

EPOXY INTUMESCENT COATING SYSTEMS FOR FIRE PROTECTION

Introduction

The first epoxy intumescent coatings for passive fire protection were developed over 30 years ago. They have become more accepted and more commonly used in recent years due to continued improvement in formulation, application and performance. These coatings are used extensively in the petrochemical, off-shore and marine markets.

Epoxy intumescent coatings have been shown to be suitable by testing and independent third party approval for fire protection and offer a variety of versatile, durable, attractive, low thickness and low weight coatings for a wide variety of structures.

This article discusses the use of this type of product, how it is tested and factors to consider where it is to be used in fire protection.

The use of epoxy intumescent.

When used to provide passive fire protection, the main function of the coating system is to provide an insulating barrier in the event of a fire. Under normal circumstances the coatings are inert but when subjected to elevated temperatures the coating develops a thick char that provides a higher level of insulation than the coating system in its un-reacted state.

The level of protection required from a coating is dependent on the system being protected. For structural steel members, the systems may be specified to ensure steel temperatures remain below the temperature at which structural failure may occur. This can give time for the evacuation of personnel and fire fighting measures to be implemented.

In the offshore and petrochemical industries epoxy intumescent coatings have been used to provide fire protection to steel structures for example on liquid natural gas carriers, oil drilling ships, floating oil and gas production vessels, oil tankers and naval vessels. In such applications, fires resulting from the ignition of hydrocarbons can be substantially more severe in terms of temperature rise and incidental heat flux when compared with fires involving traditional, 'cellulosic', building materials.

Epoxy coatings have been used successfully for decades to provide corrosion protection in challenging environmental conditions, typically off-shore applications and the petrochemical industry on shore. In terms of expected durability, claims are made (i.e. life to first maintenance) that up to 25 years or more can be achieved with careful specification and application controls.

Such coatings, combining durability, corrosion resistance and fire protection have led to these type of product being used extensively for fire protection in the petrochemical, offshore and marine industry.

Fire Testing of Epoxy Intumescent coating systems.

The fire resistance of a system is determined using specially designed and constructed furnaces using specified heating conditions and performance criteria.

One critical aspect of the fire resistance testing is the controlled rate of temperature rise in the furnace. Systems normally used in land-based buildings are tested employing the 'cellulosic' fire test curve which is considered to be representative of a building fire fuelled by the typical contents of a building, traditionally regarded as being timber based the 'cellulosic' curve. The fire testing curve reaches a temperature of around 900 °C after 60 minutes. However, when considering a fire resulting from the ignition of hydrocarbon based fuels, the cellulosic curve is not considered to be representative of this type of fire.

To assess the performance of a passive fire protection system when subjected to a hydrocarbon fire, the systems are tested under more severe conditions, for example employing the Department of Energy 'hydrocarbon curve' where the furnace temperature rises rapidly at the start reaching approximately 900 °C in 3 minutes and approximately 1033 °C in 10 minutes. Other high temperature rise curves are also used, for example in the standard UL1709 '*Standard for Safety Rapid Rise Fire Tests of Protection Materials for Structural Steel.*'

Typical elements submitted for testing include structural steelwork, steel bulkheads and decks.

The standard sizes of test specimens are typically 3m x 3m for bulkheads and 3m x 2.4m for decks. There might be a structural loadbearing aspect associated with the bulkhead or deck which would require the steel temperature to remain below critical levels in a fire to maintain structural stability. As the test specimens are generally not tested under load, a conservative limit is specified. For both decks and bulkheads the element provides a barrier which prevents the spread of fire from one area to another (compartmentation). The test assesses the ability of the barrier to prevent fire penetrating the barrier and ensures that temperatures on the non-fire side surface do not exceed specified limits.

Tests on structural steel for use in offshore applications might include loaded steel beams and columns, nominally 4m and 3m long respectively, together with a number of shorter unloaded sections. Programmes for assessing the performance of protection systems for structural steelwork are well established covering standard steel beam and column section sizes. Columns are tested with four-sided exposure and beams generally with three-sided exposure attached to the furnace roof.

For testing, the steel surface is prepared in accordance with manufacturer's instructions. This might include grit-blasting and priming of the steel surface before application of the main protection layer and any protective top coat. Thermocouples are attached to the structural steel sections to record steel temperatures and to determine when critical temperatures are reached for evaluation of loadbearing capacity in fire conditions. Using the data generated from the fire resistance tests, mathematical models are employed to evaluate the overall performance of the protection system for a range of steel section sizes and fire resistance periods.

Based on the test results, fire-protected bulkheads and decks are classified in the following groups –

Hydrocarbon fires (H0, H60 and H120), corresponding to insulation levels 0, 60 and 120 minutes insulation respectively and in all cases 120 minutes integrity and loadbearing capacity (if appropriate).

In some applications the Reaction to Fire performance of the surface finish will need to be considered. International Maritime Organisation (IMO) resolutions such as the SOLAS (Safety of Life At Sea) regulations for commercial shipping or Mobile Offshore Drilling Units (MODU) regulations for mobile offshore drilling units, contain requirements for materials to show "low flame spread" and "not be capable of producing excessive quantities of smoke and toxic products". In some applications, surfaces are required to be, "not capable of producing excessive quantities of smoke and toxic products". These are defined by test requirements described in the IMO FTP Code (Fire Test Procedures). The tests ISO 1182 non-combustibility, Surface Flammability A.653(16) and Smoke & Toxicity test IMO FTP Code Part 2, are carried out by IMO recognised laboratories such as BRE Global's reaction to fire testing group. Normally epoxy coating systems would not satisfy all of these reaction-to-fire requirements and so generally will be restricted to external locations.

Application of fire protective coatings

When preparing steelwork for the application of paint and subsequent fire testing, those preparing for the testing will have considered how the final performance of the product will be affected by the initial preparation and application.

Epoxy coatings are generally considered more tolerant of the condition of the substrate than other surface finishes; however it is critical that the manufacturers are consulted on factors such as:

- Surface preparation and blast profile. For some products the condition of the substrate is vital for the long term performance and/ or fire performance of the product. If the substrate is not suitably prepared, coatings can detach leading to early failure in a fire test.
- The use and compatibility of primers. The primer forms a vital function in ensuring the 'protective layer' is adequately adhered to the substrate. Manufacturers will specify primers that are compatible with the protective layer and ensure that these are used during the evaluation of the systems.
- Target thickness and rate of application. The protective layer will also need to be at a certain thickness to provide the required protection. There are cost implications as material thickness increases - the systems may need multiple coats to build up the required thickness which may impact on the post application inspection.
- Environmental exposure. A topcoat may be necessary to ensure that the protective layer is suitably protected in the environment in which it is installed - again this can impact on post installation inspection programmes - the thickness of individual layers needs to be known so that the thickness of the protective layer can be calculated.
- When applying Epoxy Intumescent Coating Systems (EICS) for test, factors such as sample temperature, air temperature and paint temperature are also often controlled. How these parameters, usually defined by the manufacturer of the paint system, are controlled on site can be critical to the overall performance of the system.

Third party certification of fire protection products & systems

It is recommended that any fire protection product or system is manufactured under a third party certification scheme. BRE Global can offer some services in support of this (see www.redbooklive.com). These schemes carry out regular audits on the factory production control for the product and review the supporting test and assessment evidence for the products and systems being marketed to ensure they continue to meet the appropriate

standards. In the absence of such a scheme there will be some doubt that the product tested is the same as the product/system currently marketed.

Workmanship

No matter how extensively the coating system has been tested and assessed, it is important that the systems are installed strictly in accordance with the manufacturer's instructions, with good quality workmanship. The manufacturer's instructions must comply with the tested or assessed methods. Therefore it is recommended that a specialist contractor who operates under a third party certification scheme is employed to install fire protection systems. As part of the certification scheme, regular office audits, checks on staff training and site surveillance inspections are carried out. Therefore certification schemes such as those operated by BRE Global will enhance confidence that the systems will be installed correctly.

Maintenance

It is important that all fire protection and corrosion protection systems are regularly inspected for deterioration or damage and remedial work carried out promptly to ensure a continuous level of fire protection is provided.

Conclusion

Epoxy coating systems play a vital role in protecting steel against corrosion and fire in severe environments. Lives, property and business depend on such systems and therefore the greatest of care must be taken to ensure their performance is adequately tested and assessed and the quality of their manufacture and application carefully monitored. Once applied, they must be subjected to regular inspections and maintenance to ensure that an adequate level of protection is maintained.