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British Standard

Fire tests on building materials and structures

Part 22. Methods for determination of the fire resistance of non-loadbearing elements of construction

Essais au feu des matériaux et structures du bâtiment
Partie 22. Méthodes de détermination de la résistance au feu des éléments de construction non porteurs

Brandschutztechnische Prüfungen an Baustoffen und Bauten
Teil 22. Verfahren zur Bestimmung des Feuerwiderstandes von nichttragenden Bauteilen

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Foreword

This Part of BS 476 has been prepared under the direction of the Fire Standards Committee, and describes the procedures for determining the fire resistance of non-loadbearing elements of building construction. This Part should be read in conjunction with BS 476 : Part 20 which describes the general principles 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 fire resistance of the designated element by clause number only. Therefore clauses 5 to 7 are self-contained and cross refer to BS 476 : Part 20 where necessary.

Methods for determining the fire resistance of loadbearing elements that have a finite fire resistance and of components that make a contribution to the fire resistance of a structure are described in BS 476 : Parts 21 and 23 respectively.

The general changes made to the methods described in this Part compared with BS 476 : Part 8 are described in the foreword to BS 476 : Part 20. Appendix A gives guidance and background information which will assist the designer and the testing laboratory to select and evaluate specimens that are representative of 'in use' situations.

The methods described are not relevant to the assessment of the penetration of smoke under cold and/or medium temperature conditions, and for such information on doorsets and shutter assemblies, the methods described in BS 476 : Section 31.1 and in other Sections of Part 31 (in preparation) are applicable.

Attention is drawn to the Health and Safety at Work etc. Act 1974, and the need to ensure that the methods described 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 operation and these are detailed in the Control and Safety Guides* issued by the Asbestos Research Council.

This Part, together with BS 476 : Parts 20, 21, 23 and 24, supersedes BS 476 : Part 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.

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

* Available from the Asbestos Information Centre, Sackville House, 40 Piccadilly, London W1V 9PA.

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Methods

1 Scope

This Part of BS 476 describes procedures for determining the fire resistance of non-loadbearing elements of building construction when subjected to the heating and pressure conditions specified in BS 476 : Part 20. This Part is applicable to vertical partitions, to fully insulated, partially insulated and uninsulated vertical doorsets and shutter assemblies (except fire dampers incorporated in ducts), to ceiling membranes, and to glazed elements.

The methods described are appropriate to normal combinations of these elements.

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 : Part 20 and BS 4422 apply, together with the following:

2.1 ceiling membrane. A non-loadbearing element of a building construction designed to provide horizontal fire separation as distinct from protection to any floor or roof above.

2.2 doorset. An assembly (including any frame or guide) for the closing of permanent openings in separating elements. For the purposes of this standard, the term doorset includes shutter assemblies but excludes fire dampers for incorporation into ducts.

2.3 partition. A non-loadbearing element of a building construction designed to provide vertical fire separation when exposed to fire from one side.

NOTE. The partition may incorporate either glazing or doors.

3 Test conditions

The test conditions shall be as specified in BS 476 : Part 20.

4 Apparatus

The apparatus for the test shall be as specified in BS 476 : Part 20 except that the apparatus for the provision of loading and fixity specified in **6.2** and **6.3.2** of BS 476 : Part 20 : 1987 is not required.

5 Determination of the fire resistance of partitions

5.1 General

This clause describes a method for the determination of the fire resistance of partitions and non-loadbearing walls providing vertical separation which are required to withstand exposure from fire from one or either side (see **A.1.1**).

NOTE. Loadbearing partitions or walls should be tested in accordance with BS 476 : Part 21.

5.2 Test specimen

5.2.1 *General.* Partitions shall be tested from both sides, i.e. two specimens, unless the partition is entirely symmetrical or unless the weakest direction can be clearly identified or unless the partition is known to be exposed to a fully developed fire from one side only. If testing is carried out from one side only, i.e. one specimen, the reason for this shall be clearly stated in the report.

5.2.2 *Dimensions.* The test specimen shall be of such dimensions that at least 3 m × 3 m is exposed to the furnace or full size if the element is smaller.

5.2.3 *Design of specimen*

5.2.3.1 When partitions include mechanical joints in the element for either erection, construction, or as a result of dimensional co-ordination, the specimen shall incorporate at least one joint of each type, even though these may occur at greater than 3 m centres.

Different jointing systems in a single specimen shall be avoided if they are likely to give substantially different performances and affect the evaluation of the performance of the whole system. In such cases it is preferable to conduct tests on different specimens for each jointing system.

5.2.3.2 Partitions frequently incorporate a head section that is capable of accommodating deflections from floor slabs above. When such a detail is included in the specimen, the specimen shall be tested with the deflection head in the mid-position of its adjustment.

5.2.3.3 Partitions often incorporate services; where these form an integral part of the element, the test construction shall incorporate them in a representative manner. When the services and associated fittings are not an integral part of the element but may be fitted subsequently in a manner that may have an adverse effect on the fire resistance of the element, these shall be subject to a separate test.

5.2.4 *Test construction and condition.* The construction and condition of the specimen shall be in accordance with BS 476 : Part 20 except for the requirements for fixity and loading (see **A.1.4**).

5.3 Specimen installation

5.3.1 Where the test specimen is smaller than the element in practice, three edges shall be installed as in practice (see **A.1.3**) and one vertical edge shall have freedom of movement. When testing a partition where lateral thermal expansion is likely to occur during heating, which would be resisted in practice, no allowance should be made for expansion in the mounting of the test specimen.

5.3.2 When the test specimen is full size, it shall be subjected to similar edge and end conditions as would be applied in practice.

5.3.3 A partition that is to be tested with freedom of movement along its vertical edge shall be mounted in such a manner that the gap between the specimen support frame of the furnace surround is sealed with a resilient mineral fibre gasket such that it shall not restrict the freedom of movement due to frictional forces, but will resist the penetration of hot gases.

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5.4 Examination of specimen

5.4.1 Establish the dimensions and properties of the materials used in the construction of the specimen in accordance with BS 476 : Part 20 (see **A.1.4**).

5.4.2 Mount the test construction vertically in front of the furnace.

5.4.3 Position the furnace control 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 ± 10 mm from the surface of the specimen at the start of the heating period. Where the surface is irregular, measure the 100 ± 10 mm from the median depth provided the junction is not nearer than 50 mm from any part of the exposed surface.

For partitions that incorporate glazing, place one thermocouple directly in front of a glazed area for every 20 % of the specimen area taken up by glazing.

NOTE. When the area of glass is less than 20 % of the specimen area, no special requirements apply.

5.4.4 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 : Part 20, and so that the sensing heads do not interfere with the deflection of the specimen.

5.4.5 Position five surface temperature measuring thermocouples with one placed approximately in the centre of the specimen and one at the centre of each quarter section. Do not fix these thermocouples to any glazing unless the glass is designed to provide insulation (but see note to **5.4.6**).

Where the unexposed face of an element comprises more than one material, e.g. glazing designed to provide insulation in a timber panel, place at least one thermocouple on each component material.

Where the partition incorporates doors or doorsets, test these in accordance with clause **6**. Where the partition incorporates more than 50 % of glazed screen, test the partition and glazed screen as glazing in accordance with clause **10** unless the glazing is designed to provide insulation when the partition is tested as a partition in accordance with this clause.

5.4.6 Attach additional surface temperature measuring thermocouples at positions other than those specified to determine the temperature at other points on the surface where the temperature rise is likely to be higher than elsewhere due to lower levels of insulation, and which may be required for evaluation of the maximum temperature rise.

Do not fix thermocouples to the free edges of partitions (see **5.3.2**).

NOTE. When partitions incorporate glazing, it may be necessary to fix additional thermocouples to the glazing in order to determine the time at which the use of the cotton pad should be discontinued.

5.4.7 When additional information is required with respect to internal temperatures, e.g. cavities or temperatures of individual components, fix any additional thermocouples that have not been incorporated during construction in accordance with BS 476 : Part 20.

5.4.8 Locate in position, and attach if necessary, the deflection measuring equipment at the anticipated point of maximum deflection. Where this position cannot be predetermined, take more than one deflection measurement and report the maximum deflection measured.

5.4.9 When a partition is to be examined for the amount of heat being radiated from the surface, position the radiometer in front of the partition before the start of the test, at such a distance that the field of view of its sensing unit circumscribes the specimen area.

5.5 Test procedure

5.5.1 *General.* Carry out the test in accordance with BS 476 : Part 20 and make any observations on the behaviour of the specimen.

5.5.2 *Integrity.* Monitor the unexposed face of the specimen for evaluation of the integrity in accordance with clause **9** of BS 476 : Part 20 : 1987.

5.5.3 *Insulation*

5.5.3.1 Measure the temperature rise of the unexposed face for evaluation of the insulation in accordance with clause **9** of BS 476 : Part 20 : 1987 for both the mean temperature rise and the maximum temperature rise, using the thermocouples specified in **5.4.5** and **5.4.6**. Use the measurements from the roving thermocouple, when employed, and from the additional fixed thermocouples only for determining maximum temperature rise.

5.5.3.2 If during the test a thermocouple is known to be heated directly by gases passing through the specimen from the furnace, for example owing to the occurrence of shrinkage, cracking or distortion, do not use the readings obtained from it for the purpose of determining compliance with the criterion of either mean or maximum unexposed face temperature rise and report this fact. If more than two of the thermocouples that are intended to be used in determining the mean temperature rise are affected, do not assess the specimen for compliance with the criterion for mean temperature rise and report this occurrence.

5.5.4 *Irradiance.* Monitor the irradiance of the unexposed face of any construction that is not designed to satisfy the insulation criterion by means of the radiometer described in BS 476 : Part 20.

5.5.5 *Deflection.* Monitor the maximum deflection of the specimen.

5.6 Criteria of failure, expression of results and test report

5.6.1 *Criteria of failure.* The fire resistance of a partition shall be determined with respect to integrity and insulation. The criteria of failure shall be as given in **10.3** and **10.4** of BS 476 : Part 20 : 1987 respectively.

5.6.2 *Expression of results.* The results shall be stated in terms of elapsed time to the nearest minute, between the

commencement of heating and the time of failure in accordance with BS 476 : Part 20 with respect to the two criteria given in **5.6.1**.

When the irradiance from the unexposed face of the specimen has been monitored the mean irradiance shall be reported in a graph or table with respect to time.

The distance from the surface at which these values were obtained shall be given together with the angle of view of the radiometer.

NOTE. An example of the method of expressing the results is given in **A.11** of BS 476 : Part 20 : 1987.

5.6.3 *Test report.* The test report shall include the results (see **5.6.2**) and any observations, together with the other requirements given in clause **12** of BS 476 : Part 20 : 1987. In addition, the report shall state the maximum lateral deflection and the position at which this occurred, together with the reasons for testing from one side only and the mode of failure, if applicable.

6 Determination of the fire resistance of fully insulated doorsets and shutter assemblies

6.1 General

This clause describes a method for the determination of the fire resistance of fully insulated doorsets, shutter assemblies, lift landing doors and other essentially vertical separating elements designed in such a manner as to allow the ingress of personnel or goods during normal operation, but also designed to withstand exposure to fire from one or either side when closed (see **A.2.1**).

NOTE. Fully insulated doorsets and shutter assemblies are those designed to provide insulation for the expected duration of the test.

6.2 Test specimen

6.2.1 *Number of specimens.* Doorsets and shutter assemblies shall be tested from both sides, i.e. two specimens, unless the doorset or shutter assembly, including the hardware, is entirely symmetrical or unless the weakest direction can be clearly identified, or unless the doorset or shutter assembly is known to be exposed to fully developed fire from one side only, e.g. certain lift landing doors. If testing is carried out from one side only, i.e. one specimen, the reason for this shall be clearly stated in the report.

6.2.2 *Size of specimen*

6.2.2.1 The test specimen shall be full size and shall be mounted within an appropriate section of associated construction, i.e. of the type to be used in practice or satisfying the requirements of **6.3.1**, to provide a representative size of test construction which complies with **4.5** of BS 476 : Part 20 : 1987.

6.2.2.2 If the size of the door assembly in practice is larger than can be accommodated in the furnace, it shall be tested at a dimension to enable the door and associated construction to be accommodated in a furnace having minimum dimensions of 3 m × 3 m.

NOTE. Application of the results to an element of larger dimensions than that tested should be based on knowledgeable extrapolation of the test results (see **A.2.2**).

6.2.3 *Design of specimen*

6.2.3.1 The specimen shall be designed and constructed as used in practice. The final decorative treatments, e.g. painting or veneering, may be excluded unless these are likely to significantly increase or decrease the fire resistance of the assembly. If the doorset does not incorporate a sill, the specimen shall have either a non-combustible sill or a sill covered with non-combustible material.

6.2.3.2 The test construction shall incorporate all hardware essential for the provision of the fire resistance of the element in practice. It is not necessary to test floor springs and devices fixed only to the test construction, where, once closing has been achieved, other components are responsible for providing the maintenance of the closed condition, e.g. the latch on a hinged door leaf (see **A.2.3**).

6.2.3.3 In the case of pre-hung doorsets, steel sliding or folding doors or roller shutters which are manufactured in such a manner that the gaps between the edge of the opening element and the fixed frame cannot be modified during installation, the specimen shall be constructed with gaps that are representative of normal practice. Where this cannot be established, no gap shall be less than 3 mm.

6.2.4 *Specimen construction and condition.* The construction and condition of the specimen shall be in accordance with BS 476 : Part 20.

6.3 Specimen installation

6.3.1 The specimens shall be mounted in an associated construction of a wall or partition of the type to be used in practice or, if not known, in a construction which has a known fire resistance greater than that anticipated for the specimen being tested. The construction shall be of sufficient strength to resist any thermally induced stresses that may develop during the test and shall be capable of providing adequate fixing.

6.3.2 The method of fixing the specimen to the associated construction shall be representative of that to be used in practice. The doorsets shall be in the closed position with any latching or bolting hardware engaged but not locked (see **A.2.4**).

6.4 Examination of specimen

6.4.1 Establish the dimensions and properties of the materials used in the construction of the specimen (see **A.2.5**) in accordance with BS 476 : Part 20.

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6.4.2 Mount the specimen in its associated construction (see **6.3**) vertically in front of the furnace.

6.4.3 Position the furnace control thermocouples at not less than one to every 1.5 m^2, or part thereof, of the exposed surface area of the test construction (ignoring the area of any furnace closure) with a minimum of four for test constructions of less than 6 m^2, with the exposed surface being the nominal area measured in the plane of the test construction. Distribute the thermocouples uniformly ensuring no thermocouple is closer than 500 mm from the furnace walls, and with the thermocouple hot junction at 100 ± 10 mm from the surface at the start of the heating period. Ignore any irregularities such as architraves and hardware and position the thermocouples so that the position does not vary during the heating period by more than 50 mm. For doors and shutters that incorporate glazing, place one thermocouple directly in front of the glazed area for every 20 % of the specimen area taken up by glazing.

NOTE. When the area of glass is less than 20 % of the specimen area, no special positioning is required.

6.4.4 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 : Part 20, and so that the sensing heads do not interfere with the deflection of the specimen.

6.4.5 Fix surface temperature monitoring thermocouples, in order to measure the unexposed face temperature rise of the specimen in accordance with BS 476 : Part 20, positioning them as follows.

(a) At the centre of the specimen and one in the centre of each quarter section. Do not locate thermocouples within 50 mm of a stiffener or a through member or within 50 mm of a joint between one moving element and another or any moving element and the fixed frame. Where head and/or side panels are incorporated, fix two additional thermocouples to each panel.

(b) On stiffeners or other locations on the door leaf (or leaves) which may be hotter than the average on the face. Do not locate any thermocouple within 50 mm of the edge of the door leaf (or leaves) or the door handle/lock, or closer than 50 mm to any joint between one moving element and another, or any moving element and the adjacent fixed frame.

(c) On the frame of the door assembly, one at mid-height on each vertical side member and one at the mid-point of each door leaf on the horizontal top member.

Place the thermocouples on the unexposed face of the door frame the plane of which is approximately parallel to the plane of the door leaf and in a position such that there is a 12 mm wide flat surface on which the copper disc can be placed. If these requirements cannot be satisfied for any thermocouple then omit that thermocouple.

(d) For the roving thermocouple, the positional constraints given in items (b) and (c) apply.

NOTE. The mean temperature rise should be calculated as the mean of the thermocouples in (a). Where additional thermocouples are fixed on the head or side panels, the data from these should not be used to calculate the mean temperature rise but should be reported separately.

6.4.6 Where required for extrapolation purposes attach additional temperature measuring thermocouples on the surface or within the door or shutter assembly. Do not use these for determining either the maximum temperature rise or the mean temperature rise.

6.4.7 Locate in position the equipment required for measuring lateral deflection.

NOTE 1. It may be necessary to measure more than one point on the surface of each specimen.

NOTE 2. It is difficult to determine in advance the positions of maximum deflection in a doorset or shutter assembly and it is recommended that all deflection measurements are made using portable measuring equipment.

6.5 Test procedure

6.5.1 *General.* Carry out the test in accordance with BS 476 : Part 20 and make any observations on the behaviour of the specimen.

6.5.2 *Integrity.* Monitor the unexposed face of the specimen for evaluation of integrity in accordance with clause **9** of BS 476 : Part 20 : 1987.

6.5.3 *Insulation*

6.5.3.1 Measure the temperature rise of the unexposed face for evaluation of insulation in accordance with clause **9** of BS 476 : Part 20 : 1987, for both the mean temperature rise and the maximum temperature rise, using the thermocouples specified in **6.4.5** and **6.4.6**. Use the measurements from the roving thermocouple, when employed, and from the additional fixed thermocouples only for determining maximum temperature rise.

6.5.3.2 If during the test a thermocouple is known to be heated directly by gases passing through the specimen from the furnace, for example owing to the occurrence of shrinkage, cracking or distortion, do not use the readings obtained from it for the purposes of determining compliance with the criterion of either mean or maximum unexposed face temperature rise and report this fact. If more than two of the thermocouples that are intended to be used in determining the mean temperature rise are affected, do not assess the specimen for compliance with the criterion for mean temperature rise and report this occurrence.

6.5.3.3 Monitor the temperature rise of the fixed frame components of the door or shutter assembly by means of the additional thermocouples fixed for this purpose.

6.5.4 *Lateral deflection.* Monitor the lateral deflection of the specimen.

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6.6 Criteria of failure, expression of results and test report

6.6.1 *Criteria of failure*

6.6.1.1 The fire resistance of a fully insulated doorset or shutter assembly shall be determined with respect to integrity and insulation. The criteria for integrity failure shall be as follows:

(a) during the test, the cotton pad provisions apply;

(b) during the test, the 6 mm gap gauge provisions apply to any other gap other than at sill level;

(c) during the test, the 25 mm gap gauge provisions apply to any gap;

(d) during the test, the requirements concerning sustained flaming apply.

The criteria for insulation failure shall be as given in **10.4** of BS 476 : Part 20 : 1987.

6.6.1.2 In determining compliance with the mean unexposed face temperature rise of the door and shutter assembly (insulation) only the five fixed thermocouples applied specifically for this purpose to the leaves or mobile components within the frame shall be used, except where the roving thermocouple is used to supplement data from a fixed thermocouple, as specified in BS 476 : Part 20.

6.6.1.3 In determining compliance with the maximum unexposed face temperature rise of the door and shutter assembly, the five fixed thermocouples shall be used in conjunction with the three thermocouples attached to the fixed frame members, any other fixed thermocouples and the roving thermocouple being used.

6.6.2 *Expression of results*

6.6.2.1 The result shall be stated in terms of the elapsed time to the nearest minute, between the commencement of heating and the time of failure in accordance with BS 476 : Part 20 with respect to the two criteria given in **6.6.1**.

NOTE. An example of the method of expressing the result is given in **A.11** of BS 476 : Part 20.

6.6.2.2 The temperatures from any additional fixed thermocouples shall be reported in a graph or table with respect to time.

6.6.3 *Test report.* The test report shall include the results (see **6.6.2**) and any observations together with the other requirements given in clause **12** of BS 476 : Part 20 : 1987. In addition, the report shall state the maximum lateral deflection and the position at which this occurred, together with the reasons for testing from one side only and the mode of failure, if applicable.

7 Determination of the fire resistance of partially insulated doorsets and shutter assemblies

7.1 General

This clause describes a method for the determination of the fire resistance of partially insulated doorsets, shutter assemblies, lift landing doors and other essentially vertical separating elements designed in such a manner as to allow the ingress of personnel or goods during normal operation, but also designed to withstand exposure to fire from one or either side when closed (see **A.2.1**).

NOTE. Partially insulated doorsets and shutter assemblies are designed to provide insulation for a period shorter than the expected duration of the test and include insulated doorsets and shutter assemblies incorporating non-insulating features (e.g. conventional glazing) where such features form less than 20 % of the surface area of the specimen.

7.2 Test specimen

7.2.1 *Number of specimens.* Doorsets and shutter assemblies shall be tested from both sides, i.e. two specimens, unless the doorset or shutter assembly, including the hardware, is entirely symmetrical or unless the weakest direction can be clearly identified, or unless the doorset or shutter assembly is known to be exposed to fully developed fire from one side only (e.g. certain lift landing doors). If testing is carried out from one side only, i.e. one specimen, the reason for this shall be clearly stated in the report.

7.2.2 *Size of specimen*

7.2.2.1 The test specimen shall be full size and shall be mounted within an appropriate section of associated construction, i.e. of the type to be used in practice or satisfying the requirements of **7.3.1**, to provide a representative size of test construction which complies with **4.5** of BS 476 : Part 20 : 1987.

7.2.2.2 If the size of the door assembly in practice is larger than can be accommodated in the furnace, it shall be tested at a dimension to enable the door and associated construction to be accommodated in a furnace having minimum dimensions of 3 m × 3 m.

NOTE. Application of the results to an element of larger dimensions than that stated should be based on knowledgeable extrapolation of the test results (see **A.2.2**).

7.2.3 *Design of specimen*

7.2.3.1 The specimen shall be designed and constructed as used in practice. The final decorative treatments, e.g. painting or veneering may be excluded, unless these are

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likely to significantly increase or decrease the fire resistance of the assembly. If the doorset does not incorporate a sill, the specimen shall have either a non-combustible sill or a sill covered with non-combustible material.

7.2.3.2 The test construction shall incorporate all hardware essential for the provision of the fire resistance of the element in practice. It is not necessary to test floor springs and devices fixed only to the test construction, where, once closing has been achieved, other components are responsible for providing the maintenance of the closed condition, e.g. the latch on a hinged door leaf (see **A.2.3**).

7.2.3.3 In the case of pre-hung doorsets, steel sliding or folding doors or roller shutters which are manufactured in such a manner that the gaps between the edge of the opening element and the fixed frame cannot be modified during installation, the specimen shall be constructed with gaps that are representative of normal practice. Where this cannot be established, no gap shall be less than 3 mm.

7.2.3.4 When a door is intended to be supplied exclusively as a glazed assembly, glazing of the type and extent intended to be used shall be incorporated in the construction of the specimen.

7.2.4 *Specimen construction and condition.* The construction and condition of the specimen shall be in accordance with BS 476 : Part 20.

7.3 Specimen installation

7.3.1 The specimens shall be mounted in an associated construction of a wall or partition of the type to be used in practice or, if not known, in a construction which has a known fire resistance greater than that anticipated for the specimen being tested. The construction shall be of sufficient strength to resist any thermally induced stresses that may develop during the test and shall be capable of providing adequate fixing.

7.3.2 The method of fixing the specimen to the associated construction shall be representative of that to be used in practice. The doorsets shall be in the closed position with any latching or bolting hardware engaged but not locked, (see **A.2.4**).

7.4 Examination of specimen

7.4.1 Establish the dimensions and properties of the materials used in the construction of the specimen (see **A.2.5**) in accordance with BS 476 : Part 20.

7.4.2 Mount the specimen in its associated construction (see **7.3**) vertically in front of the furnace.

7.4.3 Position the furnace control thermocouples at not less than one to every 1.5 m^2, or part thereof, of the exposed surface area of the test construction (ignoring the area of any furnace closure) with a minimum of four for test specimens of less than 6 m^2, with the exposed surface being the nominal area measured in the plane of the test construction. Distribute the thermocouples uniformly ensuring no thermocouple is closer than 500 mm from the furnace walls, and with the thermocouple hot junction at 100 ± 10 mm from the surface at the start of the heating period. Ignore any irregularities such as architraves and hardware and position the thermocouples so that the position does not vary during the heating period by more than 50 mm. For doors and shutters that incorporate glazing, place one thermocouple directly in front of the glazed area for every 20 % of the specimen area taken up by glazing.

NOTE. When the area of glass is less than 20 % of the specimen area, no special positioning is required.

7.4.4 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 : Part 20, and so that the sensing heads do not interfere with the deflection of the specimen.

7.4.5 Fix surface temperature monitoring thermocouples, in order to measure the unexposed face temperature rise of the specimen in accordance with BS 476 : Part 20, positioning them as follows, thus avoiding non-insulating features (e.g. conventional glazing).

(a) At the centre of the specimen and one in the centre of each quarter section. Do not locate thermocouples within 50 mm of a stiffener or a through member or within 50 mm of a joint between one moving element and another or any moving element and the fixed frame. Where head and/or side panels are incorporated, fix two additional thermocouples to each panel.

(b) On stiffeners or other locations on the door leaf (or leaves) which may be hotter than the average on the face. Do not locate any thermocouple within 50 mm of the edge of the door leaf (or leaves) or the door handle/lock, or closer than 50 mm to any joint between one moving element and another, or any moving element and the adjacent fixed frame.

(c) On the frame of the door assembly, one at mid-height on each vertical side member and one at the mid-point of each door leaf on the horizontal top member. Place the thermocouples on the unexposed face of the door frame the plane of which is approximately parallel to the plane of the door leaf and in a position such that there is a 12 mm wide flat surface on which the copper disc can be placed. If these requirements cannot be satisfied for any thermocouple then omit that thermocouple.

(d) For the roving thermocouple, the positional constraints given in items (b) and (c) apply.

NOTE. The mean temperature rise should be calculated as the mean of the thermocouples in (a). Where additional thermocouples are fixed on the head or side panels, the data from these should not be used to calculate the mean temperature rise but should be reported separately.

7.4.6 Where required for extrapolation purposes attach addition temperature measuring thermocouples on the surface or within the door or shutter assembly. Do not use these for determining either the maximum temperature rise or the mean temperature rise.

7.4.7 Locate in position the equipment required for measuring lateral deflection.

NOTE 1. It may be necessary to measure more than one point on the surface of each specimen.

NOTE 2. It is difficult to determine in advance the positions of maximum deflection in a doorset or shutter assembly and it is recommended that all deflection measurements are made using portable measuring equipment.

7.4.8 Position the radiometer in front of the specimen before the start of the test, at such a distance that the field of view of its sensing unit circumscribes the specimen area. Carry out any measurements of radiation from the unexposed face in accordance with BS 476 : Part 20.

7.5 Test procedure

7.5.1 *General.* Carry out the test in accordance with BS 476 : Part 20 and make any observations on the behaviour of the specimen.

7.5.2 *Integrity.* Until the criteria for insulation failure occurs, monitor the unexposed face of the specimen for evaluation of integrity in accordance with clause **9** of BS 476 : Part 20 : 1987, except that use of the cotton pad is restricted to those parts of the test specimen that do not consist of non-insulating material and the 6 mm gap gauge is applied to any gap other than a gap at sill level.

When insulation failure occurs, discontinue use of the cotton pad.

7.5.3 *Insulation*

7.5.3.1 Measure the temperature rise of the unexposed face for evaluation of insulation in accordance with clause **9** of BS 476 : Part 20 : 1987, for both the mean temperature rise and the maximum temperature rise, using the thermocouples specified in **7.4.5** and **7.4.6**. Use the measurements from the roving thermocouple, when employed, and from the additional fixed thermocouples only for determining maximum temperature rise.

7.5.3.2 If during the test a thermocouple is known to be heated directly by gases passing through the specimen from the furnace, for example owing to the occurrence of shrinkage, cracking or distortion, do not use the readings obtained from it for the purpose of determining compliance with the criterion of either mean or maximum unexposed face temperature rise and report this fact. If more than two of the thermocouples that are intended to be used in determining the mean temperature rise are affected, do not assess the specimen for compliance with the criterion for mean temperature rise and report this occurrence.

7.5.3.3 Monitor the temperature rise of the fixed frame and components of the door or shutter assembly by means of the additional thermocouples fixed for this purpose.

7.5.4 *Lateral deflection.* Monitor the lateral deflection of the specimen.

7.5.5 *Irradiance.* Monitor the irradiance by means of the radiometer described in BS 476 : Part 20.

7.6 Criteria of failure, expression of results and test report

7.6.1 *Criteria of failure*

7.6.1.1 The fire resistance of a partially insulated doorset or shutter assembly shall be determined with respect to integrity and insulation. The criteria for integrity failure shall be as follows:

(a) prior to insulation failure, the cotton pad provisions apply to any area other than that consisting of non-insulating materials, e.g. conventional glazing;

(b) during the whole test, 6 mm gap gauge provisions apply to any gap other than at sill level;

(c) during the whole test, the 25 mm gap gauge provisions apply to any gap;

(d) during the test, the requirements concerning sustained flaming apply.

The criteria for insulation failure, for that part of the specimen consisting of insulating material, shall be as given in **10.4** of BS 476 : Part 20 : 1987.

NOTE. That part of the specimen, up to 20 % of its total area, consisting of non-insulating material, e.g. conventional glazing, is not evaluated for insulation.

7.6.1.2 In determining compliance with the mean unexposed face temperature rise of the door and shutter assembly (insulation) only the five fixed thermocouples applied specifically for this purpose to the leaves or mobile components within the frame shall be used, except where the roving thermocouple is used to supplement data from a fixed thermocouple, as specified in BS 476 : Part 20.

7.6.1.3 In determining compliance with the maximum unexposed face temperature rise of the door and shutter assembly, the five fixed thermocouples shall be used in conjunction with the three thermocouples attached to the fixed frame members, any other fixed thermocouples and the roving thermocouple being used.

7.6.2 *Expression of results*

7.6.2.1 The results shall be stated in terms of the elapsed time to the nearest minute, between the commencement of heating and the time of failure in accordance with BS 476 : Part 20 with respect to the two criteria given in **7.6.1**.

NOTE. An example of the method of expressing the result is given in **A.11** of BS 476 : Part 20 : 1987.

7.6.2.2 The mean irradiance from the unexposed face of the specimen shall be reported in a graph or table with respect to time.

The distance from the surface at which these values were obtained shall be given, as shall the angle of view of the radiometer.

7.6.2.3 The temperatures from any additional fixed thermocouples shall be reported in a graph or table with respect to time.

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7.6.3 *Test report.* The test report shall include the results (see **7.6.2**) and any observations together with the other requirements given in clause **12** of BS 476 : Part 20 : 1987. In addition, the report shall state the maximum lateral deflection and the position at which this occurred, together with the reasons for testing from one side only and the mode of failure, if applicable.

8 Determination of the fire resistance of uninsulated doorsets and shutter assemblies

8.1 General

This clause describes a method for the determination of the fire resistance of uninsulated doorsets, shutter assemblies, lift landing doors and other essentially vertical separating elements designed in such a manner as to allow the ingress of personnel or goods during normal operation, but also designed to withstand exposure to fire from one or either side when closed (see **A.2.1**).

NOTE. Uninsulated doorsets and shutter assemblies are those that have not been designed to provide insulation.

8.2 Test specimen

8.2.1 *Number of specimens.* Doorsets and shutter assemblies shall be tested from both sides, i.e. two specimens, unless the doorset or shutter assembly, including the hardware, is entirely symmetrical or unless the weakest direction can be clearly identified, or unless the doorset or shutter assembly is known to be exposed to fully developed fire from one side only, e.g. certain lift landing doors. If testing is carried out from one side only, i.e. one specimen, the reason for this shall be clearly stated in the report.

8.2.2 *Size of specimen*

8.2.2.1 The test specimen shall be full size and shall be mounted within an appropriate section of associated construction, i.e. of the type to be used in practice or satisfying the requirements of **8.3.1**, to provide a representative size of test construction which complies with **4.5** of BS 476 : Part 20 : 1987.

8.2.2.2 If the size of the door assembly in practice is larger than can be accommodated in the furnace, it shall be tested at a dimension to enable the door and associated construction to be accommodated in a furnace having minimum dimensions of 3 m × 3 m.

NOTE. Application of the results to an element of larger dimensions than that tested should be based on knowledgeable extrapolation of the test results (see **A.2.2**).

8.2.3 *Design of specimen*

8.2.3.1 The specimen shall be designed and constructed as used in practice. The final decorative treatments, e.g. painting or veneering may be excluded unless these are likely to significantly increase or decrease the fire resistance of the assembly. If the doorset does not incorporate a sill, the specimen shall have either a non-combustible sill or a sill covered with non-combustible material.

8.2.3.2 The test construction shall incorporate all hardware essential for the provision of the fire resistance of the element in practice. It is not necessary to test floor springs and devices fixed only to the test construction, where, once closing has been achieved, other components are responsible for providing the maintenance of the closed condition, e.g. the latch on a hinged door leaf (see **A.2.3**).

8.2.3.3 In the case of pre-hung doorsets, steel sliding or folding doors or roller shutters which are manufactured in such a manner that the gaps between the edge of the opening element and the fixed frame cannot be modified during installation, the specimen shall be constructed with gaps that are representative of normal practice. Where this cannot be established, no gap shall be less than 3 mm.

8.2.3.4 When a door is intended to be supplied exclusively as a glazed assembly, glazing of the type and extent intended to be used shall be incorporated in the construction of the specimen.

8.2.4 *Specimen construction and condition.* The construction and condition of the specimen shall be in accordance with BS 476 : Part 20.

8.3 Specimen installation

8.3.1 The specimens shall be mounted in an associated construction of a wall or partition of the type to be used in practice or, if not known, in a construction which has a known fire resistance greater than that anticipated for the specimen being tested. The construction shall be of sufficient strength to resist any thermally induced stresses that may develop during the test and shall be capable of providing adequate fixing.

8.3.2 The method of fixing the specimen to the associated construction shall be representative of that to be used in practice. The doorsets shall be in the closed position with any latching or bolting hardware engaged but not locked, (see **A.2.4**).

8.4 Examination of specimen

8.4.1 Establish the dimensions and properties of the materials used in the construction of the specimen (see **A.2.5**) in accordance with BS 476 : Part 20.

8.4.2 Mount the specimen in its associated construction (see **8.3**) vertically in front of the furnace.

8.4.3 Position the furnace control thermocouples at not less than one to every 1.5 m^2, or part thereof, of the exposed surface area of the test construction (ignoring the area of any furnace closure) or with a minimum of four for test specimens of less than 6 m^2, with the exposed surface being the nominal area measured in the plane of the test construction. Distribute the thermocouples uniformly

ensuring no thermocouple is closer than 500 mm from the furnace walls, and with the thermocouple hot junction at 100 ± 10 mm from the surface at the start of the heating period. Ignore any irregularities such as architraves and hardware and position the thermocouples so that the position does not vary during the heating period by more than 50 mm. For doors and shutters that incorporate glazing, place one thermocouple directly in front of the glazed area for every 20 % of the specimen area taken up by glazing.

NOTE. When the area of glass is less than 20 % of the specimen area, no special positioning is required.

8.4.4 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 : Part 20, and so that the sensing heads do not interfere with the deflection of the specimen.

8.4.5 Fix surface temperature monitoring thermocouples, in order to monitor the unexposed face temperature rise of the specimen in accordance with BS 476 : Part 20, positioning them as follows.

(a) At the centre of the specimen and one in the centre of each quarter section. Do not locate thermocouples within 50 mm of a stiffener or a through member or within 50 mm of a joint between one moving element and another or any moving element and the fixed frame. Where head and/or side panels are incorporated, fix two additional thermocouples to each panel.

(b) On stiffeners or other locations on the door leaf (or leaves) which may be hotter than the average on the face. Do not locate any thermocouple within 50 mm of the edge of the door leaf (or leaves) or the door handle/lock, or closer than 50 mm to any joint between one moving element and another, or any moving element and the adjacent fixed frame.

(c) On the frame of the door assembly, one at mid-height on each vertical side member and one at the mid-point of each door leaf on the horizontal top member.

Place them on the unexposed face of the door frame the plane of which is approximately parallel to the plane of the door leaf and in a position such that there is a 12 mm wide flat surface on which the copper disc can be placed. If these requirements cannot be satisfied for any thermocouple then omit that thermocouple.

(d) For the roving thermocouple, the positional constraints given in items (b) and (c) apply.

NOTE. The mean temperature rise should be calculated as the mean of the thermocouples in (a). Where additional thermocouples are fixed on the head or side panels the data from these should not be used to calculate the mean temperature rise but should be reported separately.

8.4.6 Where required for extrapolation purposes attach additional temperature measuring thermocouples on the surface or within the door or shutter assembly. Do not use these for determining either the maximum temperature rise or the mean temperature rise.

8.4.7 Locate in position the equipment required for measuring lateral deflection.

NOTE 1. It may be necessary to measure more than one point on the surface of each specimen.

NOTE 2. It is difficult to determine in advance the positions of maximum deflection in a doorset or shutter assembly and it is recommended that all deflection measurements are made using portable measuring equipment.

8.4.8 Position the radiometer in front of the specimen before the start of the test, at such a distance that the field of view of its sensing unit circumscribes the specimen area. Carry out any measurements of radiation from the unexposed face in accordance with BS 476 : Part 20.

8.5 Test procedure

8.5.1 *General.* Carry out the test in accordance with BS 476 : Part 20 and make any observations on the behaviour of the specimen.

8.5.2 *Integrity.* Monitor the unexposed face of the specimen for evaluation of integrity in accordance with clause 9 of BS 476 : Part 20 : 1987 except that the cotton pad shall not be employed to evaluate permeability.

8.5.3 *Specimen temperature rise*

8.5.3.1 Monitor the temperature rise of the unexposed face in accordance with clause 9 of BS 476 : Part 20 : 1987, for both the mean temperature rise and the maximum temperature rise, using the thermocouples specified in **8.4.5** and **8.4.6**. Use the measurements from the roving thermocouple, when employed, only for determining maximum temperature rise.

8.5.3.2 If during the test a thermocouple is known to be heated directly by gases passing through the specimen from the furnace, for example owing to the occurrence of shrinkage, cracking or distortion, do not use the readings obtained from it for the purpose of determining either mean or maximum unexposed face temperature rise and report this fact.

8.5.3.3 Monitor the temperature rise of the fixed frame and components of the door or shutter assembly by means of the additional thermocouples fixed for this purpose.

8.5.4 *Lateral deflection.* Monitor the lateral deflection of the specimen.

8.5.5 *Irradiance.* Monitor the irradiance by means of the radiometer described in BS 476 : Part 20.

8.6 Criteria of failure, expression of results and test report

8.6.1 *Criteria of failure.* The fire resistance of an uninsulated doorset or shutter assembly shall be determined with respect to integrity. The criteria for failure shall be as follows:

(a) during the test, the 6 mm gap gauge provisions apply to any gap other than at sill level;

(b) during the test, the 25 mm gap gauge provisions apply to any gap;

(c) during the test, the requirements concerning sustained flaming apply.

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8.6.2 *Expression of results*

8.6.2.1 The result shall be stated in terms of the elapsed time to the nearest minute, between the commencement of heating and the time of failure in accordance with BS 476 : Part 20 with respect to the criterion given in **8.6.1**.

NOTE. An example of the method of expressing the result is given in **A.11** of BS 476 : Part 20 : 1987.

8.6.2.2 The mean irradiance from the unexposed face of the specimen shall be reported in a graph or table with respect to time.

The distance from the surface at which these values were obtained shall be given, as shall the angle of view of the radiometer.

8.6.2.3 The unexposed face temperatures for both maximum temperature rise and mean temperature rise together with the temperature from any additional fixed thermocouples shall be reported in a graph or table with respect to time.

8.6.3 *Test report.* The test report shall include the results (see **8.6.2**) and any observations together with the other requirements given in clause **12** of BS 476 : Part 20 : 1987. In addition, the report shall state the maximum lateral deflection and the position at which this occurred, together with the reasons for testing from one side only and the mode of failure, if applicable.

9 Determination of the fire resistance of ceiling membranes

9.1 General

This clause describes a method for the determination of the fire resistance of ceiling membranes required to withstand exposure to fire from their underside (see **A.3.1**).

NOTE. The method described is not applicable to suspended ceilings that are intended to contribute to the fire resistance of other beams or floors. The method described in BS 476 : Part 23 should be used for suspended ceilings that are intended to contribute to the fire resistance of structural steel beams.

9.2 Test specimen

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

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

9.2.2 *Size of specimen.* The specimen shall be of such dimensions that at least 4 m × 3 m is exposed to the furnace (see **A.3.2**) or full size if the element is smaller.

9.2.3 *Design of specimen*

9.2.3.1 When ceiling membranes include joints in the element for either erection or construction purposes, the test specimen shall incorporate such joints even though these occur at greater than 3 m centres.

9.2.3.2 If more than one jointing method is used in a particular form of construction, it may be possible to incorporate more than one type of joint in a test specimen but care shall be exercised to ensure that the specimen is a valid representation of the element being evaluated.

In forms of construction where supporting members for the ceiling membrane incorporate joints that are designed to accommodate expansion, the ends of all members of the suspension system shall be cut square and shall abut tightly against the perimeter framework such that all expansion joints incorporated in the members shall be accommodated within the specimen and not at the perimeter.

9.2.3.3 Where diffuser grilles, lighting fittings and the associated wiring form an integral part of the element, the test specimen shall incorporate them in a representative manner. When the fittings are not an integral part of the element but may be fitted subsequently in a manner that may have an adverse effect on the fire resistance of the element, these shall be the subject of a separate test.

9.2.4 *Specimen construction and condition.* The construction and condition of the specimen shall be in accordance with BS 476 : Part 20 (see **A.3.3**).

9.3 Specimen support conditions

9.3.1 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 specimen shall be fixed to the specimen support frame or the furnace surround without any allowance for lateral movement.

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

9.3.2 Any ceiling suspension system used shall be representative of practice and shall be erected such that the allowances for expansion do not exceed those that would be provided in practice for the length of the members involved. The ends of all members in the expansion system shall be abutted tight to the perimeter edges of the specimen support frame or the furnace surround such that all thermal suspension is accommodated within the supporting member.

9.4 Apparatus

In addition to the apparatus specified in BS 476 : Part 20, the following apparatus is required.

9.4.1 *Vertical draught screen* (see **A.3.4**), continuous around the perimeter of the specimen, fixed not more than 75 mm from the specimen edge and extending to a height of 500 ± 25 mm above the upper surface of the membrane. The walls shall be constructed of or lined with a material not less than 6 mm thick which is either non-combustible in accordance with BS 476 : Part 4, or has a class 1 surface spread of flame in accordance with BS 476 : Part 7 and has indices of performance of I and i_1 not exceeding 12 and 6 respectively when tested in accordance with BS 476 : Part 6.

9.5 Examination of specimen

9.5.1 Establish the dimensions and properties of the materials used in the construction of the specimen in accordance with BS 476 : Part 20 (see **A.3.5**).

9.5.2 Mount the specimen, in its support frame if used, horizontally on top of the furnace, such that it is subjected to heating from the underside.

9.5.3 Position the furnace control thermocouples at not less than one to every 1.5 m^2, or part thereof, of the exposed surface area, or 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 ± 10 mm from the surface of the specimen at the start of the heating period. Where the surface is irregular, measure the 100 ± 10 mm from the median depth provided the junction is not nearer than 50 mm from any part of the exposed surfaces.

9.5.4 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 : Part 20, at a position 100 mm below the surface of the specimen, or an imaginary line between the lowest points of an irregular construction in the plane of the surface, so that the head does not interfere with the deflection of the specimen during the 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.

9.5.5 Fix five surface temperature monitoring thermocouples, in order to measure the unexposed face temperature rise, to the upper surface of the specimen including any insulating material that may be used. When the thermocouples are to be attached to the upper surface of of any fibrous or resilient insulation material, use a thermocouple weight described in BS 476 : Part 20. Position the thermocouples with one placed approximately in the centre of the specimen and one at the centre of each quarter section.

NOTE. With corrugated or ribbed constructions, the number of thermocouples on the unexposed face may be increased to six to provide an equal number on the maximum and minimum thickness, providing that the element is intended to provide insulation in which case all thermocouples should be used to obtain the mean temperature rise.

9.5.6 Where additional measurements are to be made of the temperature of any part of the specimen, fix any thermocouples that have not been built into the specimen in accordance with BS 476 : Part 20.

9.5.7 Locate in position, and attach if necessary, the deflection measuring equipment at the anticipated point of maximum deflection. Where this point cannot be predetermined, take more than one deflection measurement.

9.6 Test procedure

9.6.1 *General.* Carry out the test in accordance with BS 476 : Part 20 and make any observations on the behaviour of the specimen, including the mode of failure in the event of collapse.

9.6.2 *Integrity.* Monitor the unexposed face of the specimen for evaluation of integrity in accordance with clause **9** of BS 476 : Part 20 : 1987.

9.6.3 *Insulation*

9.6.3.1 Measure the temperature rise of the unexposed face for evaluation of insulation in accordance with clause **9** of BS 476 : Part 20 : 1987 for both the mean temperature rise and the maximum temperature rise, using the thermocouples specified in **9.5.5** and **9.5.6**. Use the measurement from the roving thermocouple, when employed, and from the additional fixed thermocouples only for determining the maximum temperature rise.

9.6.3.2 If during the test a thermocouple is known to be heated directly by gases passing through the specimen from the furnace, for example owing to the occurrence of shrinkage, cracking or distortion, do not use the readings obtained from it for the purpose of determining compliance with the criterion of either mean or maximum unexposed face temperature rise and report this fact. If more than two of the thermocouples that are intended to be used in determining the mean temperature rise are affected, do not assess the specimen for compliance with the criterion for mean temperature rise and report this occurrence.

9.6.4 *Deflection.* Monitor the maximum deflection of the specimen.

9.7 Criteria of failure, expression of results and test report

9.7.1 *Criteria of failure.* The fire resistance of a ceiling membrane shall be determined with respect to integrity and insulation. The criteria for failure shall be as given in **10.3** and **10.4** of BS 476 : Part 20 : 1987.

9.7.2 *Expression of results.* The result shall be stated in terms of the elapsed time to the nearest minute, between the commencement of heating and the time of failure in accordance with BS 476 : Part 20 with respect to the two criteria given in **9.7.1**. When the mean temperature rise has not been determined due to the influence of hot gases (see **9.6.3.2**) the insulation compliance shall be adjudged on the basis of the maximum unexposed face temperature and this shall be clearly stated in the result.

NOTE. An example of the method of expressing the result is given in **A.11** of BS 476 : Part 20 : 1987.

9.7.3 *Test report.* The test report shall include the results (see **9.7.2**) and any observations together with the other requirements given in clause **12** of BS 476 : Part 20 : 1987. In addition, the report shall also state the maximum deflection obtained during test and the position at which this occurred together with the mode of failure, if applicable.

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10 Determination of the fire resistance of glazed elements

10.1 General

10.1.1 This clause describes a method for the determination of fire resistance of essentially vertical glazed separating elements (see **A.4.1**) with the exclusion of glazed doorsets and shutter assemblies.

10.1.2 When a specimen is designed and constructed in such a manner that less than 50 % of the surface area consists of glazing, it shall be tested in accordance with the procedures described for that type, i.e. partitions with less than 50 % glazing will be tested as partitions.

10.2 Test specimen

10.2.1 *Number of specimens.* Glazed elements shall be tested from both sides, i.e. two specimens, unless the glazed element, including the installation method and hardware, is entirely symmetrical or the weaker direction of exposure can be clearly identified, or unless a glazed element is required to resist fire from one side only. If testing is carried out from one side only, the reason for this shall be clearly stated in the report (see **A.4.2**).

10.2.2 *Size of specimen.* The test specimen shall be of such dimensions that at least 3 m × 3 m (see **A.4.3**) is exposed to the furnace or full size if the element is smaller.

10.2.3 *Design of the specimen*

10.2.3.1 The specimen shall be designed and constructed as used in practice (see **A.3.4**).

10.2.3.2 Where it is intended that decorative treatments are to be used, the specimen shall be finished as it would be in practice in order to evaluate the effect that these trims and finishes may have on the integrity of the specimen.

NOTE. One frequent cause of integrity loss associated with glazed elements is the ignition of decorative trims and finishes on the unexposed face of the construction.

10.2.3.3 Where the glazed element is intended to be used in a multiple paned construction, the specimen shall incorporate representative transoms or mullions between the adjacent glazed areas and the specimen shall include a pane of the maximum size intended for use.

10.2.4 *Specimen construction and condition.* The construction and condition of the specimen shall be in accordance with BS 476 : Part 20.

10.3 Specimen installation

10.3.1 The specimen shall be mounted in an associated construction of a wall, partition or door of the type to be used in practice or, if not known, in a construction that has a recognized fire resistance greater than that anticipated for the specimen being evaluated. The construction if of such known recognized fire resistance shall be of sufficient strength to resist any thermally induced stresses that may develop during the test and shall be capable of providing adequate fixing.

10.3.2 No restriction to freedom of movement shall be applied other than that resulting from the fixings used. The method of fixing the specimen to the associated construction shall be representative of that used in practice.

10.3.3 The test construction, i.e. the test specimen with any associated construction, shall be tested in conjunction with furnace closures as appropriate.

10.4 Examination of specimen

10.4.1 Establish the dimensions and properties of the materials used in the construction of the specimen in accordance with BS 476 : Part 20 (see **A.3.5**).

NOTE. Whilst the procedure and equipment for determining the moisture content as specified in BS 476 : Part 20 are not appropriate to the glass, they are appropriate to any glazing system that incorporates hygroscopic materials, e.g. timber or concrete.

10.4.2 Mount the test construction (see **10.3**) vertically in front of the furnace.

10.4.3 Position the furnace control thermocouples at not less than one to every 1.5 m^2, or part thereof, of the exposed surface area of the test construction or 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 test construction. Distribute the thermocouples uniformly ensuring that:

(a) not less than 50 % of the thermocouples are placed directly in front of the glazed part of the construction;

(b) no thermocouple is placed closer than 50 mm to the furnace walls;

(c) the thermocouple hot junctions are 100 ± 10 mm from the vertical surface of the specimen or the surrounding construction at the start of the heating period and do not vary by more than 50 mm during the test.

10.4.4 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 : Part 20, and so that the sensing heads do not interfere with the deflection of the specimen.

10.4.5 Fix five surface temperature monitoring thermocouples in order to measure the mean unexposed face temperature rise of the specimen in accordance with BS 476 : Part 20 such that one thermocouple is placed approximately in the centre of the glazed area with one thermocouple placed approximately at the centre of each quarter section. In the case of a multi-paned element, fix the thermocouples to the glazed area nearest to these positions, if the positions specified coincide with mullions or other framing members.

NOTE. The readings from these thermocouples also provide information with respect to the time at which the use of the cotton pad test is discontinued for the purpose of assessing impermeability as specified in BS 476 : Part 20.

10.4.6 Attach thermocouples at positions other than those specified above in order to determine the temperature at any point where the temperature rise is likely to be higher than elsewhere. Do not use the temperatures to compute the mean temperature rise but they may be used in

conjunction with the roving thermocouple if necessary, for determining compliance with the maximum temperature rise criterion.

10.4.7 Locate in position the equipment required for measuring lateral deflection of the specimen or, if required, any individual glazed panels. It is not normally required to monitor the deflection of individual glazed panels, but where the glazed area forms part of a complete screen determine the deflection of the screen.

10.4.8 When the glazed element is to be examined for the amount of heat being radiated from the surface, position the radiometer in front of the specimen before the start of the test at such a distance that the field of view of its sensing unit circumscribes the specimen area.

10.5 Test procedure

10.5.1 *General.* Carry out the test procedure in accordance with BS 476 : Part 20 and make any observations on the behaviour of the specimen.

10.5.2 *Integrity.* Monitor the unexposed face of the specimen for evaluation of integrity in accordance with clause **9** of BS 476 : Part 20 : 1987.

10.5.3 *Insulation.* Measure the temperature rise of the unexposed face for evaluation of insulation in accordance with clause **9** of BS 476 : Part 20 : 1987, for both the mean temperature rise and the maximum temperature rise, using the thermocouples specified in **10.4.5** and **10.4.6**. Use the measurements from the roving thermocouple, when employed, and from any additional fixed thermocouples only for determining the maximum temperature rise.

10.5.4 *Lateral deflection.* Whilst the specimen is not evaluated with respect to either the rate or extent of lateral deflection, monitor the glazing for deflection (see **A.4.6**).

10.5.5 *Irradiance.* Monitor the irradiance of the specimen by means of the radiometer in accordance with BS 476 : Part 20.

10.6 Criteria of failure, expression of results and test report

10.6.1 *Criteria of failure.* The fire resistance of a glazed element shall be determined with respect to integrity and insulation. The criteria for failure shall be as given in **10.3** and **10.4** of BS 476 : Part 20 : 1987.

10.6.2 *Expression of results.* The result shall be stated in terms of elapsed time to the nearest minute, between the commencement of heating and the time of failure in accordance with BS 476 : Part 20 with respect to the two criteria given in **10.6.1**.

NOTE. An example of the method of expressing the result is given in **A.11** of BS 476 : Part 20 : 1987.

10.6.3 *Test report.* The test report shall include the results (see **10.6.2**) and any observation together with the other requirements given in clause **12** of BS 476 : Part 20 : 1987 shall be reported. In addition the report shall state the maximum lateral deflection and the position at which this occurred together with the reasons for testing from one side only and the mode of failure, if applicable. When the irradiance from the unexposed face of the specimen has been monitored, the irradiance shall be reported in a graph or table with respect to time.

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Appendix

Appendix A. Guidance information

A.1 Partitions

A.1.1 Number of specimens

Partitions will frequently be symmetrical constructions and therefore only one specimen will be required. If a single acting doorset or a glazed panel is incorporated in the partition, this may make the construction asymmetrical and it may be necessary to evaluate the fire resistance from either side which would require two specimens to be tested, unless the weakest direction of exposure can be determined in advance.

A.1.2 Specimen construction

Partitions are frequently constructed from many individual components of nominally the same type and size. It is important to check during the construction that all components are similar in order to avoid localized failures.

A.1.3 Specimen support condition

Both vertical edges of the partition should only be restrained if it is justified in practice, i.e. where sections of partition are built between substantial and inert columns that would restrain any lateral deformation. The head and sole plates should be restrained by fixings in a manner similar to that used in practice.

A.1.4 Dimensions of specimens

In the construction of stud partitions where several components of similar nominal size are employed, it is important to determine the average size and also to quantify the variation that exists between individual components.

A.1.5 Partitions with doorsets and sub-full size fixing

Where it is known that the partition will incorporate a particular door, then that door should be mounted in the partition and the specimen evaluated as a partition containing a door, i.e. as a single element, and not as a doorset and partition separately. Where the specific use is not known, the partition should be tested without the door and the door evaluated having regard to **A.2.2**.

A.2 Doorsets and shutter assemblies

A.2.1 General

For the purposes of fire resistance classification, three test methods have been specified for doorsets and shutter assemblies, covering fully insulated, partially insulated and uninsulated products. This has been done to reflect differences in end use and thus assist specifiers in requiring the correct type of door for a specific situation. In this connection it should be noted that there is not generally any regulation for insulation unless means of escape is involved. The three test methods are essentially the same differing only in the criteria used to determine failure.

Where there is uncertainty at the outset regarding which test method should be used, it should be noted that clause **7**, which describes the partially insulated door test procedure, will provide sufficient information to enable the results to be used for either of the other two sections should these subsequently be found to be more applicable.

Door and shutter assemblies include all normal types of opening elements that enable people or goods to pass from one fire compartment to another or obtain access to a means of escape. It would usually include normal hinged doorsets, sliding doors, folding doors and rolling shutters. Horizontal doors and shutters including escalator shutters require a separate test procedure but for the time being may be tested by analogy.

The methodology of the test is, however, applicable to any form of essentially vertical openable units, e.g. serving hatches and removable service panels, where the potential weakness with respect to fire is likely to be at the edges rather than through the body of the component.

Many doors are in practice fitted with either glazed side lights or overpanels. Whilst these panels are fixed and are therefore covered by **6.1**, it is recommended that they should be tested in conjunction with the door, especially in the situation where the door frame forms a common member for both the door and the glazed panel. This member may, depending upon the behaviour of the door, be subjected to greater fire exposure and have less protection, thermal inertia and restraint than would be apparent if they were to be tested as individual elements.

A.2.2 Size of specimen

The size of the specimen is a matter of particular concern with respect to fire resisting doors and shutters. By tradition doors have become a bespoke item due to the lack of standardization that has existed in the building industry. As a result, the door manufacturer will be required to produce doors over a wide range of sizes which the user will expect to be fully certified.

There are few problems associated with the supply of doors that are smaller than the tested prototype unless the size reduction requires changes to be made to the basic construction. There is, however, a problem in supplying doors larger than the test prototype. Doors are opening elements and therefore have minimal restraint applied to them in use. Frequently the restraint is limited to only three or four places, i.e. latch and hinges, around the periphery of the opening element. If the door is made larger, it is rare for the number of restraining points to be increased and hence the distance between them increases. This has the effect, in many designs, of making the element more unstable and therefore the deformation caused by exposure to high temperature is increased which in turn reduces the possibility of maintaining an adequate seal at the door edges.

In order to alleviate the problem of supplying proven doors over a wide range of sizes, it is recommended that the specimen size is carefully considered and where possible,

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the specimen should be constructed at a size that reflects the largest anticipated size of door that would be manufactured using that particular form of construction. For very large doors it is likely that a different type of construction would be employed in order to increase the resistance to distortion either during normal use or during fire exposure. Such constructions should be the subject of a separate evaluation.

Most doors and shutters, even after taking into account the aforementioned recommendations, will be smaller than the maximum size that can be accommodated in a test furnace (3 m x 3 m). The door(s) will therefore need to be built into a suitable test construction. Where it is known that the door is to be used solely in conjunction with a particular form of construction, e.g. a steel partition, the specimen should be mounted in a test construction made in the same manner and from the same materials as would be used for the adjacent walls or partitions in practice. Where this specific use is not known, and the door may be built into many types of construction ranging from lightweight partitioning to solid concrete walls, it is not possible to specify the materials from which the test construction should be built. The test construction should, however, be able to resist any thermally induced stresses that may develop, and should not impose any significant stresses on the door or shutter assembly being tested. This construction should also be capable of providing a resistance to fire in excess of that anticipated from the specimen being tested.

In order to avoid any risk of fire exploiting the gap between the door frame and the test construction, which might cause either excessive heat transfer or allow the penetration of flames or hot gases that could influence the behaviour of the unexposed face, a seal should be used in this position with a fire performance similar to that of the test construction. Where, however, the door or shutter assembly is being tested in conjunction with a specific form of construction, the seal at this position forms part of the evaluation and the method used for sealing this gap should be that specified by the system designer.

A.2.3 Design of specimen

As explained in **A.2.2** the size of the specimen will be one of the most important factors to be considered in the design of the specimen. A further important consideration is the type of hinge, lock/latch, closer mechanism or edge sealing system to be used on the test prototype. Traditionally the choice of these items has been dominated by the internal decor of the building and has generally been specified by the architect. All of these components are, however, capable of causing a premature failure if wrongly specified.

It is recommended that care is exercised in the choice of these components as they will probably at best only be allowed to be interchanged over a restricted range of similar components or at worst may not be capable of being varied at all.

Hinged timber doors are particularly vulnerable to errors in specifications relating to products that need to be morticed into the stiles or rails of the construction. If too much timber is removed, localized burn-through might well occur which would cause a loss of integrity. Similarly any component that creates a thermal bridge when it is attached to the edge of a door, e.g. a broad leaf hinge or a closer arm, is also likely to cause a loss of integrity.

Whilst there is no requirement to fit non-essential items of door furniture to the test specimen, it is recommended that any item that may subsequently be fitted which could cause a failure, e.g. letter plates, security lenses or push/pull handles, should either be incorporated in the test specimen or should be the subject of a separate evaluation.

In order to meet the furnace pressure conditions of BS 476 : Part 20 it may well be necessary to install the specimen in the vertical wall at a height well above the hearth of the furnace. The air flow pattern between the bottom of the leaf or moving component of the assembly and the sill of the construction is likely to be significantly different during test than it would be in practice. This method of installation can lead to unacceptable scouring of the door and sill components, especially in the case of combustible constructions, due to the incoming oxygen-rich air supply at this level. A non-combustible lining to the sill reduces this scouring effect and makes the test more repeatable.

A.2.4 Mounting of specimen

The restraint on a door or shutter assembly has two separate components, i.e. restraint applied to the whole assembly within the furnace opening or the test construction and the restraint imposed on the opening element by the hinges, pivots, closers and locking/latching mechanisms.

When restraint on the complete assembly is of importance, the method of fixing and the strength of the test construction should both be similar to that likely to be used in practice and should be fully documented as this will form part of the test. This restraint will need to be operative throughout the period of fire exposure.

The restraint that is imposed by the hardware on the opening part of the element is subject to different considerations. Where no thermally activated sealing system is fitted, the hardware and its method of fixing to the door and its frame have to be capable of restraining the door throughout the full duration of the test. Some edge sealing systems are, however, capable of restraining low level stresses once they are activated. When used in conjunction with a reasonably inert construction, the restraints applied by the hardware, particularly door closers, need not be operative throughout the full duration of the test. The type of hardware should therefore be considered in conjunction with the likely behaviour of the door.

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A.2.5 Dimensions and properties of the specimen

Door and shutter assemblies are unique in respect of the need for a gap to be present in the construction to allow the door or shutter to be opened easily. Because of this the report should carry a full analysis of the gaps that are present as well as the dimensions of the construction and its component parts.

Doors are of such a size that they are normally factory made, factory finished components which frequently incorporate fully encapsulated core materials. This creates problems in determining the density, moisture content or dimensions of these core materials. Due to the lack of restraint applied to doors during test it is important to ensure that any drilling or boring that may be required to verify the properties of these cores does not cause a loss of stability or introduce weaknesses with respect to integrity. In many cases it may be a necessity to determine the properties of these materials from samples supplied by the manufacturer of the door. In such cases any evidence verifying the relationship between these samples and the test specimen, e.g. by witnessing the construction or by post-test examination, should be reported.

A.2.6 Test procedure

It is recommended that tests performed on fire resisting doors and shutters are extended beyond the period of fire resistance required by regulations, preferably up to the point of failure with respect to integrity, or even beyond. This provides information to any appropriate authority which may aid subsequent assessments, particularly in respect to changes that are required in relation to the size of the door or shutter assembly.

A.2.7 Determination of fire resistances

When door and shutter assemblies are evaluated with respect to heat flux, due to the lack of insulation or the incorporation of glazing, it is recommended that reference is made to **A.9.4** of BS 476 : Part 20 : 1987.

A.3 Ceiling membranes

A.3.1 General

A ceiling membrane may be regarded as a horizontal partition which, unlike a floor, is not required to support any imposed loading. A typical example of a ceiling membrane is an unloaded horizontal membrane separating a room from a roof cavity. The results obtained from this test do not provide any information with respect to the loadbearing capacity of structural members that may be situated within the roof cavity or in contact with the ceiling lining other than to demonstrate their ability to carry the dead weight of the ceiling should they be used as part of the ceiling suspension system.

A.3.2 Size of specimen

Ceiling membranes are sometimes used for providing a ceiling to an escape corridor. Such a membrane may only be 2 m wide and it may therefore only need to be evaluated at this size. It is not necessary for the supporting membrane to span the maximum furnace dimensions, i.e. 4 m, if, in practice, the supporting members span the shorter dimensions. In such cases, however, a length of ceiling of not less than 4 m should be evaluated.

As most horizontal furnaces have a fixed width in excess of this, closures of adequate fire resistance will be required to close off the furnace on either side of the membrane. The draught screen will not, however, encompass these closure panels and will only be fixed around the perimeter of the ceiling. As this screen will restrict vision from the normal furnace positions, care will have to be exercised to ensure that access to these closures is prohibited or that they are adequate to withstand the weight of any persons that may need to approach the specimen.

A.3.3 Construction of specimen

Ceiling membranes may in some circumstances only be capable of being erected from below due to a lack of access from above. During the construction of a specimen access will always be available from above due to the nature of the test, but advantage should not be taken of this situation and the specimen should be constructed as it would be in practice.

A.3.4 Vertical draught screen

A draught screen is erected around all ceiling membrane specimens in order to reduce or eliminate the scouring effects of draughts across the unexposed face of the specimen. The draught screen should be rigidly fixed to the furnace or the specimen support frame and should not apply any loading to the edges of the specimen or in any way influence the restraint conditions that exist.

A.3.5 Properties of the materials

In the construction of a ceiling membrane and its supporting structure many individual components of nominally the same dimension are used. It is important, therefore, not only to determine the average sizes of these components, but also to establish the magnitude of the variation between them.

A.4 Glazing

A.4.1 General

The test procedure described in clause **10** provides a method of test for evaluating the behaviour of glazing materials and glazing systems in situations where the total area of glass in the construction is more than half of the total area of the element. The area of glass to be considered should be the exposed visible area ignoring any glass hidden behind components of the retaining system. When possible the glazing should be fixed to representative constructions.

Having established the potential fire resistance of the glazing and the glazing system it will be necessary to consider what effect the glazed area might have on the element to which it is to be fitted. Glazed areas in stud partitions may cause a reduction in the diaphragm stiffness

provided by the linings. Also the additional heat transfer may cause the stud frame to suffer more damage than when protected by linings hence reducing the stability of the assembly. Fire resisting doors are designed for maximum stability in order to reduce the risk of door distortion. The cutting away of any of the framing members in a timber framed, infilled core construction could have deleterious effects on the ability of the door to remain flat. Glazing, which is only inserted into the non-structural core, should not have such serious consequences but even this will reduce the membrane stiffness provided by the facing materials.

Consequently it will often be a requirement for the system to be tested in context with an appropriate construction, e.g. wall, partitions or doorset, and the methodology of the relevant section should be used.

A.4.2 Number of specimens

Whilst glazing is often asymmetrical due to the need to supply at least one removable bead to allow the glass to be replaced should it be broken, it should normally be sufficient to test one specimen exposing the glass to the fire with the removable bead on the exposed face. The exception to this general rule is when the glazing is formed from two materials of different fire behaviour which may be sandwiched together for special effects. This technique makes it very difficult to determine in advance which direction of exposure would give the lowest level of fire resistance.

A.4.3 Size of specimen

When glass is heated it will undergo a change of state that will cause the material to behave in a plastic manner. The temperature at which this occurs will vary for the type of glass being tested but once the plastic state has been achieved the fire resistance of the glazing will be influenced by the weight of the glass and the ability of the glazing system to resist the slumping effect of the hot glass.

The force that the glazing system has to resist is therefore proportional to the weight and hence the size of the pane of glass. For this reason the fire resistance should be determined using a specimen which incorporates as large a pane of glass as it would be anticipated using.

Recent research work has shown that the ratio between the height of the pane and the width of the pane (aspect ratio) is likely to influence the maximum size of non-insulating glass that can be retained by the glazing system for periods of fire resistance in excess of 30 min. The aspect ratio should therefore be considered when choosing the size of the pane to be evaluated.

A.4.4 Design of specimen

Attention is drawn to the probable relationship between the size of the glass and the aspect ratio as described in **A.4.3** and this should be taken into consideration during the design of the specimen. In constructing the specimen it should be noted that glass is frequently a site cut component and the fit of the glass within the glazing frame should be representative of normal site practice.

Glass elements should be glazed in accordance with BS 6262.

A.4.5 Equipment and procedures for measurement of specimen

When recording the size of the glass pane, it should be clearly stated whether the measurements relate to the size of the complete pane or only the size of the pane that is visible within the glazing system, i.e. measurements based on sight lines. The latter method is recommended as it simplifies any measurements that may need to be made after installation in a building in order to check compliance with the specification given in the report.

The depth of cover to the glass edge that is provided by the glazing system and the size of any gaps between the glass and the glazing frame should also be recorded.

A.4.6 Test procedure

As glass becomes plastic when hot it will be necessary to monitor lateral deflection with care. Any equipment to be used for this purpose should not exert a force, in either direction, on the glass itself. It should also be noted that the area immediately in front of any glazing, unless it is one of the insulating type, will be subjected to fairly high levels of radiation which will rapidly increase the temperature of any measuring instruments. It will also restrict technicians approaching the glass in order to take measurements.

It may be necessary, therefore, to estimate the deflection of the glass by visual reference to a fixed plane and if done in this manner, this should be recorded in the report.

The thermocouples used for determining the unexposed face temperature rise are also used for determining the point at which the use of the cotton pad test should be discontinued.

All areas of the specimen shall be monitored by means of the cotton fibre pad test until such times that the surface temperature measurements indicate that this method of monitoring should be abandoned due to the radiation levels being of such a magnitude as to possibly cause spontaneous ignition of the cotton fibre pad. The pad should only be abandoned for those areas where such a temperature is measured. In other areas of the specimen, which remain shielded from the radiation effects, it may still be possible to use the pad for continued monitoring (see **C.10.3.2** of BS 476 : Part 20 : 1987).

A.4.7 Criteria

Glazing is evaluated with respect to heat flux. It is recommended that reference is made to **A.9.4** of BS 476 : Part 20 : 1987.

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Publications referred to

BS 476	Fire tests on building materials and structures
	Part 4 Non-combustibility test for materials
	Part 6 Method of test for fire propagation for products
	Part 7 Method for classification of the surface spread of flame of products
	Part 20 Method for determination of the fire resistance of elements of construction (general principles)
	Part 21 Methods for determination of the fire resistance of loadbearing elements of construction
	Part 23 Methods for determination of the contribution of components to the fire resistance of a structure
	Part 24 Method for determination of the fire resistance of ventilation ducts
	Section 31.1 Method of measurement under ambient temperature conditions
BS 4422	Glossary of terms associated with fire
BS 6262	Code of practice for glazing for buildings
ISO 834*	Fire resistance tests — Elements of building, construction
ISO 3008*	Fire resistance tests — Door and shutter assemblies
ISO 3009*	Fire resistance tests — Glazed elements

* Referred to in the foreword only.

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Committees responsible for this British Standard

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Association of Building Component Manufacturers Ltd.
Association of Structural Fire Protection Contractors and Manufacturers
British Coal
British Fire Services' Association
British Floor Covering Manufacturers' Association
British Plastics Federation
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British Rigid Urethane Foam Manufacturers' Association
British Wood Preserving Association
Cement and Concrete Association
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Association of Builders Hardware Manufacturers
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Door and Shutter Association
Electric Cable Makers' Confederation
Guild of Architectural Ironmongers
Hevac Association
Intumescent Fire Seals Association
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