-1 using $\gamma_m = 1,25$ and $k_{mod} = 1,0$. The shear induced by the applied load shall not exceed the maximum shear resistance.

In Annex E examples of load calculations can be found.

6 Test specimens

6.1 General

The test specimens shall be designed in order to withstand at least the requested failure time of the protection system.

The test(s) shall be chosen to suit the scope of the assessment.

Test results of the large scale test(s) shall be used for the determination of the start time of charring, the charring rate behind the fire protection system and the stickability of the tested protection system.

A model scale test shall be used to give extra information (see Annex A). Results of a model scale test give no information about the stickability of the fire protection system. Results shall be used to assess the start of charring of a fire protection system assessed for large scale test with respect to smouldering curves, see 6.2.2.

6.2 Number

6.2.1 General

The appropriate test or tests to be carried out shall be as given in 5.1. For each EN 1365 test method to be used, the following shall be carried out:

- a) Test result to be applicable to floors (and therefore to walls according to 15.1):
 - one large scale floor test with 3 incorporated charring specimens and attached fire protection system at the thickness as requested by the sponsor.
- b) Test result to be applicable only to walls:
 - one large scale wall test with 3 incorporated charring specimens and attached fire protection system at the thickness as requested by the sponsor.
- c) Test result to be applicable to beams (and therefore to columns according to 5.1):
 - one large scale beam test with 3 incorporated charring specimens and attached fire protection system at the thickness as requested by the sponsor.

6.2.2 Fire protection system variations

Additional test specimens shall be tested to provide further test data for the fire protection system when it is required to consider:

- different construction and fixing variables: One large scale test per variable shall be tested at the minimum fire protection system thickness requested by the sponsor;
- the test to the smouldering curve (see Annex G). One model scale test for minimum thickness tested on the large scale.

6.3 Dimension of test specimens

The test specimens shall follow the requirements of the standard series EN 1365 and the specifications of the sponsor with additional requirements for instrumentation and the build-up specified in this standard.

- Large scale wall test specimen: the exposed dimensions of the wall shall be as specified in EN 1365-1. The depth of the cavity is equal or larger than the depth of the incorporated charring specimens.
- Large scale floor test specimen: the exposed dimensions of the floor shall be at least 4 000 mm length and 3 000 mm width according to EN 1365-2. The depth of the cavity is equal or larger than the depth of the incorporated charring specimens.
- Large scale beam test specimen: the exposed length of the beam shall be at least 4 000 mm according to EN 1365-3. The dimensions of the timber beam are corresponding to the time of the fire test.
- Model scale test specimen: The dimensions of the specimen are corresponding to Figure A.1. The dimensions are chosen to incorporate 3 temperature measurement stations in one test specimen.

The dimensions of the charring specimen shall be calculated according to 6.4.2.

For fire protection systems comprising boards, slabs or batts: The large scale test specimen shall have at least 1 full size dimensions of the protection system as used in practice.

6.4 Construction

6.4.1 General

Any test specimen shall be assembled with 3 incorporated charring specimens.

The large scale test specimen shall be made from timber members which load bearing capacity can be calculated by EN 1995-1-2.

Test construction for testing single layer fire protection systems can be tested without incorporated charring specimens when in addition a model scale test is performed.

6.4.2 Charring specimens

By means of the charring specimens the charring behind a fire protection system will be determined by means of inserted thermocouples. Minimum 3 charring specimens shall be incorporated in a fire test.

The charring specimen consists of one to three instrumented beams protected from heat exposure on its wide sides by outer beams, see Figure 1.

The charring specimen is assembled out of timber beams of the same batch. All beams used to assemble the model scale test specimen shall have rectangular shape and the centre line rotation shall be minimized by appropriate processing. The beams shall provide a density deviating not more than 10 % from the mean value of all beams used to produce the charring specimen. The source material for the beams shall have as less wood defects as possible; holes are not allowed.

The instrumented beam(s) shall have a planned width of $w = 30$ mm. This beam(s) shall be instrumented with internal thermocouples according to Annex D. Thermocouples shall be placed at the surface of the instrumented beam(s) ($TC_{1,j}$) and inserted in the instrumented beam(s) and placed at the centre line as given in Figure 1 and Figure 3. The horizontal minimum distance for a defect free section shall be $s = 20$ mm, adjacent thermocouples shall be placed with increasing depth of 6 mm distance.

The depth h of the charring specimen is depending on the number of thermocouples n in the temperature measurement station. The number of the thermocouples n is depending on the protection system failure time, thermocouples shall be placed to follow the charring depth during the entire testing time.

The depth h of the charring test specimen shall be 80 mm deeper than the depth of the last thermocouple (see Figure 3) to prevent influence of the conditions at the non-exposed side. The minimum depth of the charring specimen shall be calculated by

$$h = \frac{t - t_{ch,1}}{k_{2,1}\beta_0} + 80 \quad (1)$$

where

- β_0 is the one dimensional charring rate according to EN 1995-1-2;
- $k_{2,1}$ is the assumed protection coefficient for charring behind the protection system: 0,7 for mineral or gypsum based ones, 0,9 for reactive coatings;
- t is the time of the fire test;
- $t_{ch,1}$ is the assumed start of charring behind the protection system.

The assumed start of charring $t_{ch,1}$ can be estimated by means of earlier experience of the test lab or the sponsor, by model scale tests or by means of the following recommendations:

For wood based materials:
$$t_{ch,1} = \frac{h_p}{\beta_{0,\rho,t}}$$

For gypsum based materials:
$$t_{ch,1} = 1,8h_p - 7$$

For mineral bound materials:
$$t_{ch,1} = h_p$$

For reactive fire protection coatings
$$t_{ch,1} = 10h_p$$

where

$\beta_{0,\rho,t}$ is the one dimensional charring rate for wood-based panels according to EN 1995-1-2

The measurement length of one temperature measurement station l_m inserted in 1 to 3 instrumented beam(s) is dependent on the number n of thermocouples which are to be arranged in minimum distance $s = 20$ mm from each other or from defects

$$l_{m,i} = s(n + 2) \quad (2)$$

where

s is the distance between thermocouples;

n is the number of thermocouples in different depths.

The position of the thermocouples may be adjusted due to defects which may increase the length of the test specimen. Depending on the timber quality it is recommended to assume the distance s to 50 mm for the calculation of the length of the test specimen.

The maximum length of the charring specimen in large scale wall or floor tests is in accordance to the spacing between the load bearing timber members, joists or studs. When the length l_m is larger than the spacing, the length shall be split to up to 3 instrumented beams.

The instrumented beam(s) for the temperature measurements shall be protected from heat flux from the wide sides by non-instrumented outer beams. Non instrumented beam(s) ($w \geq 30$ mm) are glued on each side of the instrumented beam(s). The width of the non-instrumented beam(s) attached to one side shall not be less than 120 mm to provide one dimensional heat transfer at the internal thermocouples. The lower side of all timber beams shall be laminated together so that the surface is even. The maximum width of charring specimens in large scale wall or large scale floor tests is $w_{s,max} = 330$ mm.

An example for the calculation of the dimensions of the charring specimen is given in Annex H.

No mechanical fixations (e.g. screws or nails) are placed in any charring specimen. Mechanical fixations are permitted for model scale test specimens only, see 6.4.6. The adhesive used for the glued laminated beam shall be according to EN 301 or EN 15425. Deviating from any regulations given the specified gluing pressure can be disregarded. The time from planning to glue shall be less than 6 hours.

NOTE 1 For gluing of the charring specimen it is appropriate to ensure the vertical relative positions of the beams by e.g. nails or dowels, see Figure A.2. Ensure that nails or dowels are at sufficient distance from the thermocouples, outside the heated zone.

NOTE 2 Sufficient pressure to produce charring specimens can be achieved by the use of g-clamps every 200 mm.

6.4.3 Large scale wall test specimen

The large scale wall test specimen consists of load-bearing studs, cavity insulation, a covering on the non-exposed side and a fire protection system on the fire exposed side, see Figure 5.

The large scale wall test specimen shall incorporate in minimum 3 charring specimens situated between adjacent load bearing studs as given in Figure 10. Minimum distances for the installation of the charring specimens from the edges of large scale wall test specimens shall be observed as given in Figure 11.

The construction shall ensure that the construction deflects uniformly during the fire test taking into account the reduced heat impact to the outer studs. I.e. all load-bearing studs shall exhibit the same stiffness from the beginning of the test to its termination although studs may get charred.

For board type fire protection systems, a displacement d shall be arranged as specified by the sponsor, see Figure 5.

NOTE 1 It is recommended to cut the outer studs to elements of $l \leq 300$ mm and consider them as non-loadbearing. Alternatively the outer studs can be length cut to the half and considered as loadbearing.

NOTE 2 Noggins may be used. However, these limit the applicability of the results.

6.4.4 Large scale floor test specimen

The large scale floor test specimen consists of load-bearing joists, cavity insulation, a decking on the non-exposed upper side and a fire protection system on the fire exposed lower side, see Figure 8.

The large scale floor test specimen shall incorporate in minimum 3 charring specimens situated between adjacent load bearing joists as given in Figure 10. Minimum distances for the installation of the charring specimens from the edges of large scale floor test specimens shall be observed as given in Figure 12.

The construction shall ensure that the construction deflects uniformly during the fire test taking into account the reduced heat impact to the outer joists. I.e. all load-bearing joists shall exhibit the same stiffness from the beginning of the test to its termination although joists may get charred.

NOTE 1 It is recommended to cut the outer joists to elements of $l \leq 300$ mm and consider them as non-loadbearing. Alternatively the outer joists can be length cut to the half and considered as loadbearing.

NOTE 2 Noggins may be used. However, these limit the applicability of the results.

6.4.5 Large scale beam test specimen

The large scale beam test specimen consists of a load-bearing timber beam with attached fire protection system. The specimen is subjected to fire from three sides. The timber beam may be a solid timber member or a glued laminated member. The adhesive used for the production of a glued laminated beam shall fulfil the requirements in EN 301 or EN 15425.

Beside a large scale beam test specimen charring specimens shall be arranged to assess the charring rate behind the fire protection system. It is permitted to combine charring specimens to a model scale test specimen which are tested in the same fire test or in a separate.

If charring specimens are tested in the same test minimum distances to the large scale beam test specimen of 500 mm and to the furnace walls shall be applied, see Figure 15.

6.4.6 Model scale test specimen

Minimum 3 charring specimen shall be combined to a model scale test specimen whereas minimum 3 measurement stations shall to be arranged within of the corresponding total measurement length l_m . The specimen size shall be in accordance with the dimensions of the furnace, see Figure A.1. The available length is the furnace opening in the length direction considering the limitations given in Figure A.1.

If the required minimum measurement length, for 3 charring specimens determined to

$$l_m = \sum_{i=1}^3 l_{m,i}, \text{ exceeds the available length, the temperature measurement stations shall be}$$

arranged in several adjacent instrumented timber beams. The instrumented beam(s) shall be protected on its sides by non-instrumented beams of widths of at least 120 mm on each side, see Figure 1.

Deviating from charring specimens, it is permitted that the width exceeds 330 mm considering the limitations given in Figure A.1.

Deviating from charring specimens, it is permitted to mechanically fix fire protection systems in the model scale test specimen by e.g. screws or nails of appropriate length. Any mechanical fixation shall be placed at least 100 mm from any thermocouple, see Figure A.2.

6.4.7 Application of the fire protection materials to the test specimen

6.4.7.1 Large scale wall and large scale floor test specimen

The fire protection systems shall be applied to large scale wall test specimens or large scale floor test specimens as in practice.

Fire protection systems comprising boards, slabs or batts, for the fire protection of flat, two dimensional, timber structures shall be arranged such that boards, slabs or batts of the largest practical size are used and that at least one longitudinal joint and one transverse joint, where applicable, are tested within the furnace. At least one full-size board shall be arranged, see Figure 14. No fixations shall be placed in the charring specimens.

6.4.7.2 Large scale beam test specimen

Fire protection systems comprising boards, slabs or batts, for the protection of beams shall be arranged such that boards of the largest practical size are used and that at least one longitudinal joint, one transverse joint and one horizontal joint, where applicable, are tested within the furnace. For charring specimens incorporated in the large scale beam test the application of the fire protection shall be done as for the model scale test specimen.

6.4.7.3 Model scale test specimen

The fire protection system shall be attached to the model scale test specimen in such a way that the fixations have no impact on the temperature measurements.

A minimum horizontal distance of 100 mm from any temperature measurement point should be used to attach any board, slab or batt as given in Figure A.2.

The fixations shall ensure that the fire protection system stays in place longer than during the full scale test performed. Fixations for the model scale test specimen may differ from the fixations used in the large scale test and/or in practice.

The fire protection system for the model scale test shall be applied in one piece if possible, to obtain failure later than or at the same time as during any large scale test.

Joints shall be at a minimum distance of 200 mm from any exposed surface temperature measurement point ($TC_{1,j}$ in Figure A.2).

NOTE The minimum anchorage length l_a of screws used can be verified according to EN 1995-1-2.

6.4.8 Insulating materials

6.4.8.1 Insulation material as part of the fire protection system

Where the timber structure to be protected by the fire protection material or system is to be provided with additional insulating materials, within, around or adjacent to the timber members therein, then these shall be incorporated into the test assembly as used in practice.

6.4.8.2 Insulation material as cavity insulation for large scale test specimens

Cavity insulation shall provide mechanical loading to the fire protection system and a sufficient heat barrier to heat the fire protection system during the fire tests until failure of the protection system but are not part of the assessment.

As cavity insulation for the fire tests stone wool insulation with a declared thermal conductivity of $\lambda_D < 0,04 \pm 0,005 \text{ W/(m} \cdot \text{K)}$ according to EN 13162 shall be used to fill the cavities between the timber members. Cavities shall be filled completely by means of stone wool with appropriate oversize. The stone wool has to be non-combustible with reaction to fire class A1 according to EN 13501-1.

The nominal density of the stone wool used in the cavity shall have a nominal density of $(30 \pm 5) \text{ kg/m}^3$.

6.5 Composition of the test specimen components

6.5.1 Timber

The timber species for manufacture of all test specimens shall be according to group of species WPCA, WPNN or WPCS according to EN 14081-1.

The timber used for manufacture of all test specimens shall be of a strength class of at least C24 according to EN 338 for solid timber or GL24 according to EN 14080 for glued laminated timber. For timber used for manufacture of the large scale test specimen the modulus of elasticity shall not deviate more than 10 % of the mean value, given in the relevant standard.

6.5.2 Fire protection system

The generic description of the fire protection system and its major components shall be specified by the sponsor, including at least the name, dimensions, the nominal density, thickness and moisture content according to European product standards.

6.6 Properties of test materials

The actual material properties of test specimen component materials shall be determined, according to EN 1363-1 and using appropriate product test standards, on test materials or test samples conditioned as defined in Clause 8.

The actual thickness, density and moisture content of the fire protection materials shall be measured and recorded for each test specimen at the time of test, either directly upon the fire protection material or upon special test samples taken. The procedures appropriate to different types of material are given in Annex C.

The thickness of board type fire protection systems shall not deviate by more than 15 % of the mean value over the whole of its surface. In this case, 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 15 %, the maximum thickness recorded shall be used in the assessment.

The thickness of sprayed or coated passive type fire protection systems shall not deviate by more than 20 % of the mean value over the whole of its surface. In this case, 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.

For reactive fire protection materials, the average primer thickness should be first measured and then subtracted from the total average primer and reactive coating thickness. The resulting permitted thickness tolerances excluding primer and top coat shall be in accordance with EN 13381-1.

The measurements shall be taken between 50 mm and 150 mm away from each of the thermocouple positions.

The density of the fire protection material applied to the test specimens at maximum and minimum thickness shall be recorded. The mean value of the density of the fire protection material at maximum and minimum thickness shall be used in the assessment of the results of the test, unless the difference between these is greater than 15 %, in which case the maximum density recorded shall be used.

6.7 Verification of the test specimen

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

The properties of the materials used in the preparation of the test specimen shall be measured using special samples, where necessary, as defined in 6.5 using the methods defined in Annex C.

The sponsor shall verify before the test that the fire protection material has been applied correctly and in the case of sprayed or coating materials ensure, by methods appropriate to the material that it is of the design composition and specification.

7 Installation of the test specimen

7.1 Large scale wall test

Loaded wall test specimen(s), including the fire protection system, shall be installed onto the furnace according to EN 1365-1.

7.2 Large scale floor test

Loaded floor test specimen(s), including the fire protection system, shall be installed onto the furnace according to EN 1365-2.

7.3 Large scale beam test

Loaded beam test specimen(s), including the fire protection system, shall be installed onto the furnace according to EN 1365-3.

Lightweight or aerated concrete slabs shall be provided for the beam topping which are bolted to the beam using 12 mm diameter bolts. Only the two sides and the soffit of the beams are exposed to heating, as shown in Figure 15. The slabs shall have the following properties:

- a) the width measures across the beam shall be 600 mm $\pm$ 100 mm;

- b) the thickness shall be within the range 150 mm to 200 mm;
- c) the maximum length shall be 625 mm;
- d) the nominal density of aerated slabs shall be 500 kg/m³;
- e) the nominal density of lightweight concrete slabs shall be 1 500 kg/m³;
- f) the concrete slabs shall have a gap between them sufficient to allow the beam to bend.

Each element of the concrete topping shall be secured by at least two fixings. The gap between the elements of the concrete topping shall be filled with fire resistant packing.

At the commencement of the test, the soffit of the concrete topping to the loaded beam shall be nominally flush with the soffit of the adjacent furnace cover slabs.

Arrangements, appropriate to laboratory practice, shall be made to ensure that the gap between the concrete topping to the loaded beam and the adjacent furnace cover slabs is sealed to prevent escape of furnace gases, especially when the beam is subject to deformation during the test. The loaded beam shall be installed, with special attention taken to insulate the bearings of the beam from the influence of heat. In addition, the ends of the loaded beam outside the furnace should be insulated and sufficient clearance should be provided between the underside of the protection system and the furnace walls to prevent interference.

7.4 Model scale test

The model scale test specimen(s) shall be installed horizontally on the furnace in an appropriate test frame (see Figure A.1). The furnace/test assembly interface shall be sealed with a non-combustible seal.

7.5 Installation patterns

Depending upon the width of the test specimen, more than one test specimen may be incorporated into a test to permit more than one variable to be examined per furnace test, providing the limitations of 6.3 and Clause 7 are followed.

Test specimens may be tested together on a furnace providing:

- separate specimen supports are provided and a furnace closure is applied to each to permit tests to safely run for different durations without affecting the other test specimens;
- separate loading devices are provided for different fire protection systems.

Otherwise, tests shall be run separately.

The minimum distance between a large scale beam test specimen and an incorporated charring specimen is 500 mm. If more than one large scale beam test specimens is tested in the same test, the minimum distance between the large scale beam test specimens is 500 mm.

8 Conditioning of the test specimens

The test specimens and test samples taken for the determination of material properties (specified in 6.5) shall be conditioned according to EN 1363-1. Material properties shall be determined according to methods specified in Annex C.

Timber used for the large scale test shall have a moisture content between 9 % and 12 % when tested: The mean value of the moisture content for every load-bearing timber shall be

determined by at least one measurement per meter length over the total length of the loaded timber member(s).

Timber used for the charring specimen shall be conditioned such that the moisture content is between 9 % and 12 % before the construction of the charring specimen.

9 Application of instrumentation

9.1 General

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

9.2 Instrumentation for measurement of furnace temperature

9.2.1 General

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 and positioned as specified in the appropriate test(s).

For test specimens with less than 6 m² exposed area, a minimum of four plate thermometers shall be used.

9.2.2 Large scale wall test

For large scale wall test the plate thermometers shall be installed as given in EN 1365-1.

9.2.3 Large scale floor test

For large scale floor test plate thermometers shall be installed as given in EN 1365-2.

9.2.4 Large scale beam test

The furnace temperature in the region of each loaded beam test specimen shall be measured by plate thermometers, placed at locations at 1/5, 2/5, 3/5 and 4/5 of the heated length of the loaded beam, there being two plate thermometers at each location, one on each side of the beam. The plate thermometers shall be positioned at a distance of 500 mm below the soffit as shown in Figure 19.

The plate thermometers shall be oriented so that for half their number side „A“ faces the floor of the furnace and for the other half, side „A“ faces the longer side walls of the furnace. The distribution of the different orientations shall be such that there shall be equal numbers facing the floor and the wall on each side of the beam.

9.2.5 Model scale test

Plate thermometers shall be installed as for the large scale floor test.

9.3 Instrumentation for measurement of test specimen temperature

9.3.1 General

Thermocouples for measuring temperatures upon the exposed surface of the protected timber members of large scale test specimen(s) and for measuring temperatures upon the exposed surface and within the timber member of the model scale test, shall be of the double glass fibre insulated bare wire type K specified in EN 1363-1 and be positioned and fixed as specified therein. Such thermocouples shall be new when used for this test.

For temperature measurements at the unexposed surface of the timber member, thermocouples specified in EN 1363-1 shall be used and be positioned and fixed as specified therein.

Thermocouples shall be provided to measure test specimen temperature at temperature measurement stations distributed as specified below.

Where joints are to be included within the fire protection system, thermocouples at 50 % of the locations shall be positioned at a minimum of 50 mm from any fixing.

For numbering of the layers of multi-layer fire protection systems see Figure 4.

The fixation of thermocouples is given in Annex D.

9.3.2 Charring specimen

The temperature of the protected surface shall be measured by means of welded thermocouples without copper discs. Staples shall be used for the fixation of the thermocouples.

The temperature inside of the instrumented beam in the centre of the centre beam shall be measured by appropriate number of thermocouples. The locations of the thermocouples are given in Figure 3.

Thermocouples within the instrumented beam in the centre of the specimen shall have an outer diameter including the thermal insulation smaller than 1,75 mm to ensure that the cable can be inserted into a drilled hole of maximum $\varnothing$ 1,75 mm. The open end should be placed in the centre of the centre beam. The open end shall be 3 mm long and shall have crimped or welded junctions. The first 50 mm cable from the crimped or welded junction shall be arranged parallel to the isotherms within the specimens (parallel to the lower surface of the test specimen).

Three measurement stations shall be arranged within the total measurement length l_m , (see Figure 3).

9.3.3 Large scale wall test specimen

Thermocouples comprising three groups (A, B, C) shall be provided to measure the surface temperature along the centre line of each loaded stud of the large scale wall test specimen over the total exposed length with a distance of 300 mm from each other (see Table 1 and Figure 9). Instrumentation shall start from the bottom end of the loaded timber members of the large scale test specimen.

Table 1 — Thermocouple groups for the large scale wall test specimen

Thermocouple group	Location	Centre distance (in mm)
A	At the narrow side of a stud along the centre line, between the timber and the fire protection system with a minimum distance of 200 mm from a joint.	300
B	As group A but behind a joint in the last layer of the fire protection system.	300
C	Within the field, centric between two adjacent load-bearing studs, between the non-exposed side of the fire protection system and the cavity insulation.	300

9.3.4 Large scale floor test specimen

Thermocouples comprising three groups (A, B, C) shall be provided to measure the surface temperature along the centre line of each loaded joist of the large scale floor test specimen over the total exposed length with a distance of 300 mm from each other (see Table 2 and Figure 9).

Table 2 — Thermocouple groups for the large scale floor test specimen

Thermocouple group	Location	Centre distance (in mm)
A	At the narrow side of a joist along the centre line, between the timber and the fire protection system with a minimum distance of 200 mm from a joint.	300
B	As group A but behind a joint in the last layer of the fire protection system.	300
C	Within the field, centric between two adjacent load-bearing joists, between the non-exposed side of the fire protection system and the cavity insulation.	300

9.3.5 Large scale beam test specimen

Temperature measurement stations comprising three groups (E, F, G) shall be provided to measure the surface temperature of the beam specimen within the measurement length l_m with a distance of 200 mm from each other. The measurement length is the exposed length L_{exp} of the beam test specimen excluding 1 000 mm from each side of the furnace walls.