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Fire resistance of timber door assemblies — Method of determining the efficacy of intumescent seals

Résistance au feu d'assemblages de portes en bois — Méthode de détermination de l'efficacité des joints en renflage

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

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

ISO 12472 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 2, *Fire containment*.

Introduction

This test method has been developed for a number of reasons, the primary one being the recognition of the need to have a repeatable and reproducible test procedure by which the performance of intumescent products can be evaluated, particularly so as to ascertain any change in performance resulting from “real time” ageing.

It is a common requirement under any critical product certification scheme that durability be able to be quantified. There are no recognized accelerated ageing methods suitable for use with intumescent sealing products and, as a consequence, real time ageing tests are carried out. It was considered that over a period of twenty years, manufacturing variations would probably occur on any type of proprietary fire-resisting door. The effect of such variations would be to mask any performance changes. The testing apparatus specified here is capable of being built to reproducible and repeatable specification, which will allow even small variations in performance to be identified.

The fact that the method has eradicated most of the variables, making it repeatable and reproducible, also makes it suitable for quality control purposes. As a quality control test it has the added advantage of heating the intumescent seals in the same manner as they would be in practice; in the case of pressure-forming intumescent materials, the method also allows the pressure-forming characteristics of the materials to be characterized for their shear resistance in a comparative manner. This is not measured by any other known technique.

Finally, because the test heats the specimen in a characteristic way and applies typical movement or shear forces, repeatable product-by-product comparisons can be made. This permits a restricted amount of product interchangeability covering the least onerous door modes and configurations. Even under these conditions, the intumescent material proposed to replace the existing material must itself have been the subject of a full-scale test on another door design, if confidence is to be gained in its performance at large scale.

Fire resistance of timber door assemblies — Method of determining the efficacy of intumescent seals

SAFETY PRECAUTIONS — The attention of all persons concerned with managing and carrying out this fire resistance test is drawn to the fact that fire testing can be hazardous and that there is a possibility that toxic and/or harmful smoke and gases could be evolved during the test. Mechanical and operational hazards can also arise during the construction of the test elements or structures, their testing, and disposal of test residues.

An assessment of all potential hazards and risks to health shall be made and safety precautions shall be identified and provided. Written safety instructions shall be issued. Appropriate training shall be given to relevant personnel. Laboratory personnel shall ensure that they follow written safety instructions at all times.

IMPORTANT — During fire resistance testing, the leaves shall not deflect more than half their thickness. The distortion shall be measured between the top of the opening edge and the frame of a full-sized door when tested opening into the furnace during a test in accordance with ISO 3008. If the door leaf undergoes distortion greater than this during the test, then the method is unsuitable for evaluating alternative sealing methods.

1 Scope

This International Standard specifies a test method for determining the effective sealing capability of intumescent materials or systems in the context of sealing door–to–frame clearances in timber door assemblies. Intumescent seals extend the duration for which the gap between the leaf edge and the frame will satisfy the integrity criteria of the fire resistance test, and sealing systems can be compared using this method. The method is suitable for evaluating the efficacy of exposed intumescent sealing systems used in conjunction with timber fire resisting doors of up to 1 h fire resistance. It is not suitable for comparing concealed intumescent seals. The results can be applied to proven, single-acting, single-leaf, latched, timber door assemblies of sizes up to that given in the field of direct application.

This International Standard is applicable to timber door assemblies whose intumescent seals have been tested in accordance with ISO 3008 and have satisfied the integrity and — if appropriate — the insulation criterion, whilst incorporating another form of heat-activated seal for a period appropriate to the application. The suitability of any sealing system for use on timber door assemblies of any other configuration (i.e. unlatched single doors, double leaf assemblies etc., or doors constructed of other materials) can only be evaluated by subjecting a full-sized door assembly, complete with seals, to testing in accordance with ISO 3008.

The method does not provide any measure of the ability of the seal to resist the flow of smoke (although a gap that is sealed will provide a reduction in the flow of hot products of combustion) or any information as to the additional protection that could be needed at hardware/ironmongery positions.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 3008*, Fire resistance tests — Door and shutter assemblies*

ISO 8302, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Guarded hot plate apparatus*

ISO 13943, *Fire safety — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943 and the following apply.

3.1
intumescent seal
seal comprising material or combination of materials with the property of swelling or foaming when exposed to heat, intended to improve the fire performance of the element of construction in which it is incorporated

3.2
concealed intumescent seal
seal where the material is fitted below a timber lipping of at least 4 mm thickness by a thermally softening adhesive and not visible from the outside

3.3
exposed intumescent seal
seal either set into a groove in the edge of the leaf or face of the frame, or applied directly to the face and visible when installed

3.4
integrity
ability of a separating element of building construction, when exposed to fire on one side, to prevent the passage through it of flames and hot gases or the occurrence of flames on the unexposed side

3.5
supporting construction
construction that may be required for the testing of some building elements and into which the test specimen is installed

EXAMPLE The wall into which a door is fitted.

3.6
test construction
complete assembly of the test specimen together with its supporting construction

3.7
timber fire-resisting door assembly
door assembly intended, when closed, to resist the passage of fire or combustion products or both, where the leaf edge incorporates a combustible edging not less than 5 mm thick and where the construction materials are not of metal

4 Apparatus

4.1 General

The apparatus used for the test shall generally be in accordance with ISO 834-1. Additional apparatus will be required to evaluate the contribution to the fire resistance of timber fire-resisting door assemblies provided by intumescent seals as specified in 4.2.

4.2 Additional apparatus

4.2.1 Test rig

4.2.1.1 The test rig consists of a low carbon steel angle frame (60 mm × 30 mm × 5 mm thick) with mitred welded corners forming a square with outer dimensions of 600 mm × 600 mm. A low carbon steel plate (nominally 5 mm thick), which overlaps the hardwood lipping by a depth of (10 ± 1) mm, shall be fixed centrally on a diagonally mounted 15 mm diameter round steel shaft retained in bushes at each end. The central panel shall be retained in a diagonally central position by means of locking collars bearing against the face of pivot blocks on the diagonal shaft, lightly greased, such that the gap between the central panel and the outer frame is equal on all edges (see Figure 1).

4.2.1.2 A suitable, easy-to-release mechanism such as a cam that does not disturb the panel when activated shall be mounted on the back face of the central steel panel in order to maintain the alignment of the central panel with the back of the outer frame (see Figure 2).

4.2.1.3 A steel bracket incorporating a deflection limit adjusting screw at one end shall be fixed to the panel by means of a metal block as shown in Figure 1. The screw is used to limit the deflection of the panel to that specified in Clause 7.

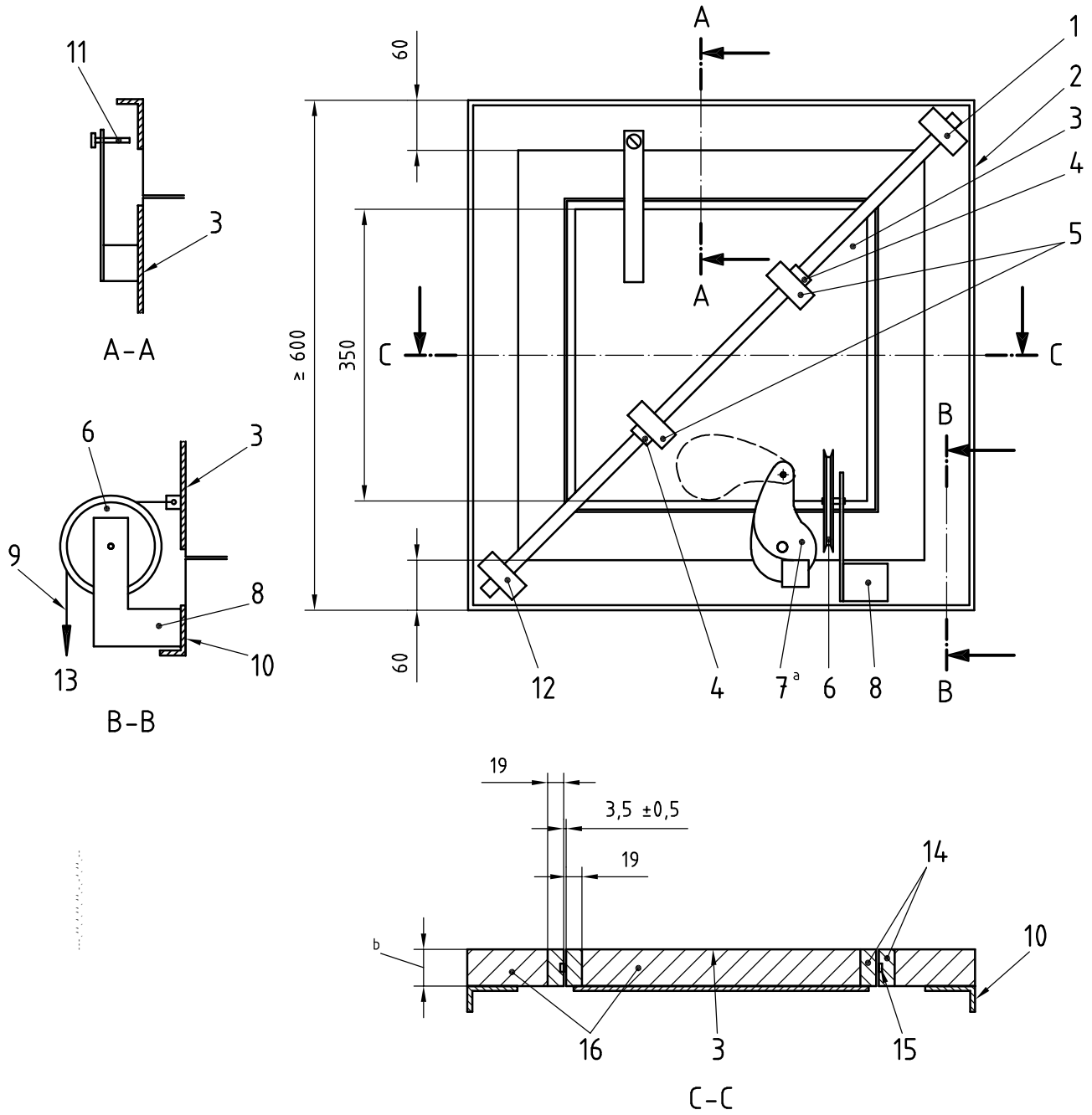
4.2.1.4 On the rear face of the frame, a 100 mm diameter pulley wheel shall be mounted on a steel pulley bracket to facilitate the application of a load to the central panel at the point shown in Figure 1. A wire rope shall be attached to the central panel at the position shown so that the rope passes over the pulley and hangs down below the rig for a length of approximately 300 mm. A weight, or a weight pan and weights, of 7,5 kg mass shall be attached to the lower end of this wire rope.

4.2.1.5 The flush face of the outer frame shall be clad with a non-combustible insulating board, or laminated boards, with a density of 680 kg/m^3 ± 10 % and a thermal conductivity of between 0,14 W/(m·K) and 0,18W/(m·K) determined using the ISO 8302 test method, to a thickness equal to the thickness of the door to which the results are normally to be applied. A lipping of hardwood (of density greater than 550 kg/m^3 oven-dry weight) shall be affixed to the inner edge of this cladding to the full thickness of the insulating board and to a depth of (19 ± 1) mm. Lipping shall be applied by means of high-temperature adhesive (resorcinol formaldehyde or similar).

The central panel shall be clad in a similar manner and a similar hardwood lipping shall be incorporated in the perimeter of this panel to a nominal depth of (19 ± 1) mm, but finally sized such that the gap between the lipping on the frame and the central panel is (3,5 ± 0,5) mm on all edges.

4.2.1.6 Special attention shall be paid to the method of corner jointing the timber lippings at the corners to ensure that they do not open up and burn through during the test. The method of jointing shown in Figure 3 is recommended.

Dimensions in millimetres



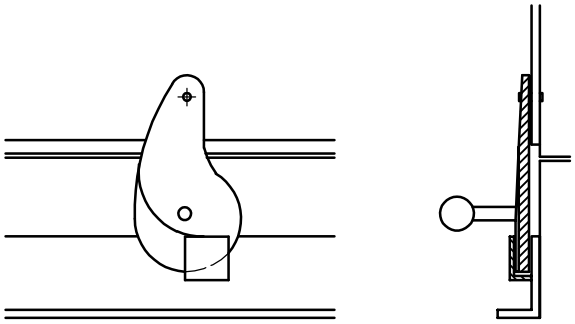
Key

1 bush
2 outer frame
3 central panel
4 locking collar
5 shaft pivot blocks
6 steel pulley wheel
7 cam-retaining device
8 steel pulley bracket
9 wire rope
10 outer frame
11 central panel deflection limit adjustment screw
12 bush
13 7,5 kg load
14 hardwood lippings (550 kg/m^3 min.)
15 intumescent sealing material
16 non-combustible insulation boards

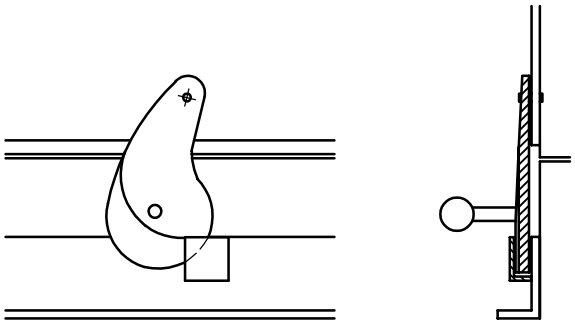
a See Figure 2.

b $\geqslant$ 54/60 or $\geqslant$ 44/30.

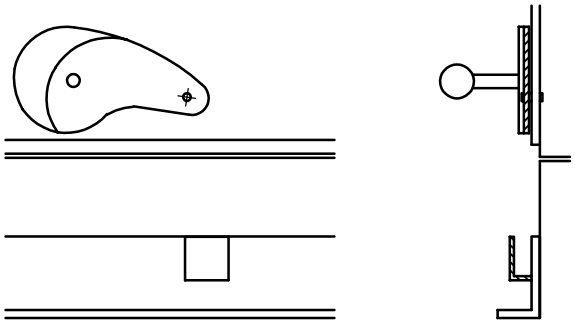
Figure 1 — Apparatus for determining contribution of intumescent seals to fire resistance of doors and shutter assemblies



a) Cam-fully-retaining central panel



b) Cam-partially-retaining central panel



c) Cam open central panel released

Figure 2 — Details of cam-operated retaining device

5 Test specimen

5.1 General

The specimen shall consist of one or more intumescent sealing strips of the type to be evaluated, fixed into or onto the hardwood edging of the test rig in accordance with 4.2.1.5 and in a manner similar to that of practice.

5.2 Specimen size

The width of the seal and the thickness of the rig panels shall in all cases be the same as would be used on the door and frame in use. The length of the sealing strip is governed by the size of the test rig, but the seal shall be continuous around the periphery of the panel, frame or both, forming butt joints at the corners —

unless other joints are to be formed in practice, when the joints shall be as they are to be in use. An example of the frame fitted construction is shown in Figure 1.

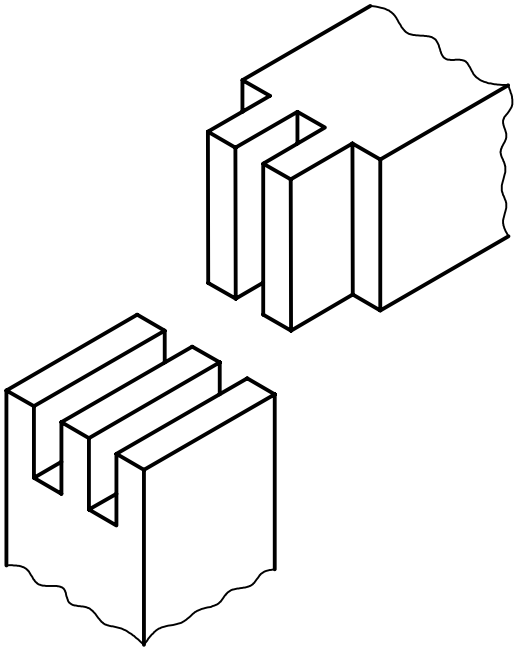


Figure 3 — Preferred method of jointing lippings at corners

5.3 Design of specimen

5.3.1 The upper surface of the intumescent seal shall be level with, or not more than 1 mm below, the surface of the hardwood lipping. In such cases the seal shall be fixed in a manner similar to that to be used in practice.

5.3.2 Where a single intumescent sealing strip is to be evaluated and the position of the seal (i.e. in the frame reveal or the leaf edge) is not known, the seal shall be fitted into a groove machined into the outer, fixed hardwood lipping as in practice such that the centreline of the lipping and the centreline of the seal are coincident. Where two or more seals are to be used, these shall be equally distributed about the centreline of lippings as they would be in accordance with the manufacturer's instructions.

5.3.3 In situations where the seal is designed to be fitted to the moving element of a door assembly (i.e. the edge of the leaf), then it is permissible to mount the seal or seals into the hardwood lipping fixed to the central, pivoted panel of the test rig as installed, or in accordance with the manufacturer's instructions.

5.4 Specimen conditioning

The conditioning of any hygroscopic material used in the manufacture of the test specimen shall be in accordance with ISO 834-1.

6 Pre-test analysis and installation

6.1 Establish the dimensions and characterize the properties of the sealing materials and the timber lippings used in the test construction in order to provide an auditable description (see Clause 10).

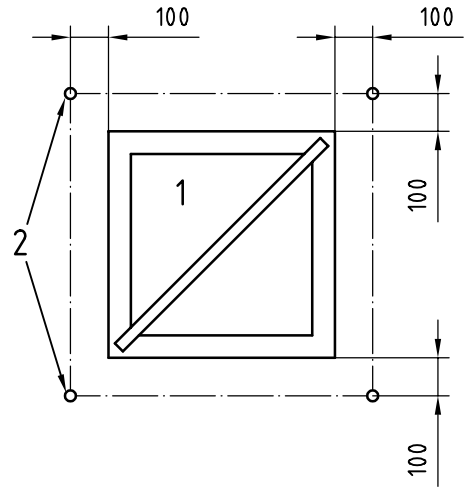
6.2 Mount the test rig, complete with its cladding and incorporating the seal under evaluation, into a supporting construction in the vertical face of the testing furnace, such that the clad face is flush with the supporting construction on the exposed face. Ensure that the supporting construction does not interfere with the operation of the weight. Ensure that the test rig is securely fixed within the hole in the supporting construction by means of additional brackets if required.

6.3 Position not less than four furnace control plate thermocouples so that the nearest edge of the thermocouple is 100 mm from the adjacent edge of the test rig and 100 mm from the face of the supporting construction, as shown in Figure 4 a). When multiple rigs are in use, the thermocouples between adjacent rigs will be common to both, as shown in Figure 4 b).

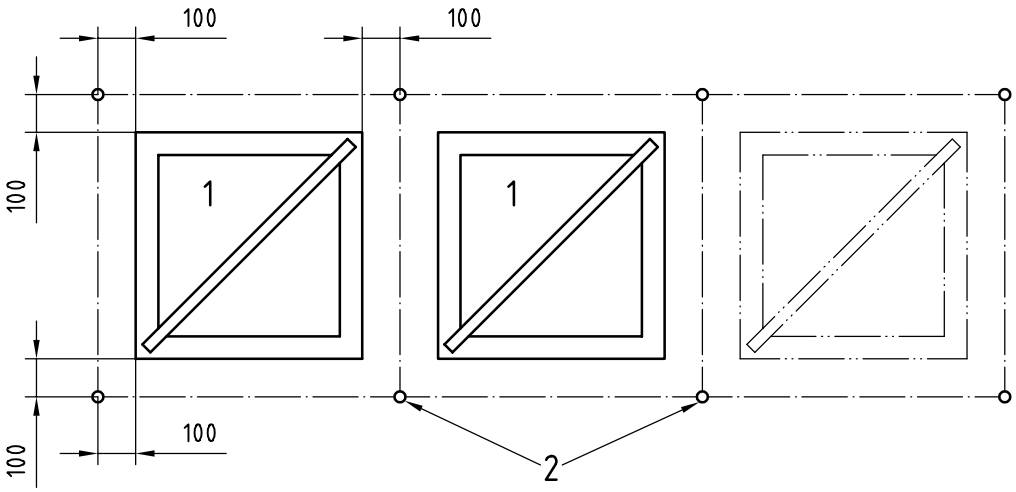
6.4 Set the adjustable deflection limiting screw to give (15 ± 1) mm deflection.

6.5 Engage the panel retaining mechanism to keep the panel in line with the outer frame. Apply a mass of (7,5 ± 0,01) kg to the loading system.

Dimensions in millimetres



a) When testing using one rig



b) When testing using two or more rigs

Key

1 test rig

2 furnace thermocouple positions (all corners similar)

Figure 4 — Thermocouple positions

7 Test procedure

7.1 Carry out the test generally in accordance with ISO 834-1, maintaining a positive pressure within the furnace, relative to the laboratory atmosphere of (20 ± 2) Pa, at a height corresponding with the top edge of the central panel (i.e. level with the upper horizontal gap).

7.2 After the test has been running for half of its anticipated duration (i.e. 15 min or 30 min), carefully apply the load by releasing the retaining mechanism. Perform this operation such that there is minimal disturbance to the position of the panel.

7.3 Measure the deflection, to the nearest millimetre, at the top corner of the central panel, immediately after the application of the load, in order to establish whether the shear resistance of the expanded intumescent seal was capable of resisting the load; continue to monitor the deflection until either the maximum limiting deflection of 15 mm is reached or until the test is terminated, as this indicates whether the material loses its ability to resist the load and if so, when. Record the time at which the limiting deflection is reached.

7.4 Monitor the gap between the inner pivoted panel and the outer fixed frame for a loss of integrity using the cotton pad specified in ISO 834-1. The size of the cotton pad may be reduced to make it easier to carry out this procedure, but shall not be less than 40 mm × 40 mm.

Disregard any deflection that occurs after termination of the heating or during the extinguishing procedures.

NOTE As all of the edges of the rig are subjected to positive pressure furnace conditions, the use of the gap gauges is not relevant.

8 Performance criteria

The contribution to the fire resistance provided by the intumescent seal shall be deemed to have ceased as a result of either the presence of continuous flaming on the unexposed face or ignition of the cotton fibre pad in accordance with ISO 834-1.

9 Expression of results

The effectiveness of the intumescent seal in maintaining the integrity of a fire-resisting door or shutter assembly shall be expressed in terms of the period for which the sealing system satisfied the integrity criteria of the test. The thickness of the test panel shall also be given.

A typical result may be expressed as follows.

Duration of the effective sealing provided by the intumescent seal: 39 min in conjunction with a 44 mm thick panel.

10 Test report

The test report shall include the results (see Clause 9), the time at which the maximum deflection of 15 mm was reached or the magnitude of the maximum deflection, together with the required information according to ISO 834-1, including the following information as indicated:

a) a full description of the intumescent seal (i.e. composition and any distinguishing features such as colour, including that of any applied protective coating);

b) the size and cross-sectional area of the total seal and of the intumescent material, if these are different;

c) the position of the seal or seals in the lipping relative to the exposed face of the test rig;

d) the gap between the edge lippings — if unequal, for all four edges of the panel;

e) the density of the timber used as the lipping material and its moisture content.

When the test involves making a direct comparison of one seal with another, then the original result should also be given.

11 Field of direct application

The results obtained from this test are applicable for use on proven, single-acting, butt-hung, single-leaf latched timber door assemblies of sizes up to that tested for fire resistance *at a thickness greater than or equal to that of the tested specimen*, unless the pressure in the furnace was only (xx) Pa — (xx) being the pressure at height 2,1 m above the lowest level of the furnace opening according to ISO 834-1 — in which case the leaf height shall be limited to 2 100 mm.

The following field of direct application statement shall appear in all test reports, immediately after the integrity rating.

> **"The test is suitable for evaluating intumescent sealing systems for use on timber fire-resisting doors with plain edges in standard rebated timber frames of up to 1 hour fire resistance. It is not suitable for over-rebated door leaves."**

The timber door assemblies to which these intumescent seals may be applied shall have been tested in accordance with ISO 3008 and shall have satisfied the integrity criterion for a period less than or equal to that obtained in the test whilst incorporating any other form of heat activated seal. These seals may not be applied to timber door assemblies which, when so tested, have deflected more than half the thickness of the door leaf from the vertical during the relevant period of the test.

When the tested seal is incorporated in the lipping applied to the central panel, then the result is suitable for applications where it is in either the frame or the door edge. When the seal is mounted in the outer panel it is only suitable for applications where it is mounted in the frame. See Annex A.

Whilst the simulated leaf is plain-edged because rebated edges prevent the panel from rotating under load, the results apply to a door of similar thickness with over-rebated lippings, provided that the over-rebated section is additional to the leaf thickness.

Annex A
(informative)

Guidance and information on the role of intumescent seals and operation and limitations of the test

A.1 General

The use of positive atmospheric pressure in the furnace during the fire resistance test has made it virtually impossible to maintain the integrity of an insulated separating element for any regulatory significant period of time if a realistic gap was present in the test construction at the start of the test or developed during fire exposure. In the majority of static elements (e.g. partitions and floors), such gaps were easily eradicated by adequate use of fillers and sealants. Moveable elements (e.g. door sets and shutter assemblies), presented special problems, as gaps had to exist around their perimeter in order for them to operate without hindrance during normal use. In order to maintain their integrity for the periods required in regulations, these gaps need to be eliminated during the heating period.

During the testing of timber door sets, some shrinkage can occur, having the effect of increasing, rather than decreasing, the risk of a loss of integrity. In these cases, heat-activated sealing systems could need to be fitted. The most common of these in current use is the intumescent seal, which, whilst letting smoke through in the early stages of the test, is expected to form an effective seal in the later stages.

For the more complex assemblies (i.e. double-leaf door sets, door sets without latches and assemblies incorporating overpanels), the intumescent seal will often perform the secondary function of giving additional restraint, which may help to maintain the stability of the leaf or leaves by either generating, or avoiding the generation of, imposed forces on the assembly during fire exposure. The suitability of any particular seal required to play such a secondary role can only be determined by subjecting the complete assembly to the test according to ISO 3008.

In the case of simpler elements (i.e. standard size, latched, single-acting timber door assemblies), the requirement for the seal to provide any additional restraint is virtually eliminated. The latch, in combination with the hinges, is capable of providing all of the required stability without any assistance from the intumescent materials and, as a result, the intumescent seals are only required to fill the gap around the perimeter of the leaf. The door set design, including all of the hardware, should have demonstrated its ability to remain stable enough to satisfy the criteria of the fire resistance test using intumescent seals where necessary. The need to change seals for either supply or cost reasons should not, however, require the whole assembly to be retested and such an assembly should be able to incorporate any seal that has demonstrated its ability to provide the required contribution to the fire resistance when tested in combination with a thickness of panel equivalent to that of the door being used.

For these reasons, this interchangeability is restricted to single-acting, timber-latched door assemblies where the door leaf component is faced with timber or other ligno-cellulosic materials, and incorporates a plain edge lipping (i.e. not rebated) of similar-density timber of at least 8 mm thickness and not more than 25 mm thickness. The door leaf should not incorporate any metal components, either structurally or as facings, and the void between the edging and the faces may be filled only with wood or other ligno-cellulosic products. The frame into which this leaf is hung should also be of solid timber or incorporate a facing of ligno-cellulosic material not less than 25 mm thickness applied to an inert non-metallic core.

The test is not suitable for evaluating the acceptability of intumescent seals for use on timber-based door sets that are to be hung in metal frames. Such combinations and all other more complex assemblies are required to be tested as complete door sets in accordance with ISO 3008, in order that the suitability of the seals for such use can be evaluated.

The test does not provide any information as to how hardware/ironmongery could need to be protected and any such protection used in the original full-scale test shall be replicated when using the substituted material.

A.2 Specimen construction

As the width and cross-sectional area of the seal under test is the only size for which the result is valid it is important that the specimen size selected be representative of that proposed to be used in practice. Similarly, the thickness of the panel, and hence the timber lipping, should also be identical to that of the door to which the results are to be applied.

When the seals are of the pre-formed strip type, the details at the corners should be as recommended by the manufacturer of the intumescent material. Where the strip is fitted in the conventional manner (i.e. in the lipping to the fixed outer frame), the jointing detail is not as important as it is for seals that are fitted to the lippings attached to the central, pivoted panel.

The intumescent seal should be fixed in accordance with the manufacturer's recommendations. Where more than one technique is recommended, the method considered to be the least effective should be used, although it is permissible to use alternative fixings in one rig.

A.3 Test rig

As the test rig incorporates a pivoted central panel it is important that the rig be maintained such that the central panel moves freely. Owing to the nature of the environment, the use of grease on the pivots should be either avoided or used very sparingly. The application of powdered graphite should be adequate to ensure reasonably free movement without the attendant risk of melting or ignition associated with the use of grease.

Although the results obtained from this test are applied to single-acting, single-leaf doors, which will invariably incorporate a stop on the frame, it is not possible to incorporate a stop on the test rig, as the central panel pivots about a diagonal axis and causes one of the corners to move into the furnace and the other out. For this reason, greater “erosion” of the timber lippings will occur during a test using the rig than would otherwise occur when using a rebated frame — especially as the gap between the lippings is greater than that recommended in the test of a door assembly.

The lipping timber density of 550 kg/m^3 is selected to ensure that the intumescent seal is capable of maintaining a seal even after the lipping has been eroded by the fire as it would be in practice. A denser lipping which burns more slowly may give an optimistic result.

The actual materials used for cladding the steel components of the rig are not important in the behaviour of the specimen unless they exhibit high shrinkage rates or high distortions, which could cause gaps to develop between the hardwood lippings and cladding material. The main purpose of these materials is to keep the steel framework relatively cool and hence it is their thermal conductivity and, to some extent, their density that is most important. Boards manufactured from bonded exfoliated vermiculite or reinforced calcium silicate or combinations of both are suitable for this purpose.

A.4 Test procedure

Release the panel-retaining mechanism after half of the anticipated duration to apply the 7,5 kg load to the edge of the central frame. This load is not intended to represent any externally applied force but is designed to reproduce typical internally-generated stresses caused by the heating of the timber door. As intumescent seals behave in dissimilar ways, some seals will allow the panel to move the full 15 mm immediately, whilst others will have sufficient shear resistance to prevent movement of the panel. The test should not influence this behaviour in any way either during or following the release of the central panel.

A.5 Limitations

When the intumescent seal is fitted in the outer frame the intumescent will always fill the gap at the corner between the leaf edge and the frame edge, even when it does not expand laterally. When the seal is fitted to the inner frame, if there is no lateral expansion then the corner gaps will not be sealed. A seal tested in the outer edge could give an optimistic result, but when then applied to the leaf edge, in practice might not seal as efficiently.

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Price based on 11 pages