



EUROPEAN INDUSTRY BEST PRACTICE GUIDE ON THE APPLICATION OF INTUMESCENT COATINGS TO CONSTRUCTIONAL STEEL



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INTRODUCTION

The use of intumescent coatings (now increasingly being referred to as reactive coatings) for the fire protection of structural steel elements in the construction of buildings and other structures is well-established throughout Europe and other parts of the world.

As highly technical products, their formulation, production and quality performance is strictly controlled by reputable manufacturers, including conformance with industry codes of practice and use of independent third party product conformity certification.

Correct selection, application, installation and maintenance of intumescent coatings in accordance with the manufacturer's instructions are essential if the intended in-service performance and, most importantly, the extension of the stability of the building structure during a fire are to be achieved. The responsibility to ensure a building protected by intumescent coatings performs as expected lies not just with the coatings manufacturer, who controls quality only up to the point of delivery of product to the application site.

Many other stakeholders involved in the conception and construction of an intumescent coated building have equal responsibilities to ensure the final structure is fit for purpose in respect of its stability in the event of a fire. In appreciation of this, three European organizations, representing the manufacturers and applicators of intumescent coatings have collaborated on the preparation of this best practice guide on the application of intumescent coatings to constructional steel.

Whilst of wide-spread interest to anyone involved in the sector, this document sets out to provide guidance primarily to

- the owner (or the owner's nominated representative)
- the applicator of the coatings
- the coatings manufacturer

Note: a number of abbreviations and technical terms found throughout the guide are explained in Section 12 (see page 23)

CEPE (the European Council of paint, printing ink and artists' colours industry) is the sole European organization representing the interests of decorative coatings, printing inks, artists' colours and industrial coatings (including intumescent coatings). More information can be found on www.cepe.org

EAIPC (the European Association of Industrial Painting Contractors) is a cooperative of national employers or contractors organisations in the field of industrial painting, whose main activity is the application of surface covering, preserving, protecting, decorating, functionality enhancing or changing, organic and inorganic layer and/or layers on untreated and treated metal surfaces and concrete structures. More information can be found on www.eaipc.eu/

EAPFP (the European Association for Passive Fire Protection) acts as a European voice on behalf of national associations representing manufacturers, contractors and other institutions involved in fire protection to steelwork, timber, and other passive fire protection applications, including penetration seals and ductwork. More information can be found on www.eapfp.com/

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1. ROLES AND RESPONSIBILITIES OF STAKEHOLDERS

1.1 A number of stakeholders are involved in the application of a fire-protection intumescent coating to a steel structure, in either a new or an existing building.

- 1.2 This guidance note applies to three main stakeholders:
- the owner (or the owner's nominated representative)
 - the applicator of the coatings
 - the coatings manufacturer

If other stakeholders are involved, i.e. inspection bodies, architects etc, then it is the responsibility of the stakeholder who has contracted them to define their roles and responsibilities.

1.3 Information relevant to each player can be found in specific sections of this guidance, as shown in Table 1.1

Table 1.1: index to the guidance

Stakeholder	Section	Title	Key sub-sections
Owner or nominated representative	1	Roles and responsibilities	Table 1.2, Table 1.3
	2	Product selection	2.1 - 2.3
	3	Verification of dry film thicknesses	3.3
	9	Dry film thickness and measurement	9.1.2, 9.2.1 9.2.2
	11	Post-application issues	11.1, 11.3 11.4
Coatings applicator	1	Roles and responsibilities	Table 1.2, Table 1.3
	4	Product storage	4.1 – 4.3
	5	Substrate preparation	5.1 – 5.3
	6	Coatings preparation	6.1 - 6.2
	7	Application – environmental conditions	7.1 – 7.3
	8	Application - equipment	8.1- 8.5
	9	Dry film thickness and measurement	9.1 – 9.4, 9.6, 9.8
	10	Manufacturer's information	10.1
Coatings manufacturer	1	Roles and responsibilities	Table 1.2, Table 1.3
	2	Product selection	2.1, 2.4
	10	Manufacturer's information	10.1 – 10.6

- 1.4 For the three groups of stakeholder covered by this Guide:
- the information flows between them are summarised in Table 1.2
 - the responsibilities of each stakeholder are summarised in Table 1.3

Table 1.2: The information flows between the stakeholder groups covered by the Guide

The provider of the information:	The information that is provided to:			
	The owner	The application company	The coatings manufacturer	Others
Owner		The required fire resistance of the steel structure (<i>see Note 1</i>)		For some projects, the owner may decide to call on an architect, engineering bureau or inspection body to establish this data.
		The Am/V (Hp/A) values of those elements of the steel structure which need protection (<i>see Note 2</i>)		
		The critical steel temperature, in case of fire, of the elements of the structure which need protection (<i>see Note 3</i>)		
		The climatic conditions to which the structure will be exposed during its lifetime, preferably according to EN ISO 12944-1 (<i>see Note 4</i>)		Damage occurring due to the loading, transport, on site storage, during erection of the structure, or by other staff on the site, should be the object of a correction job as described under a separate heading in the contractual documents. To avoid subsequent discussions, it should be made clear from the beginning, and in collaboration with all involved parties, who will execute these repairs and in what budget
		The repartition of the tasks and responsibilities will be agreed and recorded in the building specification document		
		Information of the preparation of the steel structure, e.g. has it been blasted? has it been primed? If yes, the technical data sheet of the primer should be provided		
Coatings applicator	To report progress on the application work in an agreed format, such as weekly works meetings, letters/emails etc		Hands over the information file, as received from the owner, to the coatings manufacturer in order to obtain the necessary information for a correct application of the intumescent coatings system	
Coatings		All the specifications and information		

The provider of the information:	The information that is provided to:			
	The owner	The application company	The coatings manufacturer	Others
manufacturer		needed for the applicator to apply the coatings system correctly. This will include (non-exclusive list): the type and thickness of the layer, the climatic conditions required for application, the drying time, as well as the adequate surface preparation.		
		Technical and safety data sheets of the proposed products will be made available to the applicator, including if required a statement regarding compatibility between the intumescent coating and the applied primer		

Note 1	Required fire resistance	<p>The owner has to define the required R value of the different steel elements. He will use the national or European prescriptions, national building regulations or specific prescriptions (e.g. insurance requirements, fire brigade recommendations or an engineered fire solution). As a general rule, these requirements will vary between R15 and R120 but can vary for different parts of the same building.</p> <p>In most of the cases, these values will refer to the standard fire curve as described in ISO/TR 834-2.</p> <p>The required R values will be defined and recorded in the contractual documents between parties. In the absence of any specification, the fire curve as described in ISO/TR 834-2 will be applied.</p>
Note 2	Determination of the Am/V (Hp/A)	<p>The owner has to specify the structural elements which need protection. Usually, only the structural elements will require a fire protection.</p> <p>Steel elements usually have a R value by themselves, in certain cases sufficient for the requirements. Several parameters are taken into account, e.g. the “over” design in cold conditions. In several cases, a steel element in a structure can have a R value of 15 by itself, and in some exceptional cases, R30 can be achieved. If higher R values are required, an extra protection of the steel structure is required.</p> <p>The Am/V (Hp/A) value of each of the elements will be determined by the owner. It will be done based on the EN 1993-1-2 and the technical information given by the steel manufacturer.</p>

		<p>For each of the steel profiles, the following information will be made available by the owner:</p> <ul style="list-style-type: none"> - Required R value - Type of profile and dimensions (length) - Use in the structure: column, beam etc.. - Details of the exposure of the profile (how many sizes are exposed to fire) - Am/V (Hp/A) - Critical temperature of the profile.
Note 3	Determination of the critical steel temperature	<p>The owner will calculate, according to EN 1993-1-2, the critical temperature of the different steel elements of the structure. They will differ between elements.</p> <p>Getting help from an engineering bureau might be required in order to calculate these critical steel temperatures. Sometimes, the use of a default value might be needed, but these default values are usually on the conservative side, requiring higher thicknesses of intumescent coatings than needed, thus increasing the cost.</p> <p>The critical steel temperatures of the different elements will be recorded in the contractual documents. If they are not, default temperatures will be applied according to the local regulations.</p>
Note 4	Utilisation conditions	<p>The climatic conditions to which the steel structure will be exposed, both temporarily during construction work and in the future, have to be known and communicated to the coatings manufacturer, so he can describe the adequate coatings system, and more specifically, the nature of the top coat. In general, areas like covered but open-air parking, covered and non-heated areas etc should be considered as exterior environment. A reference to a classification according to EN ISO 12944-1 might be appropriate.</p>

Table 1.3: responsibilities of each stakeholder

Stakeholder	Responsibilities
Owner	Verification of the basis for the dry film thicknesses (loadings) calculated and provided by the coatings manufacturer
	Specify the coating system (<i>see Note 5</i>)
Coatings Applicator	Responsible for the application of the coating system, in accordance with the specifications provided by the coatings manufacturer, e.g. the surface preparation, the dfts, the climatic conditions during application, drying times etc
	Obligation to verify the dry film thicknesses in accordance with Section 9. Note: This may be supplemented by an additional independent verification of dry film thicknesses by a third party inspection body.
Coatings Manufacturer	Based on the information given by the owner, to determine an adequate coatings system and calculate the required dfts to obtain the required R value of the structure
	In case of maintenance of an existing coatings system, the manufacturer has to ensure compatibility between the original coating system and his proposed coatings system. The maintenance coatings system should be adequate for the environmental and climatic conditions to which the structure will be exposed during the future life time of the building.
Note 5	Specification of the coating system: Besides the type of fire (cellulosic, hydrocarbon or other) and the type of intumescent coatings, other factors, such as the Am/V (Hp/A) of the different profiles, the critical steel temperature and the required R values are necessary to make an adequate recommendation. For each structural element, these three items will be given to the manufacturer to allow him to calculate the adequate dfts, based on the certification report as issued by a notified certification body and based upon testing done by an accredited laboratory

2. PRODUCT SELECTION (PRIMER/INTUMESCENT COATING/TOPCOAT)

- 2.1 The intumescent coating system normally comprises a primer, intumescent coating and topcoat. It is therefore essential that equal attention is given to the selection of all components of the system.

Ideally, the system should be supplied by the same manufacturer.

To ensure the correct products are specified, factors such as the required fire resistance performance, the environmental conditions and the required service life of the system should be considered. For example, in an external exposure situation or in damp conditions, some products may be unsuitable or may require additional weather protection. Product selection decisions should be based upon test evidence from an independent laboratory, backed up with manufacturer's data, where this is considered appropriate. Applicators should choose products with appropriate approvals such as CE Marking, third party certification, or national approvals.

CE Marking of intumescent coatings includes type approval testing and also primer and/or topcoat compatibility and durability testing. The European standard for testing

and assessment is EN 13381-8. Some national standards cover system testing, and a European standard on system testing (EN 16623) has been published.

The coatings manufacturer should provide a specification document that sets of the performance of the proposed coating system against the project requirements.

2.1.1 *Primer*

Nearly all intumescent coatings systems include a primer as the first coat of the system. The primer provides the interface between the substrate and the intumescent coating. The primer prevents corrosion of the steel substrate and can also provide good adhesion of the intumescent coating to the substrate.

It is imperative with intumescent coating systems that the primer is approved for use with the specific intumescent coating. Confirmation of compatibility should be sought from the manufacturer of the intumescent material.

As well as the compatibility of the primer type with the intumescent materials there may be other requirements that the primer has to meet such as dry film thickness tolerances. Specific requirements should be included within the intumescent manufacturer's recommendations.

The primer used should be chosen based upon the required corrosion protection scheme, and also taking into consideration other factors such as:

- substrate
- surface preparation
- method of application
- environmental conditions
- drying requirements

Primers are approved in accordance with testing scheme requirements. These are typically done on a generic basis, and several families of primer are usually tested. Coating manufacturers are responsible for ensuring that the primer selected is approved.

Approvals should be limited, based upon the manufacturer's stated thickness range for the approved primers.

2.1.2 *Intumescent coating*

The intumescent coating reacts under the influence of heat by swelling in a controlled manner to many times its original thickness and typically producing a layer of carbonaceous char or foam, which acts as an insulating layer for the substrate.

The choice of intumescent coating should typically be made considering a variety of factors such as:

- location of application
- environmental conditions, both at the time of application and in use
- fire resistance period

- the size and geometry of the sections that need to be covered
- the critical steel temperature, when provided by the owner

It is also advised, that any dry film thicknesses, and the failure temperatures used, are checked against the design criteria of the steel structure. Caution should be exercised by the owner, to ensure that no-one has specified a higher than appropriate limiting temperature. This would potentially leave steel members under-protected in the event of a fire.

2.1.3 *Topcoat*

The topcoat is a coating applied to the surface of the intumescent coating either as a protection against environment degradation or for decorative purposes.

The topcoat should be specified, based upon the intended lifetime of the system and the environmental conditions.

Topcoats should be tested individually to demonstrate they do not restrict the intumescence process of the intumescent coating in the event of an in-service fire. Some standards, such as ETAG 18-02 also require topcoats to be tested to demonstrate durability.

The coatings manufacturer is responsible for ensuring the topcoat has been properly tested and approved.

- 2.2 Care needs to be taken to ensure that the correct products are specified. The following should be taken into consideration
- the required fire resistance performance
 - the environmental conditions
 - the specified service life of the system

For example, in an external exposure situation or in damp conditions, certain products may be unsuitable or may require additional weather protection.

- 2.3. Decisions can be based upon manufacturer's evidence, or more preferably, third party accredited test evidence. CE marking of intumescent coatings is possible to ETAG 18-02, which covers these items. Some national standards cover system testing, and a European standard on system testing (EN 16623) has been published.
- 2.4 The coatings manufacturer should provide a specification document that explains the performance of the proposed coating system against the project requirements.

3. VERIFICATION OF DRY FILM THICKNESSES (LOADINGS)

- 3.1 Most modern fire test and assessment standards, such as EN13381-8, produce very complex and detailed assessment information covering how an intumescent coating behaves in a fire situation.
- 3.2 The assessment will cover the fire ratings, the scope of steel sections covered, in terms of shape and section factor and a multi temperature analysis to cover the above.

- 3.3 It is recommended the owner receives third-party accredited dry film thicknesses for the project, to verify that they have been tested and assessed in accordance with the relevant standards.

4. PRODUCT STORAGE

- 4.1 Materials should be stored in dry, shaded conditions, away from sources of heat and ignition. Reference should be made to the manufacturer's technical data sheets for recommended storage temperatures. Material containers should remain unopened until ready for use.
- 4.2 All products will have a shelf-life (expiry date) from the date of manufacture. After this time the fitness for purpose of the product may be impaired. If the expiry date is not indicated on the product label, then the information should be obtained from the manufacturer. Any materials which have surpassed their designated shelf-life should be not used and be quarantined. The manufacturer should then be consulted to confirm whether an extension of shelf-life is possible or the material should be removed from site and replaced.
- 4.3 The shelf life of materials may be reduced if the product is stored outside the recommended storage parameters provided by the manufacturer.

5. SUBSTRATE PREPARATION

- 5.1 All intumescent products should be applied over suitably prepared surfaces. This guidance is based on the application of intumescent systems to steel substrates (defined in EN 16623 as: "*structural steel including galvanized steel. I and H section beams and columns, circular and rectangular hollow section beams and columns, concrete filled hollow sections and beams with openings in the web*").

5.2 *Steel surface preparation*

5.2.1 The primary method for steel surface preparation is abrasive blasting using grit or other suitable abrasive. Before blasting the steel surface should be assessed and treated in accordance with EN ISO 8504-1.

The steel should then be abrasive blast cleaned to the relevant standard in accordance with the manufacturer's recommendations.

This usually is Sa 2.5 for new steel and Sa 2 for existing structures, according to EN ISO 8501-1. Also the steel class (surface conditions as to corrosion before blast cleaning) should be specified: A, B or C and D for existing structures.

If after blasting oxidation has occurred between blasting and application of the primer system the surface should be reblasted to the specified visual standard.

5.2.2 The blast profile appropriate for the choice of primer should be achieved. Surface defects revealed by the blast cleaning process, should be ground, filled, or treated in the appropriate manner.

5.2.3 Other forms of surface preparation may be acceptable. The intumescent coatings manufacturer should advise and provide recommendations.

5.3 *Galvanised or thermal metal sprayed substrates*

5.3.1 These are metallic layers which are applied to the steel substrate to provide a high level of corrosion protection. Intumescent manufacturers will have specific recommendations for the treatment of these surfaces prior to application of an intumescent coating system and guidance should be obtained from them.

6. COATING PREPARATION

6.1 Primed surface preparation

Primer surfaces should be dry and free from all contamination immediately prior to intumescent application, and the Intumescent material should be applied within the overcoating intervals specified by the manufacturer of the primer.

Areas of primer breakdown, damage, corrosion etc., should be re-prepared in accordance with the manufacturer's recommendations prior to intumescent application.

6.2 Intumescent coating preparation

6.2.1 Conditioning of material prior to use

Some intumescent manufacturers may give specific recommendations as to the temperature condition at which materials should be conditioned prior to use.

6.2.2 Mixing

Intumescent materials tend to be highly structured products. Some products can build up a temporary false structure during the time it is stored in containers. Mechanical stirring is essential to ensure that the coating is mixed to a uniform consistency. Stirring also breaks down excess structure that may have developed during storage to avoid cavitation at the spray pump, and to ensure a steady flow. Over-mixing should be avoided, as this can lead to excessive aeration of the material, which when transferred to the dry film may have a negative effect on performance.

Intumescent materials may be supplied as either single pack or two pack products. Two pack products are supplied in two parts which need to be mixed together prior to application. If the two parts are not mixed together adequately, the product will not dry and harden to realise its designed performance.

The two parts of two pack materials can be mixed together in one container prior to application or they may be applied through specialized spray equipment which pumps the two parts separately to a mixing block where they are mixed immediately prior to application. This latter procedure is used primarily for two pack materials which have a relatively short pot-life. These are fast-reacting materials that, when mixed, gel and harden in a very short period of time.

In both application methods it is essentially that the two parts of two pack materials are thoroughly mixed and homogenized prior to application. Incomplete mixing will result in under cured material, soft spots in the applied film and impaired performance.

7. APPLICATION – ENVIRONMENTAL CONDITIONS

7.1 Monitoring of environmental conditions

7.1.1 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.

7.1.2 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.

7.1.3 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.

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

7.1.5 These environmental conditions should be guaranteed before, during and after the application (in function of drying) of a layer intumescent coating.

7.1.6 Application "off-site" has the important advantage that these conditions are more under control than "on-site".

7.2 *Application of the intumescent coating*

7.2.1 Before application, the following checks should be done:

- is the primer intact, un-damaged, contaminated or any degree of deterioration
- is the primer compatible with the chosen intumescent coating system and applied in accordance with the manufacturer's technical data sheets requirements
- is the primer within the manufacturer's overcoating period
- is the primer thickness measured
- is the surface clean and dry
- is drying time respected (in function of type product, thickness, ventilation, temperature and relative humidity)
- are the technical data sheets and the SDSs available for the intumescent coating;
- are batch numbers recorded
- where different structural steel sections require different intumescent coating thicknesses, is each appropriately marked or otherwise identified for application and record purposes

7.2.2 During application, thickness checks should be done:

- during and throughout the application process (note: full compliance with all relevant health and safety, and environmental protection legislation should be demonstrated)
- apply the necessary coating thickness or in the maximum possible thickness as described in the data sheets of manufacturer

- measure the wet film thickness of each layer to have an indication of the applied coating thickness. It is considered as an internal quality control and gives only an indication
- dry film thickness has to be measured once the coating film is cured so far that the gauge cannot be pressed in the coating

7.2.3 During application, the temperature and relative humidity etc should be recorded on a regular basis.

7.2.4 Apply in accordance with the manufacturer's data sheets and recommendations.

7.2.5 Application can be by brush, roller or (airless) spray. The choice of application is not only a workability issue but also relates to accessibility to the structures; to the dimensions of the elements to be coated; and to ambient and environmental conditions.

7.2.6 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.

7.2.7 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.

7.2.8 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.

7.2.9 Only thinners approved by the manufacturer may be used.

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

7.2.11 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.

7.3 *Preparation for application*

7.3.1 Prior to application of coatings on-site, all surfaces to be coated should be in a clean, dry condition. Any areas not requiring fire protection or which may be exposed to overspray should be appropriately protected by masking.

7.3.2 The coatings applicator is responsible for:

- the quality of the application
- execution of necessary inspections and quality measurements during the application

7.3.3 The coatings applicator 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 coatings applicator must ensure that all relevant safety data sheets, application instructions and method statements are available to the application operative(s) and that they are fully understood.

7.3.4 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) typically is in the range of 5-30°C. Any water borne materials in particular should always be protected from frost. DO NOT USE, and discard, any waterborne product that has frozen. 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.

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

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

7.3.7 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.

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

7.3.9 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 applicator 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.

8. APPLICATION - EQUIPMENT

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

8.2 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 should be observed.

- 8.3 Recommended thicknesses are provided on manufacturer's data sheets, along with the maximum achievable thickness per coat by the different methods of application.
- 8.4 Spraying has to be done with appropriated equipment, mostly airless spray pump (air pressure or electrical fed). Attention points to check with the manufacturer are:
- spray tip
 - spray angle
 - pressure
 - pump characteristics
 - diameters and distance hoses
 - pump filters
- 8.5 The choice between spraying and brushing is not only a technical choice but also one based on economic and environmental considerations. The application operatives have to be trained to use the equipment.

9. DRY FILM THICKNESS AND MEASUREMENT

9.1 Definitions

9.1.1 Dry Film Thickness (DFT)

This is 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, intumescent coating or topcoat, or to the system as a whole.

9.1.2 Thickness specification

This is a schedule of intumescent coating thicknesses that are to be applied to each of the steel sections to achieve the fire resistance periods given in the contract documents.

The owner or the applicator will prepare the 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. The schedule must include, but not be limited to, the following:

- Fire resistance period(s) required
- steelwork references as noted on general drawings
- steelwork section sizes and section factors
- details of any partial fire protection provided by concrete floor slabs, etc
- name of intumescent product(s) specified or selected
- thicknesses of intumescent product(s) and topcoats for each section
- method used to determine required coating thicknesses

When tendering for a contract, the applicator should include adequate provision for the inspection of dry film thicknesses of the coatings as they are being applied, in accordance with the guidance set out in this section.

9.2 Determination of the different layers

9.2.1 Primer film thickness determination

Because the steelwork delivered to site will often be treated with a primer applied elsewhere, the overall coating specification may be dealt with under separate

contracts, with little co-ordination. Consequently, the owner 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. 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 owner or applicator must be required to conduct a primer thickness survey prior to commencement of intumescent application.

9.2.2 *Intumescent coating thickness determination*

Determination of correct thicknesses for the intumescent coating 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 intumescent coating thicknesses will normally be the responsibility of the owner or applicator who will usually prepare this in conjunction with one or more manufacturers.

In order to confirm the correct thickness of the intumescent coating, 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 coating, the average primer thickness should be subtracted from measurements taken on the intumescent coating, 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 coating

9.2.3 *Topcoat thickness determination*

Where the topcoat is included in the specification to perform the function of a sealer coat – i.e. to protect the intumescent coating 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 coating above. In all cases, dry film thickness measurement and acceptance should be carried out in accordance with the procedure outlined below.

9.3 *Film Thickness Surveys*

The following guidelines for setting out a film thickness survey are recommended:

- The applicator must provide suitable and adequate means of access, including 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 the number of steel sections should be measured in accordance with the frequency set out below. 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 the dry film thickness is outside the specified range
- If the detailed survey reveals a trend of unacceptable thicknesses, this should be taken into account when planning the remainder of the survey
- In the worst case scenario, a full and detailed survey of all accessible sections 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 thickness areas should be marked up for remedial coating by the inspector

9.4 *Frequency of measurement*

Sections should be measured in accordance with the following guidelines:

- 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 **and** one reading per metre length on the inner face of each flange.
- Square and Rectangular Hollow Sections and Angles: Two readings per metre length on each face.
- 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.

9.5 *Methodology*

9.5.1 *Measuring gauges*

The method of thickness determination shall use a gauge employing the electromagnetic induction principle, in accordance with EN ISO 2808. 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 applicator in presentation of data.

9.5.2 *Thickness measurement*

If during thickness measurement there is indentation of the coating by the measuring instrument probe, this indicates insufficient hardness of the coating and measurements should be deferred.

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 below.

9.6 *Acceptance criteria*

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

- The average dry film thickness applied to each element shall be greater than or equal to the specified nominal value.
- The average measured dry film thickness on any face of any member shall not be less than 80% of the specified nominal value.
- 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.

- All dry film thicknesses shall be at least 50% of the nominal value.
- 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.

9.7 *Correction of Defective or Inadequate Coating*

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.

9.8 *Records and reports*

Site records should contain the following information:

- 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.

10. MANUFACTURER'S INFORMATION

10.1 All manufacturers must supply by law a safety data sheet (SDS) for the materials they supply. This SDS contains the relevant safety information including hazards and risks to enable the applicator to use, transport and dispose of the product safely. Users of the products must ensure they have the most up to date SDS available and have read and understood the information contained within it before using the material.

10.2 Manufacturers will also supply technical data sheets (TDS) or product data sheets (PDS) for the materials they supply. The TDS or PDS contains technical information on the material as well as limited guidance for surface preparation, application, storage, etc of the material. The user should ensure he has the most up to date TDS available and read and understand the information contained within before using the product

10.3 Both the SDS and TDS are usually available from the websites of the manufacturers.

10.4 Some manufacturers may also supply specific application instructions or guidance for their products. The information in these documents expands on the information contained within a technical or product data sheet. If application guidance is available from manufacturers then it is recommended that users consult the document before using the material.

10.5 All containers must carry a product label. As well as having the name of the product and reference, the label must contain the minimum of health, safety and environmental information required by law. Users must ensure they have read the label and understand the hazards and risks associated with using the product so they can take appropriate measures to protect applicators and others. The label should also contain a product reference and a unique batch number. Users should take note of this information. In case of a product complaint or product fault the batch number can be used to identify which batches may be at fault.

10.6 Where appropriate, the container and associated documents will identify the CE Marking and the Declaration of Performance of the product.

11. POST-APPLICATION ISSUES

11.1 *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.

The life of an intumescent coating system is the time that elapses before maintenance of the coating system is likely to become necessary. This is known as the 'life to first maintenance' and is dependent on the in-service environment and the properties of the selected coating system.

In most cases, correctly applied intumescent coating systems, exposed internally in corrosivity category C1 from EN ISO12944-2 (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.), should not require any maintenance over the design life of the building, other than for decorative purposes or where mechanical damage has occurred.

For all the other corrosivity categories specified in EN ISO 12944-2, the owner should establish periodic inspection and maintenance schedules. The advice of the intumescent coating manufacturer on the life to first maintenance should always be sought.

11.2 *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 intumescent coating, 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 intumescent coating is damaged, fresh intumescent coating 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.

11.3 *Change of ownership*

In some European countries it is a legal requirement for any records of any fire protection system to be passed on to the owner or the person responsible for the operation of the building. It therefore follows that any such information needs to be passed onto any new owners should the ownership of the building change. This is necessary so that the new owner of the building is aware of the level of fire protection afforded to the building and also that he/she is aware of any maintenance requirements for the fire protection.

11.4 *Change of use of building*

If the use of the building changes, usually as a result of change of ownership as described in Section 11.3 above, an assessment needs to be made of the adequacy of the applied fire protection. This applies for all fire protection measures, not just the application of intumescent paint. For example, if the building changes from office use to storage use, then the applied fire protection – usually specified or calculated on the basis of a low load ratio – may be inadequate and further fire protection, or other compensatory measures may need to be applied. This assessment will need to be undertaken according to the relevant legislation in each Member State.

12. ABBREVIATIONS AND GLOSSARY OF TERMS

Term	Section or table no.	Explanation
Am/V	Table 1.2 (Note 2)	Surface area of the heated section per unit length (Am)/volume per unit length (V)
Dft or dft	Table 1.3 (Note 5)	Dry film thickness
Hp/A	Table 1.2 (Note 2)	Heated perimeter of the heated section (Hp)/cross-sectional area (A)
loading	Table 1.3 Section 3	Another term for dry film thickness
PDS	Section 10.2	Product data sheet
R	Table 1.2 (Notes 1, 2)	Resistance to fire
Reactive coatings	Introduction	Preferred term for intumescent coatings
SDS	Sections 7.2.1, 10.1, 10.3	Safety data sheet
TDS	Section 10.2, 10.3	Technical data sheet
VOC	Section 7.2.11	Volatile organic compound

13. Standards and other information sources

Reference	Section or table no.	Title	Available from
ISO/TR 834-2:2009	Table 1.2, Note 1	Fire-resistance tests -- Elements of building construction -- Part 2: Guidance on measuring uniformity of furnace exposure on test samples	www.iso.org
EN ISO 2808:2007	Section 9.5.1	Paints and varnishes -- Determination of film thickness (ISO 2808:2007)	www.cen.eu
EN ISO 8501-1:2007	Section 5.2.1	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings (ISO 8501-1:2007)	www.cen.eu
EN ISO 8504-1:2001	Section 5.1.1	Preparation of steel substrates before application of paints and related products - Surface preparation methods - Part 1: General principles (ISO 8504-1:2000)	www.cen.eu
EN ISO 12944-1: 1998 (under revision)	Table 1.2, Note 4	Paints and varnishes -- Corrosion protection of steel structures by protective paint systems -- Part 1: General introduction (ISO 12944-1:1998)	www.cen.eu
EN ISO 12944-2: 1998 (under revision)	Section 11.1	Paints and varnishes -- Corrosion protection of steel structures by protective paint systems -- Part 2: Classification of environments (ISO 12944-2:1998)	www.cen.eu
EN 1993-1-2: 2005/AC:2009	Table 1.2, Note 3	Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design	www.cen.eu
EN 13381-8:2013	Section 2.1	Test methods for determining the contribution to the fire resistance of structural members - Part 8: Applied reactive protection to steel members	www.cen.eu
EN 16623: 2015	Sections 2.1, 2.3 and 5.1	Paints and varnishes - Reactive coatings for fire protection of metallic substrates - Definitions, requirements, characteristics and marking	www.cen.eu
ETAG 18-02	Sections 2.1 and 2.3	Fire protective products Part 2: Reactive Coatings for Fire Protection of Steel Elements	www.eota.eu