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Fire-resistance tests — Elements of building construction —

Part 7: Specific requirements for columns

Essais de résistance au feu — Éléments de construction —

Partie 7: Exigences spécifiques relatives aux poteaux

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 834 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 834-7 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 2, *Fire containment*.

ISO 834 consists of the following parts, under the general title *Fire-resistance tests — Elements of building construction*:

— *Part 1: General requirements*

— *Part 3: Commentary on test method and test data application*

— *Part 4: Specific requirements for loadbearing vertical separating elements*

— *Part 5: Specific requirements for loadbearing horizontal separating elements*

— *Part 6: Specific requirements for beams*

— *Part 7: Specific requirements for columns*

— *Part 8: Specific requirements for non-loadbearing vertical separating elements*

— *Part 9: Specific requirements for non-loadbearing horizontal separating elements*

— *Part 10: Method to determine the contribution of applied protection materials to structural metallic elements*

— *Part 11: Method to assess the contribution of applied protection materials to structural metallic elements*

Annexes A and B of this part of ISO 834 are for information only.

Introduction

This part of ISO 834 contains specific requirements for fire-resistance testing which are unique to the elements of building construction described as columns. The requirements for these loadbearing elements are intended to be applied in appropriate conjunction with the detailed and general requirements contained in ISO 834-1.

Fire-resistance tests — Elements of building construction —

Part 7:
Specific requirements for columns

1 Scope

This part of ISO 834 specifies the procedures to be followed for determining the fire resistance of columns when tested on their own.

Columns are normally tested with all sides fully exposed to heating. However, when in practice the exposure is from fewer than four sides, appropriate exposure conditions have to be reproduced.

The application of this test to other untested forms of construction is acceptable when the construction complies with the direct field of application as given in this part of ISO 834 or when subjected to an extended application analysis in accordance with ISO/TR 12470. Since ISO/TR 12470 gives only general guidelines, specific extended application analyses are to be performed only by persons expert in fire-resistant constructions.

General guidance on this test method is given in annex A.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 834. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 834 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 834-1:1999, *Fire-resistance tests — Elements of building construction — Part 1: General requirements.*

ISO/TR 12470, *Fire resistance tests — Guidance on the application and extension of results*.

ISO/IEC 13943, *Fire safety — Vocabulary.*

3 Terms and definitions

For the purposes of this part of ISO 834, the terms and definitions given in ISO 834-1 and ISO 13943, and the following apply.

3.1
column
vertical non-separating element of building construction which is loadbearing

3.2
controlled eccentricity
defined distance from the vertical centre axis of the column to where the load is applied

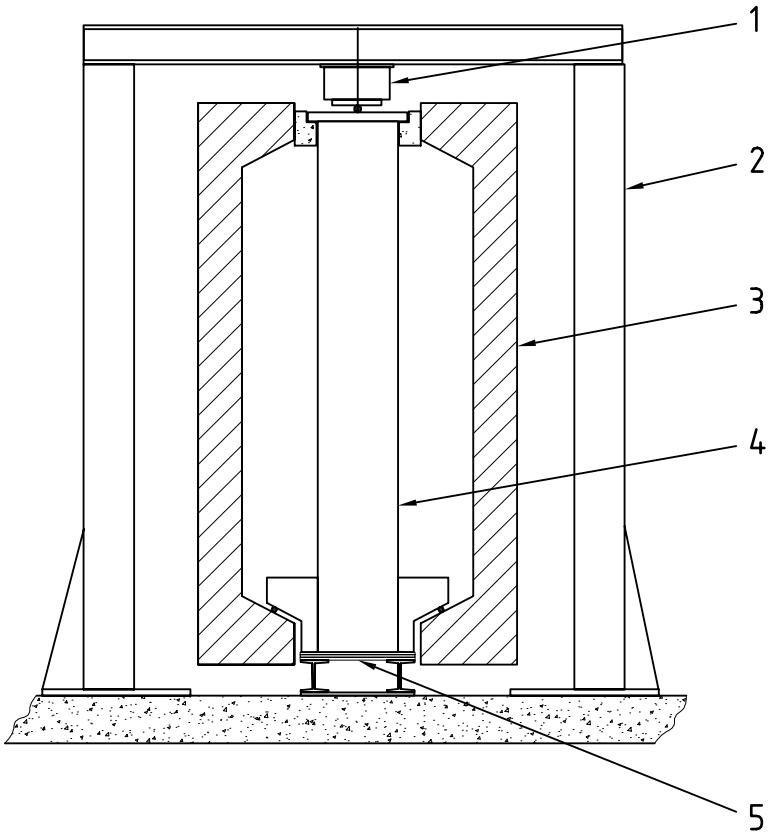
3.3
loading platens
flat plates used between the loading equipment and each end of the column to ensure correct application of the applied load

4 Symbols and abbreviated terms

Refer to ISO 834-1 for symbols and abbreviated terms appropriate for this test.

5 Test equipment

Equipment employed in the conduct of this test consists of a furnace, loading equipment, restraint and support frames and instrumentation as specified in ISO 834-1. An example of the test equipment is illustrated in Figure 1.



Key

1	Hydraulic ram	4	Column
2	Loading frame	5	Loading platens
3	Furnace		

Figure 1 — Example of the test arrangement for loaded columns

6 Test conditions

6.1 Restraint and boundary conditions

Restraint and boundary conditions shall comply with the requirements given in ISO 834-1 and the requirements of this part of ISO 834.

6.2 Loading

6.2.1 All columns shall be tested when subjected to loads calculated in accordance with subclause 6.3 a), b) or c) of ISO 834-1:1999, in consultation with the sponsor to produce the conditions the structure is designed to accommodate. The material properties utilized in the calculation of the load shall be clearly indicated and their source given.

6.2.2 When the height of the proposed test specimen is greater than can be accommodated in the test furnace, the load shall be adjusted to be compatible with the slenderness ratio of the loadbearing elements being tested, so that the load level of the full size construction is provided.

6.2.3 The ends of the specimen shall be designed and detailed for the proper transmission of the test load from the loading platens to the specimen with the required conditions of fixity and eccentricity. The load bearing faces, at top and bottom, shall be nominally parallel and perpendicular to the axis of the column to avoid introduction of bending moments.

6.2.4 For protection of the loading equipment against heat, provision shall be made for the attachment of collars at each end of the specimen. These shall be designed to locate the column and to provide an adequate seal with the furnace interior surfaces and shall be suitably attached and supported so that they remain effective and in position throughout the heating period.

The method adopted to provide the seal shall allow the test specimen to move within the furnace without affecting the load transmitted from the loading rig to the specimen or the fixity at the ends of the specimen.

6.2.5 The loading system shall be capable of compensating for the maximum allowable deformation of the test specimen.

7 Test specimen preparation

7.1 Specimen design

When in practice joints occur in fire-protection claddings, any specimen that incorporates such protection shall include at least one representative joint situated approximately at mid-height.

When hollow encasement is applied to columns, the encasement shall terminate so as to be representative of the exposure and restraint conditions in practice. The gap at the top and between the encasement and the column shall be sealed when such conditions are likely to exist in practice.

When testing columns with applied fire protection, provision should be made to ensure that no artificial stresses are introduced in the fire protection as a result of applying the load.

7.2 Specimen size

The test specimen shall be full size. For elements that have a height in excess of 3 m, the minimum size of specimen exposed to the heating shall not be less than 3 m. The overall height shall not exceed the heated height by more than 300 mm at each end. This extra height shall be minimized to prevent conduction of heat from the specimen under test and shall be used for locating the column into the loading equipment and also for distancing the loading equipment from the furnace atmosphere.

7.3 Number of test specimens

The number of test specimens shall comply with the requirements given herein and in ISO 834-1.

7.4 Specimen conditioning

At the time of the test, the strength and moisture content of the test specimens shall approximate the conditions expected in normal service. This includes any infills and jointing materials. Guidance on conditioning is given in ISO 834-1. After equilibrium has been achieved, the moisture content or state of cure shall be determined and recorded. Any supporting construction, including the lining to the test frame, is exempt from this requirement.

7.5 Specimen installation and restraint

7.5.1 The column ends shall be either fully rotationally restrained or hinged to simulate conditions of use in practice. However, the data cannot be transferred directly from one condition of restraint to the other. When full information is required, multiple tests shall be carried out with different end fixity conditions. When one or both ends are hinged, care is needed to ensure that there is no frictional restraint.

7.5.2 When a pin-joint is utilized, this shall be represented either by placing a spherical hinge, cylindrical roller or knife edge between one end of the column and the loading equipment. When a cylindrical roller is used, its axis shall be parallel to the weak axis of the column.

7.5.3 The hinge shall be mounted between two loading platens (one belonging to the loading equipment, the other in contact with the column) in order to improve the load distribution over the cross-section of the column.

7.5.4 The hinge shall be accurately located with respect to the central axis of the column so as to allow a controlled eccentricity of loading of $L/500$ (where L is the buckling length of the column) or 7 mm maximum. Special care shall be taken to minimize friction in the hinges.

7.5.5 When fixed end conditions are utilized, a contact shall be ensured between the loading platens and the ends of the column.

8 Application of instrumentation

8.1 Furnace thermocouples (plate thermometer)

Plate thermometers shall be provided to measure the temperature of the furnace and shall be uniformly distributed to give a reliable indication of the temperature in the region of the test specimen. These plate thermometers shall be constructed and located in accordance with ISO 834-1.

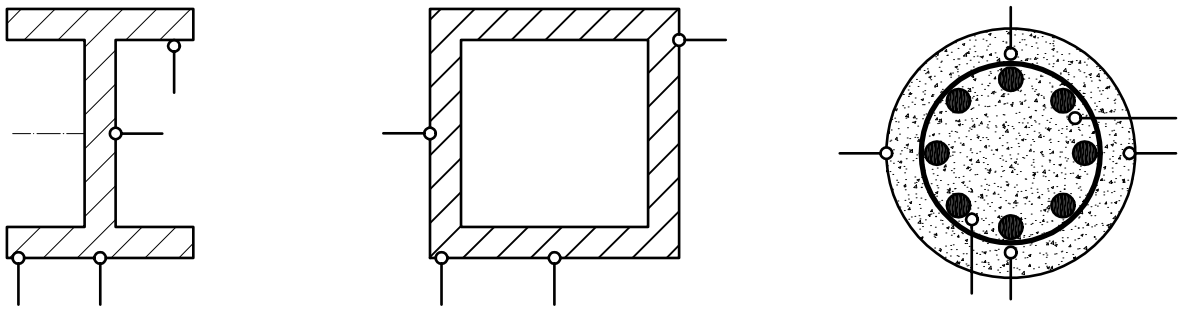
At least six plate thermometers shall be placed in pairs inside the furnace on opposite sides of the specimen at ¼, ½, and ¾ of the exposed length.

Plate thermometers shall be positioned such that at the commencement of heating they are (100 ± 50) mm from the respective faces of the specimen, not closer than 400 mm to the top of the furnace and shall not vary from these positions by more than 50 mm during the test. Each plate thermometer shall be oriented so that side “A” faces the wall of the furnace and the insulated part faces the test specimen.

8.2 Specimen thermocouples

When the column is manufactured from steel or another material for which high temperature property information is known, measurement of specimen temperatures will assist in the prediction of failure and enable the result to be used for possible assessment techniques. The use of screws, welding or peening shall be suitable means of attaching thermocouples to steel. Care shall be taken to ensure that a minimum of 50 mm of both thermocouple wire leads remains in a region isothermal to the thermo-junction.

Thermocouples shall be located at four levels, with a minimum of three thermocouples at each level. The upper and lower levels shall be 600 mm from the ends of the heated section of the column, and the two intermediate levels shall be equally spaced in between. Typical thermocouple positions at each level are shown below in Figure 2.



a) Steel I-column **b) Steel box column** **c) Reinforced concrete**

Figure 2 — Typical positions for specimen thermocouples

8.3 Deformation measurement

The zero point for the test is the axial deformation measured after the load has been applied at the beginning of the test before commencement of heating and after the deformation has stabilized.

The longitudinal axial deformation of the column shall be measured at 1-min intervals thoughout the test using transducers or dial indicators.

9 Test procedure

9.1 Load application

Apply and control the load to the column in accordance with ISO 834-1 and 6.2 of this part of ISO 834.

9.2 Furnace control

Monitor and control the furnace temperature and pressure conditions in accordance with ISO 834-1.

9.3 Measurements and observations

Monitor the specimen for compliance with the criterion of loadbearing capacity and make relevant measurements and observations in accordance with ISO 834-1.

10 Performance criteria

The fire resistance of the column shall be judged against the loadbearing capacity criteria as specified in ISO 834-1.

11 Validity of the test

The test shall be considered to be valid when it has been conducted within all of the specified limits of the requirements pertaining to: the test equipment, test conditions, test specimen preparation, instrument application and test procedure according to this part of ISO 834.

The test shall also be considered for acceptance when the fire-exposure conditions relating to furnace temperature, pressure and ambient temperature are in excess of the upper limits of the tolerances specified in this part of ISO 834.

12 Expression of results

The results of the fire-resistance test shall be expressed in accordance with ISO 834-1.

When a test has been performed on a specimen which has been subjected to a service load intended for a specific application less than the maximum which would be applied in consideration of a recognized structural code, the loadbearing capacity shall be qualified in the result by the term “restricted”. Full details shall be provided in the test report concerning its derivation.

13 Test report

The report shall be in accordance with ISO 834-1.

Annex A
(informative)

General guidance on the test method

A.1 General

Whilst the procedures are written with the assumption that the test will be applied to vertical loadbearing members subjected to compression loads, the method is also appropriate to the evaluation of members subjected to tensile loads, i.e. vertical ties. In such cases the support equipment should provide mechanical connections that are able to transmit the applied tensile load.

A.2 Design considerations

A.2.1 End support conditions

The permissible load that can be carried by a column depends to a great extent on the end conditions. In slender columns which are assumed to be hinged, even small forces due to friction within the supports can considerably increase the loadbearing capacity. In a fire test, an unintentional end restraint can produce a fixity that would have the effect of increasing the fire resistance. Free rotation can generally be achieved by using spherical or cylindrical end supports.

A.2.2 Conditioning of end collars

Where end collars comprise concrete casing around the ends of the column, it is important that these are conditioned to equilibrium dryness in a similar manner to the test specimen in order to avoid spalling, excessive steam generation or cooling effects during the test.

A.3 Loading

The column should be tested under the loading and support conditions corresponding to its cold design. It will not usually be possible to reproduce in a test, changes of end moment or loading that might occur during an actual fire.

If the loading and support conditions are clearly defined in practice and can be reproduced in a test furnace, then the test load should be calculated using these conditions.

Where it is not possible to reproduce the practical end use conditions, then representative test conditions are idealized and the test load should be calculated on the basis of these and also the fixity used.

A.4 Temperature measurement

The siting of specimen thermocouples should be such that maximum useful information on the temperature profile of the column is gained.

Where composite constructions are used (e.g. concrete-filled hollow steel sections), knowledge of the temperature of the individual components as well as the temperature gradient across the construction is useful and can permit further evaluation of the data.

Thermocouples can be used to measure temperatures between columns and fire protective cladding. Information gained in this way may be extrapolated to the fire protection, with the same protective material, of other column materials and types with different critical temperatures.

A.5 Column behaviour in the test

Axial deformation of vertical elements can arise from thermal expansion, shrinkage from drying of structural components, or axial deformation under load resulting from loss of strength or reduced effective cross-sectional area.

A structural steel column is likely to expand as the temperature rises as long as the column is able to support the test load. Once this can no longer be supported, contraction will occur as the steel deflects, either locally or as a whole, under the load applied. Hence the measured column length will reach a maximum and then reverse.

The situation is more complicated with a concrete-filled steel tube. While the tube is carrying the load, the initial deformation will be similar to that of a structural steel column. As the steel tube heats up, it will deform and transfer the load to the concrete, but retain sufficient strength to keep the concrete confined. The concrete will continue to support the test load until finally it is no longer able to do so.

Timber columns, being poor conductors of heat, will show little initial expansion and the average temperature of the cross-sectional area supporting the load will not alter. After a while, charring will occur and the effective cross-section will diminish and axial deformation in the direction of loading will be seen.

Annex B
(informative)

Direct application of results

The results of a fire-resistance test are applicable to a similar untested column provided that all the following are true

a) The length is not increased.

b) The load is not increased and its eccentricity is not increased.

c) The end conditions are unchanged.

d) The dimensions of the cross section are not reduced.

e) Characteristic strength and density of any basic materials are unchanged.

f) The number of heated surfaces is unchanged.

g) There is no change in the design of the cross section (e.g. reinforcing bars within the cross-section).

ICS 13.220.50

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