INFORMATION SHEET No. 1

Date: December 2009

The Role of Intumescent Materials in the Design and Manufacture of Timber Based Fire Resisting Doorsets

---

CPD MEMBER Construction CPD Certification Service

CPD CERTIFIED Construction CPD Certification Service

THE HOME OF REACTIVE PROTECTION SYSTEMS

Intumescent Fire Seals Association
www.ifsa.org.uk

CONTENTS **Page**

The Role of Intumescent Materials in the Design and Manufacture of Timber Based Fire Resisting Doorsets

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

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, holding the door in place and restricting the spread of smoke and hot gases.

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

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:

i) Ammonium phosphate

Products 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. The material has an activation temperature of about 180°C and generates virtually no pressure during expansion. It is an excellent gap filler and can accommodate significant movement of components in fire conditions. Seals based on

MAP or APP are hygroscopic and may be protected by a suitable binder system or a surface coating applied during manufacture.

ii) Hydrated sodium silicate

This material is also hygroscopic and the most widely used commercial version is coated with an epoxy resin to protect against atmospheric water vapour. The expansion is mainly uniaxial giving hard foam which exerts considerable pressure during expansion, normally in excess of 1 atmosphere. The activation temperature of sodium silicate intumescent is about 110 – 120°C and is the lowest of the commercially used materials described here. Consequently, it will fill the gap more rapidly than other materials but it does not have any reserves of expansion and will not be able to accommodate subsequent gap movements once activation has occurred.

iii) 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 is generated if the expansion is restricted (more than 10 atmospheres if the degree of constraint is sufficient) and the expanded material is compacted but spongy. In practice, the degree of expansion and the pressure exerted by graphite intumescent seals depends on the amount of graphite incorporated into the product but the free expansion may be 20 fold, with the capability of exerting pressure of several atmospheres if sufficient graphite is used. The activation temperature is typically around 200°C. Graphite is not hygroscopic so it does not require protection from the atmosphere.

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 pressure 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 material is 'best' will vary according to what is required from the intumescent. The substitution of one type of strip for another should never be considered without consultation either with the intumescent manufacturer, or with an appropriately experienced expert. IFSA will be pleased to give technical advice on the suitability of intumescent materials for different applications.

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 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 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. A typical door without seals would be unlikely to get 15 minutes integrity now. The fitting of an intumescent seal in the leaf to frame or leaf to leaf gap was found to be an ideal method of eliminating this form of failure. 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'.

It is extremely unlikely for doors to achieve an integrity rating of even 20 minutes without such seals regardless of the narrowness of the gap and the depth of the doorstop, when evaluated by the cotton pad.

Intumescent seals also make an important contribution to the control of warm smoke. Although the intumescent seal's activation requires heat, and as a consequence it will not restrict the flow of cold smoke, once the seal has been activated it will severely limit the passage of smoke from then on. This has a beneficial influence on means of escape and subsequent fire fighting. 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 fire fighting are obvious.

THE USE OF INTUMESCENT DOOR SEALS

Fire resisting doorsets 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 to be paid to items of ironmongery/builders 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.

SPECIFIC CONSIDERATIONS

a) 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 seal to be visible in either position, although in many cases the intumescent material itself will be enclosed within some form of integral protection. A typical example is shown in Figure 1.

With a latched door, the main purpose of the intumescent seal is to fulfil a gap-filling role, as the latch and the closer, when fitted, will provide much restraint.

The intumescent seal will then only need to be of modest dimensions. Most suppliers will have a product with a nominal face width of 10mm within their range, which will prove adequate for most design of half hour doors, although large leaves or some lightweight forms of construction will often require more. At least twice this amount of material will be required for 60 minute doors.

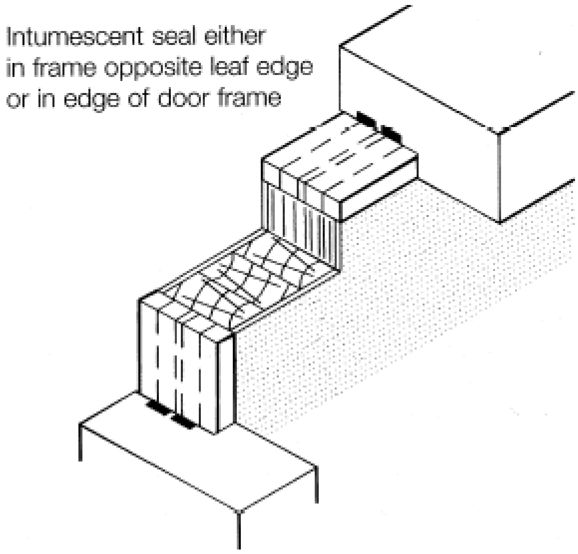

Figure 1: Partview of doorset showing alternative positions for the intumescent fire seal

There is a test method called 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 doorset 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 slowed 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.

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. The principles of BS476: Part 23 have recently been adopted internationally by the adoption of ISO TR12472: 2003.

Any concealed sealing system used must either be tested to BS476: Part 23: 1987 or as a part of a full door assembly to Part 22, 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 2.

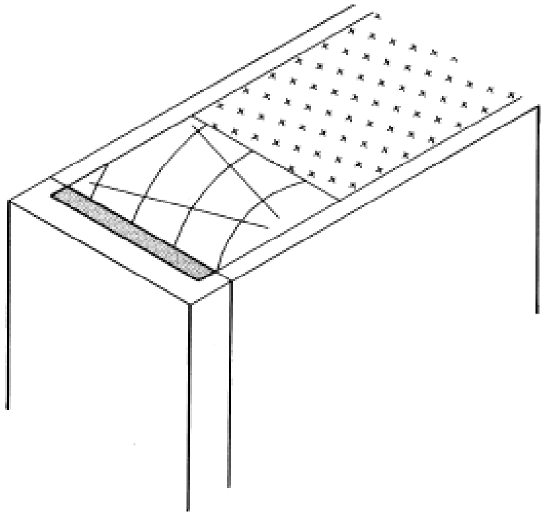

Figure 2: Typical arrangement of pressure generating intumescent seal concealed behind door lipping

There is ample test evidence to show that with intumescent seals there is no real purpose in having doorstops of greater than 12mm, a view which is fully supported in BS8214: 2000, Code of Practice for fire doors with non-metallic leaves. Deep stops can prolong the time before activation of the seal and are best avoided.

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 3. Care must be exercised when fitting ironmongery to door leaves with concealed intumescent seals; the seals and/or door manufacturer should be contacted for more details.

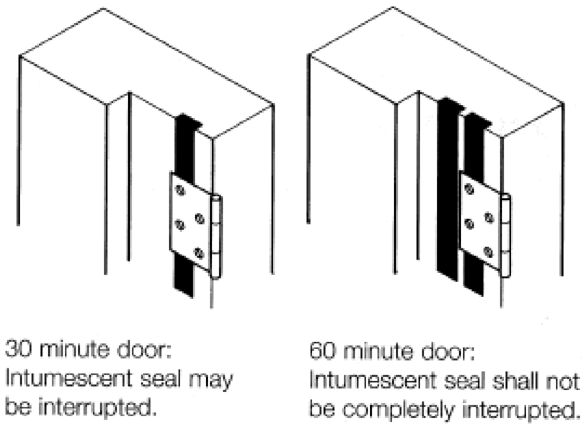

Figure 3: Intumescent seal detail at hinge position

* BSEN 1634-1 has identified that the bottom hinge may need special detailing. Following door manufacturers' advice

Experience has shown that the bottom hinge is more prone to failure in tests carried out to BS EN 1634-1 and may need special detailing. The door manufacturer's advice should be sought.

b) Single leaf, single swing or double swing unlatched doors

As in a) 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 doorset. The main difference is that the leaf is less restrained due to the omission of the latch/lock in the opening jamb. The intumescent seal, particularly in the head of the door, will either be one of the pressure generating types, able to provide significant restraint to the leaf, or of a type capable of providing high volumes of foam to seal any gaps which may be growing as a result of unrestrained distortion to the leaf.

The head seal is likely to be wider or have a greater cross section on an unlatched door. 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 4).** The results of tests to BS476: Part 23: 1987 are not applicable to unlatched doors.

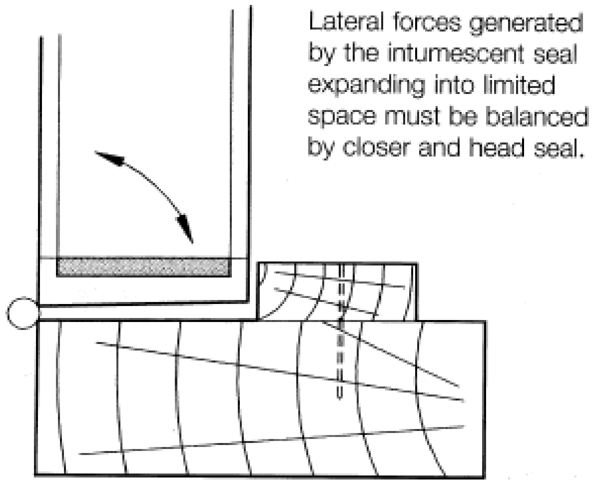

Figure 4: Concealed intumescent seal employed on unlatched door

c) Double leaf, single swing, latched doors

The main difference between single and double leaf doors is the problem of sealing the meeting stiles in an adequate manner. Careful consideration must be given to the detailing of intumescent fire seals and ironmongery 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 ironmongery and its positioning. Bolts, for example, should be fitted onto or into the face of the leaf rather than be fixed into the edge of the door, in the meeting stiles. Ironmongery fitted into the edge of the door leaf interferes with the intumescent seals. 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.

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 overmorticing, 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. Two improvements to the intumescent seal specification (when compared with a single leaf door) are recommended in order to either restrict or to 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 go 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 very 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 not recommended.

Individual intumescent seal manufacturers may have solutions for rebated meeting stiles and these could form 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.

d) **Double leaf, single and double swing, unlatched doors**

The basic principles for selecting seals for use on unlatched double doors is similar to that given in section c) 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 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 overcome the limited restrain which closers can provide at increasingly elevated temperatures. Bearing this in mind, successful designs have been established using either soft or pressure generating intumescent seals, or carefully selected combinations of the two.

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 influence the integrity of the leaf adversely. Whilst being no more prone to malfunction than any other item of ironmongery, the consequence of a selector malfunction is severe as 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.

e) **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 and, as a rule of thumb, only half the quantity used to seal the door edge of any construction is normally required for a fixed, flush overpanel to frame joint. The characteristics of the intumescent seals are not normally critical in this application.

f) **The door frame to wall gap**

After installation of a doorset 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 potential weak point in the structure, particularly in the case of doorsets 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 gaps, the seal manufacturer should always be consulted prior to installation.

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, ironmongery 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.intfire.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 Doorsets'*

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 and receives technical advice from its Principal Consultant, Peter Jackman.

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 doorsets, 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 now forms a draft technical report in ISO (DTR 10295-3) 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 due to be published in 2010.

Fire stopping, service penetration sealing, fire doors and fire glass are all critical aspects of fire safe premises and under the new 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. IFSA has produced a number of downloadable guides (electronic communiqués) to help risk assessors know and understand when a particular intumescent application is right or wrong, or how a risk may be controlled by the use of the correctly specified sealing product. These guides were commended by the ABE in the 2006 Fire Safety Award competition.

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 co-operated 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'. This did win the ABE's Fire Safety Award in 2009.

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.

Intumescent Fire Seals Association
20 Park Street
Princes Risborough
Buckinghamshire HP27 9AH
Tel: +44 (0)1844 276928
Fax: +44 (0)1844 274002
Web: www.ifsa.org.uk
Email: contactus@ifsa.org.uk