

DfYg\_i gbY'a YfcXY'nUi [ cHj`Ub^Ydf]gdYj\_U\_'dcÿUfb]cXdcfbcgh]\_cbglfi\_V'g\_]`  
YYa Yblcj`!\* "XY.'NUý ]Hj ch]`^Y`Yb]`ghVfcj`g'dc`b]ca`]n'VYfcbU

Test methods for determining the contribution to the fire resistance of structural members  
- Part 6: Applied protection to concrete filled hollow steel columns

Prüfverfahren zur Bestimmung des Beitrages zum Feuerwiderstand von tragenden  
Bauteilen - Teil 6: Brandschutzmaßnahmen für betonverfüllte Stahlverbund-Hohlstützen

Méthodes ds'essai pour déterminer la contribution a la résistance au feu des éléments  
de construction - Partie 6: Protection appliquée aux poteaux métalliques creux remplis  
de béton

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**Ta slovenski standard je istoveten z: ENV 13381-6:2002**

**ICS:**

|           |   |  |
|-----------|---|--|
| 13.220.50 | Požarna odpornost gradbenih materialov in elementov | Fire-resistance of building materials and elements |
| 91.080.01 | Gradbene konstrukcije na splošno                    | Structures of buildings in general                 |

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EUROPEAN PRESTANDARD  
PRÉNORME EUROPÉENNE  
EUROPÄISCHE VORNORM

**ENV 13381-6**

July 2002

ICS 13.220.50

English version

## Test methods for determining the contribution to the fire resistance of structural members - Part 6: Applied protection to concrete filled hollow steel columns

This European Prestandard (ENV) was approved by CEN on 1 March 2002 as a prospective standard for provisional application.

The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard.

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

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## Foreword

This document ENV 13381-6:2002 has been prepared by Technical Committee CEN/TC127 "Fire safety in buildings", the secretariat of which is held by BSI.

This document has been prepared under the mandate given to CEN/TC127 by the Commission of the European Communities and the European Free Trade Association.

As there was little experience in carrying out these tests in Europe CEN/TC127 agreed that more experience should be built up during a Prestandardisation period before agreeing text as European Standards. Consequently all parts are being prepared as European Prestandards.

This European Prestandard 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 the ENV 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 7: Applied protection to timber members.

Annexes A and B are normative.  
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### Caution

The attention of all persons concerned with managing and carrying out this fire resistance test, is drawn to fact that fire testing may 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 test should be followed.

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

## ENV 13381-6:2002 (E)

**1 Scope**

This part of this European Prestandard specifies a test method for determining the contribution of fire protection systems to the fire resistance of structural concrete filled hollow steel columns. The concrete can be lightweight, normal-weight or heavy-weight concrete and of strength classes 20/25 (LC/C/HC) to 50/60 (LC/C/HC).

The method is applicable to all fire protection systems used for the protection of such structural columns and includes sprayed fire protection, coatings, cladding protection systems and multi-layer or composite fire protection materials.

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

The test method is only applicable to fire protection systems which are fixed directly to the structural column. Fire protection systems where the fire protection material is not attached directly to the composite column, leading to a continuous cavity between the column and the fire protection material of size greater than 5 mm are the subject of ENV 13381-2.

This European Prestandard contains the fire test which specifies the tests which should be carried out to determine the ability of the fire protection system to remain coherent and fixed to the composite column and to provide data on the temperatures of the outer steel surface of the composite column, when exposed to the standard time/temperature curve according to the procedures defined herein.

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

This exposure, applicable to reactive fire protection materials, is used only in special circumstances, where specified in the national building regulations of a member state of the European Union, and is not intended to be mandatory for all fire protection materials applied to concrete filled hollow steel columns.

The fire test methodology makes provision for the collection and presentation of data which can be used as direct input to the calculation of fire resistance of concrete/steel composite members in accordance with the procedures given in ENV 1994-1-2.

This European Prestandard also contains the assessment which prescribes 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 permitted direct application of the results to different steel/concrete composite columns, steel types and thicknesses, concrete densities, strengths, thicknesses and production techniques over the range of thicknesses of the applied fire protection system tested.

## 2 Normative references

This European Prestandard 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 Prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

|                   |   |
|-------------------|---|
| EN 1363-1         | Fire resistance tests - Part 1: General requirements.   |
| EN 1363-2         | Fire resistance tests - Part 2: Alternative and additional procedures.  |
| EN 206-1          | Concrete - Part 1: Specification, performance, production and conformity.   |
| EN 1365-4         | Fire resistance tests for loadbearing elements - Part 4: Columns.   |
| ENV 1992-1-1      | Eurocode 2: Design of concrete structures<br>Part 1-1: General rules and rules for buildings.                                     |
| ENV 1994-1-1:1992 | Eurocode 4: Design of composite steel and concrete structures<br>Part 1-1: General rules and rules for buildings.                 |
| EN 10210-1        | Hot finished structural hollow sections of non-alloy and fine grain structural steels<br>Part 1: Technical delivery requirements. |
| ISO 8421-2        | Fire protection - Vocabulary - Part 2: Structural fire protection.  |
| EN ISO 13943      | Fire safety – Vocabulary (ISO 13943:1999).  |

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## 3 Terms and definitions, symbols and units

### 3.1 Terms and definitions

For the purposes of this European Prestandard, the terms and definitions given in EN 1363-1, EN ISO 13943, ISO 8421-2 and EN 206-1, together with the following, apply.

#### 3.1.1

##### **concrete filled hollow steel column**

element of building construction which is loadbearing and is fabricated from an outer hollow steel column which has been filled with concrete and may or may not contain steel reinforcement within the concrete

#### 3.1.2

##### **fire protection material**

material or combination of materials applied to the outer surface of a concrete filled hollow steel composite column or the purpose of increasing its fire resistance

#### 3.1.3

##### **passive fire protection materials**

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

#### 3.1.4

##### **reactive fire protection materials**

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

## ENV 13381-6:2002 (E)

**3.1.5****fire protection system**

fire protection material together with a prescribed method of attachment to the concrete filled hollow steel composite column

**3.1.6****fire protection**

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

**3.1.7****test specimen**

concrete filled hollow steel test column plus the fire protection system under test

**3.1.8****fire protection thickness**

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

**3.1.9****stickability**

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

**3.1.10****characteristic temperature**

surface temperature of the steel outer surface of the concrete filled hollow column which is used for assessment purposes

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**3.2 Symbols and units**

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| Symbol          | Unit | Designation  |
|-----------------|------|--|
| $h_{exp}$       | mm   | Height of the column exposed to heating according to EN 1365-4.                      |
| $h_{sup}$       | mm   | Centre to centre distance between the test column supports (according to EN 1365-4). |
| $h_{spec}$      | mm   | Height of the test column excluding plates and hinges.                               |
| $P$             | kN   | Load applied to the concrete filled hollow steel test column.                        |
| $\theta_{crit}$ | °C   | Critical temperature (as specified in ENV 1994-1-2).                                 |

**4 Test equipment****4.1 General**

The furnace and test equipment shall conform to that specified in EN 1363-1.

**4.2 Furnace**

The furnace shall be designed to permit the dimensions of the test specimen to be exposed to heating as specified in 5.1 and its installation to be as specified in clause 7.



### 4.3 Loading equipment

Loading equipment shall conform to that specified in EN 1363-1. The loading system shall permit loading, of the magnitude defined in 5.3, to be applied and controlled throughout the test according to EN 1363-1.

## 5 Test conditions

### 5.1 General

Test columns, subjected to predefined loading, are heated in a furnace in vertical orientation, under specified temperature/time conditions.

Tests are made on loaded and unloaded columns to provide information on:

- a) the temperature of the steel surface of the column behind the fire protection system;
- b) the ability of the fire protection system to remain attached to the steel surface of the test column (stickability).

It is recommended that the test be continued until the temperature of the steel surface reaches a mean value of at least 650 °C (or until any single maximum value of 800 °C is recorded) to give the necessary information on the stickability of the fire protection system. These temperatures may be modified if requested by the sponsor.

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

The procedures given in EN 1363-1 and, where appropriate, EN 1363-2 shall be followed in the performance of this test unless specific contrary instructions are given.

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### 5.2 Support and restraint conditions for columns

The support and restraint conditions employed for the installation of test columns shall be as specified in EN 1365-4.

Where a pin-joint condition is specified this shall be created according to EN 1365-4.

Where a fully restrained, fixed end, condition is specified this shall be created according to EN 1365-4.

### 5.3 Loading conditions

Loading shall be applied to the full size test specimens.

The magnitude and distribution of the load shall produce an eccentrically and axially applied load ( $P$ ) which represents 60 % of the design load, for the column in combined compression and uniaxial bending according to 4.8.3.13 of ENV 1994-1-1:1992. The factors,  $\gamma_M = 1$  (for both steel and concrete), a buckling length equal to  $h_{sup}$  and those actual material properties defined in 6.5 shall be used in the calculation of the load to be applied.

## 6 Test specimens

### 6.1 Number of test specimens

At least one loaded full size composite test column with the minimum thickness of applied fire protection system and one unloaded small size test column with the maximum thickness shall be tested. If the system is only available in one thickness, then the full size loaded test only shall be carried out, at that thickness and the applicability of the result restricted.

Additional unloaded small size columns may be tested with the fire protection system applied at intermediate thicknesses or to other sizes of cross-section (within the same cross-section shape only) in order to provide temperature data which may be used for direct application purposes.

Two unloaded small size test columns, one with the maximum and one with the minimum thickness of applied fire protection system is used when the test is carried out to the smouldering curve, according to annex A (unless the material is available in one thickness only).

## 6.2 Size of test specimens

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

**Table 1 - Sizes of test specimens**

|   | small specimen                                     | large specimen  |
|---|--|---|
| Exposed height $h_{\text{exp}}$ (mm)  | $\geq 5$ times $\varphi$ (1 000 min) <sup>1)</sup> | $\geq 3\ 000$   |
| Height of column $h_{\text{sup}}$ (mm)  | Not applicable                                     | $h_{\text{sup}} < (h_{\text{exp}} + 600)$ <sup>2)</sup> |
| <sup>1)</sup> The size of small test column shall be $\geq 5$ times the equivalent diameter ( $\varphi$ ) of its circular cross-section or $\geq 5$ times the smallest cross-sectional dimension if square or rectangular.<br><sup>2)</sup> This additional length beyond the supports and required for installation purposes shall be as specified in EN 1365-4 and kept as small as possible. |  |   |

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## 6.3 Construction of test specimens

### 6.3.1 Construction of concrete filled hollow steel test columns

The concrete filled hollow steel composite test column shall comprise a square steel hollow section of size (150 to 160) mm  $\times$  (150 to 160) mm or a circular column of (160 to 170) mm diameter. The thickness of the steel will normally be the minimum available.

Both large and small hollow steel test columns shall contain at least two 20 mm diameter holes (one at either end) for steam venting (see Figure 1). The hollow steel test columns shall be filled with concrete to the composition specified in 6.4.2.

Steel plates of area greater than the cross-sectional area of the test column and its applied fire protection system, by at least 10 mm in every direction and 20 mm approximate thickness shall be welded to both the top and the bottom of both large and small test columns, after the column is conditioned and before testing.

### 6.3.2 Application of the fire protection system to the composite test column

The steel surface of the composite test column shall be prepared as in practice. The outer steel surface of the composite test column shall normally be dried prior to the application of the fire protection system.

The fire protection system shall be uniformly applied to the test column, as in practice, including any required fixing aids and in the same manner for both maximum and minimum thickness.

The fire protection system shall extend over the full exposed surface of the concrete filled hollow test column and be applied prior to the application of the test load (if any).

Where a fire protection system creates small cavities between the concrete filled hollow steel test column and the

fire protection material, the ends shall be sealed with fire resistant material to prevent any flow of hot gases out of the cavities.

Board type fire protection materials shall include joints in accordance with the following:

- large size test column: at least one transverse joint positioned at a distance no further than 500 mm from mid column height;
- small size test column: at least one transverse joint positioned at a distance no further than 100 mm from mid column height.

## 6.4 Composition of components of test specimen

### 6.4.1 Hollow steel column

The steel used shall be at least of grade S 235 or comparable grade as defined in EN 10210-1.

### 6.4.2 Concrete

The concrete in the test specimen shall normally be of type 25/30 to 30/37 [LC/C/HC - (light-weight, normal-weight or heavy-weight concrete) according to EN 206-1 and ENV 1992-1-1], although other grades within the strength range 20/25 to 50/60 may be used.

The applicability of the results of the assessment arising from the testing of a particular density or strength of concrete will be restricted according to 15.4 and 15.5.

The concrete shall be prepared from silicious aggregates, of maximum aggregate size of 20 mm, and Portland cement. The composition and properties of the concrete used shall be appropriate to those specified in EN 206-1 and ENV 1992-1-1.

Other non-silicious and lower density aggregates may be permitted, but the applicability of the results of the assessment will be restricted according to 15.6.

The consistency of the wet concrete, which shall be poured into the hollow steel column positioned in vertical orientation, shall be of type S3 or F3 determined in accordance with EN 206-1 to allow for good compaction and contact with the steel.

### 6.4.3 Fire protection system

The composition of the fire protection system shall be specified by the sponsor and include, at least, its expected nominal density, thickness and moisture content. For confidentiality reasons, the sponsor may not wish detailed formulation or composition details to be reported in the test report. Such data shall, however, be provided and maintained in confidence in laboratory files.

## 6.5 Properties of test materials

### 6.5.1 General

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.

### 6.5.2 Concrete

The density, moisture content and concrete strength of the concrete component of each concrete filled hollow steel composite column, shall be measured at intervals throughout the conditioning process and on the day of test using small representative samples prepared at the same time and from the same concrete batch as each composite column tested. The method used to prepare these samples and the means by which they were conditioned shall be reported.