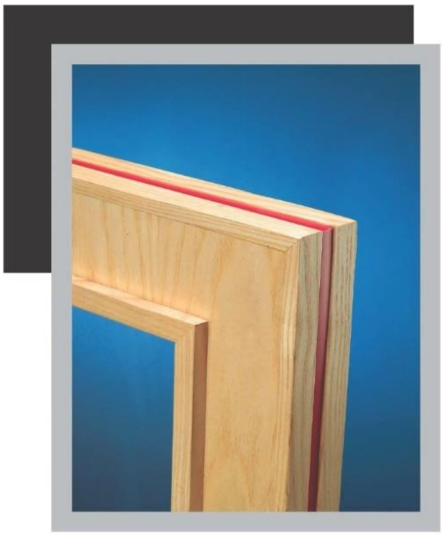
Information Sheet 1

The Role of Intumescent Materials in the Design and Manufacture of Timber Doors

Intumescent Fire Seals Association



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1. INTRODUCTION

This IFSA Information Sheet is intended to give guidance to specifying and controlling authorities, fire prevention officers, enforcement officers, door manufacturers and builders on the use of intumescent fire seals in timber based fire resisting door assemblies. It describes what intumescent materials are, and shows why they are essential in this application.

2. INTUMESCENT SEALS

Most materials expand slightly when heated. Materials described as 'intumescent' have the additional property that, upon reaching a certain temperature, they expand dramatically, some to many times their original volume. This makes them ideal for sealing the gaps that, inevitably, exist around the edges of fire door leaves. Properly specified and installed, these seals can lay dormant for years, only activating and expanding when subjected to the characteristic temperature and pressure conditions of a fire. Upon activating, they expand to seal the gaps around the edges of the leaves and restrict the spread of warm smoke and hot gases.

A number of materials exhibit intumescent behaviour, but only three types are currently used in seals for fire resisting door assemblies:

i) Ammonium phosphate
ii) Hydrated sodium silicate
iii) Intercalated graphite

The characteristics of these materials are quite different from each other and significant variations may occur within each type, according to the precise formulation used. Brief details of the main characteristics of each type of material follow:

2.1 Ammonium phosphate

Intumescent materials of this type were originally based on mono-ammonium phosphate (often abbreviated to MAP) but in recent years ammonium polyphosphate (APP) has also been used. These materials have an activation temperature of about 180°C and typically generate large volumes of protective foam accompanied by virtually no pressure. This is ideal for certain applications where forces associated with pressure development may have an undesirable disruptive effect on the structure. Intumescent materials based on ammonium phosphate are excellent gap fillers and can also accommodate significant movement of components in fire conditions.

Availability: Sheets, strips and other fabricated components for door assemblies and other structures, plus as additives for pastes, mastics and paints.

2.2 Hydrated sodium silicate

These materials are available in several different forms but, typically, have a relatively low activation temperature in the region 110 - 120°C, moderate expansion volume accompanied by significant pressure generation, and providing a hard, mechanically stable foam, with excellent insulation properties. Reinforcements such as glass fibres are common, adding to the stability, and resulting in a more uniaxial expansion if preferred. The hydrated nature of these materials enables a significant cooling effect to be achieved and further slowing down the degradation of critical elements of timber-based door assemblies under fire exposure.

Availability: Sheets, strips and fabricated finished components for door assemblies and other structures, plus as additives for special purpose intumescent compounds.

2.3 Intercalated graphite

Intercalated graphite differs from ordinary graphite in having water molecules sandwiched between the layers of carbon. On heating, the water is turned into steam causing the graphite to exfoliate, producing a light 'fluffy' material. During the expansion phase a considerable pressure may be generated, if the expansion is restricted, and the resulting material will typically be compacted but spongy. There are many variants of intercalated graphite materials, and they are commercially provided either in a pre-compounded form within a flexible PVC matrix or incorporated into mineral fibre composites. Activation temperatures are generally in the region of 170 - 200°C.

Availability: Sheets, strips, and fabricated finished components for door assemblies and other structures, plus as additives for pastes and mastics.

It can be seen that although intumescent materials have the common property of expansion when heated, the initiation temperature, the increase in volume and the pressures generated differ greatly, not only between types of materials but also within material types. In these circumstances, it must be understood that one product cannot be substituted for another without due consideration of the behaviour of both products.

Which intumescent material is 'best' will vary according to the application and what is required from it. The substitution of one type of material for another should never be considered without consultation either with the intumescent manufacturer, or with an appropriately experienced expert. It is worth noting that some assessing authorities and/or third party certification bodies do not allow substitution of intumescent materials within fire resisting door assemblies, in the absence of direct test evidence, even for the same type of materials. IFSA will be pleased to give technical advice on the suitability of intumescent materials for different applications.

Third party certification schemes for intumescent seals are designed to ensure consistency of product conformity by independently verifying the seals performance to relevant British and European test standards, and checking that adequate factory production control measures are in place.

An intumescent seal that is manufactured under the auspices of such a scheme would therefore be expected to be capable of consistent performance as established by test, offering the end user assurance that the intumescent seal will be able to perform in the event of fire. It is recommended that the independent certification body providing third party certification is accredited by UKAS. Most UKAS accredited bodies that provide third party certification schemes will list third party certificated manufacturers on their website and will be able to provide a list of the certification requirements for a particular scheme.

3. THE NEED FOR INTUMESCENT SEALS

During a fire, gases expand as a direct result of the increased temperature of the environment which, together with additional products of combustion, causes an overpressure to develop within the fire compartment. This causes hot gases to flow through any gaps or holes, from the high to low pressure side, which may cause the fire to spread to the adjacent area. This could either be by direct ignition of adjacent combustible materials, or as a result of the spontaneous ignition temperature being reached.

For many years the tests which were used to establish the fire resistance of elements of construction did not reflect this pressure influence and consequently the fire resistance of some components was rated artificially high. Fire door assemblies always incorporate a clearance gap in their construction and were, therefore, one of the components most optimistically rated by these early tests. It was not until the International Standard tests were published in the late 1960s and early 1970s (ISO 834 and ISO 3008), followed by the publication of BS476: Part 8 in 1972 which tests incorporated overpressure. Soon after the adoption of these tests, fire door assemblies were evaluated for integrity in addition to flaming by means of the 'cotton pad' test and were generally found to fail integrity at between 15 and 25 minutes.

The subsequent revision of BS476: Part 8 published as BS476: Part 22: 1987 made the test slightly more aggressive and as the series of EN tests were adopted, the introduction of larger thermocouples and the reduction in the height of the neutral pressure axis to as low as 0.5m made the test even more onerous, e.g. BS EN 1634-1.. The fitting of an intumescent seal in the leaf to frame or leaf to leaf gap was found to be an ideal method of coping with the more onerous conditions. Door assemblies were able to satisfy the integrity criterion of 30 minutes and the seals often provided protection up to the duration of the leaf's ultimate resistance to 'burn through'.

Intumescent seals also make an important contribution to control of warm smoke. Although the intumescent seals activation requires heat, and as a consequence it will not restrict the flow of cold smoke, once the seal has been activated it wills severely limit the passage of smoke from then on. This has a beneficial influence on means of escape and subsequent firefighting. Whilst there is no mandatory requirement to limit the spread of warm or hot smoke the advantages of doing so in terms of life safety, damage limitation and firefighting are obvious.

4. THE USE OF INTUMESCENT DOOR SEALS

Fire resisting door assemblies are invariably required in regulations to restrict the spread of fire from either side. Whilst the primary purpose will be to protect one area of a building from a perceived hazard in another area, e.g. a corridor from adjacent rooms, a staircase from linking corridors, and a restaurant from a kitchen etc., fire is, by its very nature, unpredictable. For this reason the intumescent protection should be applied in such a way that its benefits are not rapidly lost should the fire come from the less likely direction. The maximum benefit is obtained, therefore, if the intumescent seal is applied symmetrically about the centre line of the leaf, although there may be some exceptions to this rule when special attention has been paid to items of hardware, builder’s hardware, etc. In order to give more detailed advice as to the method of fixing and the type and the quantity of intumescent, consideration is now given to specific combinations of door leaf and frame components, modes of action and configurations.

5. SPECIFIC CONSIDERATIONS

The following considerations apply to common situations and are for general information only. The position, size and configuration of intumescent seals for particular door design will be detailed by the door manufacturer, based on fire test evidence, which must take precedence.

5.1 Single leaf, single swing, latched doors

The intumescent seal can either be positioned in the edge of the leaf or in the face of the frame opposite the leaf edge. The position selected will depend upon a variety of considerations, either practical or aesthetic. With latched doors in particular there are no significant functional benefits to be gained from one or the other. It will be usual for the intumescent seals to be visible in either position, although in many cases the intumescent material itself will be enclosed within some form of integral protection.

Latched single doors are likely to require smaller intumescents, as the latch will provide much of the restraint to hold the leaf within the frame. Large leaves and lightweight forms of leaf construction will often require larger intumescent seals to control increased leaf distortion and 60 minute fire resisting door assemblies typically need double the amount of intumescent at the leaf perimeter compared with a 30 minute fire resisting door assembly.

There is a test method within BS476: Part 23: 1987, which includes a method for evaluating the contribution made by intumescent seals to the fire resistance of a door assembly. The test uses a rig in lieu of a door assembly because of the greater reproducibility it can provide. The rig simulates a typical opening stile top corner, with a gap of 4mm and no rebate and the leaf's typical tendency to distort is replicated in the test. The ability of the seal to provide integrity is determined by means of the normal criterion of the cotton pad. Any size of a specific seal which has passed this test is allowed to be used only in conjunction with a previously tested timber door (not exceeding 2100mm x 900mm in size) hung as a single leaf, single swing, latched leaf in a timber frame. The door must not have distorted by more than 15mm during the fire test. The restricted field of application applied to seals which have satisfied Part 23 means any evidence of performance based upon this test in isolation is generally not a suitable basis on its own for specifying a seal. The principles of BS476: Part 23 have now been adopted internationally by the approbation of ISO 12472: 2003.

There is sometimes a requirement for the intumescent seal to be concealed behind timber lippings. This technique requires an intumescent material capable of generating sufficient pressure to break the glue bond between the lipping and the leaf. The time at which sealing starts is governed, in part, by the thickness of the timber covering the intumescent seal. This is because the timber insulates the intumescent from the heat source. To be effective it is important that the gaps are sealed before 15 minutes exposure is reached; therefore the timber edge cover should not exceed 6mm at either side of the leaf. It is normal to incorporate an exposed seal across the head of the door with this technique, as it is important that the top edge seals before the jambs to reduce any tendency to distort.

Any concealed sealing system used must be tested to BS476: Part 22: 1987 as a part of a full door assembly, as the type of intumescent seal, the adhesive and both the core and the lipping materials all influence the performance of such systems. A typical concealed intumescent arrangement is shown in Figure 1.

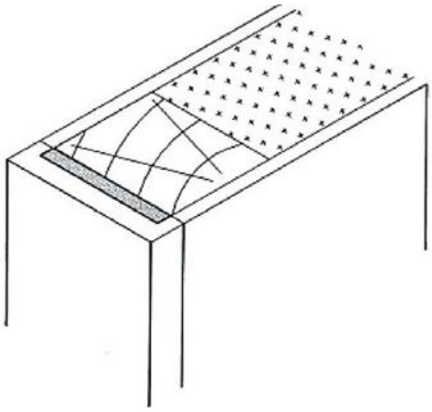

Figure 1: Typical seal arrangement of pressure generating intumescent seal concealed behind door lipping

There is ample test evidence to show that with intumescent seals there is no real benefit in having doorstops of greater than 12mm..

Tests have shown that generally the intumescent seal can be interrupted at lock/latch and hinge positions for 30 minute doors, but a continuity of sealing should be maintained for all periods in excess of 30 minutes; see Figure 2. Care must be exercised when siting hardware to door leaves with concealed intumescent seals; the seals and/or door manufacturer should be contacted for more details.

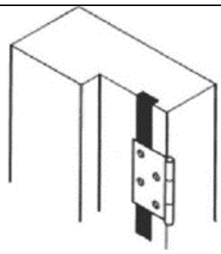	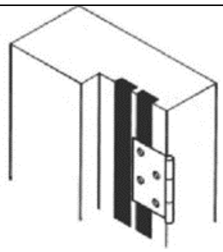
30 minute door	60 minute door
Intumescent seal may be interrupted	Intumescent seals must not be fully interrupted

Figure 2: Intumescent seal detail at hinge position

5.2 Single leaf, single swing or double swing unlatched doors

As in Section 5.1 the seal can normally be positioned in either the frame or the leaf edge. There are a few additional requirements for the sealing system on an unlatched door compared to a latched door assembly. The main difference is that the leaf is less restrained due to the omission of the latch/lock in the opening jamb, which places greater reliance on the edge seals to be able to control the distortion of the door leaf during fire conditions. Concealed seals are able to be used, but it is vitally important that the head seal and closer are able to resist the lateral forces generated in the hanging jamb, caused by the expansion of a wide strip of pressure forming intumescent seal in a limited space (see Figure 3). The results of tests to BS 476: Part 23: 1987 are not applicable to unlatched doors.

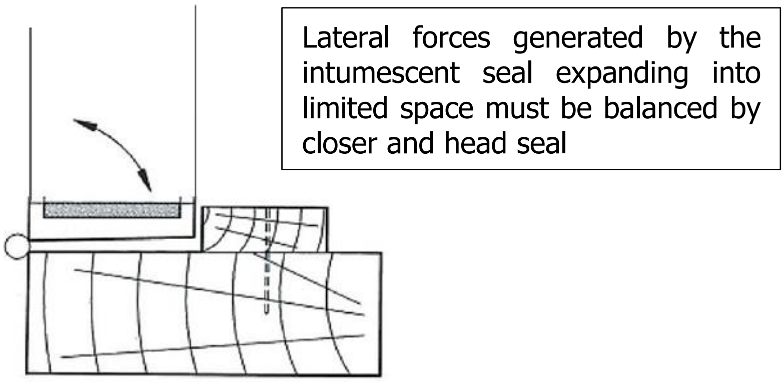

Figure 3: Concealed intumescent seal employed on unlatched door

5.3 Double leaf, single swing, latched doors

The main difference between single and double leaf doors is the issue of sealing the meeting stiles in an adequate manner. Careful consideration must be given to the detailing of intumescent fire seals and hardware to provide maximum continuity of fire sealing. Latched double leaf doors require one leaf to be bolted closed for latching to be achieved. The initial consideration, therefore, has to be given to the selection of hardware and its positioning and associated intumescent protection.. For example, even if intumescent seals are incorporated in the plain door edge opposite a bolt, there is a risk that the intumescent seal will be prematurely exhausted by the extra thermal conductivity of the metal. Bolts are often wider than the intumescent seals and, therefore, conduct heat to a point on the wrong side of the seal with the attendant risk of ignition of the timber; similarly the latch and keep plate interrupt the seals at a vulnerable point. It should not therefore be assumed that additional items of hardware can be fitted in the meeting edges of a double leaf door without supporting test evidence for the item of hardware and the intumescent seal arrangement.

The meeting stiles of thirty minute doors can normally tolerate interruptions to the intumescent seals at latch positions, so long as the door leaves are of the conventional 44mm thickness and the keep and the latch forend do not span the full width of the leaf edge. Obviously, the bolts, and the latch, must not remove so much of the door that there is a risk of a burn-through, although it may be possible for any over morticing, either by accident or by design, to be compensated for by the use of intumescent materials. The seal manufacturer should be consulted in advance to assess the suitability of his material for such functions.

Even with bolts and a latch, there is still a risk of differential movement between the leaves, either above or below the latch. An enhanced intumescent seal specification (when compared with a single leaf door) is sometimes necessary in order to either restrict or accommodate this movement. These are as follows:

i) An exposed pressure forming intumescent strip which is wider or of greater cross section may be fitted to the head of the leaves (normally at least equivalent in area to a 25mm x 2mm seal for 30 minutes and 35 x 2mm for 60 minute applications) to restrict movement

ii) Additional strip(s) or increased volumes of intumescent material may be inserted in the leaf edge to cope with possible differential movement and/or widening meeting stile gaps, caused by continuing leaf shrinkage throughout the test duration. There is normally no need to increase the intumescent seal down the hanging stiles. It is not possible to give an exact specification for these various junctions as each type of door construction will exhibit different tendencies to distort or shrink. Consequently, only tested or assessed specifications which relate to the door type being considered should be used.

Traditionally, single swing, double leaf, latched door assemblies have rebated meeting stiles. Rebates generally make an assembly intolerant to differential movement, as a meeting stile with equal rebates may only permit a leaf to distort half of its thickness before an excessive gap develops. Plain meeting stiles, however, permit differential movement of up to 80% of the thickness of the leaf before separation occurs. For this reason rebated meeting stiles are considered more onerous. Individual intumescent seal and door manufacturers may have solutions for rebated meeting stiles and these could from the basis of any assessment or further test proposal. Where the rebate is only used as a way of breaking the sight gap then the incorporation of combined intumescent fire and smoke seal in an otherwise plain edge door serves a similar function.

5.4 Double leaf, single and double swing, unlatched doors

The basic principles for selecting seals for use on unlatched double doors us similar to that given in Section 5.3 above. However as the meeting stiles are not 'tied together' at any point there is an even greater risk of differential distortion between the leaves at the meeting stile junction. For this reason, it is important that the seal at the head of the doors incorporates sufficient intumescent material to provide the maximum restraint to distortion and the meeting stile seals have sufficient expansion to cope with the large gaps. The application of pressure forming intumescent seals in the jambs and meeting stile junctions has to be considered with prudence, as excessive lateral pressures in these gaps can force the leaves open during the later stages of a fire test, leading to premature integrity failure..

For unlatched, single swing doors, where both leaves are likely to be used frequently, the rebated meeting stile is even further deprecated as such doors require door selectors to be used, the fitting of which can adversely influence the integrity of the leaf. Whilst being no more prone to malfunction than any other item of hardware, the consequence of a selector malfunction is severe as it may inhibit the door from closing into the frame.

Some solutions utilising intumescent seals are available for such items, but the manufacturer or supplier should be fully consulted before fitting. Unequal width rebates are more easily sealed than equal rebates as they tolerate greater differential movement.

If the intumescent seals are limited to the edge of one of the leaves forming the meeting gap, then the other leaf is able to be 'sized' more readily on site.

5.5 Door assemblies incorporating non-transomed overpanels

The junction between the door head and a flush overpanel above may be considered as being equivalent to a horizontal meeting stile joint and, as such, similar considerations apply.

There is a risk of differential movement, particularly in connection with unlatched or double swing leaves, caused by the restraint at each end of the overpanel compared with the restraint only being at one edge of the leaf. Similarly, the gap will probably continue to increase during exposure to fire due to the shrinkage of both the leaf and the overpanel. As a consequence, the intumescent seal must be capable of protecting a gap which is increasing as the fire continues. Unlike the meeting stile joint, where the use of pressure forming intumescent seals have to be used with caution, the overpanel to leaf gap benefits from the vertically applied pressure because of the restraint it provides against lateral separation. This assumes that the material has sufficient shear resistance to lateral distortion forces.

The junctions between the fixed overpanel and the frame jambs and head invariably benefit from the incorporation of an intumescent seal. Whilst the junction between the overpanel and frame is fully restrained by mechanical fixings, there is invariably a gap around the perimeter of the overpanel, if not at the time of installation, then at any subsequent point in time where a reduction in the moisture content of the components has been experienced. The fixings eliminate differential movement under the fire exposure and so the conditions to be sealed are not as onerous as those prevailing in a door leaf to frame junction. The amount of intumescent seals can, therefore, be reduced significantly but, as a rule of thumb, the intumescent specification will typically match that given for the door jambs, for ease of manufacture. The characteristics of the intumescent seals are not normally as critical in this application.

5.6 The door frame to wall gap

After installation of a door assembly there can be a gap of up to 20mm between the door frame and the wall. This gap, even though covered by architraves, is a weak point in the structure, particularly in the case of door assembly of 60 minutes or more fire resistance. These gaps can be effectively sealed with intumescent fire seals fitted to the back of the frame prior to installation, or by the use of intumescent sealants afterwards. Since these gaps are potentially much wider than the door/frame gap, suitable fire test evidence to BS 476: Part 22 or BS EN 1634-1, for the required period of fire resistance, and for the same application as that required on site, should be obtained from the seal manufacturer prior to installation.

6. CONCLUSION

It can be seen that, whilst intumescent seals make a vital contribution to the fire resistance of a door assembly, they are only one component in the total design. The frame, hardware and leaf construction all play a role in satisfying the test criteria. It is important to ensure that the correct type of intumescent seal is specified. It is recommended that seals should be identified by name, or at least type, in any specification. If doubt exists the manufacturer should be consulted to establish compatibility between the proposed seal and its intended use. Manufacturers within IFSA have test evidence to support their products when incorporated in a wide range of door types.

Intumescent seals are not a new innovation. Intumescent strips have been in use for more than 30 years and, when used correctly, there are no reasons to doubt their longevity. This fact is substantiated by the ageing tests being performed in conjunction with International Fire Consultants (www.ifcgroup.com) where the results on the materials of participating IFSA members were very reassuring.

Intumescent materials, once activated, do restrict the spread of warm smoke. Many intumescent sealing products are available with a seal which can restrict the spread of cold smoke. Further information on the subject of smoke control is to be found in IFSA Information Sheet No. 3, 'Guide to the use of Smoke Seals in Door Assemblies'

7. INFORMATION ABOUT IFSA

The Intumescent Fire Seals Association (IFSA) is a trade association established in 1982 with the following objectives:

- To promote the life safety benefit associated with the use of intumescent and smoke seals
- To promote research and development into extending the areas where these benefits can be utilised
- To participate in the development of test procedures for fire protection products in BSI, CEN and ISO which are fair, repeatable and reproducible.

IFSA maintains close links with the fire community. The Secretariat is based at International Fire Consultants Ltd, from which the association receives technical advice and support.

At the time of its formation, IFSA recognised the need for a simple standard test to compare the performance of intumescent fire seals for use in fire door assemblies, which was free from the influence of other materials and constructional variations and yet subjected the intumescent material to the conditions which prevail in a full scale test.

It, therefore, sponsored the development of such a test and this is now embodied in BS476: Part 23: 1987. Whilst the results of the test have a limited field of application, only being usable on single leaf, single action, latched doors of limited size and distortion characteristics, it does allow the sealing capability of intumescent seals to be compared without any influence from the leaf.

There is now an ISO equivalent test, i.e. BS ISO 12472: 2003. Due to its repeatability the test method is being used successfully to evaluate the influence that real time ageing may have on the properties of intumescent fire seals produced by IFSA member companies. The programme is planned to investigate 25 years exposure to a variety of controlled and uncontrolled environments. Early findings showed no detectable visual decline and tests are being undertaken soon to confirm these findings.

A test programme undertaken in conjunction initially with DOE/BRE to produce standardise conditions for evaluating penetration seals formed the basis of the standard configuration incorporated in the CEN test procedure EN 1366-3 for evaluating seals for use with metal pipes. This configuration has been refined and incorporated in ISO/TR 10295-3: 2012 where a method of extrapolating the results of penetration sealing tests, using simple solid conductors, can be used to establish the field of application of intumescent sealants.

Fire stopping, service penetration sealing, fire doors and fire glass are all critical aspects of fire safe premises and under the Regulatory Reform (Fire Safety) Order and the ongoing reliance on fire risk assessments, it is vital that risk assessors understand the role and function of these products.

The move away from brickwork, blockwork and cast concrete forms of construction, towards a greater use of studwork and joisted walls, floors and ceilings, has left many of our fire separating constructions compromised by the fitting of electrical services (switches, plug sockets, concealed lighting, extract fans). IFSA has cooperated with the

Electrical Safety Council (ESC), in the preparation of their guide, 'Electrical installations and their impact on the fire performance of buildings; Part 1, Domestic Premises'.

Intumescent materials can seriously reduce the impact that such installations may produce. Correctly fitted sealing systems make a greater contribution to life safety in a fire than almost any other measure. If you do nothing else to enhance life safety- at least seal up the building with fire and smoke seals, preferably from an IFSA Member because they take fire safety seriously.

CURRENT IFSA MEMBERS AND CONTRIBUTORS TO THE INFORMATION SHEET

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