



ASFP Technical Guidance Document – TGD 11

Code of practice for the specification & on-site installation of intumescent coatings for fire protection of structural steelwork

FIRE AND YOUR LEGAL LIABILITY

Fire losses in the UK were over £1bn in 2013. That's why we must all play our part.

Why is this of relevance to me?

If you are involved in provision of a fire protection package, at any level, then you share liability for its usefulness and its operation when it's needed in fire, and that liability will still be there in the event of a court case.

I place the order; it is not my responsibility to install the works!

If it is your responsibility to specify the materials and/or appoint the installation contractor, it is also your responsibility to ensure that they can prove competency for the fire protection materials used, or the works to be carried out. It's no longer simply a duty of care or voluntary – it's a legal obligation.

If you knowingly ignore advice that leads to a failure in the fire performance of any element of installed fire protection within a building, then you are likely to be found to be just as culpable as the deficient installer.

You share liability for the provision of information required under Building Regulation 38 that tells the user of the building about the fire prevention measures provided in the building. Otherwise, the user cannot make an effective risk assessment under the Regulatory Reform (Fire Safety) Order 2005, the Fire Scotland Act 2005, and the Fire & Rescue Services (Northern Ireland) Order 2006.

What is expected of me?

In the event of fire, and deaths, a court will want to know how every fire protection system was selected; the basis for selection of the installer, whether adequate time was provided for its installation, and whether there was adequate liaison between the different parties to ensure it was installed correctly. No ifs, no buts – it's all contained in the Construction, Design and Management Regulations 2007.

The CDM 2007 regulations, enforced by Health and Safety Executive concentrate on managing the risk, and the health and safety of all those who build, those that use the building, those who maintain it and those that demolish it – cradle to grave.

Be aware – the time to consider the above is before the event, not after it!



The Association for Specialist Fire Protection (ASFP)

The Association was formed in 1976, and currently represents the majority of UK contractors and manufacturers of specialist fire protection products, with associate members representing regulatory, certification, testing and consulting bodies.

The ASFP seeks to increase awareness and understanding of the nature of fire, and the various forms, functions and benefits provided by passive fire protection.

It is willing to make available its specialist knowledge on all aspects of fire protection and can assist specifiers and main contractors in identifying products suitable for specific requirements, both in UK and overseas.

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AMENDMENT SHEET: ASFP Code of practice for on-site application of intumescent coatings.

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Note 1. Amendments may only be inserted by ASFP Secretariat with approval of the ASFP Technical Officer.

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1. INTRODUCTION

Through Approved Document B⁽¹⁾, Building Regulations define fire protection requirements and standards that must be observed in buildings in England and Wales. The regulations are not concerned with the commercial or financial losses that usually follow the destruction of a building by fire, but set out clear guidelines to ensure that in the event of a fire, the occupants of the building have both the means and the time to escape safely.

The key clause in Approved Document B is that which establishes this intent, stating that ***‘the building shall be designed and constructed such that, in the event of a fire, it will maintain its stability for a reasonable period’***.

BS 9999⁽²⁾ is being developed to take the rules for fire protection beyond those in Approved Document B and may be used as an alternative basis for design. The different approaches are described in Annex D, and are intended to provide the same end result – safety in the event of fire.

Most major construction projects in the UK are designed using steel to create the shape of the structure and to provide its main load-bearing strength. Providing the strength of its steel frame is not subsequently compromised, therefore, the building will remain intact.

In order to fulfil the requirements of Building Regulations to ‘maintain the building’s stability for a reasonable period’, therefore, the load bearing elements in the structure must not be allowed to heat up to a temperature at which they begin to weaken and, eventually, collapse.

There are several mechanisms by which steel structures can be insulated from the heat generated in a fire, in order to prevent or, at worst, delay collapse of the building.

Active mechanisms include installing sprinklers or gas release systems, which are activated as soon as a fire breaks out.

Passive fire protection systems are installed on or around the elements to be protected, and provide localised protection generally by thermal insulation.

Typical passive systems include fire resistant boards, mineral fibre, cementitious sprayed systems and intumescent coatings.

The Construction Markets Annual Survey (Corus Construction and Industrial, 2003)⁽³⁾ showed that intumescent coatings at that time held over 40% of the multi-storey market, and that of this two-thirds was applied on site and one-third off site (in shop).

SCI Publication P160⁽⁴⁾ provides design guidance on the use of off-site applied thin film intumescent coatings for structural steelwork in buildings, and guidance on intumescent coatings – both in general and for commercially available systems – is available in the ASFP publication *‘Fire Protection for Structural Steel in Buildings’*, otherwise known as the *‘Yellow Book’*⁽⁵⁾.

The current publication provides guidance in the specification and use of intumescent coatings applied on site, and deals specifically with hot rolled structural sections and hot rolled structural hollow sections designed for use in buildings.

1.1 Scope

Because of the potential loss of life that may result from fire in occupied buildings, it is of vital importance that all fire protection measures necessary, are installed in a manner that assures their effectiveness and provides confidence that they will perform as required in the event of fire.

In its section on ‘Use of Guidance – Materials and Workmanship’, Approved Document B goes further, in that it advocates the adoption of independent certification schemes specifically in the installation of fire protection, as follows:

‘Since the fire performance of a product, component or structure is dependent on satisfactory site installation and maintenance, independent schemes of certification and registration of installers and maintenance firms of such will provide confidence in the appropriate standard of workmanship being provided’.

The importance of fire safety is further emphasised in recent legislation, and under the Regulatory Reform (Fire Safety) Order 2005⁽⁶⁾ the ‘responsible person’ (who may be the owner, designer or architect,

specifier or contractor) is responsible for ensuring that the structure is fully compliant with all known, current legislation appertaining to the fire protection of the building.

This guidance document considers the entire process of fire protection using intumescent coatings, but its prime objective is to establish procedures for the specification, application and control of intumescent coatings at site. Not only will these procedures ensure that the required level of fire protection is provided for the structure, but they should provide the evidence necessary to satisfy the 'responsible person' that the installation has been correctly carried out.

Much of the information provided in SCI Publication P160 applies equally to on-site as to off-site use of intumescent coatings, so this document will cross refer to P160 where appropriate, to avoid unnecessary duplication. As far as possible, procedures and definitions will be kept consistent between the two documents.

Definitions

For the purpose of this document, the following definitions apply:

Applicator:

The company responsible for the application of the intumescent works.

Basecoat:

An intumescent coating, which reacts to heat by swelling in a controlled manner to many times its original thickness to produce a carbonaceous char which acts as an insulating layer to protect the substrate

Coating Manufacturer:

The company or companies who manufacture the materials used in the fire protection system supplied by the 'Applicator'.

Contract Administrator:

The person responsible for co-ordinating the various requirements of the contract and ensuring that all documentation is completed and in order. The contract administrator may be a nominee of the client or specifier, but more usually would be appointed by the contractor.

Contractor:

The company responsible for the execution of the intumescent protection works.

Decorative Coat:

A coating applied over the basecoat for decorative purpose only. It could also act as a Sealer or Top Coat

Designer:

The architect or engineering house responsible for the design of the structure. The designer will generally define the fire protection standards for the building, but not the detailed fire protection specification.

Dry Film Thickness (DFT):

The thickness of a fully dried coating. When quoting dry film thickness, it should be made clear whether the quoted thickness refers individually to the primer, basecoat or topcoat, or to the system as a whole.

Intumescent Coating System:

A system comprising the primer, the basecoat and the sealer, top or decorative coat. In some environments, and with the approval of the intumescent manufacturer, the sealer may be omitted from the system.

Primer:

A protective coating, usually anti-corrosive, applied to the substrate prior to application of the basecoat. For site applied intumescent coatings, the primer is the only part of the specification that would normally be applied in shop.

Quality and Inspection Plan:

The document setting out the specific quality practices, standards and sequence of activities relevant to the contract. This document may be used as an aid to efficient management of the contract, as a 'sign-off' document verifying formal inspection and acceptance of the work, or both.

Responsible Person:

The building owner or his delegated representative, or the person who has control of the premises.

Sealer Coat or Top Coat:

A coating applied over the basecoat to prevent the basecoat from environmental degradation

Specification:

The document in which the detailed fire protection requirements are defined for all elements of the structure. The specification may allow the use of any approved product or it may nominate a preferred supplier for the intumescent system, depending on the client's wishes.

Specifier:

The person or company who issues the specification for fire protection.

VOC:

Volatile Organic Compound. VOC is defined in the Paints Directive (Directive 2004/42/CE) and all organic solvents normally used in intumescent coatings would fall under this definition, including thinners and cleaning solvents.

Wet Film Thickness (WFT):

The thickness of any coat immediately after application.

2. GUIDANCE FOR SPECIFIERS OF INTUMESCENT COATINGS

In order to arrive at the most appropriate product specification, the specifier must take into account a range of factors including:

- Service conditions
- Regulatory requirements
- Technical requirements and standards
- Conditions and potential constraints of site application
- Health, Safety and Environmental considerations

Specifications for intumescent fire protection systems are structured in a similar way to any other coating specification, but as well as the standard clauses that would apply to the use of coatings, the specifier must also identify the requirements for fire resistance of the coating system, to meet the standards required by Building Regulations and/or stipulated by the building designer.

They also provide an opportunity for the specifier to stipulate procedural and contractual requirements of the work, for example quality assurance standards required to satisfy the 'responsible person' under the Regulatory Reform Order.

This section identifies the main factors to be taken into account when preparing a specification for a site-applied intumescent system.

2.1 Factors Affecting System Performance

The following factors can affect the in-service performance of the system, and must therefore be considered early in the design process:

2.1.1 In-service environment.

The nature of the environment to which the coatings will be exposed may affect their durability or their performance in a fire situation, and must therefore have a major influence on the properties required of them. Environment may have a significant bearing not only on the choice of intumescent basecoat, but also on the type and thickness of anticorrosive primer (if any) and on the type and thickness of sealer coat.

For steel protection generally, BS EN ISO12944-2:1998⁽⁷⁾ defines a number of environments in terms of 'corrosivity', based on relative corrosion rates of carbon steel, as follows:

Category C1	Very low
Category C2	Low
Category C3	Medium
Category C4	High
Category C5-I	Very high (Industrial)
Category C5-M	Very high (Marine)

ISO 12944 relates these categories to the composition and thickness of different protective coating systems required to provide short, medium or long term protection against corrosion, but only categories C1 and C2 would be considered typical of most thin film intumescent applications.

Examples of typical environments for each category are given in Table 1 below.

For C1 environments (the most common for fire protection) corrosion protection may not be strictly necessary but for site-applied intumescent coatings an anticorrosive primer may still be specified to provide temporary protection during the build programme.

For all other environment categories some degree of corrosion protection would normally be included, but the specifier must also consider the type and thickness of sealer coat that may be necessary to prevent degradation of the intumescent by moisture from humid atmospheres, condensation etc.

Table 1: Classification of Environment Types

Corrosivity Category	Corrosion / Exposure Rating	Examples of typical environments in a temperate climate (information only)	
		Exterior	Interior
C1	Very low	N/A	Inside heated or air-conditioned buildings with clean atmospheres. Low relative humidity and no likelihood of damp or condensation e.g. offices, schools, shops, hotels.
C2	Low	Atmospheres with low level of pollution and fairly dry climate. Mostly rural areas. Intumescent use mainly in sheltered locations e.g. under canopies.	Occasional damp or wet conditions. Unheated buildings where water leakage or condensation may occur, e.g. unheated warehousing, sports halls, plant rooms etc and in roof voids.
C3	Medium	Urban and industrial atmospheres, moderate sulphur dioxide pollution. Coastal areas with low salinity. Examples would include exposed car parks.	Constant damp atmosphere, but may be warm and well ventilated. Production rooms with high humidity and some air pollution, e.g. food processing plants, kitchens, laundries, breweries, dairies.
C4	High	Industrial areas with high sulphur dioxide pollution and coastal areas with moderate salinity. Typical areas include tank farms, petrochemical installations etc or exposed exterior surfaces of any structure in a polluted environment.	Interior of chemical plants subject to continual injection of chemical vapours or steam in the atmosphere. Constant warm and high humidity conditions such as in swimming pools. Coastal ship and boat yards.
C5-I	Very high	Industrial areas with high humidity and aggressive atmosphere. Thin film intumescent should only be used with manufacturer advice	N/A
C5-M	Very high	Coastal and offshore areas with high salinity. Thin film intumescent should only be used with manufacturer advice	N/A

Apart from considering the 'corrosivity' classification of the general environment of the building, the fire protection specifier must also consider a number of other questions which might influence product choice, as follows:

- Could the environment change in the foreseeable future?
- Is some form of local pollution present? For example, high levels of sulphur dioxide could produce acidic conditions and this in turn may influence the type of sealer coat required.

- Do conditions vary within the building? For example, are roof spaces (of an otherwise air conditioned building) unheated and so subject to periodic condensation?
- Are some elements of the construction particularly vulnerable to impact damage?
- Are any unusual processes likely to cause localised special conditions, such as splashing, water pooling, localised high temperatures etc?

Where unusual conditions are likely to arise, the advice of the coating manufacturer should be sought.

2.1.2 Design life and life to first maintenance

The need to completely remove and reinstate the intumescent coating system at any stage in the life of a building would involve considerable cost and disruption, so the fire protection should be specified to last for the design life of the building.

In most cases, correctly applied intumescent systems exposed internally in corrosivity category C1 should not require maintenance over the design life of the building, other than for decorative purposes or where mechanical damage has occurred. Even so, a good specification should allow for regular inspections to check for degradation due to abnormal conditions, damage or cosmetic deterioration. Also, over a long building life, accumulated knowledge about long term intumescent durability may lead to recommendations for increased frequency of inspection in later years.

For all other corrosivity categories and/or special conditions, the specification may require the inclusion of a special sealer coat or higher sealer coat thickness – for example to increase water resistance, to provide acid resistance or for other reasons.

In addition, where exposure conditions are particularly onerous, the following measures might be considered appropriate:

- Increased quality control surveillance during site application, particularly of sealer coat
- Regular and fairly frequent inspections of the condition of the fire protection
- A schedule of regular maintenance included in the specification.

If there is any doubt about the capability of a thin film intumescent system to provide the required long term durability, a thick film system may be advised.

Life to first maintenance for systems in C1 environments will be governed by the aesthetic appearance of the finish, and will probably fall within normal redecoration cycles.

For other environments the life to first maintenance will depend on the severity of the particular exposure conditions, and if maintenance in situ is likely to be difficult (due to access problems etc) the specifier should take this into account and, if necessary, increase the safety margin in the specification accordingly.

2.1.3 Ease of maintenance

The specifier should take into account the ease of maintenance of the fire protection system. For C1 environments this will involve only a consideration of the manufacturer's recommendations for recoating the sealer coat / decorative finish and the effect of increased sealer coat thickness on the performance of the intumescent. For other environments it may require a consideration of repair procedures in the event of the intumescent itself being damaged or degraded in service.

2.1.4 Repair procedure

The repair procedure for most thin film intumescent coatings will be relatively straightforward – see also section 3.8.2. The advice of the manufacturer should always be sought for confirmation, but in cases where the intumescent has detached due to mechanical damage, or suffered localised degradation due to water ingress, the normal repair procedure would involve mechanical removal of the damaged or denatured coating to a firm (unaffected) edge, followed by reinstatement of the system to the original, specified thickness. If the underlying steel substrate has become corroded, this should be re-prepared in accordance with the manufacturer's instructions prior to re-application of the intumescent.

The cause of the damage or degradation should obviously be addressed prior to carrying out the repairs, to avoid any repetition.

The main considerations for the specifier when preparing his specification concern the possible consequences of having to carry out repairs – for example the location of any defective coatings may cause problems of access (and hence disruption) in occupied buildings, resulting in high repair costs. Minimising the likelihood of any possible coating failure in service should therefore be a major consideration at the design / specification stage.

2.1.5 Surface preparation

Generally, steel erected on site will already be blasted and primed but, if this is not the case, the specification may need to include blasting standards and procedures, and criteria for primer selection.

Prior to the commencement of blast cleaning all steel surfaces should be clean and dry. Blast cleaning may not remove all contaminants and general surface contaminants may need to be removed by other appropriate mechanical means. Oil and grease contaminants should be removed by the use of suitable emulsifying degreasers, suitable clean organic solvents or steam cleaning before the commencement of blasting.

Steel surfaces should be prepared by removing scale and rust using abrasive blasting to a minimum standard of Sa2½ as defined in BS EN ISO 8501-1: 2001 “Preparation of steel substrates before application of paints and related products”⁽⁸⁾.

A surface profile will usually be specified within the range of 35 – 75 microns and, in general, will not exceed 100 microns. Guidance regarding profile should be obtained from the primer supplier. All dust and spent abrasive must be removed from the prepared steelwork. This can be achieved by blowing down with clean dry compressed air.

The primer, where specified, should be applied before the blast cleaned surface deteriorates.

In exceptional cases, such as small localised areas, it may be possible to apply the intumescent system onto un-blasted steel, although this would have to be checked with the manufacturer on a case by case basis and would only be permissible if supporting test evidence were available. In all such instances it would be necessary to remove loose mill-scale and rust by such methods as hand or power wire brush, powered abrasive discs, needle gun etc, prior to the application of a compatible surface tolerant primer.

Where the steel sections are (more normally) blasted and primed in shop, the same surface preparation standards as above would be specified, but after transportation and site storage further measures need to be included to ensure cleanliness of the primer prior to over-coating with the intumescent basecoat.

2.1.6 Primer selection

The choice and thickness of primer will depend on:

- the service environment, which in turn will affect the degree of anti-corrosive protection required. For C1 environments, no anticorrosive coat may be strictly necessary, whereas for more severe environments – for example swimming pool steelwork – a full thickness anti-corrosive primer may be essential.
- where the primer is to be applied, and the schedule for subsequent intumescent basecoat application. If the build programme requires a significant delay between steel preparation in shop and final erection and completion of coating at site, the primer specification needs to have suitable weathering properties and durability, it must be suitable for over-coating with the intumescent coating after the appropriate time interval, and it should be sufficiently tough to be transported with minimum mechanical damage.

2.1.7 Compatibility between coats

The intumescent basecoat and sealer coat or decorative top coat would normally be sourced from the same manufacturer, so the specifier can be assured of the compatibility of these two coatings. Ideally the entire system should be similarly sourced, but in reality shop primed steelwork will not always be coated with a primer supplied by the intumescent manufacturer.

In such instances, the specifier may only be able to specify that the various components of the system should be compatible, so that prior to the application of the intumescent basecoat, the applicator must obtain confirmation from the intumescent supplier that the primer and intumescent basecoat are compatible in both ambient and fire conditions. The technical data sheet for the primer, the actual primer thickness and information regarding the length of time the primer has been applied should be given to the

intumescent material supplier, who should then be able either to give approval for use of the primer, or to provide alternative advice.

In general, primers which themselves have poor heat resistance are likely to have a detrimental effect on the performance of the intumescent in a fire, while primers based on weaker solvents than the (solvent based) intumescent, may exhibit defects such as rivelling and/or wrinkling when over-coated.

In the future, testing to prENV 13381-8⁽⁹⁾ and the resultant CE-marking procedure will provide confirmation of compatibility, as the product ETA will give details of the testing carried out. This will include compatibility with a range of primers and durability testing in a range of environments when over-coated with a number of topcoats.

2.1.8 Compatibility of Intumescent coatings with zinc rich primers

Zinc rich primers, usually based on epoxy resin or silicate binders, are often used as corrosion protection coatings on structural steelwork.

During weathering, the zinc provides protection by sacrificially corroding in preference to the steel. This can lead to the formation of zinc salts on the surface of the coating.

If subsequent coatings, including intumescent, are applied over this layer of zinc salts, problems may be experienced with inter-coat adhesion. In such situations therefore, it is essential that the zinc salts are completely removed by, for example, washing down with clean fresh water.

Where full removal of zinc salts cannot be guaranteed, the only safe option is to remove the zinc coating and re-prime the steelwork.

Zinc salts can be prevented by applying a tie-coat over the primer at the fabrication stage. The intumescent coating can then be applied to the tie-coat after normal site preparation.

The application of water based intumescent coatings directly over zinc rich primers is not recommended.

In all cases, the intumescent coating manufacturer should be consulted to confirm the compatibility of the priming system with the intumescent system and, where applicable, the tie coat.

2.1.9 Compatibility of intumescent coatings with existing paint layers

Steelwork requiring refurbishment will usually be treated with an existing coating system. The existing paint coatings are likely to be old and their adhesion to the substrate, or between layers of the system, may be poor.

It is possible that the paint system may not be consistent throughout the building and that varying systems have been applied to different pieces of steel. With so many variables it is not possible to confidently predict the performance of the intumescent coating system under fire conditions. The only safe option is complete removal of the coatings and the application of a primer/primer system compatible with the intumescent system.

Abrasive blast cleaning is the preferred method of preparing the steel to ensure the old paint coatings are effectively removed. Sa 2½ to BS EN ISO 8501-1 is the accepted standard and provides a suitable base for the application of the new priming system.

There are some situations where site conditions may make abrasive blast cleaning impractical or unacceptable. In these cases the use of manual cleaning methods may be considered.

Impact tools such as chipping hammers and needle guns are reasonably effective in removing old paint coatings but are labour intensive. Power rotary wire brushes will wear away the paint layers. They may not achieve 100% removal but will get back as near as is practical to bare steel, which may be acceptable where a compatible surface tolerant primer is used. When using power tools care should be taken to avoid polishing the surface, and to achieve an acceptable profile or anchor pattern. The intumescent system manufacturer should be consulted to provide advice about surface preparation standard, with appropriate supporting evidence.

Where a manufacturer wishes to demonstrate that compliance with the Building Regulations can be achieved by the application of an Intumescent system over existing painted surfaces of known generic type and thickness, fire test evidence should be available in every case to provide a technical justification. Agreement should be reached with the client, the building control officer, and other interested parties as to the applicability of the test data to the circumstances which prevail on the specific site.

2.1.10 Upgrading of fire protection systems

The ASFP recommends that the refurbishment or upgrading of intumescent systems – either with further intumescent or with alternative fire protection systems – and the upgrading of other systems using intumescent coatings, should always be carried out in accordance with the advice of the manufacturer. Issues such as compatibility, effectiveness and stickability of combined thicknesses etc are important considerations, as described in ASFP Technical Guidance Note 010⁽¹⁰⁾.

Where a reactive coating fire protection system is to be added next to an existing fire protection system to form a junction, ASFP reactive coating specialists consider that the best guidance is to have a simple butt joint between the two different fire protection systems. Where this is not possible then independent advice should be obtained from the fire protection system manufacturers involved, based on the test information available, or from independent consultants as described in government guidance documents.

Where unprotected meet fire protected elements in a structure, it is normally considered good practice to overlap the fire protection onto the adjoining 500mm of 'unprotected' structural steel to limit heat transfer into the protected substrate.

Further guidance on junctions between different types of fire protection on a structure is given in ASFP Technical Guidance Note 008⁽¹¹⁾.

2.1.11 Standards of cosmetic finish

The standard of finish required by the client should be included in the specification. Typically, the quality of finish that can be offered will fall into one of the following categories:

(i) Basic Finish:

The coating system achieves the required fire performance and corrosion protection performance, but is not required to achieve any requirement for standard of finish.

(ii) Decorative Finish:

In addition to the requirements for (i) above, a good standard of cosmetic finish is generally required, when viewed from a distance of 5 m. Minor orange peel or other texture resulting from application or localized repair is acceptable.

(iii) Bespoke Finish

In addition to the requirements for (i) above, the coating finish is required to have a standard of evenness, smoothness and gloss agreed between the specifier and contractor. When agreeing a bespoke standard of finish, the specifier and contractor should take account of the effects of steel size, section shape, design complexity and the required period of fire resistance.

The contractor will normally provide for a basic finish unless otherwise noted in the contract documents.

Where a decorative finish or a bespoke finish is required, the contractor must provide the designer or specifier with representative sample(s), prior to the commencement of the works, as a guide to the standard(s) of finish(es) that can be achieved with the intumescent coating system proposed.

Alternatively, by agreement, reference can be made to other completed projects.

On some projects, the specification may accept different standards of finish on different parts of the structure, with the highest standard being limited to the most high-profile areas.

2.2 Considerations for Management of Application at Site

2.2.1 Potential for disruption of other site activities

The specifier, contractor or application sub-contractor may take into account the extent of possible disruption of other site activities when deciding on the most appropriate intumescent specification. This may favour, for example, systems that provide the necessary level of fire protection but which will not affect the programming of other services in the area where application is taking place. For example, irrespective of VOC compliance considerations, water based systems will sometimes be favoured for on-site work purely for this reason.

The specifier's decision may have a major bearing on the contractor and painting sub-contractor's interaction with other services on site, as outlined in section 3.10 below.

2.3 Importance of the Specification for Regulatory Compliance

Whether or not the specifier is himself the 'responsible person' under the Regulatory Reform (Fire Safety) Order 2005, it would be prudent to ensure that measures to ensure regulatory compliance are built into every contract at the design and specification stages.

The specification provides an opportunity to ensure that all aspects of the fire protection installation are properly co-ordinated, and that everyone in the contractual chain understands their legal and contractual responsibilities.

The following contractual requirements should therefore be covered in the contract documentation:

2.3.1 Design Review

Prior to commencement of coating at site, a design review should be carried out to confirm that no alterations to the design have been made that might affect the drawings and hence the film thickness requirements for the structural members.

2.3.2 Primer film thickness

Because the steelwork delivered to site will often be treated with a primer applied elsewhere in shop, the overall coating specification may be dealt with as separate contracts, with little co-ordination between the two.

As stipulated in section 2.1.7, the specifier should ensure that the primer is compatible with the proposed intumescent treatment (and vice versa). Of equal importance, however, is the thickness of primer applied.

In order for the intumescent applicator to determine that he has applied the correct thickness of fire protection, he must know the thickness of primer underneath. Film thickness after completion of application will be of the combined coats, so it is necessary to subtract the thickness of primer from the total to establish the true thickness of intumescent.

It should be a requirement of the contract that steelwork delivered to site in primed condition should be accompanied by a documented record of primer thickness supplied by the fabricator.

If this is not available, the site contractor must be required to conduct a primer thickness survey prior to commencement of intumescent application.

The specifier should also ensure that any restriction on primer thickness is included in the specification. For example, there may be a maximum primer thickness above which the performance of the intumescent may be impaired in a fire situation, so advice would need to be sought from the intumescent manufacturer.

2.3.3 Film thickness specification of intumescent systems.

Primer and sealer coat or decorative top coat thicknesses will normally be included in the specification, and should take into account all relevant factors from section 2.1 above.

Determination of correct thicknesses for the intumescent basecoat is a more complex process, as every construction project will contain a variety of steel section sizes and configurations. The correct film thickness must be determined for each section, in order to produce a list of section sizes with their associated film thicknesses for the entire project.

The detailed breakdown of basecoat thicknesses will normally be the responsibility of the contractor (but may in some circumstances be provided by the architect / specifier or delegated to the applicator), who will usually prepare this in conjunction with one or more manufacturers.

Most of the necessary information can be obtained from the manufacturers' product assessments, but in order to make the specifying process simpler and quicker, most of the major intumescent suppliers have developed 'Product Calculator' software which carries out the calculations automatically.

By inputting information about every section in the project – including location, surface area etc.- a good product calculator can produce not only a coating schedule for the applicator (which in turn can be used as a means of proving application complies with design), but can also generate a cost model for the project. However, the contractor should be aware that the cost model would be based on theoretical data and so would have to be modified to include his estimate for losses in application etc.

The thickness calculations will only be accurate if the correct information is fed into the model, so the following information must be provided as part of the contract documentation:

- Fire resistance period required.
- Steelwork drawings clearly marked to show the members to be protected and the extent of the protection.
- Steelwork section sizes.
- Design limiting temperature.
- Nature of any partial protection provided by concrete floors, fire resistant walls, etc.

Any discrepancies should be highlighted to the Contract Administrator for clarification.

In addition to the above, the specifier must provide all relevant structural information, including that relating to steelwork connections, which may affect the limiting temperatures to be used in designing the fire protection thicknesses.

Any variations in intumescent thicknesses resulting from specific design features must be carried out by a competent person in accordance with the standards defined in Annex D of this document and other appropriate guidance. Such variations must be noted by the contractor and reported back up the contractual chain via the Contract Administrator.

The contractor will prepare a schedule of intumescent coating thicknesses required to provide fire protection to each of the steel sections to achieve the fire resistance periods given in the contract documents. This schedule will be submitted to the Contract Administrator for review, prior to commencing the works. The schedule must include, but not be limited to, the following:

- (i) Fire resistance period(s) required.
- (ii) Steelwork references as noted on general drawings.
- (iii) Steelwork section sizes and section factors.
- (iv) Details of any partial fire protection provided by concrete floor slabs, etc.
- (v) Name of intumescent product(s) specified / selected.
- (vi) Method used to determine required coating thicknesses.

The average measured dry film thickness of any face of any member should not exceed the manufacturer's recommended maximum thickness for the particular member shape and orientation.

2.3.4 Health and Safety provisions

Health, Safety and Environmental precautions on site are delegated to the contractor, but it remains the designer or specifier's duty of care under the 'Construction – Design and Management (CDM) Regulations – 2007'⁽¹²⁾ to eliminate any identifiable hazards at the design stage.

While this does not necessarily mean that the specifier should stipulate the 'safest' or least hazardous product or specification, he should require that any products used on site are used in full compliance with the recommendations of manufacturers' health and safety data sheets, and that the safety of all personnel in the vicinity of the application is protected.

The specification should require the contractor to provide to the Contract Administrator either as part of the pre-contract selection process or at latest before the commencement of the work:

- A copy of his Health and Safety Policy
- A contract-specific risk assessment and plan for safe working, including provision of safe access, arrangements for working at heights, provision and use of personal protective equipment, training of site personnel and health and safety training of visitors to the site etc.
- Where applicable, confirmation of compliance with the contractor's Health and Safety Assessment Scheme⁽¹³⁾.

2.3.5 Compliance with EU Environmental Regulations

Concerns over emissions of VOCs into the atmosphere have resulted in two major pieces of legislation being introduced by the European Commission to limit, and ultimately reduce, the amount of organic solvent emitted to atmosphere.

Painting operations where the application is carried out in a dedicated painting 'installation' are governed by the European Solvent Emissions Directive – Directive 1999/13/EC⁽¹⁴⁾. Any off-site intumescent application which uses more than 5 tonnes of VOC per year must comply with this legislation, which is implemented in the United Kingdom through the Pollution Prevention and Control (England and Wales) Regulations 2000⁽¹⁵⁾.

For site applied fire protection coatings, a different Directive applies across the EU. This is the so-called 'Paints Directive' – Directive 2004/42/CE⁽¹⁶⁾. Annex 1 of this Directive imposes limits to the VOC content of "coatings applied to buildings, their trim and fittings, and associated structures for decorative, functional and protective purpose". This Directive is transposed into UK law as the VOCs in Paints, Varnishes and Vehicle Refinishing Products Regulations 2005⁽¹⁷⁾.

The VOC limits are applied by product category, the two categories which apply to intumescent products, and the VOC limits that apply to them, being as follows:

Table 2. VOC Limits for Performance Coatings (2004/42/CE)

Product Category	Product Category Description	Product Type	Maximum VOC Content (gm/ltr)	
			From 1.1.2007	From 1.1.2010
(i)	One-pack Performance Coatings	Water based	140	140
		Solvent based	600	500
(j)	Two-pack Performance Coatings	Water based	140	140
		Solvent based	550	500

The Directive requires that all coatings supplied for use on buildings are labelled to show compliance with the appropriate VOC limits. The specification should stipulate that only compliant products may be used on site.

From 1st January, 2007, all paints used on buildings must be labelled to show compliance with the Paints Directive. The label must carry the following information in the form of written words or a code:

Directive reference and Product category / 2007 EU VOC limit (g/l) / 2010 EU VOC limit (g/l) / This product contains max (XX) g/l VOC.

2.3.6 Quality Control and Quality Assurance provisions

In any coating process, it is essential that procedures are put in place to ensure that the standards necessary for correct performance of the applied system, are fully complied with throughout the construction and application stages. This is particularly important where fire protection systems are involved.

In addition to covering all technical and management aspects of the work, therefore, the specification should stipulate the quality control measures to be implemented in order to ensure that the technical standards defined in the specification are met.

The Contractor may be required to demonstrate quality competence through current registration to BS EN ISO 9001:2000⁽¹⁸⁾.

The main quality control provisions for site application of intumescent coating systems are set out in section 4 of this document.

The specification would also stipulate the reporting requirements for the project, the minimum extent of which is detailed in section 5.

3. GUIDANCE FOR THE APPLICATION OF INTUMESCENT COATINGS AT SITE.

In terms of their performance, and the critical importance of correct application, intumescent paints must be regarded as highly specialised products. As such, they require application by specialist contractors who know and understand not only the practicalities of coating application, but also the importance of attention to detail in the installation process.

This requirement is reflected in the statement from Approved Document B which was quoted in the Scope of this document: **‘Since the fire performance of a product, component or structure is dependent on satisfactory site installation and maintenance, independent schemes of certification and registration of installers and maintenance firms of such will provide confidence in the appropriate standard of workmanship being provided’.**

Section 2 above set out the criteria the specifier should take into account to ensure that the specification will deliver the correct standard of fire protection. This section describes the practical procedures and measures to be adopted for on-site application of intumescent systems, in order to comply with the requirements of the specification.

3.1 Priming of Steel Sections

Because the specified standard of surface preparation for structural steelwork will normally require abrasive blast cleaning prior to application of fire protection systems, this part of the process will normally be carried out in a dedicated blasting and painting facility off-site. Where the intumescent basecoat is to be applied on site, therefore, the primer will already have been applied and the steelwork delivered to site in pre-primed condition.

In the rare circumstances where the steel members are to be prepared entirely on site, the specified method of surface preparation should be used in order to achieve the required standard of surface cleanliness. In this case any residual dust or other contamination should be removed by suitable means, such as by blowing off with dry compressed air, prior to commencement of primer application.

The primer should be applied to the specified dry film thickness and the thickness measured in accordance with the method described in Section 4.7 of this document.

When thicknesses are found to be outside the specification, the advice of the specifier and/or primer and intumescent coating manufacturer should be sought and remedial action carried out as necessary.

The mean primer thickness should then be calculated and deducted from subsequent combined (primer + basecoat) thickness in order to provide a true basecoat thickness measurement.

Because different structural steel sections may require different intumescent basecoat thicknesses, it is important to ensure that all sections are correctly marked or otherwise identified for application and record purposes. Marking is best carried out after completion of priming and should not interfere with the application or operation of the intumescent coating system.

3.2 Handling, Transportation and Storage of Shop-Primed Steelwork

In general, primers used for the shop priming of structural steelwork will be fairly tough and resilient, and will be more resistant to mechanical damage than a full intumescent system applied in shop.

Nevertheless, the contractor is required to implement protective measures and appropriate care during the transport, storage and erection of steel structures.

Coatings should be sufficiently dry before handling and members should be lifted at designated lifting points or by using lifting brackets where available. The use of lifting chains in contact with coated steel is preferred to strops/webbing slings as the former cause only minimal damage that is normally easy to rectify. Single lift should be used unless specially designed multi-lift cradles are available.

The loading of trailers should be carefully planned, with timber supports positioned, where possible, in uncoated contact areas (e.g. areas to receive bolted connections). Where contact of supports with coated areas is unavoidable, members should be supported on their toes to minimise the contact area. Where thin-film prefabrication primer only has been applied in shop, members which may fill with water should be prevented from doing so by the use of covers to avoid premature breakdown under immersion. Loads

are best secured with the careful use of clean chains and it is advised that loaders wear overshoes and where possible avoid walking on coated surfaces in order to minimise contamination.

Where site storage is unavoidable, similar care should be taken in the handling and support of the coated steel using the same lifting and support points as those used in transportation. Where possible members should not be stacked and water ponding should again be avoided using localised protection where necessary. The main contractor, site management and operatives should be made fully aware of the importance of good handling practice and storage areas should be roped off with signage clearly explaining the need to avoid contamination and mechanical damage to the coating finishes.

Similar care should be taken during the erection phase, with any lifting activities making use of strategically positioned holes, lifting lugs and brackets etc to minimise damage to the body of the paintwork.

3.3 Treatment of Shop-primed Steelwork at Site.

3.3.1 Repair of transit damage

Despite the contractor's efforts to be careful, some damage to the coating will inevitably occur during handling and transportation. Further damage may occur as a result of site modifications, welding etc prior to the application of the intumescent basecoat.

The nature and extent of primer repair required will vary, dependent on:

- The scale of damage incurred.
- The degree of deterioration of the damaged surface.
- The type of exposure – i.e. the service environment and the importance of the primer in providing long-term anticorrosive protection.

Even where damage to the primer is extensive, provided that the exposed steel surface has not badly corroded it may be sufficient to re-prepare the surface to an acceptable standard (e.g. BS EN ISO 8501-1, St3) prior to application of the intumescent basecoat overall i.e. without reinstating the primer. This might be acceptable, for example, where conditions during application are acceptable and subsequent exposure is to an environment of corrosivity category C1, provided the intumescent coating manufacturer agrees. The manufacturer may also impose other conditions if the repair intumescent is water based.

In cases where on-site welding, cutting or grinding has been necessary, all affected areas must be re-prepared to a standard agreed with the intumescent manufacturer, and cleaned down to remove any resultant contamination.

In general, site welding would be carried out prior to application of the intumescent basecoat, and the welds and heat-damaged areas then re-prepared by suitable mechanical means such as power discing and/or grinding prior to reinstatement of the primer. Where welding is carried out after application of the intumescent basecoat, any heat-damaged coating should be cut back to a sound coating (distance) prior to re-preparation and reinstatement of all coats in the area of repair.

Where subsequent service is to be in an environment subject to damp or wet conditions – e.g. humid buildings without air conditioning, swimming pools etc – the anticorrosive coating may be important to the long term performance of the system and a good standard of surface preparation and reinstatement of the full anticorrosive primer thickness may be necessary.

In all cases, the advice of the intumescent manufacturer should be followed.

3.3.2 Contaminated and corroded primer

Where a thin coat of primer is specified to provide protection of the blast cleaned steel during the transport and erection stages only, any delays in the build programme may result in some breakdown of the coating and consequent corrosion (rust rashing) of any exposed steelwork. The specifier should anticipate this possibility and would normally require advice regarding re-preparation to be provided by the intumescent manufacturer. Depending on the extent of corrosion and the nature of the intended service environment, the advice may range from no re-preparation to manual re-preparation of affected areas followed by immediate application of the intumescent basecoat overall, or manual preparation to BS EN ISO 8501-1 St3 standard, followed by re-application of primer prior to completion of intumescent coating.

Where the primer forms a functional part of the long term protective system – for example when the exposure environment is particularly severe – the latter standard of re-preparation at site will always be required.

Where the primer is in good condition but in a contaminated state, the specification should require that it be cleaned – using suitable methods such as washing using detergent and/or fresh water pressure washing – and allowed to dry before application of the intumescent basecoat.

3.3.3 Primer compatibility

Compatibility of the primer and proposed intumescent coating should have been established at the specification stage, but circumstances may arise where the primer on the steelwork delivered to site has been changed or is unknown.

It is vital that no intumescent application is carried out until the nature of the surface preparation carried out and the identity of the primer has been confirmed, and the compatibility of primer and intumescent confirmed in writing by the intumescent manufacturer.

3.3.4 Primer thickness

Where priming has been carried out off site, the results of a dry film thickness survey of the primer should be supplied by the off site contractor or fabricator, as described in section 2.3.2, otherwise the film thickness should be established at site prior to erection.

3.3.5 Sealing of inaccessible areas

Some design features inevitably leave gaps where moisture ingress may occur, which if not sealed may cause problems such as blistering or degradation of the intumescent coating after application.

The interface between the top flange and concrete decking, particularly bison type planks, may allow moisture to penetrate and this will take a long time to dry out, even if environmental conditions are satisfactory for paint application. This area needs to be sealed prior to application of the intumescent basecoat. One solution is to seal the gap with a moisture resistant intumescent mastic prior to the full intumescent basecoat.

3.4 Preparation of Galvanized Steelwork before Coating.

Galvanized steelwork can be difficult to coat successfully, so the intumescent manufacturer's recommendations should always be meticulously followed.

Fresh galvanizing is normally prepared for painting by flash blasting or by degreasing followed by the use of a mordant solution (T-wash) to etch the surface, but other surface treatments may also be employed depending on the intumescent manufacturer's experience and the severity of subsequent service conditions. The decision of whether a solvent or water based intumescent coating is to be used may also influence the suitability of a particular surface treatment.

Galvanizing that has been weathered for some time before erection will usually be affected to a greater or lesser degree by surface zinc salt formation. In this case, thorough fresh water washing to remove soluble salts (ideally high pressure washing, or normal pressure accompanied by stiff bristle brushing) would be the minimum recommendation prior to coating application, but again specific guidance from the intumescent manufacturer should be followed.

3.5 Preparation of bolted connections before painting

In the case of site applied intumescent fire protection, bolted connections can be coated at the same time as the main structure but special provision has to be made for the coating of bolts / connections, which may require cleaning and a special adhesion primer before application of the intumescent depending on the type of bolt, so the intumescent manufacturer's recommendations should always be meticulously followed. In all cases, therefore, both the design engineer and the coating supplier should be consulted for advice.

If the bolt is galvanised it should be prepared in accordance with the recommendations in Section 3.4

Sheradised bolts are normally prepared for painting by degreasing but other surface treatments may also be employed depending on the intumescent manufacturer's experience.

Steel fixings are normally prepared for painting by using site 'touch up' primer but other surface treatments may also be employed depending on the intumescent manufacturer's experience and the severity of subsequent service conditions.

Black bolts are normally prepared for painting by degreasing and may require no further treatment but other surface treatments may also be employed depending on the intumescent manufacturer's experience and the severity of subsequent service conditions.

The protection thickness on bolt heads and connections should be the same as that on adjacent steel sections.

3.6 Preparation for Application

Prior to site application, all surfaces to be coated should be in a clean, dry condition and any areas not requiring fire protection or which may be exposed to overspray should be appropriately protected by masking.

The application sub-contractor should ensure that all equipment required to carry out the surface preparation and application of all components of the intumescent coating system, to the project specification, are available and in good working order. The application sub-contractor must ensure that all relevant Health and Safety data sheets, application instructions and method statements are available to the application operative(s) and that they are fully understood.

The storage of all material(s) should be in accordance with the manufacturer's written instructions/ requirements. As a general guide, the storage temperature for all material(s) will be within the range of 5 - 30°C, and any water based materials in particular should always be protected from frost. Material containers should remain unopened until needed and should be used in date order. Material should be stored off the ground and protected from the elements.

All materials delivered to site must be used within the manufacturer's stated shelf life, or otherwise be approved as suitable for use by the original manufacturer.

Where required, any mixing should be carried out in accordance with the manufacturers' instructions. Materials taken from store should attain the temperature recommended for use before being applied.

The scheduling of the works should be such that sufficient areas are made available, allowing free access for the applicator of the intumescent coating system to apply the material to the required specification.

All work should be scheduled to ensure that the conditions required by the manufacturer (temperatures and humidity, over-coating times etc) can be met.

It is particularly important that where application is to be carried out in a partially clad building (i.e. not theoretically open to the elements), the contractor ensures that the building is water-tight and that areas where coatings are to be applied are not directly exposed to external weather conditions at any time.

3.7 Application Methods

The application of all coatings should be carried out fully in accordance with manufacturers' technical data sheet requirements and the applicator's method statement. These in turn must reflect fire test and assessment conditions.

While airless spray is generally the preferred method of application for most coatings, the use of this method on site may be restricted, in which case the specification may need either to include provision for sheeting-in to protect adjacent buildings and the surrounding environment from overspray, or may have to concede the use of brush or, in some cases, roller application instead. Where spray is not possible, a larger number of coats by brush or roller will normally be required, and minimum and maximum over-coating times must be observed.

Recommended thicknesses are provided on manufacturer's data sheets, along with the maximum achievable thickness per coat by the different methods of application.

3.8 Practical Application of Intumescent Coating Systems

3.8.1 Monitoring of environmental conditions.

No application should take place on site when environmental conditions – air and steel temperatures, relative humidity, dew point – are outside the limits laid down by the coating supplier.

Typically, steel temperatures should be more than 3°C above the dew point to ensure that no (visible or invisible) moisture or condensation is present on the surface during application.

Minimum and maximum air and steel temperatures may also be stipulated for some products, and attempts to continue application outside those limits may well have detrimental effects on both film formation and integrity of the coating (especially water based systems) as well as on long term performance.

It is the applicator's responsibility to monitor these conditions in accordance with the specification, and to maintain auditable records to demonstrate compliance.

3.8.2 Thinning and equipment cleaning.

Thinning of intumescent product may be permissible to aid application characteristics, particularly where ambient temperatures affect product viscosity and make a good quality finish difficult to achieve. However, excessive thinning can create sagging, drying and film formation problems, particularly where high film thicknesses are involved, so all thinning is subject to approval by the manufacturer in writing. Only thinners approved by the manufacturer may be used.

Similarly, solvent used for equipment cleaning should be approved by the coating manufacturer as being compatible with the coating system, as incompatible gun-washes left in equipment overnight can give rise to film formation defects if mixed in with the coating.

It should be noted that thinning with solvent will invalidate the wet to dry ratio given on the product data sheet and may significantly affect the VOC content of the coating, and hence may adversely affect compliance with environmental legislation. The applicator should ensure that the thinned product still complies with the VOC limits stipulated in Directive 2004/42/CE. – see Table 2.

3.8.3 Film thickness determination

Whatever the method of application employed, it is essential to ensure that the correct dry film thickness of each coat of the specification is achieved. This is particularly important in the case of the site-applied intumescent basecoat, as this is the part of the system that confers the necessary fire protection for the structure.

In order to confirm the correct thickness of the basecoat, it is necessary to know – either from measurements provided by the fabricator / shop applicator or from measurements taken physically at site – the average thickness of anticorrosive primer. After application of the intumescent basecoat, the average primer thickness should be subtracted from measurements taken on the basecoat, to establish the true intumescent thickness.

Alternatively, adding the measured primer thickness to the amount of intumescent required will give a target thickness for the combined primer plus site-applied intumescent basecoat.

It is important to confirm that the correct thickness of intumescent has been applied before proceeding to application of the decorative topcoat, as any deficiency in intumescent thickness is best corrected at this stage.

Where the topcoat is included in the specification to perform the function of a sealer coat – i.e. to protect the basecoat from the effects of moisture – its thickness is equally important. Correct application of the topcoat must therefore be confirmed in the same way as for the intumescent basecoat above.

In all cases, dry film thickness measurement and acceptance should be carried out in accordance with section 4.7 of this document.

Where decorative appearance is important and requires additional coats of finish, or where additional topcoat thickness is required to protect from severe environmental conditions, the intumescent manufacturer should be consulted to confirm that the additional thickness will not inhibit the fire resistance of the system.

3.9 Repair and Maintenance of Intumescent Coatings

During the application process and after completion of the work, repairs may be necessary to ensure that the standard of fire protection, surface integrity and finish is in accordance with the original specification.

Before carrying out on-site remedial works, a written Method Statement for repair procedures shall be prepared by the contractor and submitted to the Contract Administrator for review.

The contractor shall be responsible for identifying all areas requiring remedial works and for rectification in accordance with the coating manufacturer's recommendations.

The ASFP recommends that the refurbishment of intumescent systems shall always be carried out in accordance with the advice of the coating manufacturer. Issues such as compatibility, effectiveness and stickability of combined thicknesses etc are important considerations, as described in ASFP Technical Guidance Note 010⁽¹⁰⁾.

3.9.1 Repair of film thickness deficiencies

If the dry film thickness of the intumescent basecoat or topcoat, measured in accordance with Sections 3.8 and 4.7 of this document, does not comply with the nominal dry film thickness stated in the schedule of thickness, work shall be undertaken to bring the affected area up to the required thickness.

Where a decorative finish or bespoke finish has been specified, the contractor shall make provision for the removal of all visible dirt from the surface of the coating, following erection of the steelwork.

3.9.2 Repair of damage to completed Intumescent coating systems

Remedial work on complete fire protection systems will depend on both the extent of the damage and whether or not a sealer coat was applied to the original coating.

Minor damage, such as chips and scrapes, will not normally affect the performance of the material unless the service environment is wet or exposed, in which case damage may allow moisture ingress and lead to degradation of the intumescent. It is therefore always recommended that minor damage should be repaired at the earliest opportunity, following the procedure given below.

In cases of damage to the basecoat, the damaged area should be cut back to a firm edge. If the primer coat is damaged, any corrosion products which may have formed should be removed and the steelwork "patch primed" using a suitable compatible primer.

If only the basecoat is damaged, fresh basecoat or approved repair material should be applied to match the existing thickness, taking care not to excessively overlap onto the surrounding intact sealer. When the dried intumescent material matches the surrounding thickness, the recommended sealer coat (if any) should be applied either to the patch repair or overall.

If only the sealer coat is damaged, fresh sealer coat should be applied, either to the localised area, or over the whole section.

In the unlikely event that major repairs are required (i.e. due to water or chemical attack), the intumescent coating manufacturer should be consulted for specialist advice.

3.10 Site Health and Safety and Environmental Compliance

Prior to commencement of site application, and possibly as part of the pre-contract selection process, the contractor must provide confirmation of Health and Safety competence and procedures as outlined in section 2.3.4 of this document.

During and throughout the application process, full compliance with all relevant Health and Safety and Environmental legislation must be demonstrated. As a minimum this includes:

- Observance of all precautions and conditions for use of the coating system, as defined in the manufacturer's Product Safety Data Sheets.
- Compliance with relevant Site Storage Regulations, including COSHH Regulations where applicable⁽¹⁹⁾.
- Compliance with relevant Waste Disposal Regulations, in particular the Hazardous Waste (England and Wales) Regulations 2005⁽²⁰⁾; Waste Duty of Care Regulations 1991⁽²¹⁾ and, as of April 2008, the Site Waste Management Plan Regulations 2008⁽²²⁾ which will apply to all contracts with a value of £300,000 or more.

In addition, records should be maintained to show that all coating materials used on site (in thinned or un-thinned state) comply with the VOC limits quoted in Table 2, and are labelled as required in section 2.3.5.

3.11 Interaction with Other Services

Whereas the specifier may take into account the potential of the application process for causing disruption of other activities on site, when deciding on the criteria for product selection, it is the contractor who is responsible for arranging the site application schedules.

The coating schedule must be drawn up in consultation with other trades, so that all parties understand the demands and constraints of the application process.

The time available for coating will be limited by environmental conditions (and hence probably time of year), access, time pressures and deadlines – on the coating process and other trades - and probably a range of other factors as well.

This interaction with other trades and services is an important part of the site management role of the contractor, not only in avoiding conflict but also in ensuring that the time and conditions for a quality intumescent application are maintained as far as possible throughout the programme.

4. CONTROL OF SITE APPLICATION

This section sets out the factors that need to be considered to ensure that the site application delivers the quality of work defined in the specification, and satisfies all legal requirements.

Because intumescent thicknesses vary from section to section, attention to detail throughout the process is vital. Failure to apply the fire protection correctly may put lives at risk so mechanisms for ensuring that this does not happen are also included in this section.

4.1 Allocation of Responsibility

For any site application contract it is essential that every stage in the coating process is identified and responsibility clearly defined for administration, work progress, compliance with relevant regulations and quality of work carried out.

The main areas of responsibility to be defined and agreed for a fire protection contract include:

- The specification – responsibility for defining system performance requirements and detailed product and procedural standards to be applied.
- Choice of product and supplier, including responsibility for assuring compatibility between different coats if supplied by different manufacturers.
- Preparation of method statements, schedules and procedures for application and for dealing with technical issues that may arise on site – e.g. the need for site repair of damaged coatings etc.
- Health, safety and environmental precautions at site
- Compliance with all other relevant legislation, including site storage and waste disposal regulations.
- Responsibility for carrying out quality inspection and for raising and/or approving concessions and carrying out any necessary and approved corrective actions.
- Responsibility for maintaining appropriate records and for providing reports confirming that the application has been completed fully in accordance with the specification.
- Particular responsibility and arrangements for measuring and recording intumescent thicknesses should be defined.

4.2 Choice of Applicators

Competence in application requires an understanding of the importance of such factors as surface preparation, data sheet limitations for conditions during applications, achievement of film thickness etc. Such competence is important for any coating operation, but for intumescent paints the potential consequences of coating failure make the standard and control of application quality even more critical.

Confirmation of contractor competence in the procedures for installation of fire protection and the control of quality can be provided through third party contractor certification, and all ASFP contractor / applicator members must now hold third party certification for the application of intumescent coatings. Requirements

for such a scheme include verified skills training, ability to choose suitable products, certificated operatives and supervisors, random inspection, issue of certificates of conformity on completion, an audit trail and a UKAS accredited approval body. There are several such schemes available.

At the level of the operative, Informal evidence of competence in coating application can be provided in the form of completion of training courses run by individual manufacturers of intumescent coatings, but as these courses are unregulated the quality of the 'applicator approval' may vary.

Many client authorities and specifiers now require applicators to provide more formal evidence of staff competence, through completion of recognized applicator training courses.

As well as competence in application, application sub-contractors should be able to demonstrate a commitment to the health and safety of their staff working on site, as well as an appreciation of their Health and Safety and Environmental obligations under the law. Many clients and specifiers now make membership of the Contractor Health and Safety Assessment Scheme an essential element of their contractor selection criteria.

Use of such independent assessment schemes provides clients and specifiers with confidence regarding the competence of potential contractors, helps to fulfil their own duty of care responsibilities under the CDM regulations and gives the 'responsible person' confidence of compliance with the Regulatory Reform Order.

4.3 Quality Control Considerations and Equipment

Quality control measures at site should be adequate to confirm that the standards of surface preparation and application stipulated in the specification, and in manufacturers' technical data sheets, are being met. They should also be realistic and cause minimal disruption to the overall coating process (unless defective work is identified and corrective action becomes necessary).

Essential quality control criteria are defined in section 4.6 below and require the following fully calibrated and certificated measurement equipment to be available on site:

- Where steel surface preparation is to be carried out at site, pictorial standards for blast cleaning and for manual / mechanical surface preparation as supplied with EN ISO 8501-1:1988 should be available to ensure the correct standard is being achieved.
- Comparator plates or Testex tape and micrometer are required to determine the blast profile, where relevant. EN ISO 8503-1:1988 and EN ISO 8503-5:2004 apply.
- Ambient temperature thermometer
- Minimum – maximum thermometer
- Steel temperature gauge, preferably electronic
- Whirling hygrometer, together with a relative humidity and dew point calculator as included in EN ISO 8502-4:1999, or electronic equivalent.
- NB. Instruments are available which provide ambient and substrate temperatures, relative humidity and dew point calculations automatically.
- Tape measure to check steel section sizes, if necessary
- Wet film thickness gauges
- Dry film thickness gauges having a measurement range appropriate to the specified dry film thickness. Ideally the instruments used should have the capability to record thickness readings in batches, and it would aid the completeness of records if the readings were also downloadable to computer.

4.4 System Approvals and Certification

4.4.1 Product quality assurance

The manufacturer of intumescent coatings should be capable of providing irrefutable evidence of product quality and fitness for purpose. Assurance regarding product quality can be provided by the manufacturer in a number of ways. ISO 9000 registration is a good starting point – and most manufacturers are registered to this standard.

However, product-specific third party approvals carry more weight. Most third party product certification schemes focus quality audits specifically on fire protection and will ensure consistency in the manufacture, testing and batch approval process for intumescent coatings.

As stated in Annex C of this document, such third party product certification is now a requirement for listing of products in the ASFP Yellow Book, as well as being favoured by Building Regulations AD-B and contributing significantly to compliance with the Regulatory Reform Order.

4.4.2 System assessment and verification of fire performance

The above procedures will confirm that products are manufactured consistently to the approved formulation and tested to recognised standards, giving confidence about the quality of certificated products. Following laboratory testing, it is necessary for products to be assessed in order to determine the appropriate thicknesses for a range of steel section sizes and orientations.

The validity of assessments can be checked by reference to the procedures set out in the PFPF guidelines document referred to Annex C, or more specifically by reference to loading tables given in the Yellow Book. For standard sections the checking of assessed data is therefore relatively straightforward and is covered by third party certification as described above. The quality of bespoke fire engineering assessments is perhaps more difficult to check but again PFPF guidelines advise on the necessary qualifications, experience and competence of those who carry out the assessments.

At the present time, third party certification and/or listing in the Yellow Book are perhaps the most effective ways of demonstrating product quality and fitness for purpose.

In the future, testing to ENV 13381-8 and CE-marking will provide a further step in verifying product performance. Not only will this provide confidence about the fire performance of the system, but it will also provide independent information about product compatibility and durability in different environments.

4.5 Film Thickness Plan

Most construction projects are complex and involve a range of section sizes and configurations, each requiring a different thickness of intumescent coating to provide the specified level of protection. Some sections and configurations may also have been independently assessed, to determine the most efficient coating thickness.

The coating schedule for such a structure may therefore be quite complicated, and one of the main tasks for the site sub-contractor will be ensuring that each steel section receives the correct thickness of fire protection.

In order to assist the sub-contractor to deliver the correct quality of work, and to provide an easy reference for subsequent quality control checks, the following documents should be made available at the commencement of the work:

- A copy of the plans and drawings of the structure
- A list of the intumescent thicknesses required for each steel section size, or a printout from the intumescent supplier's product calculator for the project.
- A schedule of the measured primer thickness for pre-primed steelwork.

The coating sub-contractor may use this information to prepare a film thickness plan that best suits his schedule and work methods, but must retain the documentation for quality control purposes, either by his own QA inspector or to assist any third party inspection required by the contract.

4.6 Quality Plan, Inspection Criteria and Methodology

4.6.1 Quality plan

Competent contractors and applicators will already have in-house systems in place to control site work and to demonstrate compliance with specification requirements. The following mechanism is therefore offered as a possible refinement of those systems, but is not a mandatory or prescriptive requirement.

For most sizeable painting projects involving several tiers of contractual responsibility, it is good practice for the contractor to prepare a quality plan which documents the sequence of activities required to deliver the specified quality of finish. This plan also identifies the inspection stages in the process, and will normally be submitted to the Contract Administrator at the commencement of the work for his comment

and approval, and also to advise him of the key inspection stages or quality 'hold points' in the process. 'Hold points' are points in the coating programme where opportunities are offered to the client or third party inspector to confirm acceptance of the standards being achieved, before work is allowed to proceed to the next stage.

The quality plan can be produced in the form of a simple table and may serve a number of functions, as follows:

- It summarises the quality requirements contained in the specification and in coating suppliers' data sheets
- It can be structured to include reference to the standards or methods of test to be used, and criteria for work acceptance
- It can be used to record conformance with specification at each stage of the process
- It can be structured to include sign-off by client, third party agency etc at key points (hold points) in the process. However, periodic inspection by the client or third party inspector does not absolve the contractor of the ultimate responsibility for the quality of the finished work.
- The quality plan could be used as both a checklist for inspection, and a summary verification document to demonstrate compliance with the specification.

A typical layout for a quality plan / checklist is provided in Annex 1.

4.6.2 Site inspection criteria

Typically, the inspection criteria for a large construction project would include the following:

1. Surface preparation:

- Surface preparation standard – as specified, usually against EN ISO 8501-1
- Surface profile minimum and maximum – as specified (EN ISO 8503-2)
- Dust or other contamination – visual or EN ISO 8502-3

2. Application:

- Air temperature, substrate temperature, relative humidity and dew point (throughout the application process) – as specified or as manufacturer's data sheet.
- Batch numbers of all products used
- Dates and times of application and compliance with recommended over-coating times from manufacturer's data sheets
- Wet film thickness checks

3. Dry film checks:

- Dry film thickness survey and records:
 - (i) at primer stage
 - (ii) after application of intumescent basecoat and
 - (iii) on completion of coating
 Thicknesses at each stage should be in accordance with the specification.
- Visual appearance – as specified or in accordance with agreed standard.

NB. Dry film thicknesses should always be checked against the contractor's film thickness schedule, which defines the required thickness for each individual steel member. Drawings or tables showing the correct thickness for each member must therefore be available to the inspector (contractor's QA representative or independent inspector) prior to a dry film thickness survey.

4.6.3 Inspection methodology

Application must not proceed if the prevailing environmental conditions are outside the limits set out in the manufacturer's technical data sheets.

As a general rule, environmental conditions – air and steel temperatures, humidity and dew point – should be determined before commencement of work in the morning, afternoon and evening (if appropriate), and

at other times if conditions show a noticeable change (e.g. if it starts raining). All measurements should be logged and be available for inspection at all times.

For surface preparation and most application checks, the methods are clearly defined in recognized standards documents or in instructions provided with test equipment, and criteria for acceptance should be stipulated in the specification or in the coating manufacturer's technical data sheets.

The most important inspection requirements to ensure fitness for purpose of the applied fire protection coating are the determination of film thickness.

Wet film thickness measurements should be taken during application using a wet film gauge. These readings will provide a guide for the applicator to ensure that the required dry film thickness of the basecoat will be achieved. Wet film thickness measurements indicate the thickness of an individual coat. Care should be taken when applying subsequent coats, as readings may be misleading due to the gauge sinking into a softened previous coat.

Information on the wet film thickness necessary to give a specified dry film thickness should be obtained from the relevant intumescent manufacturers' technical data sheet(s).

Requirements for dry film thickness determination are more complex and of critical importance, so are covered in full in section 4.7 below.

4.7 Dry Film Thickness (DFT)

4.7.1 Measuring gauges

The method of thickness determination shall use a gauge employing the electro-magnetic induction principle. Such instruments shall have a range appropriate to the specified dry film thickness and shall be calibrated on a smooth plate prior to use. Calibration should use shims appropriate to the specified film thickness.

The instruments should be capable of storing data. Ability to print and/or download to computer would assist the contractor in presentation of data.

4.7.2 Thickness measurement

Primer thickness may be determined either after application in shop, or on site prior to commencement of application of the intumescent basecoat. Method of measurement should be as described in 4.7.3 below, and establishing the correct primer thickness is important as explained in sections 2.3.2, 3.3.4 and 3.7.4.

Allowing for the thickness of primer applied, the total dry film coating thickness of the intumescent basecoat should be determined prior to the application of any specified protective/decorative topcoat(s). Measurement at this stage will more easily facilitate any subsequent corrections which may prove necessary.

If the total intumescent dry film coating thickness, allowing for the underlying primer, is found to be within specified tolerances, application of the next coat (usually a decorative and/or protective coat) can proceed.

If the total intumescent dry film coating thickness is found to be outside the specified tolerances, the procedure outlined in section 4.8 should be followed.

Indentation of the coating by the measuring instrument probe indicates insufficient hardness of the coating and measurements should be deferred. However, if programming requires coating to proceed urgently, by agreement with the specifier a shim of known thickness can be used to spread the load of the probe tip on the coated surface, allowing measurement to proceed before the coating has fully hardened. The dry film thickness of coating and shim together can then be measured and the shim value deducted to give the coating thickness.

The protective/decorative coating thickness is difficult to measure due to the variance in thickness of the underlying coats and its usual relative low thickness. However, the thickness may be important to ensure the longevity of the system. Application within the specified tolerances is best ensured by careful monitoring of material usage and the elimination of surface defect prior to application.

When taking dry film thickness readings, it is recommended that no readings are taken within 25mm of the edge of an I section or within 25mm of the join of flange to web of an I section.

Taking the above into account, readings should be taken randomly over the remaining areas of the section with a frequency as described in 4.7.3 below.

4.7.3 Frequency of measurement

Sections should be measured in accordance with the following guidelines:

- (i) I Sections, Tee Sections and Channels
 Webs: Two readings per metre length on each face of web
 Flanges: Two readings per metre length on the outer face of each flange
 One reading per metre length on the inner face of each flange.
- (ii) Square and Rectangular Hollow Sections and Angles:
 Two readings per metre length on each face.
- (iii) Circular Hollow Sections:
 Eight readings per metre length evenly spread around the section

Where members are less than 2m in length, three sets of readings shall be taken, one at each end and at the centre of the member. Each set shall comprise the number of readings on each face given by (i), (ii) or (iii) above, as appropriate.

4.7.4 Film Thickness Surveys

In an ideal situation, every steel member in a construction would be measured in accordance with the above frequency guidelines, to provide a comprehensive picture of the fire protection of the completed work. Ideally also, such dry film thickness surveys should be carried out by an independent third party.

In practice, third party verification of thicknesses may not be called for in the specification, so the 'responsible person' must either commission such a survey or rely on data provided by the applicator for assurance that adequate thickness has been applied. Third party certification of applicators includes an assessment of their competence to carry out film thickness checks on their work, and involves continual assessment of their application standards and records.

The responsible person may therefore accept the data provided by certificated contractors as evidence of satisfactory coating thickness, where no independent survey has been carried out.

However, the question then arises as to what constitutes an acceptable film thickness survey. On a major construction project, measuring every steel member in accordance with the above guidelines would be extremely difficult if not impossible, bearing in mind the pressures of the build programme (often requiring steelwork to be clad-in or hidden behind ducting etc as soon as the coating has been applied) and the need for the coatings to become hard dry before meaningful readings can be taken. ISO19840:2004⁽²³⁾ recognises the need for thickness surveys to be practicable, and so relates the frequency of measurement to the area coated, with reduced frequency on larger areas. Unfortunately, the same logic is more difficult to apply to structures consisting of a large number of relatively small and complex elements.

Some compromise must therefore be agreed when setting out the criteria for an intumescent survey on site. These criteria should always be defined in the specification, to avoid uncertainty later.

Whether carried out by an independent third party at completion of application or by the contractor on an ongoing basis, the following guidelines for setting out a film thickness survey would be recommended:

- The contractor must provide suitable and adequate means of access, including to difficult and / or partially inaccessible areas. It is therefore important that surveys are scheduled when the fullest possible access is still available on site.
- All equipment used must be correctly calibrated, and if more than one party is carrying out thickness checks, agreement regarding calibration of all instruments must be reached before commencing.
- At least 10% of steel sections should be measured in accordance with the frequency set out in 4.7.3 above. These should include a representative mix of section sizes, and difficult access sections as well as those that are easiest to access.
- All other sections should be measured with reduced frequency, unless the detailed survey (of 10% of sections) identifies a recurrent problem of thickness.

- If the detailed survey reveals a trend of unacceptable thickness, this should be taken into account when planning the remainder of the survey.
- In the worst case scenario, a full and detailed survey according to 4.7.3 may be required.
- If certain faces of the sections are repeatedly found to be unacceptable (e.g. top flange or one face known to be difficult to access), the remainder of the survey should include detailed measurements of that face as well as random measurements of other faces.
- Where no unacceptable trends are identified, the remainder of the survey should consist of random readings taken at a frequency of 4-5 readings per metre length.
- Unacceptable low areas should be marked up for remedial coating by the inspector.

4.7.5 Acceptance criteria

The coating thickness acceptance criteria shall be as follows, assuming that the specified thickness is a nominal value:

- (i) The average dry film thickness applied to each element shall be greater than or equal to the specified nominal value.
- (ii) The average measured dry film thickness on any face of any member shall not be less than 80% of the specified nominal value.
- (iii) Dry film thickness values less than 80% of the specified nominal value are acceptable, provided that such values are isolated and that no more than 10% of the readings on a member are less than 80% of the specified nominal value.

Where any single thickness reading is found to be less than 80% of the specified nominal value, a further two, or where possible three, readings shall be taken within 150 to 300 mm of the low reading. The initial reading may be considered isolated if all the additional readings are at least 80% of the specified nominal value. If one or more of the additional readings are less than 80% of the specified nominal value, further readings shall be made to determine the extent of the area of under thickness. In such cases, low thickness areas identified should be brought up to the required thickness before proceeding to the next application stage.

- (iv) All dry film thicknesses shall be at least 50% of the nominal value.
- (v) The average measured dry film thickness of any face of any member should not exceed the manufacturer's recommended maximum thickness for the particular member shape and orientation.

4.8 Correction of Defective or Inadequate Coatings

4.8.1 Thickness correction

The importance of dry film thickness checking is emphasised where inadequate thickness is identified prior to application of the final sealer coat / decorative top coat.

In such situations it is a relatively simple exercise to define the extent of the deficient area(s) and to apply further coat(s) of intumescent product to bring the overall thickness up to acceptable standards.

However, if low thickness is not detected until after the sealer coat / decorative top coat has been applied, detailed guidance must be sought from the intumescent coating manufacturer. In some circumstances – and with supporting test evidence – it may be possible to remedy the situation by the application of further coats of intumescent paint, but in the other extreme it may be necessary to remove previous coatings in order to build up the necessary fire protection from scratch.

Where the intumescent coating thickness exceeds the limits stated in the manufacturer's recommendations, guidance should be obtained from the manufacturer.

4.8.2 Dispute procedure

A dispute as to the achieved thickness of an intumescent coating may arise for a variety of reasons, including:-

- Misinterpretation of specification.

- Incorrect matching of film thickness to section size.
- Faulty or inappropriate measurement equipment.
- Incorrect calibration of measurement equipment.
- Misinterpretation of the guidance given on measurement.

Where the parties are unable to agree, the following procedures are recommended:-

- The basis of the dispute is set out in written format.
- Where appropriate the coating manufacturer's advice is sought.
- Where appropriate, measurement instruments are re-checked for accuracy/calibration.
- The extent of the disputed area(s) is clearly defined by increasing the frequency of readings in the vicinity of exceptionally high or low readings.
- Where correction of the application is required, the procedures set out in 4.8.1 are followed.

5. RECORDS AND REPORTS

Detailed and accurate records are important for any coating contract, but for fire protection projects they are an essential contract requirement. Because the work can extend over a long period of time, several locations and possibly more than one product supplier and sub-contractor, evidence of compliance with the specification will often rely on the existence of a detailed and accurate dossier of information and records.

Such records will also be necessary to demonstrate compliance with statutory requirements. However, the mere existence of records may be insufficient to provide complete confidence that the work has been carried out to the required standards, therefore wherever possible key stages in the installation process should be witnessed by an independent QA representative or third party.

Validation may be through recognised third party certification schemes or through first hand inspection and acceptance (using a sign-off procedure, for example as suggested in Annex A). Alternatively, a combination of both may be used.

Where appropriate, site records should contain the following information:

5.1 Verification of Product and Specification

Confirmation of product testing and certification, preferably in accordance with a third party certification scheme and/or listing in ASFP 'Fire protection of steel in buildings'.

Confirmation of assessment in accordance with PFPF guidelines, comprising manufacturer's own data (or product calculator data) and/or assessment carried out by a fire consultant qualified to PFPF guidelines.

In addition, any contract specific requirements regarding product or specification should form part of the site records. For example, where appearance of the finish is important, and where sample paints or panels have been approved by the specifier or architect, these should form part of the product dossier.

5.2 Basic Contract Information

- Contract location
- Building owner
- Architect / design engineer
- Main/ management contractor
- Fire protection contractor
- Building control authority
- District surveyor
- Fire protection materials used – manufacturer and product type
- Inspection agency (if any).

5.3 Contract documentation covering the fire protection product and its installation.

- Substrate type (i.e. section sizes and shape, orientation, A/V value, etc.)
- Substrate location
- Surface preparation (i.e. degreasing, blast cleaning, etc. and standard)
- Identification of any primer and information concerning compatibility with intumescent coating.
- Evidence of third party product certification, including proof of specific testing for cellular beams and fire-engineered situations, giving relevant report reference etc.
- Declarations of Supply covering the fire protection products used.
- Batch numbers of products supplied.
- Thickness of intumescent coating required for the specified fire resistance period.
- Any variations or concessions agreed during the course of the contract.
- Design review to confirm any design changes and their effect on the specification, prior to commencement of application.

5.4 Quality Control Records

- All records should identify the areas inspected with reference to the relevant drawings, and should include:
- Environmental conditions – air and substrate temperature, relative humidity and dew point.
- Dry film thicknesses per coat and for the full fire protection system, for each element of the structure. Measurements should include:
 - the member identification mark
 - the number of readings taken
 - maximum coating thickness recorded
 - minimum coating thickness recorded
 - average coating thickness
 - any supplementary readings taken to establish if low readings (below 80% of specification) are limited and isolated areas.
- Variations, corrective actions or concessions carried out in relation to environmental conditions or dry film thicknesses.

5.5 Site Remedial Work

Where dry film thicknesses are checked after application of each coat, it is a fairly simple procedure to correct low thickness as this can be achieved by simply applying an additional coat (or part coat) before proceeding to the next stage of the specification.

If film thicknesses are not carried out with the required regularity, or if low thicknesses are not detected until the application process has been completed, it will be necessary to seek the manufacturer's advice regarding the best method of bringing the coating up to the required level of protection.

Advice may vary from complete removal of applied coatings, to selective removal of sealer coat or, if supporting test evidence is available, to building up the thickness of the intumescent basecoat (on top of the sealer coat) followed by re-application of further sealer coat.

In all cases, records must show the nature of defect, source of remedial advice and the full extent of remedial work carried out at site.

5.6 Independent Verification of Site Application

In the section on 'Use of Guidance – Materials and Workmanship', Approved Document B advocates the adoption of independent certification schemes specifically in the installation of fire protection, as follows:

'Since the fire performance of a product, component or structure is dependent on satisfactory site installation and maintenance, independent schemes of certification and registration of installers and maintenance firms of such will provide confidence in the appropriate standard of workmanship being provided'.

The ASFP now insist that contractor / applicator members should have third party accreditation, and it also aids compliance with the Regulatory Reform (Fire Safety) Order 2005.

Installers who subscribe to such schemes would be expected to maintain detailed records of the work and to carry out their own dry film thickness surveys to ensure that the completed job complies with the specification, and inspection/approving bodies should then be able to accept their data and/or Certificates of Conformity as a basis for signing off the work.

From a QA point of view, therefore, building owners and designers should be aware of the benefits of using reputable, independently certificated applicators. Where un-certificated contractors are nevertheless used, the contract should clearly define the responsibility for checking that project records are complete and that correct thicknesses have been applied.

The benefits of film thickness checking in process by the contractor cannot be over emphasised. At the application stage, any deficiencies in coating thickness can be rectified fairly easily.

Conversely, if checking is left to the end of the construction phase, any rectification work becomes much more difficult, costly and disruptive. In a worst case scenario, doubts resulting in the need for a full fire protection survey at this stage could result in delays to the commissioning of the building.

5.7 Compliance with the Regulatory Reform Order

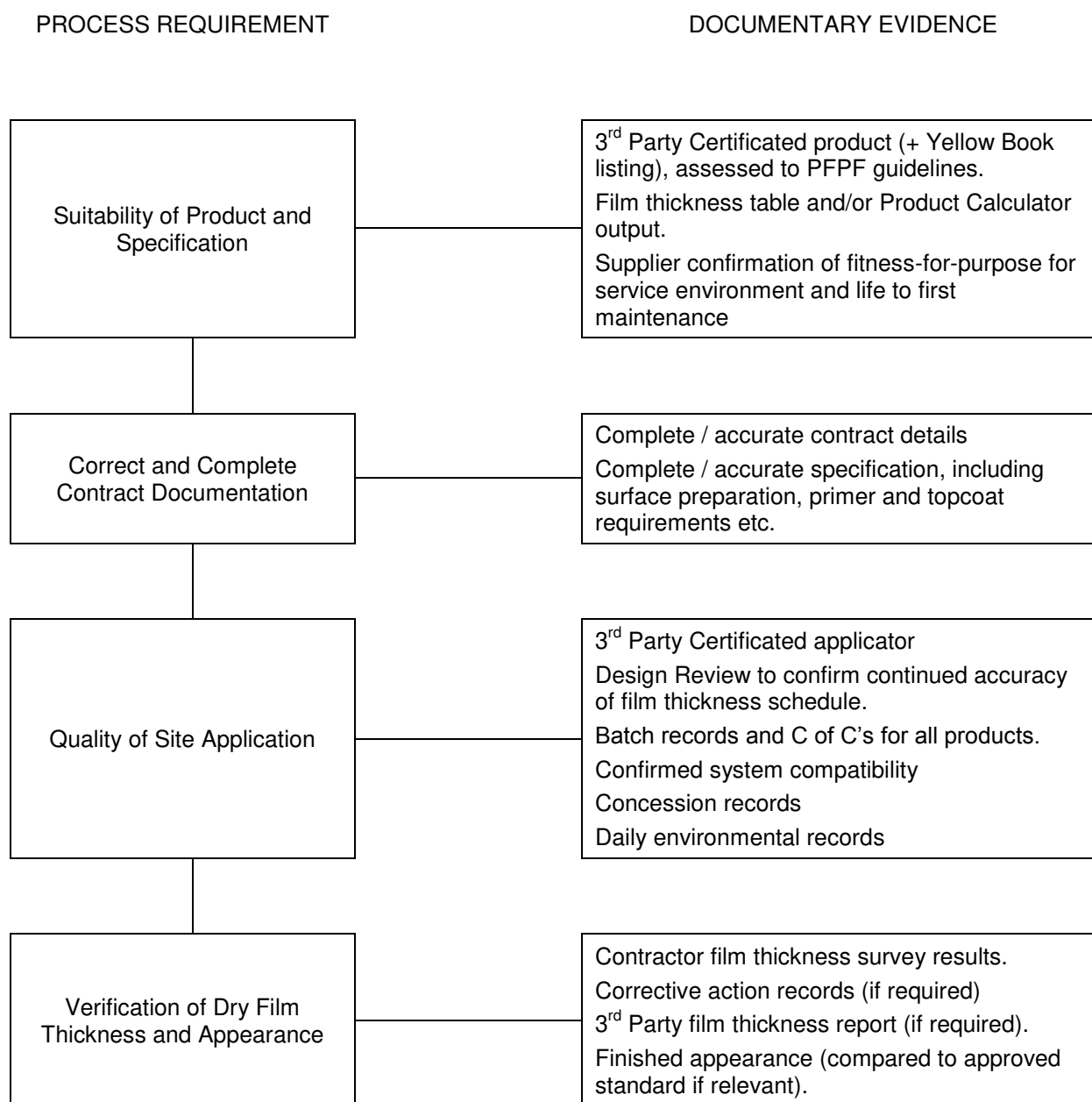
Under the Regulatory Reform (Fire Safety) Order 2005, the 'responsible person' (who may be the designer, specifier or contractor) is responsible for ensuring that the structure is fully compliant with all known, current legislation appertaining to the fire protection of the building.

Third party certification of product and applicator along with a completed Quality and Inspection Plan (**Annex A**) – supported by the Contractor's detailed records as detailed in Annex 2 - could be used as evidence of compliance with legal requirements as well as with the specification.

5.8 Contract Validation Checklist

Full compliance with this document will provide confidence that any site applied intumescent fire protection system has been correctly installed and that the relevant statutory requirements have been diligently and responsibly complied with.

A checklist of requirements – and the mechanisms for evidencing compliance – is provided in Annex B and summarised in Fig 1 below:

Fig. 1. Process Flowchart showing Key Validation Records, Reports and Certification.

6. ANNEXES

Annex A Site Quality and Inspection Plan / Checklist

The Inspection Plan / Checklist is not prescriptive, but may be used as a template either for:

- A verification document to confirm that every stage of the process has been completed satisfactorily in accordance with the specification. If used in this way, it could be submitted along with the full documentation package as a summary of the evidence (of compliance) contained in the package, or

- A simple checklist to assist the Contractor, Specifier, 3rd Party Inspector or Responsible Person to monitor or audit the process.

PROJECT (X)

Site Quality and Inspection Plan / Checklist			
1	Contractor	A	Approval Required
2	Sub-contractor	D	Document Required
3	Customer	H	Hold Point (advance written notice required)
4	Customer Agency	W	Witness Point (advance written notice required)
		V	Verification (may be observation or document review)
		R	Review
	PROJECT		ISSUE DATE

REF NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	REMARKS
	JOB OR PART IDENTIFICATION							
1	DESIGN CRITERIA	Document check	Validation of requirements					Load ratio / limiting temperature to BS 5950-8 or Eurocodes? Fire rating based on AD-B or BS 9999?
2	PRODUCT CERTIFICATION	Document check	Independent report or 3 rd party certification					
3	ASSESSMENT VALIDATION	Document and qualification check	3 rd party certification + PFPF guidelines					
4	DOCUMENT AVAILABILITY							
	Product Data Sheets	Document check	Available and complete					
	Method Statements							
	Design Drawings							
	Other Contract Documents							
5	SURFACE PREPARATION							
	Check Contractor daily records for completeness and spec conformance, and physically check 'SUBSTRATE' items below:	Document check	Complete and conforming with spec.					
	Part identification	Document check	Correct references					
	Visual appearance before / after degrease	Visual	No defects					
	Surface Preparation standard	ISO 8501-1	Sa2½ min. or as specified					
	Surface profile	Comparator ISO 8503-2	Specification					

REF NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	REMARKS
	JOB OR PART IDENTIFICATION							
	Dust grade	ISO 8502-3	Specification					
	Ambient environmental conditions – air and surface temperature, humidity, dewpoint.	Document check	Specification / data sheets					Danger of re-rusting
	HOLD POINT 1 – SURFACE PREPARATION							
6	PAINT APPLICATION : 1st Coat Primer							
	Pre-application checks – Check Contractor daily records for completeness and spec conformance.	Document check	Complete and conforming with spec.					
	Pre-application checks – Ambient Conditions							
	Air temperature	Elcometer 319 or equivalent	>5°C or as spec					Note also paint manufacturers' recommendations.
	Steel temperature		5 – 35°C; >3°C above dew point					
	Relative Humidity		<85% or as spec.					
	Dew point							
	Primer Application checks							
	Check product name, colour, batch numbers, coat number and that these match details on Contractor records	Visual container and document check						
	Check stripe coat (if specified)	Visual	Specification					
	Witness wet film thickness check	Comb gauge	Specification					
	Dry film thickness minimum, maximum and mean.	As this document	Specification					
	Visual appearance	Visual	No defects					
	HOLD POINT 2 – PRIMER CONDITION							
7	PAINT APPLICATION – Intumescent Basecoat							
	Pre-application checks – Check Contractor daily records for completeness and spec conformance.	Document check	Complete and conforming with spec.					
	Pre-application Checks – Ambient Conditions							
	Air temperature	Elcometer 319 or equivalent	>5°C or as spec					Note also paint manufacturers' recommendations
	Steel temperature		5 – 35°C; >3°C above dew point					
	Relative Humidity		<85% or as spec.					
	Dew point							

REF NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	REMARKS
	JOB OR PART IDENTIFICATION							
	Paint application checks							
	Check product name, colour, batch numbers, coat number and that these match details on Contractor records	Visual container and document check						
	Check drying time of last coat	Document check	Specification					
	Check stripe coat (if applicable)	Visual	Specification					
	Witness wet film thickness check	Comb gauge	Specification					
	Dry film thickness minimum, maximum and mean	As this document	Cumulative dft as specification					
	Visual appearance	Visual	No defects					
	HOLD POINT 3 – INTUMESCENT							
8	PAINT APPLICATION – Topcoat (if applicable)							
	Pre-application checks – Check Contractor daily records for completeness and spec conformance.	Document check	Complete and conforming with spec.					
	Pre-application checks – Ambient conditions							
	Air temperature	Elcometer 319 or equivalent	>5°C or as spec					Note also paint manufacturers' recommendations
	Steel temperature		5 – 35°C; >3°C above dew point					
	Relative Humidity		<85% or as spec.					
	Dew point							
	Paint application checks							
	Check product name, colour, batch numbers, coat number and that these match details on Contractor records	Visual container and document check						
	Check drying / over coating time of last coat	Document check	Specification					
	Check stripe coat (if applicable)	Visual	Specification					
	Witness wet film thickness check	Comb gauge	Specification					
	Dry film thickness minimum, maximum and mean	As this document	Cumulative dft as specification					
	Visual appearance	Visual	No defects					
	FINAL INSPECTION - HOLD POINT 4							
9	FINAL DOCUMENT CHECK	Document check	Full data pack, including independent certification if					

REF NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	REMARKS
	JOB OR PART IDENTIFICATION							
			required in the contract, and approval of site remedial work, if any.					

Annex B Contract Validation Checklist

Process Stage	Key Criteria	Requirement / Evidence
1. Design requirements	Is the basis for fire resistance rating defined?	AD-B or BS 9999
	What is the basis for load ratio / limiting temperature?	BS 5950-8:2003 or Structural Eurocodes ENV 1993-1.2 and 1994-1.2
2. Product Testing and Assessment	Is the product fully tested and approved for fire resistance?	BS 476 Pt21 or prEN13381-8 test data (independently verified)
	Has the fire protection system been fully and independently assessed across a defined A/V range?	CE-mark Third party certificated manufacturer plus Yellow Book listing.
	Does the design involve cellular beams and is specific test evidence available/	Testing in accordance with ASFP test protocol.
3. Contract specification	Will the product satisfy all design requirements for the project?	Section v. DFT table or printout from manufacturer's product calculator
	Are any fire engineered assessments included and are these correct?	Independent fire-engineer's assessment to PFPF guidelines
	Has a film thickness breakdown for each section been produced?	Section v. DFT table or printout from manufacturer's product calculator
	Will the specification satisfy durability requirements?	Manufacturer's test evidence. prEN13381-8 plus CE-mark.
	Are all coats compatible?	Manufacturer's test evidence or advice. prEN13381-8 plus CE-mark.
	Are all products compliant with the Paints Directive for VOC content?	Technical Data Sheets and container labels.
4. Installation Contractor competence	Is the contractor competent in his understanding, application and quality control of intumescent coatings?	Contractor audit, or Third party accreditation and Yellow Book listing. ISO 9000:2000 registered.
	Are the contractor's site supervisors and operatives competent in all aspects of intumescent application?	Training verified through third party certification and Yellow Book listing.
	Does the Contractor have a complete	Contract schedule, method statement(s)

Process Stage	Key Criteria	Requirement / Evidence
	understanding of the particular project, and a working plan to deliver contract requirements in full?	and quality and inspection plan.
	Is independent inspection of the contractor's work (including DFT surveys etc) necessary to validate the installation of fire protection?	Not if third party accredited.
	Are site Health & Safety measures properly covered?	Contractor Safety Policy, project risk assessments and safe working plans Should include compliance with site storage and waste disposal regulations. Compliance with / membership of the Contractor Health and Safety Assessment Scheme. Product Safety Data Sheets.
5. Contract Documentation (required at start-up)	Evidence that all above requirements are met.	Existence and quality of documents and supporting evidence.
	Correct allocation of intumescent thickness to each element of the structure.	Film thickness schedule and drawings (relating DFT to each individual structural element)
	Evidence of safe, serviceable and accurate equipment.	Servicing records or calibration certificates as appropriate.
	Other contract specific requirements.	Supporting documents Product Technical Data Sheets etc.
6. Completed project documentation.	Start-up documentation	Copies of all relevant documentation from the above.
	QA records – surface preparation, product details, environmental conditions, application, dry film checks etc.	Completed Quality and Inspection plan (or equivalent) plus supporting detailed records from site.
	Problems, faults requiring rectification during the course of the contract, corrective actions and concessions.	Documented evidence of any problems and actions taken, including all correspondence, justification, supporting evidence, manufacturer recommendations etc and authorisation of action.
	System validation.	Independent survey report (if any)
	Any other contract specific documentation required.	Supporting documents.

Annex C Fire Protection Materials and Systems

In order to fully appreciate the need for strict control procedures for the installation of intumescent fire protection systems on site steelwork, it is first necessary to understand the properties – including the strengths and limitations - of the technologies involved, their mode of action and the methods by which their fitness for purpose is determined and verified.

C1. Intumescent Coatings

The verb 'intumesce' means to swell, so that the process of intumescence in the context of fire protection is the reaction of active components of a coating to cause swelling when heated, producing an insulating char which affords protection to the surface to which the coating is applied.

Typically, intumescent coatings can swell to between 5 and 50 times their original applied thickness so that a 1mm film can produce up to 50mm of char.

The properties of the charred layer can be varied depending on the composition of the coating, from a light and fluffy layer to a dense, crisp and quite solid honeycomb. Whatever its appearance and integrity, the char will contain air vacuoles in a carbonaceous matrix, which effectively insulates the underlying steel substrate from the rapid temperature increase that would otherwise occur in a fire.

The intumescent therefore extends the load-bearing capacity of the steel structure, the time for which it protects the building from collapse being dependent on the thickness of the coating and the depth and insulation properties of the char produced from it. Most fire resistance periods required to meet UK building regulations can be achieved using this type of technology.

Intumescent basecoats usually comprise the following ingredients:

- A catalyst which decomposes to produce a mineral acid such as phosphoric acid. Ammonium polyphosphates are common catalysts.
- A carbonific such as starch which combines with the mineral acid to form a carbonaceous char.
- A binder or resin which softens at a predetermined temperature.
- A spumific agent which decomposes together with the melting of the binder, to liberate large volumes of non-flammable gases. These gases include carbon dioxide, ammonia and water vapour. The production of these gases causes the carbonaceous char to swell or foam and expand to provide an insulating layer many times the original coating thickness.

Intumescent coatings are essentially paints which are formulated for application at fairly high film thicknesses (typically 1.0 – 1.5 mm in a single coat). Two distinct categories of intumescent basecoats can be identified – thin-film and thick-film coatings.

C1.1 Thin film intumescent coatings

Thin film intumescent coatings can either be solvent or water borne and typically have a dry film thickness (dft) no greater than 5 mm. Intumescent coatings are widely used to protect steelwork for fire resistance periods of 30, 60 and are increasingly being used for periods of 90 minutes in cellulosic fire situations. In some instances, coatings can achieve 120 minutes fire resistance. In the UK, more than 70% of multi-storey construction (by floor area) has a fire resistance requirement of 60 minutes or less⁽²⁴⁾.

Most thin film intumescent coatings are designed for internal use or for sheltered protected locations in external environments. During the construction phase, some intumescent coatings can be temporarily exposed to the external environment and a protective sealer coat may be required. For all external exposure, the advice of the intumescent coating manufacturer should be sought.

C1.2 Thick film intumescent coatings

Thick film intumescent coatings are usually epoxy based and typically have a dry film thickness of up to 25 mm for 120 minutes fire resistance. These materials have been developed predominantly for use with hydrocarbon fires where the test heating regime is much more severe than that used for most industrial and commercial construction. While these materials may be used for on-site application in the construction industry, their use is not specifically covered in this publication.

C2. Intumescent Coating Systems

Whilst the intumescent basecoat is the system component that provides protection from fire, it forms only one part of the overall coating specification for structural steelwork. Of equal importance to the performance of the coating system are the other components and processes that provide protection – be this protection of the substrate or, in some cases, protection of the intumescent basecoat itself from the external environment.

For a typical thin film intumescent coating system the main components are:

- The primer. This may be included in the specification to provide anticorrosive protection or simply to enhance substrate adhesion. For on-site applied intumescent coatings, the primer will usually be applied under controlled conditions in shop, immediately after preparation of the steel surface (usually by blast cleaning). Its function will therefore be to protect the substrate during the transit and erection phases of the construction, and possibly – depending on service environment – for prolonged periods in service.
- The intumescent basecoat.
- A sealer coat or decorative top coat. For site applied systems, a sealer coat would normally only be applied if the service environment required the intumescent basecoat to be protected, for example in conditions of high humidity or possible condensation. A decorative top coat would usually be included in the system to provide colour and an aesthetic finish, and may therefore be omitted from hidden elements, for example in roof spaces or behind claddings. As a general rule, the coating supplier's advice should always be sought regarding the need for a sealer coat in any given environment. For most intumescent coating systems, the sealer coat and decorative top coat would be combined in a single product.

For systems where the primer is applied in shop but the intumescent basecoat and sealer coat are site-applied, the sources of the various coats may vary so it is essential that compatibility of the different components of the system has been confirmed with the manufacturer(s) before the primer is applied.

C3. Properties of Intumescent Coating Materials

Because intumescent coatings are specialised paint coatings, they are applied using the same techniques as any other paint system – normally by spray, brush or roller. The method of application offers a number of benefits, the most important of which are:

- Speed of application. This particularly applies where spray application techniques are used, as the required protection can be built up very rapidly in the hands of an experienced sprayer.
- Aesthetic appearance. Most intumescent systems are capable of a good standard of painted finish and so can provide an aesthetically pleasing appearance. They are also applied directly to the structural elements and so allow the designer to make a feature of the shape and size of individual elements.
- The quality of the surface finish can be affected by factors outside the applicator's control, such as the quality of the steel surface, so that procedures to remove surface defects – such as grinding of welds etc – may have to be included in the specification where a very high quality of finish is required.
- Protection of complex shapes. Intumescent coatings can be easily sprayed, brushed or rolled into complex joints and angles to provide the required fire resistance without the need for special fitting. The only provision is that application on such areas should be carried out with care, to avoid creating runs, sags and other surface blemishes that may affect the aesthetic appearance of the structure.
- Flexibility. Intumescent coatings are infinitely variable in terms of film thickness capability, so the exact thickness needed to protect a given steel section for a given time, can be specified and – with care - applied. This minimises wastage and hence cost.
- Savings in ceiling height. Intumescent coatings can be assessed for the protection of elements such as cellular beams, and hence can be applied to give the desired fire protection time without blocking the holes in the webs. This means that the design does not need to allow for services to be passed through the ceiling space, so reducing the height needed per floor – and possibly enabling additional floors to be added in high-rise structures.
- Ease of maintenance. Intumescent coatings do not need to be removed for inspection, nor generally for retro-fitting of new or changed services. Inspection is very easy – for example, as part of routine risk assessment of the building's fire protection, visual examination of the coating is generally sufficient to establish whether or not any deterioration has occurred over time. If so, removal and reinstatement of any affected coating can be carried out in the same way as for the maintenance of any other paint system.

The flexibility of intumescent coatings and their ability to be specified at precise thicknesses related to section sizes, also create potential difficulties for the applicator.

Putting procedures in place to ensure that the correct thickness is achieved on every individual section of the construction, is therefore of vital importance.

C4. Testing of Intumescent Coatings

Fire protection systems for steel structures are tested for their ability to retard the rate at which the steelwork heats up in a fire.

The 4th Edition of the Yellow Book recommends that limiting temperatures may be calculated for each element of the structure, using load ratios determined individually from fire design codes such as BS 5950-8:2003⁽²⁵⁾ or the Structural Eurocodes EC3-1.2 and 4-1.2, designated ENV 1993-1.2 and 1994-1.2⁽²⁶⁾.

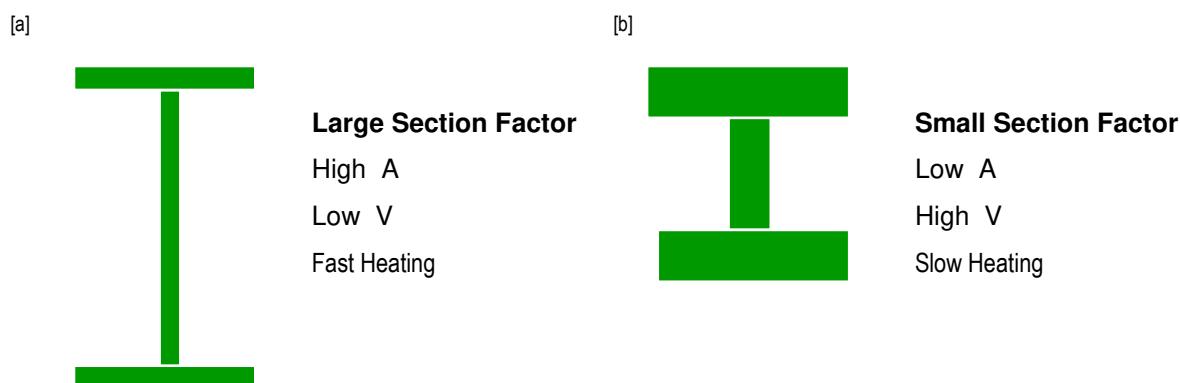
This therefore allows thickness data to be related to limiting temperatures for each particular element of the design, allowing fire protection thickness to be optimised wherever the load ratio – and hence limiting temperature – is known. Where this information is not available, thicknesses should be calculated in relation to agreed default limiting temperatures.

The structural strength of a steel beam is directly related to its mass and dimensions. Lightweight sections heat up faster than heavy sections, and hence require more protection. In the case of intumescent coatings this means that the thickness of coating required will increase as the weight of the steel element decreases.

Thickness of intumescent is determined, therefore, in relation to the 'section factor' of the steel, which in turn is defined as the exposed surface area (A) divided by its volume (V), resulting in the formula A/V .

In Figure 1 below, section (a) is a lightweight piece of steel having a large perimeter and therefore a high A/V , while section (b) is made of heavy steel with a short perimeter measurement and large cross-sectional area, giving it a relatively low A/V . Section (b) therefore has a larger heat sink than (a) and even without protection will take longer to heat up to its limiting temperature. It will therefore require less additional fire protection than section (a).

Figure 1. Effect of Different Steel Cross – Sections on Calculated A/V



This relationship between Section Factor, limiting temperature and thickness of fire protection is explained in the 'Yellow Book', which stipulates that the amount of fire protection required should be established by practical fire testing in a fully calibrated furnace by a UKAS-registered test laboratory. As the thickness of intumescent will be related to the steel section factor, the testing of intumescent coatings is fairly complex and needs to cover the range of sections used in construction.

It would be impossible to fire test every steel section size and configuration in order to establish the precise intumescent thickness needed for each duration of protection. The fire test programme for intumescent therefore consists of a limited but representative range of A/V sections for each protection time. Key sections are tested under load, but the majority are tested unloaded.

Testing is carried out in accordance with the methods detailed in the Yellow Book – currently BS 476 Part 21⁽²⁷⁾ but increasingly (and eventually exclusively) prEN 13381-8 for reactive systems - and to obtain the most cost-effective results the manufacturer's aims must be to achieve the desired test duration using the lowest possible coating thickness for each section size. The 'stickability' or adhesion of the coating is also assessed in the test, an important requirement and hence the need for the inclusion of the "loaded" tests.

On completion of the test programme the laboratory normally issues a Test Report. This gives details of the sections tested, the thicknesses of intumescent used and the time taken for each section to reach limiting temperature. prENV 13381-8 does not require failure temperature to be reported, but establishes a range of thicknesses related to limiting temperature, which in turn is directly related to applied load.

Test reports should not be confused with certification – independent fire-test laboratories issue technical reports containing factual data, and do not issue 'fire certificates' to verify intumescent thicknesses or test data.

Testing and assessment guidelines are included in the Yellow Book, which also assists specifiers by listing products already assessed in accordance with its guidelines.

C5. Assessment and Approval of Specification Thicknesses

The Fire Test Report itself will only give details of the actual sections selected for test – but once issued this becomes the basis for professional 'Assessment' – a process in which the test data is used to calculate the optimum thicknesses required for the full range of section sizes covered in the test programme. Depending on the composition of the test programme – and of course the results achieved – the assessment may cover a range of section types (e.g. I-sections, circular and/or rectangular hollow sections etc.) and orientations (e.g. beam and column).

Carrying out assessments of fire protection is a skilled operation and must be carried out by a competent fire engineer. The completed assessment should ideally be issued through an organisation subscribing to the Passive Fire Protection Federation (PFPF) document 'Guide to Undertaking Assessments in Lieu of Fire Tests'⁽²⁸⁾.

This document gives the assessment credibility as it sets out not only the standards and procedures that should be applied when conducting a fire test assessment, but also the skills, training and qualifications required for competent Assessors.

Approved Document B also favours the use of third party assessment, and it is now mandatory for all ASFP – listed products in the Yellow Book to carry third party certification issued by a UKAS notified body.

The assessment forms the basis of the manufacturer's data sheet specifications.

PFPF guidelines ensure that correctly assessed thicknesses are only possible within the limitations of the test data available, so that:

- Some products have assessed thicknesses across the full range of section sizes and orientations, so can be specified for all A/V values.
- Some products work well and are very competitive over a limited A/V range, but fail or perform poorly – i.e. require highly uncompetitive thicknesses – outside this range.
- Some products have very competitive loadings at some test durations, but fail or perform badly at others e.g. a good 60-minute product will not necessarily give good results at 90 minutes.

It is therefore unsafe to attempt to predict thicknesses for products outside the range that can be supported by actual test data. As a general rule, therefore, assessments are based on interpolations between data point, and extrapolations significantly beyond the test data are not valid or require specific justification.

Annex D Design for Fire Protection

D1. General Principles

The guiding principle of fire protection for steel framed buildings is that the steelwork should not increase above the limiting temperature for at least the appropriate period of time stipulated in Approved Document B in support of Building Regulations, or BS 9999 as published by BSI

Since the rate of uncontrolled temperature increase in a real fire situation will be extremely rapid, in order to ensure that the stability of the building is maintained in line with statutory requirements, the design must normally allow for an insulating barrier to be created between the fire source and the structural steel elements.

Where the fire protection is provided by intumescent coatings, and where the thickness of coating can be optimised for individual steel elements (as described in Annex C), fire engineering assessments carried out at the design stage can provide tailor-made, cost effective solutions.

D2. Protection for Partial Exposure to Fire

Calculations for fire protection loadings for columns normally assume exposure to fire on all four sides, while beams usually support concrete floor slabs so are assumed to require only 3-sided protection.

There are a number of circumstances where only partial protection is required. The most common of these are described in the Yellow Book and include 'Slimflor' and 'Slimdeck' beams, block filled columns, columns in walls and shelf angle floor beams.

D3. Fire Engineered Solutions

Other situations where intumescent thicknesses may be varied, either as a result of fire engineering considerations or by design-specific testing, are described in the current version of ASFP 'Fire protection for structural steel in buildings', so are only briefly covered in this document.

In all cases where the particular design requires or justifies variations in fire protection thicknesses, these variations should be determined by a qualified fire engineer and in accordance with recognised standards e.g. PFPF guidelines. Such variations may require more or less fire protection, and the most important situations where they may be applied are as follows:

D3.1 Composite beams

Because the limiting temperatures for composite beams supporting concrete slabs are lower than for non-composite beams, higher fire protection thicknesses may be required for beams in composite construction. Comprehensive design guidance is available for this type of composite construction⁽²⁹⁾⁽³⁰⁾. The guidance includes an explanation of where the voids in trapezoidal decking require filling.

D3.2 Bracing elements

The load ratio on bracing elements of a building may be assessed by the structural designer by reference to recommendations given in BS 5950-8, which may result in variations in the degree of fire protection required.

In some circumstances, no fire protection at all may be necessary, depending on the height of the building and/or its particular design.

D3.3 Cellular beams

Fire protection products on cellular beams do not behave in a uniform or typical manner, so that cellular beams require specific testing and assessment.

The ASFP 'Fire protection for structural steel in buildings' includes new guidance on the fire protection of cellular beams and castellated sections. Section 6.2 of that document provides guidance for intumescent coatings. Section 6.3 describes the fire testing protocol for reactive coatings.

Methods for determining limiting temperatures for such sections are described in ASFP Technical Guidance Note 009⁽³¹⁾, which states that 'simplified guidance is available from the intumescent fire protection manufacturers in the form of tables of limiting temperatures from product specific RT's, but only for beams with circular web openings. Geometrical limitations apply to the positions and sizes of the openings, and further guidance may be obtained from SCI Guidance Note RT 1187'.

Other methods described in TGN 009 are the use of proprietary software for the calculation of limiting temperatures for the particular design, and advanced fire-engineering analysis, which produces a thermal model for the design that can be applied for beams with rectangular openings as well as circular ones.

In all cases, fire protection loadings will be product specific, so that all intumescent coatings used on cellular beams must have been tested to the ASFP Protocol described in the current version of ASFP 'Fire protection for structural steel in buildings' publication.

D3.4 Concrete filled columns

Fire protection requirements for hollow steel columns filled with concrete can be significantly downgraded because of the strength and increased heat sink imparted by the concrete core in a fire situation.

D3.5 Lattice girders

Current 'Fire protection for structural steel in buildings' recommendations for lattice girders are that ideally the fire protection should be determined by full testing as a loaded member. Where this is not practicable, thicknesses should be assessed in accordance with a general limiting temperature of 550°C as for four sided exposure, regardless of the design loading.

In all cases where fire engineering considerations may be applied, the 'Yellow Book' should be consulted for guidance.

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