Information Sheet 4

Intumescent Fire Seals Association

The Ageing Performance of Intumescent Seals

THE HOME OF REACTIVE PROTECTION SYSTEMS

Contents

THE AGEING PERFORMANCE OF INTUMESCENT SEALS

SUMMARY

Following concerns expressed over the longevity of some intumescent products the Intumescent Fire Seals Association embarked upon a 10 year, real time ageing programme in 1984. The programme was designed to demonstrate that the forms of intumescent normally used in the fire door and penetration sealing industry were not adversely affected over such a time scale. In order to compare results to the different time intervals it was agreed that the test described in BS476: Part 23 would be used to evaluate the seals. This was likely to be the most repeatable method, albeit at this stage it was in the prototype form just as IFSA had developed. Limited samples of the materials were therefore evaluated in the form of door seals although the results would be equally applicable to other uses where similar levels of protection were provided. After 10 years, the tests show that the seals were all still able to meet the half-hour integrity rating that they were originally designed to provide.

INTRODUCTION

The Intumescent Fire Seals Association (IFSA) was formed in 1982 by the leading manufacturers and suppliers of intumescent sealing materials. These materials were essential for sealing around fire doors, sealing gaps between elements or around penetrations and for providing a seal between glass and glazing beads. One of the main reasons for forming the Association was to ensure that the intumescent materials supplied by the members were of a good and consistent quality and those standards in the industry were maintained. Intumescent materials, unlike most of the products used in fire protection work, need to be activated to perform their functions. For most fire protection materials it is their physical characteristics that determine their behaviour. Intumescent materials expand upon heating, giving them very enhanced properties compared with their pre-activated characteristics. Because these activated properties cannot be checked at room temperature, and only destructively at fire temperatures, concerns have always existed in the minds of some users as to the long term performance of the materials. Recognising this unique aspect of intumescent material IFSA embarked upon a programme to produce evidence of long term performance as soon after the Association was formed as was possible. The test was carried out on door sealing strips, as this was perceived to be the primary use of these materials at that time. The same materials are used for many gap and penetration seals and it is felt that the results apply to other applications where the materials may be similarly protected if that is applicable.

METHOD OF APPROACH

In order to make the ageing information available quickly, IFSA initially considered whether there was a suitable accelerated ageing process that could be used. It concluded that no procedure had been developed that was really suitable for exposing narrow strips of material, particularly in a way that was representative of their use in practice. It was also felt that the recipient of any ageing data that had been achieved artificially quickly would still be concerned as to its authenticity unless it was backed by parallel experience. Whilst it is fortunate that there are not too many accidental fires, this would clearly delay the collection of experience. The decision was therefore made to embark upon a 10 year controlled "real-time" ageing programme. This introduced further complications. If the results were to be meaningful the results of the test should not be affected by changes in construction, and hence performance of the element to which the seals were attached, e.g. a fire door. It was deemed unlikely that a typical 1984 fire door would still be available several years later, and therefore "like" would not be able to be compared with "like". To overcome this a special test rig was developed that enabled just the intumescent and the associated timber lippings to be tested, allowing the minimum amount of variation. This test rig was subsequently to become the method incorporated in BS476:Part 23: 1987 to evaluate the contribution that intumescent seals make to the fire resistance of latched, single leaf, single acting timber fire door assemblies.

THE MATERIALS

At the time of the initiation of the test programme the major intumescent materials in existence were strips or sheets manufactured from monoammonium phosphate (MAP) or sodium silicate based compounds. Unless they are specially formulated or protected, both materials are hygroscopic by nature. This is overcome in practice by combining with low permeability binders, coating or covering and it was decided to test the materials in the form that they would be used in practice. These were fixed directly into grooves machined into hardwood lippings as they would normally be applied. Each lipping has overall dimensions of 25mm x 45mm x 750mm so that they could be cut to length to suit the size of the rig when ready for testing. The intumescent was that recommended by the manufacturer / supplier as suitable for a half-latched, single leaf single acting door assembly.

The programme incorporated the following range of IFSA members' Intumescent sealing materials:

Intumescent Type	Overall Dimension	Intumescent Dimension
monoammonium phosphate paste 10 x 2 mm 10 x 2 mm	10 x 2 mm	10 x 2 mm
monoammonium phosphate coated strip 10 x 2 mm 10 x 2 mm	10 x 2 mm	10 x 2 mm
monoammonium phosphate strip in a metal holder 7.5 x 9.5 mm 9 x 3 mm	7.5 x 9.5 mm	9 x 3 mm
sodium silicate strips in extruded uPVC sleeves 10 x 3 mm 8 x 2 mm	10 x 3 mm	8 x 2 mm
sodium silicate, resin coated strip behind timber lippings 32 x 2 mm 32 x 2 mm	32 x 2 mm	32 x 2 mm

*not rectangular – equivalent dimensions given

THE PROGRAMME

The programme had the joint objectives of establishing whether the performance of intumescent sealing materials was degraded by:

i) being exposed to controlled environmental conditions during an extended exposure, up to 10 years, and
ii) being installed in a timber with a significantly different acidity to the materials being examined.

In respect to the first objective, storage chambers at the Furniture Industry Research Association (FIRA) were selected with conditions that represent low, normal and high internal humidity conditions. The materials were stored continuously in the low and normal humidity conditions whist a third set of specimens were stored in the normal environment and every 6 months transferred to the higher humidity chamber for a period of 2 weeks. This was selected to represent two prolonged spells of extreme wet or humid weather per year which were sufficient to ensure that the conditions would be imposed well inside a building. None of the exposure conditions were meant to represent an external or even "partly-exposed" environment where manufacturers would normally recommend enhanced protection to their products. The temperature and humidity conditions selected to represent these three exposure conditions were:

- Low 35 % RH @ 25oC
- Normal 50-65 % RH @ 25oC
- High 80 % RH @ 25oC

For these ageing tests the materials were to be evaluated after 1, 2½, 5 and 10 years exposure using the BS476: Part 23 test procedure. For evaluating the possible timber influence the following species were used:
Normal - utile High acidity - oak

These samples were stored under the cyclical conditions, i.e. normal humidity with two periods per annum of high humidity. Because the influence was likely to be less detectable in the short term the exposed face of the intumescent seal was heated by means of an even radiation source with a radiation intensity of 20kW/m2, rather than compare differences using the fire resistance contribution method as used in the main ageing process. The activated foam was compared with respect to both the speed of activation and the height of the activated foam. Any influence would soon become obvious and as a consequence this programme was only designed to age the samples for 5 years with assessment after both 1 and 5 years storage.

FINDINGS

The first experiment to be completed was that designed to establish whether an acid timber had any deleterious effect. This programme ended in 1989 and showed that there was no significant difference in either the time to activation or the amount of expansion for materials installed in oak rather than utile. There were variations but these were within the expected experimental error band. In most cases any change either in volume or activation time for a material in one lipping species was reversed by a similar amount in the other specimen, i.e. oak being worse than utile in year 1 and better in year 5 and vice versa.

The ageing influence was not deleterious as the intumescent in the oak lippings provided foam depths greater than, or at least equal to, the depth of foam measured on the un-aged, "control" materials. Only two materials exhibited a reduction in foam thickness over 5 years when stored in utile but these changes did not appear significant and most of the other materials showed much greater increases in foam height when compared with the control.

An analysis of the findings showed that any concern over the acidity level in some timbers, causing a reduction in the efficiency of intumescent sealing materials, would appear to be unfounded. Those materials installed directly in contact with the lipping rather than being housed in a hold certainly showed no deterioration.

Figure 1. Average integrity performance from BS476: Part 23 for the different environmental conditions

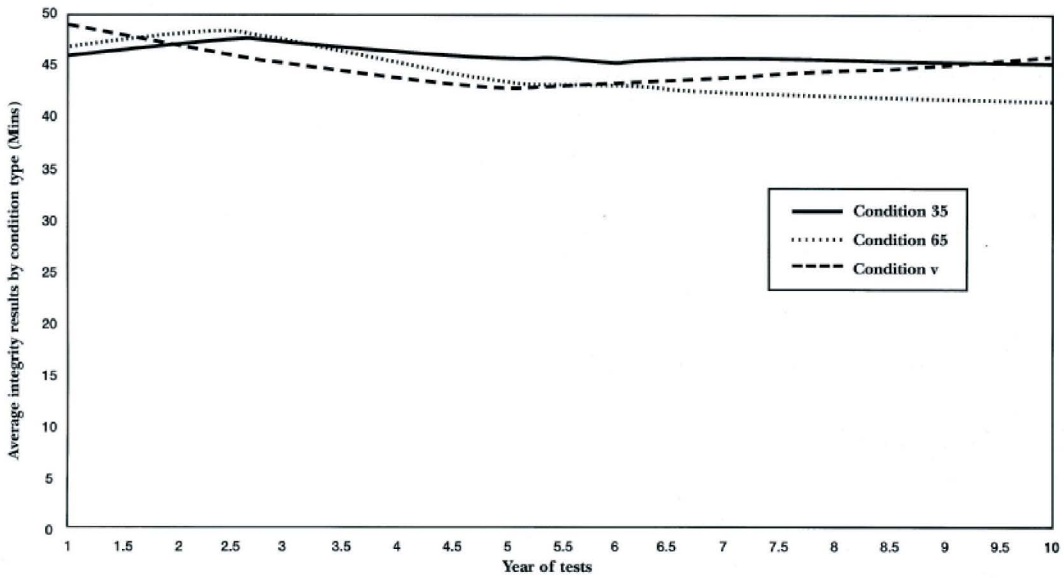

Figure 1. Average integrity performance from BS476: Part 23 for the different environmental conditions In the main ageing programme, after 10 years, all of the materials demonstrated that they were able to provide in excess of the 30 minute integrity rating that they were designed to provide. This was established by means of the BS476: Part 23 test method. Whilst this test cannot do more than generally reproduce the conditions representative of a latched, single leaf single acting door assembly, the localised edge conditions of a 4mm straight through gap, unprotected by a door stop, is probably more severe than that experienced in a normal fire door assembly. Therefore to achieve ratings in excess of the designed 30 minutes often after 10 years indicates that intumescent materials of the type evaluated in this programme do not deteriorate significantly when exposed to a range of "internal" storage conditions. There was no obvious difference between those materials stored in the "dry" conditions and those that experienced two brief exposures a year to the high humidity conditions. Similar to the results of the programme evaluating possible differences due to timber, there was a scatter in the results. This could be due to variations in the furnace pressure, temperature, oxygen content of the furnace atmospheres and procedral differences all of which affect the basic fire test. However, once these are accounted for it can be seen that the changes were small, some even giving enhanced ratings over the 10 years and others slightly reduced. From this it can be concluded that the materials that were incorporated into the 20 year programme have not suffered any obvious reduction in performance after 10 years, when installed in utile lippings in a manner representative of their use in practice. This result applies across the range of storage conditions given earlier. This was confirmed by a visual examination of the specimens where no change in appearance could be detected.

MATERIALS NOT INCLUDED IN THE IFSA AGEING PROGRAMME

Since the programme started in 1984, a number of new intumescent materials have been developed. Several IFSA members now manufacture or supply intumescent seals based upon graphite. The activation of certain types of graphite is more of a physical rather than a chemical one, i.e. it exfoliates at high temperatures increasing its volume as it does so. Whilst these exfoliating graphites have not been incorporated into the programme and, therefore, there is no direct evidence to substantiate their performance, there should be little cause to doubt their longevity.

Graphite based intumescent seals use exfoliating graphite as the active ingredient. Exfoliating graphite is produced by intercalating water molecules between the layers of carbon atoms. Seal manufacturers' own test revealed that the expansion characteristics of materials that had been naturally aged for 2½ years had not changed. This has been supported by accelerated ageing tests carried out by the suppliers of the graphite which suggests that there may be a deterioration of up to 1% per year. However, to achieve this accelerated ageing, higher temperatures than ambient are used which may well influence the results. As stated earlier, because of the complexity of the process, accelerated ageing is not recommended for intumescent products but at least it indicates that major changes in the material do not take place. There are two factors that support this contention. The first is that the activation temperature of the graphite is about 200 to 250oC. This indicates that the water is bound very well within the graphite layers. Other materials such as sodium silicate intumesce at temperatures much nearer the boiling point of water (i.e. 110-120oC) indicating that the water is not so tightly bound. It is a fairly safe assumption that the more tightly bound the water is, the longer it will take to be lost at room temperature. The second factor is that in practice the graphite particles are embedded in a binder of some type which means that any potential loss of water is further reduced since the water has to diffuse through the binder before it can evaporate from the surface of the compounded material. Graphite, being carbon, is chemically stable at normal ambient temperatures and the exfoliating version contains tightly bound water forming a chemically stable compound. The product is not, therefore, hygroscopic and all the evidence to date suggests that it will not significantly change over period of many years.

CONCLUSIONS

Whilst the raw materials used in the manufacture of some intumescent sealing products are potentially prone to moisture induced degradation, IFSA members have always striven to provide products that are stable and reliable. The analysis of the results of the ageing test programme confirm his, as standard products scientifically tested after 10 years exposure to a variety of internal environments all continued to provide an integrity rating in excess of 30 minutes. The following IFSA members have had selected products evaluated in the ageing programme:

- BASF
- Lorient Polyproducts Ltd
- Mann McGowan Fabrications Ltd
- Sealmaster Ltd

A subsequent 20 year ageing programme on IFSA members' materials that were not available at the time of the original programme is in the course of preparation.

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 to intumescent materials 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 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.

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