Good Practice Guide

GPG 01

Specification & application of Intumescent Coating Systems for the fire protection of structural steel

Version 1

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FIRE PROTECTION ASSOCIATION AUSTRALIA

Acknowledgements

FPA Australia would like to acknowledge and thank the Association for Specialist Fire Protection (ASFP), UK, for permission to use their Technical Guidance Document TGD 11 “Code of practice for the specification & on-site installation of intumescent coatings for fire protection of structural steelwork” as the base document for the development of this FPA Australia Good Practice Guide.

Specification & application of Intumescent Coating Systems for the fire protection of structural steel

FPA Australia aims to promote the protection of life, property and the environment from fire and related emergencies.

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Specification & application of Intumescent Coating Systems for the fire protection of structural steel

FPA Australia aims to promote the protection of life, property and the environment from fire and related emergencies.

1.0 Scope

This document has been prepared by FPA Australia's Technical Advisory Committee for Passive Fire Protection (TAC/19) to provide guidance to the fire protection and construction industry in relation to the specification and application of intumescent coating systems (ICS) for the fire protection of structural steel.

ICS's are an emerging method of providing fire protection to protect structural steel however, the specification and application of each component of an ICS is fundamental to the performance of the system. This guideline presents features of good practice in relation to the specification and application of ICS's and is recommended to industry in order to achieve consistency in the use and performance of ICS's.

2.0 Definitions

Appendix C includes definitions of particular words used in this document.

3.0 Intumescent coating systems

3.1 The use of ICS's and requirement for fire protection

In Australia, the predominant use of intumescent coating systems (ICS) is for the protection of structural steel against the effects of fire. Such systems are able to provide sufficient fire protection to prevent the structural collapse of the steel substrate of a building and to ensure that the structural fire resistance levels (FRL's), as required by the National Construction Code (Volumes 1 and 2 – Building Code of Australia), are achieved.

Figure 1 Sample of structural steel with an intumescent coating system applied.

Fire Resistance Level (FRL) requirements are expressed by the BCA deemed-to-satisfy requirements in minutes for the components of structural adequacy/integrity/insulation.

The FRL is the nominal grading period in minutes that is determined by subjecting a specimen to the standard time temperature curve regime set out in AS 1530.4, to specify:

(i) Structural adequacy

(ii) Integrity

(iii) Insulation

and expressed in that order.

It is also typical for alternative solutions developed to satisfy the performance requirements of the BCA to express FRL requirements in these terms.

The minutes required for each component are reflective of the time a product has continued to perform when exposed to the standard fire tests outlined in the AS 1530.4-2005. Care should be taken not to confuse these time periods with how the product may perform when exposed to a fire event in a building, the size and intensity of which is subject to several variables. FRL's simply provide a consistent way of measuring performance.

Minimum FRL's specified by the BCA deemed-to-satisfy requirements for the fire protection of building elements vary depending on building classification, fire compartment size and rise in storeys (Types of construction). These three variables, which contribute to and therefore reflect fire risk in a building, determine the type of construction required, type A, B or C. Depending on the type of construction, the FRL requirement varies accordingly.

As structural steel members do not play a role in providing a barrier to fire and smoke spread in a building, structural adequacy is the only relevant FRL requirement (refer to Appendix A for further detail in this regard). Accordingly FRL requirements for structural steel are expressed in the BCA as being between 30/-/- and 240/-/-. Manufacturers and distributers of ICS's should be able to provide copies of independent test reports that confirm that when applied as per the manufacturers recommendations, ICS's will achieve the required FRL, expressed in this way.

ICS's provide a method of achieving required FRL performance without encasing structural steel in concrete, vermiculite or fire rated board systems. This allows structural steel to become a feature of the architectural design. The following photographs illustrate traditional methods to achieve required FRL's.

Figure 2 Cementitious coating on steel beams

Figure 3 Vermiculite coating on steels beams and slab

Figure 4 Board product applied to steel beams and columns

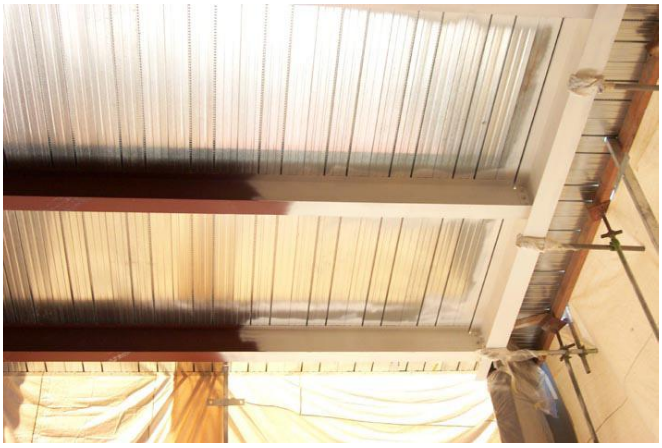


Figure 5 ICS applied to steel beams

3.2 Components of an ICS

An ICS generally has three main components—a primer, a basecoat (the coat that reacts to fire) and a sealer coat. In some cases the sealer coat may not be necessary.

The primer assists with the adhesion of the basecoat to the steel and the sealer protects against degradation of the basecoat. The basecoat is the key component that reacts to and provides protection from fire.

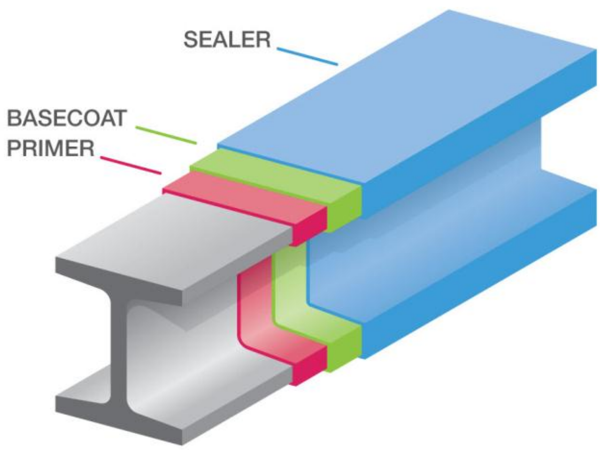


Figure 6 Steel beam with intumescent coating system (ICS) including primer, basecoat and sealer

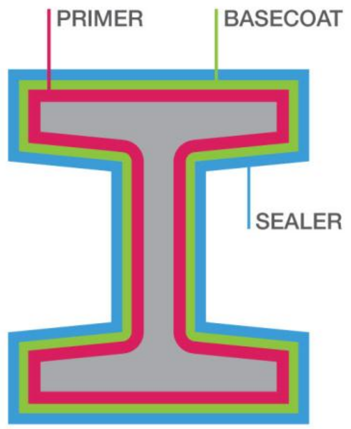


Figure 7 Steel beam with ICS in cross-section

Intumescent basecoats usually consist of the following:

- A catalyst, which decomposes to produce a mineral acid such as phosphoric acid.

  Ammonium polyphosphates are common catalysts.
- A carbohydrate, such as starch, which combines with the mineral acid to form a carbonaceous char.
- A binder, or resin, which softens at a predetermined temperature within the upper limits of the reaction temperature range.
- 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 binder to foam and expand to provide an insulating char many times the original coating thickness.

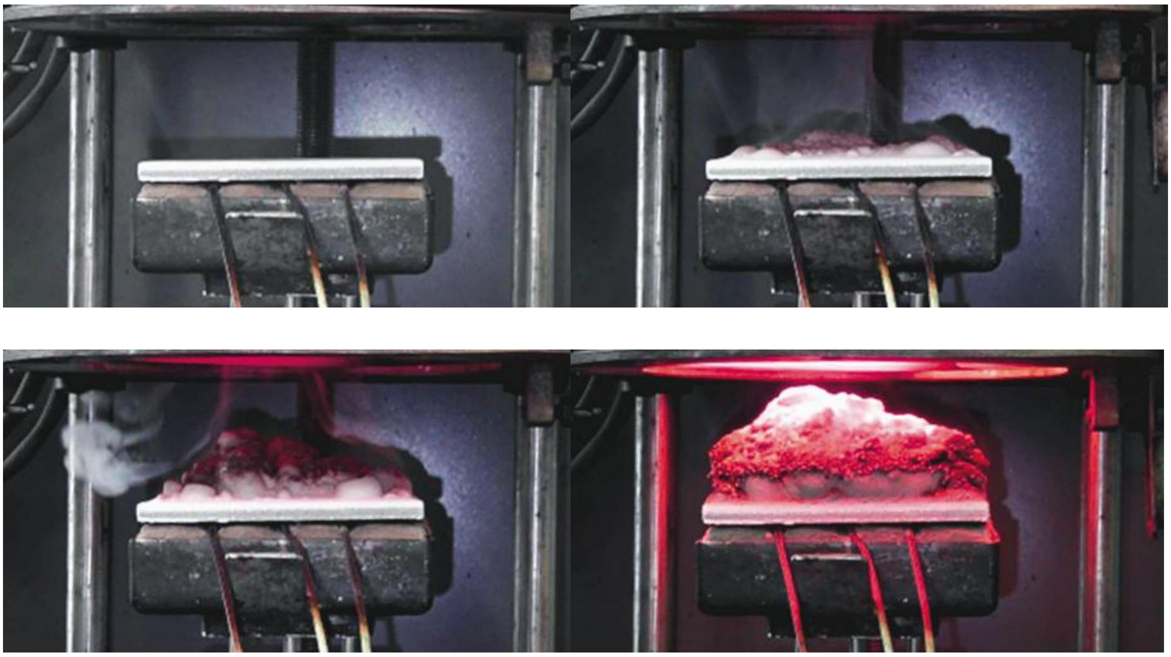


Figure 8 Intusmecent coating system exposed to radiant heat

3.3 Types of intumescent coating

Two generic types of intumescent coatings are manufactured for use by the construction industry and can be classified as thin film and thick film coatings.

3.3.1 Thin film intumescent coatings (single component)

Thin film intumescent coatings are the most commonly used of the two. They are easy to apply by normal painting techniques and usually provide a surface finish which is aesthetically pleasing. Their use covers all types of building development but they are particularly used in commercial buildings where the designer wishes to express the form of the steel structure.

The coatings can be solvent or water based and most are intended for internal use, although some are available for use in fully external situations. Many of the intumescent coatings are able to withstand a limited period of external exposure during the construction phase; usually by the application of a sealer coat.

3.3.2 Thick film intumescent coatings (two component epoxy)

Thick film intumescent coatings are normally epoxy based and typically used in external and/or aggressive environments or when longer periods of fire resistance are required.

Application can be either by spray, trowel or casting techniques where, in the case of the latter, very high quality hard smooth finishes can be achieved.

These coatings are very tough and durable and are ideally suited to areas which may be subjected to environmental extremes and mechanical damage, or where access for future inspection and maintenance will be restricted.

> Note: The main body of this document relates to thin film intumescent coatings, with occasional reference to thick film coatings where appropriate.

4.0 Specifying an intumescent coating system

4.1 Life of an intumescent coating system

The following flowchart shows the life of an ICS from the identification of the required FRL through the specification of the ICS, its application, verification that this application meets the specification, collating the documentation to demonstrate it meets compliance and finally maintenance. This Section covers the first three steps but all need to be considered when specifying an ICS.

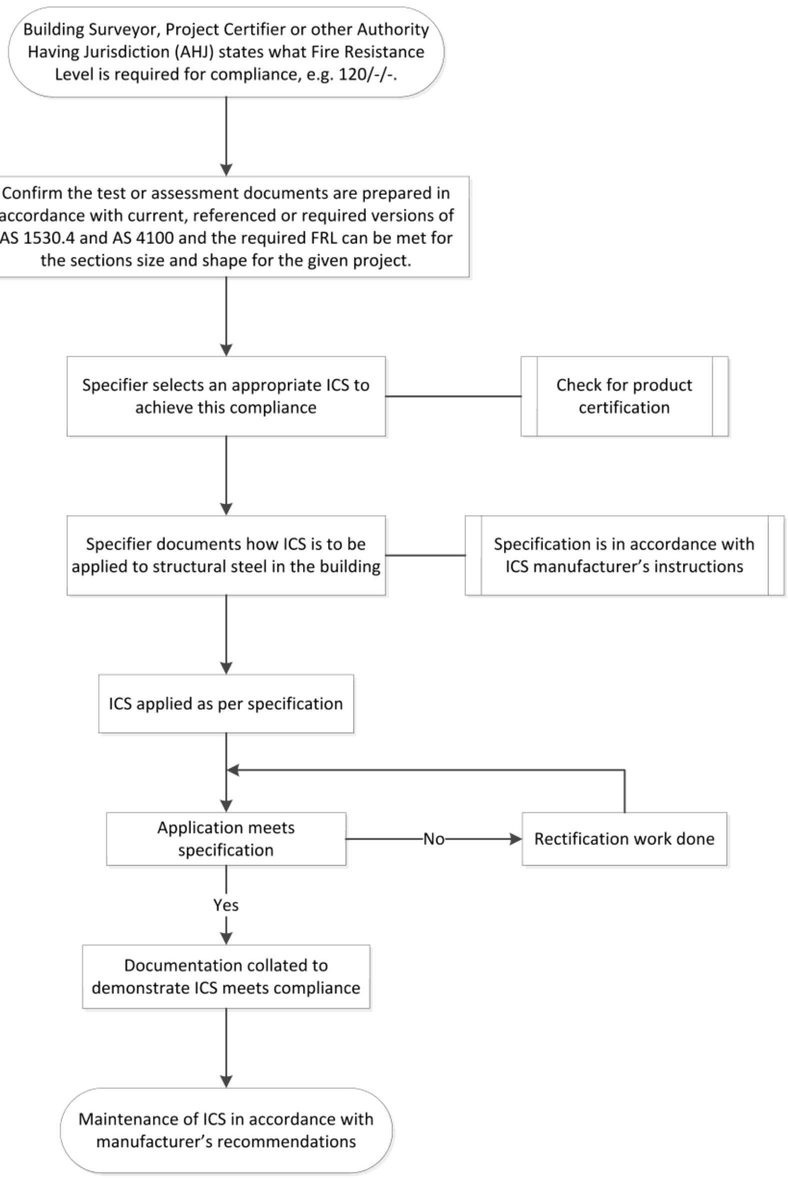


Figure 9 Life of an intumescent coating system

4.2 Intumescent coating system (ICS) components

When specifying an ICS, it is important that all components of the ICS and their application are fully considered to ensure their effectiveness. For a typical ICS these components include:

- The steel substrate that the ICS will be applied to
- The primer
- The basecoat
- The sealer or decorative coat, where applicable

Thick film intumescent coating systems may also require a sealer coat to prevent surface chalking when exposed to ultraviolet or moist conditions.

Advice should be sought from the manufacturer for the selection of each of the individual components listed above in order to ensure they meet the specific requirements of the application. It is also essential to ensure that each component is considered for compatibility with the other elements of the whole coating system.

Reference should be made to the manufacturer's data sheets to determine what type of primer is required to ensure good adhesion of the basecoat. Where a primer is used it is essential that it has been fully evaluated by the intumescent coating manufacturer as being compatible in both ambient and fire conditions and is supported by fire test or assessment.

4.3 Who specifies the required fire resistance?

The responsibility for the specification of the resistance requirements varies between projects.

However, regardless of who's responsible on a particular project, the FRL requirements should be clearly identified and the fire resistance period(s) for the ICS accurately defined, including any limitations of base coat thickness, critical steel temperature or Hp/A for the given FRL (*see* Appendix A for explanation of Hp/A). The Building Surveyor, Project Certifier or other Authority Having Jurisdiction (AHJ) should be consulted as to what the minimum FRL requirements that need to be specified are or to confirm the information that has already been provided is correct.

Information regarding periods of fire resistance can be obtained from the manufacturer and care should be taken to ensure that:

- The product information refers to the specific ICS to be used;
- It is up to date; and,
- It is confirmed by test or assessment documents prepared in accordance with AS 1530.4 and AS 4100.

4.4 Factors for consideration when specifying an ICS

Several factors need to be considered when specifying an intumescent coating system:

- The design life and life to first maintenance of coatings;
- The required fire resistance level (FRL);
- The required protection for the environment in which the ICS will be exposed;
- The required thickness and/or limitations of all coats; and,
- The compatibility of the primer, basecoat, sealer and, if applicable, decorative coat.

4.4.1 Design life of intumescent coatings

Before a particular ICS is specified, consideration should be given to the environmental conditions that the system must withstand, both during the construction phase and throughout the life of the building. Once again, advice should be sought from the manufacturer to ensure that the most appropriate system is selected for the anticipated environmental conditions. The projected life of the ICS is based on the time which can elapse before maintenance of the coating system may be necessary. This time is known as the “life to first maintenance”.

The “life to first maintenance” of an ICS is dependent on the in-service environment and the properties of the selected coating system. In the majority of cases the application of thin film intumescent systems to internal dry environments will require little or no maintenance over the lifetime of the building. Where maintenance is required it is often to preserve aesthetic appearances demanded by the architectural specifications and, as such, falls within normal redecoration cycles. For more severe environmental conditions however, thin film intumescent systems, where suitable, are likely to require a specified maintenance programme. In some cases a thick film system may be considered more appropriate.

In addition to the above, intumescent paints are expected to be included as part of the buildings routine maintenance plan for the life of the building. A competent person must repair all areas of mechanical damage or else performance may be seriously impaired.

Figure 10 ICS failure - bubbling

Figure 12 ICS failure – incompatible primer

Figure 11 ICS success – perfect finish

4.4.2 Testing – fire resistance level

A range of intumescent coating materials are available to enhance the fire resistance of structural steel members. To identify the fire resistance level of an ICS achieved by the protected structural element, fire tests of the ICS on load bearing elements of the building construction should be carried out by a NATA accredited test authority in accordance with the methods defined in AS 1530.4 and assessed by a registered test authority using the methods specified in AS 4100.

Confirmation of the fire resistance level for an ICS can be obtained by seeking a copy of the independent test or assessment documents from the ICS manufacturer referencing the test method applied and the results achieved.

Figure 13 Example of intumescent column (short section) test

4.4.3 Classification of environment

4.4.3.1 Environments

Environments can be classified into atmospheric categories. There are two Australian Standards that cover this:

- AS/NZS 2312, Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
- AS 4312, Atmospheric corrosivity zones in Australia

Both standards classify environment types into five different groups; however, they each use different rating systems. Corrosion categories are as follows:

AS 2312	AS 4312	Corrosivity Rating	Typical Environment
A	C1	Very Low	Dry indoors
B	C2	Low	Arid/Urban inland
C	C3	Medium	Coastal/Industrial
D	C4	High	Marine(calm water)
E	C5	Very High	Marine (ocean surf)

An additional classification 'T' has been included in AS 4312 to cover tropical zones of Australia, which takes into consideration the effects of monsoonal weather. It has a similar corrosive rating for metals as B/C2 but also needs to consider exposure to high levels of UV and rainfall.

The majority of construction applications of ICS are likely to fall into categories A/C1 and B/C2. AS 2312 and AS 4312 are for the design of corrosion protection rather than fire protection; however, consideration may be required where a sealer or top coat is required to protect the intumescent basecoat, particularly if used for external applications.

4.4.3.2 Environments and environmental factors requiring special attention

Some examples of environments and environmental factors that are corrosive or otherwise require special attention are:

(a) Exterior situations exposed to the weather or salt spray

(b) Corrosive atmospheres

(c) Tropical / humid environments

(d) Extremes of temperature

(e) Biological attack, (i.e. food processing plants and breweries)

(f) Frequent cleaning/washing, (i.e. medical facilities and abattoirs)

(g) Splash zones

(h) Risk of mechanical abrasion and/or impact

(i) Continuous or intense vibrations

4.4.3.3 Suitability

Intumescent coating manufacturers can confirm the suitability of their system(s) for use in the environment or environmental conditions in which the coating is likely to be exposed.

4.4.4 Specifying intumescent basecoat thickness requirements

Once the fire resistance requirements for the building are known this can be used to determine the required basecoat and basecoat thickness.

The responsibility for specifying the basecoat thickness shall be clearly identified in the project specification and may be allocated to the architect, structural engineer, applicator or material supplier.

Intumescent basecoat thicknesses can be obtained from manufacturer's data sheets and are also included in the test and assessment reports. Intumescent basecoat thickness for the purpose of fire tests and assessments are reported in dry film thickness (DFT).

In order to establish the correct intumescent basecoat thicknesses required to meet the specified fire resistance periods, the following information must be available:

- Fire Resistance Level (FRL)
- Steelwork arrangement drawings, clearly marked to show the elements to be protected and the extent of protection
- Steelwork section sizes and weights
- Nature of any partial fire protection provided by concrete floor slabs, fire resisting walls, etc.

4.4.5 Specification and compatibility of basecoat and primer

The basecoat manufacturer typically lists the compatible primers that can be used and vice versa for a primer manufacturer. Where there is any doubt, good practice is to consult the manufacturer(s).

4.4.6 Specification and compatibility of sealer coat

Normally, the intumescent basecoat manufacturer will supply the sealer coat, but it may be possible to use alternatives. However, if you plan to use an alternative you should confirm its compatibility with either (or both) the basecoat manufacturer or sealer coat manufacturer.

4.4.7 Standard of cosmetic finish

The visual quality of the intumescent basecoat finish will vary depending on the method of application. The required standard of finish should therefore be included in the project specification and, in order to satisfy the standard of visual appearance, samples could be prepared to show the finishes which can be achieved.

The types of finishes that can be specified are:

(i) Basic finish

A basic finish appropriate for non-visible areas or where surface finish is not important. Reasonably smooth and even; "orange peel", or other texture, minor runs and similar minor defects are acceptable.

(ii) Normal decorative finish

A good standard of cosmetic finish, generally when viewed from a distance of 5m. Minor "orange peel", brush marking or other texture is acceptable.

(iii) High decorative finish

A high standard of evenness, smoothness and gloss level when viewed from a distance of 2m.

To ensure the required surface finish will be obtained, the intumescent coating should be of an acceptable standard before application of the sealer and/or decorative coat. A sealer coat, or decorative coat, is normally relatively thin, which will highlight the texture of the surface over which it is to be applied. It should be noted that intumescent coatings applied by spray will provide a superior finish to those applied by brush or roller.

Figure 14 Application of basecoat by spraying

Figure 15 Application of basecoat by roller

5.0 Preparation for application

5.1 Allocation of tasks

The use of intumescent coatings requires the co-operation of different suppliers, contractors and sub-contractors with differing independent management. In order to ensure that all procedures are met, each management team should be aware of their individual responsibility to complete tasks and meet the correct specification conditions.

Responsibility for all operations involving the use of intumescent coatings—including design, specification, scheduling, application and repair—should be clearly stated between specifiers, suppliers, contractors and sub-contractors.

However, notwithstanding the above, it is the responsibility of the application contractor to ensure that the ICS is applied to meet the required specification and to confirm the compatibility of the system with the manufacturer.

5.2 Factors affecting the choice of application contractor

Application contractors should be able to provide evidence of their knowledge and competence in the application of ICS and have an endorsement from the intumescent coating manufacturer.

Supervisors of application should have an understanding of the principles of the fire protection of structural steel using ICS.

5.3 Material supply

It is advisable to check with the manufacturer(s) and/or supplier(s) to ensure that sufficient quantities of the specified materials are, or will be, available to meet the requirements of the construction programme. Where sufficient quantities are of the specified materials are not available, care should be taken to ensure that any substitute materials meet all the requirements of the original specification.

Also, the application contractor should ensure that all materials supplied have been manufactured to ISO 9000, that they are within the stated shelf life and suitably identified to allow traceability.

5.4 Storage of materials

The storage of all materials should be in accordance with the manufacturer's data sheets. As a general rule, the following advice applies:

- All materials should be stored within the range of 5°–30°C.
- Material containers shall remain unopened until needed and shall be used in date order.
- Material should be stored off the ground and protected from the elements.

5.5 Mixing of materials

All mixing should be carried out in accordance with the manufacturer's data sheets. Materials taken from store should attain the temperature recommended for use (and steel temperatures should be within guidelines) before being applied.

5.6 Scheduling

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

5.7 Quality control equipment

The application contractor should ensure that all equipment to carry out the surface preparation and application of all components of the ICS, to the project specification, are available and in good working order.

The equipment manufacturer's instructions should be followed and each instrument operated in accordance with its own instruction manual.

Some of the equipment that may be used is listed on the following page.

Some of the equipment that may be used includes:

- Comparator gauge or "Testex" tape for measuring blast profile
- Steel temperature gauge, preferably electronic
- Atmospheric temperature thermometer, including minimum and maximum temperature
- Wet film thickness gauge

Figure 16 Wet film thickness gauge – micron scale

- Dew point gauge

Figure 17 Dew point gauge

- Dry film thickness gauge

Figure 18 Dry film thickness gauge

5.8 Documentation

The application contractor shall ensure that all relevant data sheets, application instructions and method statements are available to their employees who are applying the ICS and that they are fully understood.

5.9 Health and safety

The application contractor must always demonstrate compliance with all relevant health and safety and environmental legislation for all aspects of the work.

5.10 Environmental conditions

To ensure appropriate application, ambient conditions should be measured immediately prior to the start of preparation/application and thereafter at a maximum of four hourly intervals. If ambient conditions are likely to be subject to change, the frequency of measurements should be modified appropriately based on the anticipated speed of change. The ambient temperature and relative humidity should be within the range recommended by the coating manufacturer throughout the application and curing process.

6.0 Application

6.1 Marking of steel for identification and traceability

It is usual, for structural steel sections, to require different coating thicknesses. It is therefore important to ensure that all sections are correctly identified for application and record purposes. Such identification on site should not interfere with the application of the ICS.

6.2 Steel surface preparation

Generally, steel erected on site will already be blasted and primed but, if this is not the case, all steel surfaces should be clean and dry prior to the commencement of blast cleaning. 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 can be removed by the use of suitable emulsifying degreasers, suitable clean organic solvents or steam cleaning.

Figure 19 Steel surface pre-blast

Blast cleaning of steels surfaces to remove scale and rust should be done in accordance with ISO 8501-1 Sa2.5 or AS 1627 class 2.5 or the project specified equivalent.

A surface profile will usually be specified within the range of 35 – 75 microns and, in general, will not exceed 100 microns. All dust and spent abrasive must be removed from the prepared steelwork. This can be achieved by blowing down with clean dry compressed air. Inspection of all the prepared steel surfaces, and any corrective action required, should be carried out as required.

Figure 20 Steel surface after blasting

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

> **Note:** In some instances it may be possible to apply the intumescent system onto unblasted steel, although this would have to be checked with the manufacturer on a project by project basis as they may have test data to support the fire resistance of unblasted coated steel.
>
> In all such instances it will still be necessary to remove loose mill scale and rust by such methods as hand or power wire brush, needle gun, etc., prior to the application of a compatible surface tolerant primer.

6.3 Masking and overspray

Figure 21 Example of masking to avoid overspray onto other surfaces

The application contractor should ensure that areas not requiring fire protection should be adequately masked and other areas, which may be subject to overspray, are also appropriately protected.

6.4 Primer application

In instances where the application contractor is required to apply a primer, it must be applied strictly in accordance with the technical data sheet of the primer manufacturer.

The dry film thickness of the primer should be measured to ensure compliance with the specification.

The primer thickness should then be deducted from the subsequent intumescent basecoat thickness in order to provide a true basecoat thickness measurement.

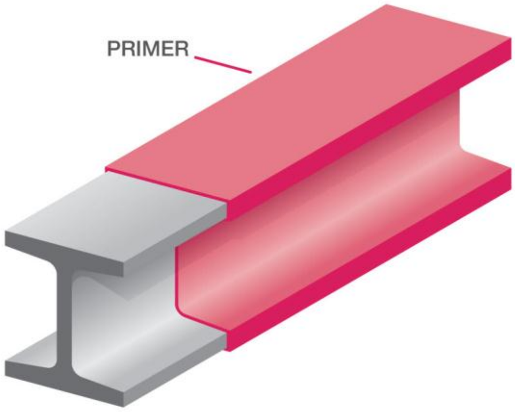


Figure 22 Steel beam with primer

Where primer thicknesses are found to be outside the specification, the advice of the specifier and/or primer and intumescent coating manufacturer should be sought and rectification carried out as necessary due to the risk of non-acceptable variations in total DFT of the ICS resulting from inconsistent primer thicknesses.

In the majority of instances, the steel at site will already be blasted and primed. In such instances, and prior to the application of the intumescent basecoat, the applicator should seek confirmation from the intumescent material supplier that the primer and the 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 also be given to the intumescent material supplier, who will then be able to endorse the use of the primer, or provide alternative advice. The application contractor should keep the appropriate records to form part of their Quality Assurance Plan – refer section 9.0.

Figure 23 Application of anti-corrosive primer

There will always be instances where the steel to be coated has a multi-layer paint system, usually of unknown origin, applied to it. In such instances, the only safe option is the complete removal of all of the existing coatings, followed by the application of a compatible primer.

Appendix B provides further advice on the treatment of coated steel work with existing paint layers or Zinc rich primers.

6.5 Condition of substrate for basecoat application

6.5.1 Unprimed steel substrate

Where a primer has not been specified, the steel surface should be prepared in accordance with the requirements of clause 6.2.

6.5.2 Primed steel substrate

Before the application of the intumescent basecoat, the following conditions should be met:

- The primer thickness should be within the tolerances specified by the intumescent coating manufacturer.
- The primer should be confirmed as being compatible with the intumescent basecoat in both ambient and fire conditions.
- The primer should be intact and free from damage and degradation.
- The primer should be within its stated overcoating period.
- The primer surface should be clean, dry and free from all surface contamination

If any of the above is in doubt, contact the intumescent coating manufacture for advice.

6.6 Intumescent basecoat application

The application of the basecoat should be carried out in accordance with the manufacturer's technical data sheet and/or method statement.

Airless spray and brush are generally recommended methods of intumescent basecoat application, although roller application may also be an acceptable method. This should be confirmed with the manufacturer.

For information on thicknesses achievable per coat, refer to manufacturer's' data sheet(s).

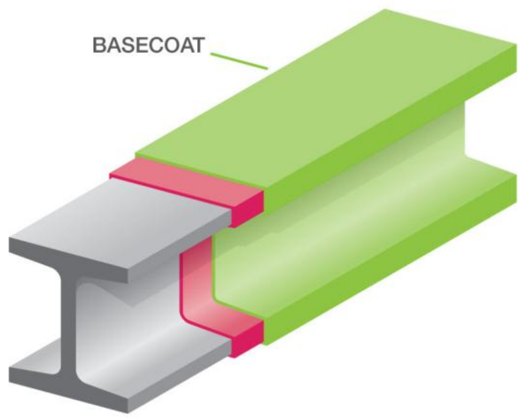


Figure 24 Steel beam with basecoat

The thickness of basecoat must be relevant to the product being applied and the steel section type and size.

After applying the basecoat and before applying a sealer and/or decorative coat, ensure the thickness is correct in accordance with Section 7.0.

6.7 Application of sealer coat

Where a sealer coat is specified, it should be applied in accordance with the manufacturer's data sheet(s). Most ICS will require a sealer coat to be applied, which may vary depending on the final exposure conditions – refer to clause 4.4.3. A check shall be made with the intumescent manufacturer to confirm that the intumescent coating/sealer coat is suitable for the exposure conditions.

The protective coating thickness is difficult to measure due to the variance in thickness of the underlying coats and its own usually relatively low thickness.

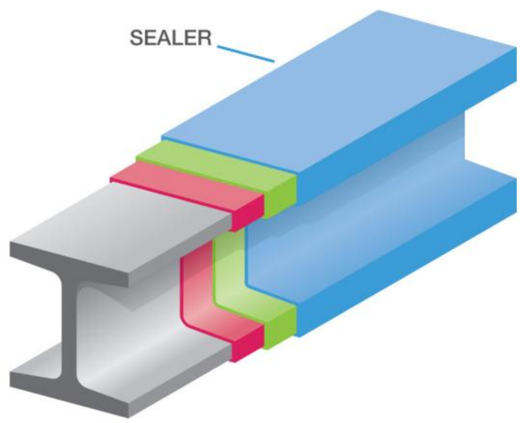


Figure 25 Steel beam with sealer

The thickness may, however, be important to ensure the longevity of the system. The application, within specified tolerances, should be checked by careful monitoring of material usage and the elimination of surface defects prior to application.

6.8 Application of additional decorative coat

Any additional decorative coating should be compatible with the intumescent system and must not inhibit its fire resistance performance. It is normal for the sealer coat alone to provide the required decorative finish. Where any additional coatings are required, the advice of the intumescent basecoat manufacturer should be sought.

A check should be made that the sealer or decorative coating meets the finish requirements of clause 4.4.7.

7.0 Thickness control of basecoat

7.1 Basecoat thickness

The thickness of the basecoat needs to be measured both when wet and when dry to ensure that the basecoat reaches the required thickness.

7.2 Wet film thickness (WFT)

Wet film thickness (WFT) measurements should be taken during application using a wet film gauge.

Figure 26 Wet film thickness gauge – micron scale

Figure 27 Measuring wet film thickness of intumescent coating

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

Information on the WFT necessary to give a specified DFT should be obtained from the relevant intumescent manufacturer's technical data sheet/s and confirmed by fire test reports and/or assessments from a NATA Approved Registered Testing Authority.

7.3 Dry film thickness (DFT)

The final dry film thickness (DFT) achieved (allowing for primer coat) should be in accordance with the required specifications. A suitable gauge should be used for measuring.

Such instruments should have a range appropriate to the specified DFT and all readings taken should be recorded. The gauge/instrument should be calibrated on a smooth steel plate prior to use, following the gauge manufacturer's instructions.

DFT readings should be taken when the intumescent basecoat is sufficiently hard to prevent the probe indenting the surface, and prior to the application of any sealer or decorative coat(s). Alternatively, it may be possible to measure thickness through a plastic shim of known thickness, placed on the surface of the intumescent. The thickness of the shim should then be deducted from the reading obtained.

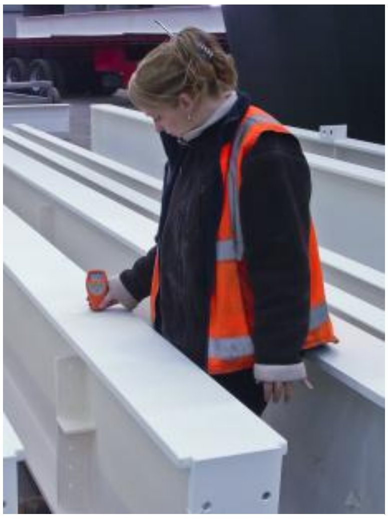


Figure 28 Measuring dry film thickness of intumescent coating

Remember, where a primer coat has been applied, remove the primer coat thickness from the reading to achieve an accurate reading of the basecoat's DFT.

Readings should be taken on every steel section as follows:

- I sections, T Sections, Channels, Angles and Square and Rectangular Hollow Sections:
  - Webs: One reading per metre length on each face
  - Outer Flanges: One reading per metre length on each face
  - Inner Flanges: One reading per metre length on each face
  - Rectangular Hollow Sections: One reading per metre length on each face

  No readings taken within 25mm of any edge or web-flange junction should be used for the purpose of accessing adequacy.
- Circular Hollow Sections: Four readings per metre length spread evenly around the section

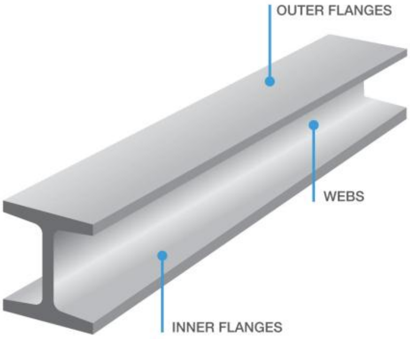


Figure 29 Beam with parts labelled

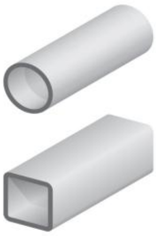


Figure 30 Hollow sections (circular, rounded square)

For steelwork, such as lattice girders, wind bracing, etc., more or less readings than those stated above may be necessary.

DFT should be recorded on the basis of the section identified, together with details of the number of readings and the maximum and average coating thickness. These readings will form part of the quality assurance records – refer to clause 9.2.

7.4 Dry film thickness (DFT) acceptance criteria

The acceptance criteria should be as follows:

i) The average thickness should be equal to or greater than the specified thickness, however the average measured DFT of any member should not exceed by more than 10% the maximum tested thickness for the particular steel section.

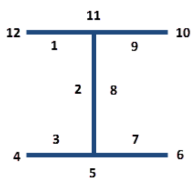
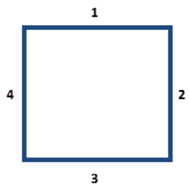
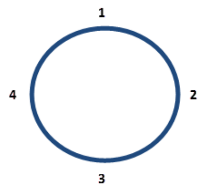
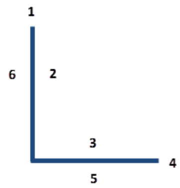
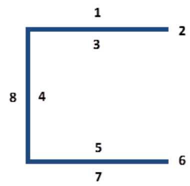
ii) Where any single thickness reading is found to be less than 80% of the specified thickness, a further three readings should be taken within a 300 mm radius of the low reading. If any of the additional readings are less than 80% of the specified thickness, further readings should be taken to establish the extent of the area of "underthickness" and the whole area should be brought up to the specified thickness.

iii) Individual thickness readings of less than 50% of the specified thickness are not acceptable.

See the following page for a sample table for recording DFT measurements.

FPA Australia aims to promote the protection of life, property and the environment from fire and related emergencies.

This table suggests a useful way of clearly recording DFT measurements.

Dry Film Thickness Survey				
 Universal Beam or Column	 Square or Rectangular Hollow Section	 Circular Hollow Section	 Equal Angle	 Parallel Flange Channel
Steel Section Type (UB, UC, SHS, RHS, CHS, EA or PFC, see above)				
Steel Section Location				
Steel Section Identification				
Specified Thickness				
	Reading (mm)			
Part of steel section (as per above diagrams)	#1	#2	#3	#4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

7.5 Correction procedure

i) Where the intumescent coating thickness is found to be less than that required by the specification (using the criteria from 7.4), rectification will be necessary. This must be carried out in accordance with the manufacturer's instructions. See Section 8.0 for further information on rectification work.

ii) DFT checks should be made prior to the application of any sealer or decorative coat(s). Where such a coating has already been applied, confirmation of the thickness of the sealer or decorative coat(s) must be sought. If it is not possible to confirm the thickness detailed guidance should be obtained from the intumescent coating manufacturer and/or the sealer/decorative coat manufacturer.

iii) Where the intumescent coating thickness exceeds the limits stated in 7.4 (i) guidance should be sort from the intumescent coating manufacturer that the additional coating thickness does not adversely affect the performance of the ICS in fire conditions and shall be identified in fire test or assessment.

8.0 Rectification Work

All discrepancies should be clearly identified and listed on the appropriate site documentation; that is, the inspection and test plan (ITP).

8.1 Damage to existing coatings

The required rectification work will depend on both the extent of the damage and whether or not a sealer coat has been applied to the original coating.

Minor damage, such as chips and scratches, will not affect the fire rating performance of the intumescent coating, but it is recommended that these should be repaired at the earliest opportunity, particularly if the sealer is providing a protective barrier for the intumescent basecoat.

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

If only the basecoat has been damaged, apply fresh basecoat or approved repair material to match existing thickness.

When the dried intumescent material matches the surrounding thickness, overcoat with the recommended sealer coat, if required.

If only the sealer coat has been 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 (e.g. due to water or chemical attack) contact the intumescent coating manufacturer for advice.

9.0 Quality assurance plan

9.1 Inspection

i) The inspection regime should form part of the quality assurance plan, with the requirements clearly stated.

ii) Inspection is not a substitute for adequate supervision and correct specification. The primary objective is to check that the specification is being followed and that any deficiencies are identified on an Inspection and Test Plan (ITP) so that rectification action can be effectively undertaken.

9.2 Records

i) It is essential that the application contractor retains all quality assurance records. These records should cover all stages of the application of the intumescent coating system. Thought should also be given to providing these records to the building owner or facilities manager as part of the commissioning documents. The builder should also be provided with these records.

ii) Site documents should include the following details:

- Inspection & Test Plan
- Record of materials (i.e. batch numbers, quantities)
- Daily log of environmental conditions (i.e. relative humidity, steel temperatures and dew point)

Atmospheric Measurements				
Date and Time	Air Temperature	Steel Temperature	Humidity	Dew Point

Example of daily log of environmental conditions

- Condition of Steelwork (i.e. how it was prepared and to what standard)
- Existing primer, identification and thickness measurement
- Thickness of intumescent basecoat

10.0 Conclusion

Use of the considerations and processes outlined in this good practice guide will assist industry with the professional use of ICS's and achievement of structural steel performance criteria under fire conditions.

This good practice guide addresses the key components that should be considered for the specification and application of ICS's. However, the manufacturer's requirements must always take precedence and verification of these requirements and that products have been tested to appropriate test standards and conform to relevant quality control requirements is vital to achieving expected performance.

11.0 Disclaimer

The opinions expressed in this correspondence reflect those of FPA Australia. However these are subject to change based on receipt of further information regarding the subject matter. You should interpret the technical opinion or information provided carefully and consider the context of how this opinion/information will be used in conjunction with the relevant requirements outlined in regulations (state and/or federal); standards, codes or specifications; certification; accreditation; manufacturer's documentation and advice; and any other relevant requirements, instructions or guidelines. FPA Australia does not accept any responsibility or liability for the accuracy of the opinion/information provided, nor do they accept either directly or indirectly any liabilities, losses and damages arising from the use and application of this opinion/information.

12.0 References

- FPA Australia Technical Advisory Committee for Passive Fire Protection (TAC/19).
- ASFP Technical Guidance Document – TGD 11, *Code of practice for the specification & on-site installation of intumescent coatings for fire protection of structural steelwork*, Published by Association for Specialist Fire Protection (ASFP), UK, 18 March 2010.
- AS 1530.4-2005, *Methods for fire tests on building materials, components and structures - Fire-resistance test of elements of construction* – Published by Standards Australia International Ltd.
- AS 1627.4-2005, *Metal finishing - Preparation and pretreatment of surfaces - Abrasive blast cleaning of steel* – Published by Standards Australia International Ltd.
- AS 2312-2002, *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings* – Published by Standards Australia International Ltd.
- AS 4100-1998, *Steel structures* – Published by Standards Australia International Ltd.
- AS 4312-2008, *Atmospheric corrosivity zones in Australia* – Published by Standards Australia International Ltd.
- ISO 8501-1:2007, *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* – Published by International Organization for Standardization (ISO).
- ISO 9000:2005, *Quality management systems - Fundamentals and vocabulary* – Published by International Organization for Standardization (ISO).
- National Construction Code Series – Volumes 1 and 2, Building Code of Australia – Published by Australian Building Codes Board, Canberra.

For more information, please see www.fpaa.com.au or contact FPA Australia on: (03) 9890 1544.

Appendix A – Fire resistance testing

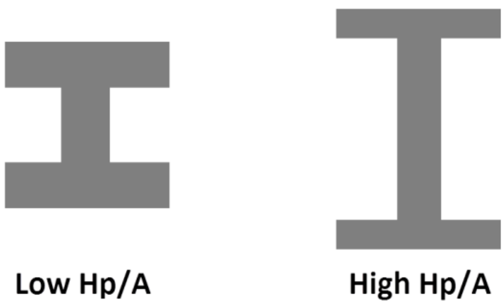
Fire resistance tests do not necessarily reflect the structural behaviour that could be expected in a real fire situation. Rather, they are a means of obtaining a measure of the relative performance of the structural elements and materials when tested to the fire test heating curve.

In a fire test, the loaded elements of structure are heated in a fire test furnace until they fail to support the applied load. The time for which the load is supported is the fire resistance time of a structural element and the protection material.

A beam is deemed to have failed when the deflection exceeds specified limits and a column is deemed to have failed when it is unable to support the applied load.

Section factor method (Hp/A)

A steel section with a large perimeter (Hp) exposed to a fire will receive more heat than one with a smaller perimeter. Also, the greater the cross sectional area (A) or mass of the section, the greater the heat sink. When these two factors are considered, it follows that a small thick section exposed to a fire will be slower to increase in temperature than a large thin section.



Example of low and high Hp/A

Hp/A, the section factor, is thus a measure of the rate at which a steel section will heat up in a fire. The higher the Hp/A value, the greater will be the thickness of the protection material/system required.

AS 4100 uses the term Ksm for section factor. Ksm is related to Hp/A by the following equation:

Ksm = (Hp/A) / 7.85

Calculation of section factor (Hp/A)

When calculating the Hp/A section factor, the full cross sectional area A, or mass of the steel element is used. Hp is, however based upon the actual perimeter of the section that is directly exposed to the fire. The Hp for the "profiled" protection is taken as the perimeter of the steel section itself, whereas for "boxed" protection the Hp is the sum of the smallest possible rectangle or square encasement (except for circular hollow sections).

Partially exposed members

When a steel section is partially exposed to fire, (i.e. when a column is built into a fire rated wall or a beam is embedded in a floor slab) the Hp may be taken as the perimeter of the steel section which is actually exposed to the fire. The total cross sectional area or the total mass of the section is used not just the area exposed to the fire.

Appendix B - The use of Intumescent Coatings in Conjunction with Old Paint Coatings

B1 Existing paint layers

Existing steelwork requiring refurbishment will usually be treated with a new intumescent coating system. The existing paint finishes are likely to be old and the effectiveness of their adhesion to the substrate, or between the layers of coating may be poor. Also, it is possible that the paint system may not be consistent throughout the building and that varying systems have been applied to different sections of steel.

With so many variables it is not possible to confidently predict the performance of the intumescent coating system under fire conditions. Optimum performance of any intumescent system will only be achieved if it is applied to a properly prepared substrate. Therefore, the only assured option is the complete removal of the existing coatings and the application of a new intumescent coating system.

B1.1 Removing existing paint layers

The intumescent system manufacturer should be consulted on the best method of preparing the steelwork.

Abrasive blast cleaning is the preferred method of preparing the steel to ensure the old paint coatings are effectively removed. ISO 8501-1 Sa2.5 or AS 1627.4 class 2.5 are the accepted standards and provides a suitable base for the application of the new ICS.

However, there are some situations where site conditions may make abrasive blast cleaning impractical. In these cases manual cleaning methods may be employed, although results are unlikely to provide as good a result.

For example, power rotary wire brushes will wear away the paint layers but they are unlikely to achieve 100% removal though they will get back as near as practicable to bare steel, which may be acceptable where a compatible surface tolerant primer is used.

Once the existing paint layers are removed, the new ICS can be applied as per this guide.

Always consult manufacturer requirements.

B1.2 Applying an ICS over existing paint layers

In some cases, an ICS may be applied over existing paint layers. However, evidence from the ICS manufacturer is needed to demonstrate that this is suitable and agreement should be reached with the client—and approval confirmed with the Building Surveyor, Project Certifier, AHJ and any other interested parties—as to the applicability of the test data to the circumstances which prevail on the project.

Manufacturers wishing to demonstrate that the application of an intumescent system over existing painted surfaces of known generic type and thickness is suitable, should be able to provide fire test evidence of this suitability.

B2 The use of intumescent coating in conjunction with zinc rich primers

Zinc rich primers, usually based on epoxy resin or silicate binders, are often used as corrosion protection 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 intercoat adhesion. In such situations therefore, it is essential that the zinc salts are completely removed and a compatible coating (i.e. tie coat) applied within the appropriate time frame.

When full removal of zinc salts cannot be guaranteed it is recommended to remove the zinc coating and reprime the steel.

Applying a tie coat over the primer at the fabrication stage can prevent zinc salts. The intumescent coating can then be applied to the tie coat.

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. A test report or assessment should confirm acceptance of the use of any such tie coat.

Appendix C – Definitions

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

- Application Contractor

  The person or company applying the intumescent coating system.

- Basecoat

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

- Decorative coat

  A coating applied over the basecoat for decorative purposes only. It could also act as a sealer or top coat.

- Dry film thickness (DFT)

  The thickness of the fully dried intumescent coating system (ICS).

- Fire resistance level (FRL)

  The nominal grading period, in minutes, that is determined by subjecting a specimen to the standard time temperature curve regime set out in AS 1530.4 to specify—

  (a) structural adequacy;

  (b) integrity; and

  (c) insulation,

  which are expressed in that order.

- Hp/A (section factor)

  A geometric ratio of the exposed surface area and the cross sectional area. It is also a measure of the rate at which a steel section will heat up in a fire, *see* Appendix A for further detail.

- Inspection and test plan (ITP)

  A checklist of quality control procedures. It may include “hold points” to be signed off by stakeholders before the next process of the application may proceed.

- Intumescent coating system (ICS)

  A system comprising the preparation of steel, primer, the basecoat and the sealer, top or decorative coat.

- Mask, Masking, Masked

  "To mask" something is to cover an area so that it is protected from overspray.

- Member

  An individual piece of steel work, e.g. columns, beams, braces, trusses, stairs, handrails, joists, metal decking etc..

- NATA (National Association of Testing Authorities, Australia)

  An authority that provides assessment, accreditation and training services to laboratories and technical facilities throughout Australia and internationally.

- Primer

  A protective coating, usually anti-corrosive, applied between the steel substrate and the basecoat.

- Project specification

  The documentation that specifies what is required of the intumescent coating system for a project.

- Sealer coat or top coat

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

- Section

  One physical piece of steelwork. It may form an entire member or part of a member.

- Specifiers

  The person that specifies the criteria for an intumescent coating system. The person responsible for this differs between projects.

- Tie coat

  A coat of paint used to bond two incompatible coats.

- Wet film thickness (WFT)

  The thickness of the basecoat immediately after application.