

Fire tests on building materials and structures —

Part 23: Methods for determination of the contribution of components to the fire resistance of a structure

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The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Association of Builders Hardware Manufacturers	Guild of Architectural Ironmongers
British Steel Industry	Hevac Association
Department of the Environment (Building Research Establishment, Fire Research Station)	Intumescent Fire Seals Association
Door and Shutter Association	National Association of Lift Makers
Electric Cable Makers' Confederation	Suspended Ceilings Association
	Thermal Insulation Manufacturers' and Suppliers' Association (TIMSA)

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Foreword

This Part of BS 476 has been prepared under the direction of the Fire Standards Committee, and describes the specific equipment and procedures for determining the contribution made by components to the fire resistance of structures. These components need not have any fire resistance in their capacity as isolated components. This Part should be read in conjunction with BS 476-20 which describes the general requirements for these methods.

This Part has been prepared in such a way as to allow reference to be made to the appropriate method of determining the contribution made by the designated component to the fire resistance of the structure by clause number only. Therefore clauses 5 and 6 are self-contained and cross refer to BS 476-20 where necessary. Methods for determining the fire resistance of loadbearing and non-loadbearing elements of construction are described in BS 476-21 and BS 476-22 respectively. The general changes made to the method for suspended ceilings compared with BS 476-8 are described in the foreword to BS 476-20. The method for determining the contribution of intumescent seals is a new test procedure developed as a quality control test by the intumescent sealants industry and has not previously been published.

An appendix is included which gives guidance and background information which will assist the designer and the testing laboratory to select and evaluate specimens which are representative of "in use" situations.

Attention is drawn to the Health and Safety at Work etc. Act 1974, and the need to ensure that the methods specified in this standard are carried out under suitable environmental conditions to provide adequate protection to personnel against the risk of fire and/or inhalation of smoke and/or toxic products of combustion.

CAUTION. The mechanical sawing of asbestos cement components attracts the provisions of the Asbestos Regulations 1969. Adequate methods exist to control levels of dust during such operations and these are detailed in the Control and Safety Guides¹⁾ issued by the Asbestos Research Council.

This Part, together with BS 476-20, BS 476-21, BS 476-22 and BS 476-24 supersedes BS 476-8:1972 which is withdrawn. However, the latter will still be made available on request since it is referred to in building regulations and other legislative documents.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

¹⁾ Available from Asbestors Information Centre, Sackville House, 40 Piccadilly, London W1V 9PA.

1 Scope

This Part of BS 476 describes procedures for determining the contribution made by components to the total fire resistance of a structure or other elements used in conjunction with them when subjected to the relevant heating and pressure conditions specified in BS 476-20. This Part provides the requirements for specimen selection and/or its design and construction, the edge conditions, the equipment including any special apparatus or instrumentation, and the procedures and criteria as they apply to components which make a contribution to the fire resistance of a complete assembly. The methods are applicable to suspended ceilings protecting steel beams and intumescent seals for use in conjunction with single-acting, latched timber fire resisting door assemblies.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 476, the definitions given in BS 476-20 and BS 4422 apply, together with the following.

2.1

suspended ceiling

a horizontal membrane and its associated suspension system which is provided below, and not in direct contact with, the structural, unprotected steel beams for the express purpose of protecting them from a fire environment, and which does not incorporate any loadbearing member of the structure

2.2

intumescent seal

a seal comprising material or a combination of materials with the property of swelling or foaming when exposed to heat, intended to improve the fire performance of the element of construction in which it is incorporated

3 Test conditions

The test conditions shall be as specified in BS 476-20 except, when performing tests in accordance with clause 5, the pressure immediately below the suspended ceiling shall be neutral, i.e. in equilibrium with the laboratory.

4 Apparatus

The apparatus for the test shall be as specified in BS 476-20. Additional equipment will be required in order to evaluate the contribution to the fire resistance provided by these specified components and this equipment shall be as specified in 5.4 and 6.3.

5 Determination of the contribution of suspended ceilings to the fire resistance of steel beams

5.1 General

5.1.1 This clause describes a method for determining the effective, protection that is provided by a suspended ceiling to a standard supporting construction of steel beams and specified concrete deck when exposed to specified conditions of heating and pressure from below.

The method is applicable to ceilings used in situations where the cavity above the ceiling is entirely surrounded by barriers which have the effect of restricting the transfer of hot gases (see A.1.1).

5.1.2 The suspended ceiling is protecting loadbearing steel beams and the method described permits the test to be carried out in either of the following ways:

- a) without any load being applied to the structural steel beams in which case only the maximum temperature of the beams is used to determine the limit of effective protection; or
- b) with the steel beams loaded, using one of the loading options given in A.4.2 of BS 476-20:1987, in which case the degree or rate of deflection is used to determine the limit of effective protection.

5.1.3 The results obtained by this method are not directly applicable to all types of steel beam/concrete floor deck assemblies. The method provides for additional temperature measurements to be taken in order that the potential contribution of the suspended ceiling to the protection of other steel beam/concrete floor deck assemblies may be assessed.

5.1.4 When it is required to determine directly the fire resistance of a particular floor or flat roof assembly with a suspended ceiling, the methods described in this clause are not applicable (see clause 7 of BS 476-21:1987).

5.2 Test specimen

5.2.1 *Number of specimens.* A single specimen shall be tested from its underside.

NOTE Whilst a suspended ceiling is generally an asymmetrical construction, the fire protection is only required with respect to fire attacking its underside.

5.2.2 Size of specimen. The specimen shall be of such dimensions that at least $4\text{ m} \times 3\text{ m}$ is exposed to the furnace or full size if the element is smaller, and the specimen shall cover the full width and length of the furnace.

5.2.3 Design

5.2.3.1 The contribution to the fire resistance of steel beams, as provided by a suspended ceiling, shall be determined by erecting the test specimen beneath either the specified form of construction described in 5.2.5.2 or a suitable construction as described in 5.2.5.3. The specimen shall be designed such that it is suspended from the supporting construction in a manner representative of that used in practice. In the case where the beams are loaded, however, the suspension system shall be such as to allow the ceiling to deflect in sympathy with the beams.

The suspended ceiling shall normally be erected such that the ceiling is not closer than 5 mm nor further than 400 mm from the soffit of the steel beams. When the incorporation of other fittings, e.g. lighting units or duct entry grilles, requires a larger cavity the ceiling shall be fitted as close to the soffit of the steel beams as these items will allow (see A.1.2.1).

5.2.3.2 The ceiling suspension system shall be designed and erected such that the allowances for expansion do not exceed those provided in practice for the lengths of the members involved (see A.1.2.2); where gaps are left at ends to provide additional expansion they shall be reported.

5.2.3.3 The size and types of ceiling panels or tiles used shall not be mixed when designing the specimen (see A.1.2.3).

5.2.3.4 In use, many suspended ceilings incorporate lighting fittings, speaker grilles, duct openings, etc. but these items shall not be incorporated in a test specimen that is intended to evaluate the basic performance of the membrane. The influence of these items shall be assessed or tested separately (see A.1.2.4).

5.2.4 Specimen construction and condition. The construction of the specimen and the condition of the materials shall be in accordance with BS 476-20. Whilst it may be convenient to install the panels or tiles from above, the final closing of the cavity shall be performed from below as it would be in practice.

5.2.5 Supporting construction

5.2.5.1 The specimen shall be tested under either non-loadbearing or loadbearing conditions when the supporting construction shall be as described in 5.2.5.2 or 5.2.5.3 respectively.

5.2.5.2 For a non-loadbearing test the construction shall consist of steel beams supporting concrete slabs as shown in Figure 1 (see A.1.3).

The steel beams shall be of solid rolled type having a perimeter to cross sectional area ratio (P/A ratio) larger than or equal to 210 m^{-1} (three-sided exposure) (a nominal serial size of $203\text{ mm} \times 133\text{ mm} \times 30\text{ kg/m}$). The ratio between the total exposed surface area of steel beams and the plan area of the suspended ceiling shall be less than 0.8 : 1.

The cover slabs shall be constructed from lightweight aggregate concrete (density $1\,600 \pm 100\text{ kg/m}^3$) and shall be 150 mm thick.

When more than one cover slab is used to cover the area of the cavity then all joints shall be substantially sealed.

The perimeter wall of the cavity between the cover slabs and the suspended ceiling shall be manufactured from concrete with a density of $1\,100\text{ kg/m}^3$ or less with a thickness of not less than 50 mm, or where a higher density concrete is used then an insulating materials shall be applied to the cavity face in order to provide similar degrees of insulation. The joints between this perimeter frame and the cover slabs shall also be substantially sealed.

The cover slabs shall be bedded on to the top surface of the steel beams using a compression gasket of dry mineral fibre insulation material of density 90 kg/m^3 to 115 kg/m^3 , and 12 mm thickness. This gasket shall be full width and placed on the upper flange of the beam prior to the positioning of the floor slabs.

5.2.5.3 For a loadbearing test the construction shall be a floor construction comprising steel beams with a concrete deck and the loadbearing beams shall be loaded in a similar manner to that specified in BS 476-21.

NOTE 1 An example of a suitable construction is shown in Figure 2. (See also Figure 3.)

Either one or two loadbearing beams shall be used in the construction.

NOTE 2 These beams should preferably have a P/A ratio equal to 210 m^{-1} (three-sided exposure) (a nominal serial size of $203\text{ mm} \times 133\text{ mm} \times 30\text{ kg/m}$), usually grade 43A of BS 4360. These beams shall be simply supported.

The concrete cover slabs to the furnace shall be made up of precast lightweight concrete units (density $1\,600 \pm 100\text{ kg/m}^3$) and the test load may be transmitted to the test beam through these slabs. They shall be laid on the steel beams allowing them to deflect under the influence of load during the test. The butt joints between the slabs shall be adequately sealed (see A.1.3.2).

The perimeter wall of the cavity between the cover slabs and the suspended ceiling shall be manufactured from concrete with a density of $1\,100\text{ kg/m}^3$ or less with a thickness of not less than 50 mm, or where a higher density concrete is used then an insulating material shall be applied to the cavity face in order to provide similar degrees of insulation. The joints between this perimeter frame and the cover slabs shall also be substantially sealed.

The cover slabs shall be bedded on to the top surface of the steel beams using a compression gasket of dry mineral fibre insulation material of density 90 kg/m^3 to 115 kg/m^3 , and 12 mm thickness. This gasket shall be full width and placed on the upper flange of the beam prior to the positioning of the floor slabs.

Other suitable constructions may be used but these shall be reported and have an appropriate relationship with the suspended ceiling under test.

5.2.5.4 The cover slabs or topping materials shall be conditioned in a similar manner to the test specimen except that they can be used at moisture contents below representative levels (see A.1.4).

5.3 Specimen support conditions

When the specimen is full size all edges shall be fixed as in practice. For specimens that are smaller than the element of construction, all edges of the suspended ceiling shall be fixed to the specimen support frame or the furnace surround with any allowance for lateral movement limited to that specified in 5.2.3.2.

NOTE Vertical movement of the ceiling edges or any suspension system need not be inhibited.

5.4 Additional apparatus

In addition to the apparatus specified in BS 476-20, the following apparatus is required if additional measurements are to be made (see 5.5.5).

5.4.1 *Thermocouple weight*, as shown in Figure 4, for holding the specimen surface thermocouples in position. The legs of the thermocouple weight shall bear on the corners of the insulating pad so as to trap the thermocouple centrally between the resilient material and the underside of the pad.

NOTE The weight is only necessary when the upper surface of a ceiling membrane consists of a resilient insulation material.

5.5 Examination of specimen

5.5.1 Establish the dimensions and properties of the materials used in the construction of the specimen in accordance with BS 476-20 (see A.1.5.1).

5.5.2 Mount the test construction horizontally on top of the furnace, such that it is subjected to heating from the underside.

5.5.3 Position the furnace thermocouples at not less than one to every 1.5 m^2 , or part thereof, of the exposed surface area, with a minimum of four for specimens of less than 6 m^2 with the exposed surface area being the nominal area measured in the plane of the specimen. Distribute the thermocouples uniformly ensuring that no thermocouple is closer than 500 mm from the furnace walls, and with the thermocouple hot junctions at $100 \pm 10\text{ mm}$ from the surface of the specimen at the start of the test. Where the surface is irregular, measure the $100 \pm 10\text{ mm}$ from the median depth provided the junction is not nearer than 50 mm from any part of the exposed surfaces.

5.5.4 Position at least one pressure sensing head in the furnace such that the pressure conditions in the furnace are measured and controlled in accordance with BS 476-20 so as to maintain equilibrium pressure with the laboratory at a point 100 mm below the soffit of the specimen. In the case of an irregular profile maintain the pressure at the specified level 100 mm below an imaginary line between the lowest points of the irregular surface. Ensure that the pressure sensing head does not interfere with the deflection of the specimen during test.

NOTE The pressure sensing head is not required to be maintained at a fixed distance from the surface of the specimen during the test.

5.5.5 In order to measure the temperature of the steel beams, peen six thermocouples to each beam so that they are distributed uniformly along the length of each beam and are on the inside of the lower flange of the beam midway between the web and the toe of the flange (see A.1.5.2).

When measurements are to be made of the surface temperature of either the unexposed face of the ceiling tiles or panels or the soffit of the cover slabs, fix the thermocouples specified in 6.4.2.1 of BS 476-20:1987 in the conventional manner. When measurements are to be made on any horizontal fibrous or resilient insulation materials use a thermocouple weight (see 5.4.1).

When measuring air temperatures within the cavity use thermocouples that comply with 6.4.2.1 of BS 476-20:1987.

5.5.6 When the test is to be performed with a loaded supporting construction, position the loading equipment, and locate in position and attach, if necessary, the equipment required for measuring vertical deformation at the point of anticipated maximum deformation.

NOTE As beams are simply supported, the point of maximum deformation can normally be assumed to occur at midspan.

5.6 Test procedure

5.6.1 Carry out the test in accordance with BS 476-20, with the exception of the furnace pressure conditions, and make any observations on the behaviour of the specimen, including the dislodgement of any tiles or the mode of failure in the case of a loaded supporting structure (see **A.1.6**).

5.6.2 In the case of a non-loaded supporting structure, monitor the temperature of the steel beams to check compliance with the maximum temperature criteria given in **5.7.1 a**).

5.6.3 In the case of a loaded supporting structure, monitor the deflection and the rate of deflection for compliance with the limiting deflections constituting a loss of loadbearing capacity as required in **5.7.1 b**).

5.6.4 Monitor all other thermocouples installed for the purpose of providing additional temperature information.

5.7 Criteria of failure, expression of results and test report

5.7.1 Criteria of failure. The performance of a suspended ceiling shall be determined by its ability to provide protection to steel beams to enable them to retain their loadbearing capacity. The limit of effective protection provided by the suspended ceiling shall be deemed to have occurred when any of the following criteria, as applicable, have been exceeded.

- a) In a non-loaded test the temperature at any measuring point on any beams reaches 400 °C.
- b) In a test with a loaded supporting construction the beams fail to satisfy the criteria given in **10.2.3** of BS 476-20:1987.

5.7.2 Expression of results. The test results shall be stated in terms of the elapsed time, to the nearest minute, between the commencement of heating and failure under one of the criteria given in **5.7.1**, as applicable. If no failures have been recorded then the elapsed time between the commencement of heating and the termination of the test shall be reported as the limit of the effective protection provided by the suspended ceiling.

NOTE A typical result may be expressed as follows.
Duration of effective protection: 74 min.

5.7.3 Test report. The test report shall include the results (see **5.7.2**) and any observations together with the information required by items a) to f) of clause **12** of BS 476-20:1987. In addition the following information shall be included.

g) Details of the expansion joints in the members supporting the ceiling and other features considered essential for the stability of the system. The expansion allowance per unit length of the grid system members and/or the spacing between expansion joints shall be stated and justified.

h) Details of any light fittings, grilles, openings and ducting that were incorporated in the specimen.

i) The test loading, if any, and its relationship to the design conditions.

j) The depth of the ceiling void.

k) The restraint conditions that applied to the suspended ceiling during the test.

l) Temperature/time curves for the steel beams.

m) The duration of effective protection to the steel beams.

n) An analysis of the behaviour of any expansion joints as determined by a post-test examination.

o) Where a loadbearing steel beam section has been tested which does not have a perimeter to cross-sectional area ratio of 210 m^{-1} , the reason for the deviation, and the limiting effects on the tested section.

6 Determination of the contribution of intumescent seals to the fire resistance of timber door assemblies

6.1 General

6.1.1 This clause describes a method of test for determining the effective sealing capability of intumescent materials or systems in the context of sealing door to frame clearances in timber door assemblies (see **A.2.1**).

The results obtained from this test are applicable for use on proven single acting, single-leaf latched timber door assemblies of sizes up to that tested but not greater than 2 100 mm by 926 mm at a thickness equal to that of the tested specimen.

The test is suitable for evaluating intumescent sealing systems for use on timber fire resisting doors of up to 1 h fire resistance.