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Fire resistance tests - Part 1: General requirements

Feuerwiderstandsprüfungen - Teil 1: Allgemeine Anforderungen

Essais de résistance au feu - Partie 1: Exigences générales

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This European Standard was approved by CEN on 18 February 1999.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This European Standard 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of an identical text or by endorsement, at the latest by February 2000, and conflicting national standards shall be withdrawn at the latest by February 2000.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of the Construction Products Directive.

This European Standard is technically related to ISO 834-1 prepared by ISO/TC92/SC2 'Fire resistance tests'.

EN 1363 'Fire resistance tests' consists of the following

Part 1: General requirements.

Part 2: Alternative and additional procedures.

Part 3: Verification of furnace performance (published as an ENV).

Introduction

The objective of determining fire resistance, is to assess the behaviour of a specimen of an element of building construction when subjected to defined heating and pressure conditions. The method provides a means of quantifying the ability of an element to withstand exposure to high temperatures, by setting criteria by which the loadbearing capacity, the fire containment (integrity) and the thermal transmittance (insulation) functions amongst others can be evaluated.

A representative sample of the element is exposed to a specified regime of heating and the performance of the test specimen is monitored on the basis of criteria described in the standard. Fire resistance of the test element is expressed as the time for which the appropriate criteria have been satisfied. The times so obtained are a measure of the adequacy of the construction in a fire but have no direct relationship with the duration of a real fire.

Caution

The attention of all persons concerned with managing and carrying out this fire resistance test, EN 1363-1 is drawn to the fact that fire testing may be hazardous and that there is a possibility that toxic and/or harmful smoke and gases may be evolved during the test. Mechanical and operational hazards may also arise during the construction of the test elements or structures, their testing and 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.

Uncertainty of measurement of fire resistance

There are many factors which may affect the result of a fire resistance test. Those concerned with the variability of the specimen including its materials, manufacture and installation are not related to the uncertainty of measurement. Of the remainder, some, such as the different thermal dose provided by different furnaces are much more significant than others such as the accuracy of calibration of the data logging system.

Because of the very labour intensive nature of the test, many of the factors that have a bearing on the result are operator dependent. The training, experience and attitude of the operator is thus crucial to eliminate such variables, significantly affecting the degree of uncertainty of measurement. Unfortunately, it is not possible at present to numerically quantify these factors and therefore, any attempt to determine uncertainty of measurement that does not take into account operator dependent variables is of limited value.

1 Scope

This part of EN1363 establishes the general principles for determining the fire resistance of various elements of construction when subjected to standard fire exposure conditions. Alternative and additional procedures to meet special requirements are given in EN 1363-2.

The principle that has been embodied within all european standards relating to fire resistance testing is that where aspects and procedures of testing are common to all specific test methods e.g. the temperature/time curve, then they are specified in this test method. Where a general principle is common to many specific test methods, but the detail varies according to the element being tested e.g. the measurement of unexposed face temperature, then the principle is given in this document, but the detail is given in the specific test method. Where certain aspects of testing are unique to a particular specific test method e.g. the air leakage test for fire dampers, then no details are included in this document.

The test results obtained may be directly applicable to other similar elements, or variations of the element tested. The extent to which this is permitted is considered under the field of direct application of the test result. This is restricted to the provision of rules which limit the variation from the tested specimen without further evaluation. The rules for determining the permitted variations are given in each specific test method.

Variations outside those permitted by direct application are covered under extended application of test results. This results from an in-depth review of the particular product design and performance in test(s) by a recognised authority. Further consideration on direct and extended application is given in annex A.

The duration for which the tested element, as modified by its direct or extended field of application, satisfies specific criteria will permit subsequent classification to be made.

All values given in this Standard are nominal unless otherwise specified.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

prEN 520	Gypsum plasterboards - Specification - Test methods (ISO 6308:1980 modified)
EN 1363-2	Fire resistance tests Part 2: Alternative and additional procedures
ENV 1363-3	Fire resistance tests Part 3: Verification of furnace performance
prEN ISO 13943	Fire safety - Vocabulary (ISO/DIS 13943:1998)
EN 60584-1	Thermocouples - Part 1: Reference tables (IEC 584-1:1995)

3 Definitions, symbols and designations

3.1 Definitions

For the purposes of this Part of EN1363 the definitions given in prEN ISO 13943, together with the following, apply:

3.1.1 actual material properties: Properties of a material determined from representative samples taken from the test specimen for the fire test according to the requirements of the specific product standard.

3.1.2 characteristic material properties: Properties of a material which are specified for a grade of material which may be used for design purposes.

3.1.3 associated construction: A form of construction required to test some types of test specimen, e.g. the aerated concrete slabs on top of a beam.

3.1.4 deflection: Movement associated with structural and or thermal actions.

3.1.5 element of building construction: A defined construction component, e.g. wall, partition, floor, roof, beam or column.

3.1.6 exposed face: The side of the test construction that is exposed to the heating conditions of test.

3.1.7 glowing: The emittance of light without flaming associated with combustion of a material.

3.1.8 insulation: The ability of a test specimen of a separating element of building construction when exposed to fire on one side, to restrict the temperature rise of the unexposed face to below specified levels.

3.1.9 integrity: The ability of a test specimen of a separating element of building construction, when exposed to fire on one side, to prevent the passage through it of flames and hot gases and to prevent the occurrence of flames on the unexposed side.

3.1.10 loadbearing capacity: The ability of a test specimen of a loadbearing element to support its test load, where appropriate, without exceeding specified criteria with respect to both the extent of, and rate of, deflection..

3.1.11 loadbearing element: An element that is intended for use in supporting an external load in a building and maintaining this support in the event of a fire.

3.1.12 neutral pressure plane: The elevation at which the pressure is equal inside and outside of the furnace.

3.1.13 notional floor level: The assumed floor level relative to the position of the building element in service.

3.1.14 restraint: The constraint to expansion or rotation (induced by thermal and/or mechanical actions) afforded by the conditions at the ends, edges or supports of a test specimen. Examples of different types of restraint are: longitudinal, rotational and lateral.

3.1.15 separating element: An element that is intended for use in maintaining separation between two adjacent areas of a building in the event of a fire.

3.1.16 smoke leakage: The ability of an element of construction to reduce the passage of hot and/or cold gases or smoke from one side of the element to the other to below specified levels.

3.1.17 supporting construction: The construction that may be required for the testing of some building elements into which the test specimen is assembled, e.g. the wall into which a door is fitted, see annex B.

3.1.18 sustained flaming: Continuous flaming for a period of time greater than 10 seconds.

3.1.19 test construction: The complete assembly of the test specimen together with its supporting construction.

3.1.20 test frame: The frame containing the test construction for the purpose of mounting onto the furnace.

3.1.21 test load: The load applied to the test specimen.

3.1.22 test specimen: An element (or part) of building construction provided for the purpose of determining either its fire resistance or its contribution to the fire resistance of another building element.

3.1.23 discrete area(s): A portion(s) of the total surface of the construction, excluding framing/joints etc, which may be expected to have different fire insulation performance.

3.2 Symbols and designations

The symbols and designations listed below define those used in this document.

Symbol	**Unit**	**Description**
A	°C min	the area under the average furnace temperature/time curve
A_s	°C min	the area under the standard temperature/time curve
C	mm	axial contraction measured from the start of heating
d	mm	the distance from the extreme fibre of the design compression zone to the extreme fibre of the design tensile zone of the structural section of a flexural test specimen
D	mm	the deflection measured from the commencement of heating
h	mm	the initial height of the loaded vertical test specimen
L	mm	the length of the span of the test specimen
t	min	the time from the commencement of heating
T	°C	the temperature within the test furnace

4 Test equipment

4.1 General

Equipment used to carry out the test consists essentially of the following:

a) a specially designed furnace to subject the test specimen to the test conditions

b) control equipment to enable the temperature of the furnace to be controlled as required in 5.1

c) equipment to control and monitor the pressure of the hot gases within the furnace as required in 5.2

d) a frame in which the test construction can be erected and which can be positioned in conjunction with the furnace so that appropriate heating, pressure and support conditions can be developed

e) arrangement for loading and restraint of the test specimen as appropriate, including control and monitoring of load

f) equipment for measuring temperature in the furnace and on the unexposed face of the test specimen, and where needed within the test specimen.

g) equipment for measuring the deflection of the test specimen.

h) equipment for evaluating integrity and for establishing compliance with the performance criteria described in clause 11.

i) equipment for establishing the elapsed time.

j) equipment for measuring the oxygen concentration of furnace gases.

4.2 Furnace

The test furnace shall be designed to employ liquid or gaseous fuels and shall be capable of:

a) heating of vertical or horizontal separating elements on one face, or

b) heating of columns on all sides, or

c) heating of walls on more than one side, or

d) heating of beams on three or four sides, as appropriate

Other special furnaces may be required for specific elements.

The furnace linings shall consist of materials with densities less than 1000 kg/m^3. Such lining materials shall have a minimum thickness of 50 mm and shall constitute at least 70% of the internally exposed surface of the furnace.

The furnace shall be capable of providing the standard fire exposure conditions with respect to thermal exposure and pressure.

NOTE. Furnaces may be designed so that assemblies of more than one element can be tested simultaneously, provided all the requirements for each individual element can be complied with.

4.3 Loading equipment

The loading equipment shall be capable of subjecting test specimens to the level of loading determined in accordance with 5.4. The load may be applied hydraulically, mechanically or by the use of weights.

The loading equipment shall be able to simulate conditions of uniform loading, point loading, concentric loading, axial loading or eccentric loading as appropriate for the test construction. The loading equipment shall be capable of maintaining the test load at a constant value (± 5% of the required value) without changing its distribution and following the maximum deflection and the rate of deflection of the test specimen until failure of loadbearing capacity occurs as defined in 11.3 or for the duration of the test, whichever occurs sooner.

The loading equipment shall not significantly influence the heat transfer through the specimen nor impede the use of the thermocouple insulating pads. It shall not interfere with the measurement of surface temperature and/or deflection and shall permit general observation of the unexposed face. The total area of the contact points between the loading equipment and the test specimen surface shall not exceed 10% of the total area of the surface of a horizontal test specimen.

4.4 Test frames

Special test frames or other means shall be employed to reproduce the boundary and support conditions appropriate for the test constructions as required by 5.5. Different types of test constructions will require test frames of differing stiffness. The performance of the test frames shall be evaluated by applying an expansion force within the frame at mid-width between two opposite members and measuring the increase in the internal dimension. The increase shall not exceed 5 mm with an applied force of 25 kN. This evaluation shall be conducted in both directions of the frame.

Where test frames are to meet different requirements then these are given in the specific test method.

4.5 Instrumentation

4.5.1 Temperature

4.5.1.1 Furnace thermocouples

The furnace thermocouples shall be plate thermometers which comprise an assembly of a folded steel plate, the thermocouple fixed to it and containing insulation material.

The plate part shall be constructed from (150 ± 1) mm long by (100 ± 1) mm wide by (0,7 ± 1) mm thick nickel alloy sheet strips folded to the design as shown in figure 1.

The measuring junction shall consist of nickel chromium/nickel aluminium (type K) wire as defined in IEC 584-1, contained within mineral insulation in a heat resisting steel alloy sheath of nominal diameter 1 mm, the hot junctions being electrically insulated from the sheath. The thermocouple hot junction shall be fixed to the geometric centre of the plate in the position shown in figure 1 by a small steel strip made from the same material as the plate. The steel strip can be welded to the plate or may be screwed to it to facilitate replacement of the thermocouple. The strip shall be approximately 18 mm by 6 mm if it is spot welded to the plate and nominally 25 mm by 6 mm if it is to be screwed to the plate. The screw shall be 2 mm in diameter.

The assembly of plate and thermocouple shall be fitted with a pad of inorganic insulation material nominally (97 ± 1) mm by (97 ± 1) mm by (10 ± 1) mm thick, density (280 ± 30) kg/m^2.

Before the plate thermometers are first used, the complete plate thermometer shall be aged by immersing in a pre-heated oven at 1000 °C for 1 h.

Note Exposure in a fire resistance furnace for 90 min under the standard temperature/time curve is considered to be an acceptable alternative to using an oven.

Where a plate thermometer is used more than once, a log of its use shall be maintained, indicating for each use, the checks made and duration of use. The thermocouple and the insulation pad shall be replaced after 50 h exposure in the furnace.

4.5.1.2 Unexposed surface thermocouples

The temperature of the unexposed surface of the test specimen shall be measured by means of disc thermocouples of the type shown in figure 2. In order to provide a good thermal contact, type K thermocouple wires, as defined in IEC 584-1, 0,5 mm in diameter shall be soldered or welded to a 0,2 mm thick by 12 mm diameter copper disc.

Each thermocouple shall be covered with a (30 ± 0,5) mm x (30 ± 0,5) mm x (2.0 ± 0,5) mm thick inorganic insulating pad, unless specified otherwise in the standards for specific elements. The pad material shall have a density of (900 ± 100) kg/m^3. The insulation pads shall be cut to accommodate the thermocouple wires. The slots may originate from opposite corners of the pad or from mid way along opposite edges as shown in figure 2. The measuring and recording equipment shall be capable of operating within the limits specified in 4.6.

4.5.1.3 Roving thermocouples

One or more roving thermocouples of the design shown in figure 3 shall be available to measure the unexposed surface temperature during a test at positions where higher temperatures are suspected. The measuring junction of the thermocouple shall consist of type K thermocouple wires as defined in IEC 584-1, 1,0 mm in diameter soldered or welded to a 12 mm diameter, 0,5 mm thick copper disc. The thermocouple assembly shall be provided with a handle so that it can be applied over any point on the unexposed surface of the test specimen.

4.5.1.4 Internal thermocouples

If information concerning the internal temperature of a test specimen or particular component is required it shall be obtained by means of thermocouples having characteristics appropriate to the range of temperatures to be measured, as well as suitable to the type of materials in the test specimen. A specification for the thermocouples for measurement of internal temperature is given in annex C.

4.5.1.5 Ambient temperature thermocouple

A thermocouple shall be used to indicate the ambient temperature within the laboratory in the vicinity of the test specimen both prior to and during the test period. The thermocouple shall be nominally 3 mm diameter, mineral insulated, stainless steel sheathed type K thermocouple as defined in IEC 584-1. The measuring junction shall be protected from radiated heat and draughts.

4.5.2 Pressure

The pressure in the furnace shall be measured by means of one of the designs of sensors described in figure 4. The measuring and recording equipment shall be capable of operating within the limits specified in 4.6.

4.5.3 Load

When using weights no further measurement of load in a test is needed. The loads applied by hydraulic loading systems shall be measured by means of a load cell or other relevant equipment having the same accuracy or by monitoring the hydraulic pressure at an appropriate point. The measuring and recording equipment shall be capable of operating within the limits specified in 4.3 and 4.6.

4.5.4 Deflection

Deflection measurements can be made by using equipment employing mechanical, optical or electrical techniques. Where such equipment is used in relation to performance criteria, e.g. measurements of deflection or contraction, it shall be capable of operating at a frequency of at least one reading per minute. All necessary precautions shall be taken to prevent any drift in the sensor readings due to heating. Details of precision of measuring equipment are given in 4.6.

4.5.5 Integrity

4.5.5.1 Cotton pad

Unless specified otherwise in the standards for specific elements, the cotton pad employed in the measurement of integrity shall consist of 100% new, untreated, undyed and soft cotton fibres, nominally 20 mm thick x 100 mm square, and shall weigh between 3g and 4g. It shall be conditioned prior to use by drying in an oven at (100± 5) °C for at least 30 min. After drying it may be stored in a desiccator for up to 24 h or stored in airtight containers for up to one week before oven drying again as described above. For use it shall be mounted in a wire frame, as shown in figure 5, provided with a handle of suitable length.

4.5.5.2 Gap gauges

Two types of gap gauge, as shown in figure 6, shall be available for the measurement of integrity. They shall be made of cylindrical steel rod of (6± 0,1) mm and (25± 0,2) mm diameter. They shall be provided with insulated handles of suitable length.

4.6 Precision of measuring equipment

For conducting fire tests, the measuring equipment shall meet the following levels of precision:

a)	temperature measurement:	furnace	± 15 °C
		ambient and unexposed face	± 4 °C
		other	± 10 °C
b)	pressure measurement:		± 2 Pa
c)	load level:		± 2,5% of test load
d)	axial contraction or expansion measurement:		± 0,5 mm

e) other deflection measurements: ± 2 mm

5 Test conditions

5.1 Furnace temperature

5.1.1 Heating curve

The average temperature of the furnace as derived from the thermocouples specified in 4.5.1.1 shall be monitored and controlled such that it follows the relationship

$$T = 345 \log_{10} (8t + 1) + 20 \qquad \text{(see figure 7)}$$

where

T is the average furnace temperature, in degree Celsius
t is the time, in minutes

5.1.2 Tolerances

The percentage deviation (d_e) in the area of the curve of the average temperature recorded by the specified furnace thermocouples versus time from the area of the standard temperature/time curve shall be within

a) 15% for $5 < t \leq 10$

b) $(15 - 0{,}5\,(t-10))\%$ for $10 < t \leq 30$

c) $(5 - 0{,}083\,(t-30))\%$ for $30 < t \leq 60$

d) 2.5% for $t > 60$

where

$$d_e = \frac{A - A_s}{A_s} x\ 100$$

d_e is the percentage deviation

A is the area under the actual furnace temperature/time curve

A_s is the area under the standard temperature/time curve

t is the time in minutes

All areas shall be computed by the same method, i.e by the summation of areas at intervals not exceeding 1 min and shall be calculated from time zero.

At any time after the first 10 min of test, the temperature recorded by any thermocouple in the furnace shall not differ from the corresponding temperature of the standard temperature/time curve by more than 100 °C.

For test specimens which burn rapidly, a deviation in excess of 100 °C above the specified temperature/ time curve may be exceeded for a period not in excess of 10 min provided that such excess deviation is clearly identified as being associated with the sudden ignition of significant quantities of combustible materials increasing the gas temperature in the furnace.

Note: Whilst no tolerances are given for compliance with the temperature/time curve during the first five minutes of the test, it is expected that the laboratory shall attempt to follow the prescribed relationship as closely as possible during that period such that the difference between the integrals of the prescribed and achieved curves is kept to a minimum at any period during the test.

As a consequence of the rapid temperature increase in the first five minutes of the test, furnace operators may experience difficulties to control the furnace such that compliance with the tolerances that apply after this period can be achieved. To provide additional information to assist in avoiding this problem one or more thermocouples of conventional type (e.g. 3 mm stainless steel sheathed) may be used to provide supplementary data for the purpose of furnace control. With the benefit of experience of the comparison between them and the plate thermometers, closer compliance of the plate thermometer temperatures with the specified temperatures may be achieved by furnace operators and control systems.

However, compliance with the prescribed temperature/time relationship during any period of the test is on the basis of the information given by the plate thermometer.

5.2 Furnace pressure

5.2.1 General

The pressure distribution over the height of a furnace is mainly influenced by the natural buoyancy effect of the gases and for the purpose of controlling pressure it can be assumed that the pressure gradient will be approximately 8,5 Pa per metre height of furnace.

The pressure measuring system shall be such that it disregards rapid fluctuations in pressure (e.g. with cycles of 1 second or less) associated with turbulence etc. The furnace pressure shall be established relative to the pressure outside the furnace at the same height.

The furnace pressure shall be monitored and controlled so that by 5 minutes from commencement of the test it is ± 5 Pa of the pressure specified for the particular element under test and that from 10 minutes onwards it shall be ± 3 Pa of the pressure specified for the particular element under test.

5.2.2 Establishing the neutral pressure plane

5.2.2.1 General

The furnace shall be operated so that the neutral pressure plane (a pressure of zero) is established 500 mm above notional floor level. Irrespective of this, the pressure at the top of the test specimen shall at no time exceed 20 Pa and this requirement may result in adjustment of the height of the neutral pressure plane.

5.2.2.2 Multiple vertical separating elements

For those test methods where several specimens can be accommodated over the height of the furnace and where a fixed pressure is specified for the element being tested, then the fixed pressure shall apply to the lowest test specimen and the limit of 20 Pa at the top of the specimen(s) does not apply.