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Express Yourself

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Thin-film intumescent fire-protective materials provide designers with increased aesthetic flexibility when it comes to exposed steel.

THERE IS AN INCREASED EMPHASIS ON EXPOSED STRUCTURAL STEEL IN THE DESIGN OF COMMERCIAL AND INSTITUTIONAL STRUCTURES THESE DAYS. As a result, intumescent coatings are experiencing expanded use as a tool that offers fire-protective capabilities while at the same time meets the aesthetic objectives of architects, providing an opportunity for design expression in the exposed steel.

Cementitious Coatings

Before discussing the benefits and application of intumescent coatings, it's important to recognize the role of spray-applied fire-resistant materials. SFRMs are the most commonly used fire-protective materials and are usually gypsum-based or cementitious materials. They can be applied by means of wet spray, where the water is mixed with the dry material at the pump, or dry spray, where the water is injected at the spray nozzle.

Intumescent Coatings

By contrast, intumescent mastic materials or coatings are relatively thin-film products that expand rapidly in a fire to insulate the steel. They come in various proprietary formulas that include a mixture of binders and acids that react under temperature to expand up to many times the original thickness of the film, creating a char that insulates the steel. Normally, we expect this reaction to begin when the heat of the fire reaches 350 °F, and continue for a specified time to help the steel substrate remain below 1,100 °F during a test or actual fire (steel loses half its strength at 1,100 °F).

Intumescents are usually spray-applied at thicknesses less than 50 or 100 mils and rarely more than 300 mils, while typical corrosion-resistant coatings are considered thick-film if they are thicker than 18 or 20 mils.

Cost Considerations

Formulations for intumescent coatings have improved over the years, resulting in better-looking and easier-to-apply offerings; as demand for intumescents has increased, so have coating choices. So, engineers and designers that have not looked into using intumescent materials lately might be pleasantly surprised to see how much better and cost-effective today's materials are than those used 10 or 15 years ago.

Also, consider that since the material cost for intumescents increases as the number of coatings increase, one way to bring down the intumescent cost is to up-size the steel. This way, fewer layers will be required to achieve the two-hour fire rating.

Where It's Useful

In addition to wide-flange shapes, architects are increasingly employing hollow structural sections (HSS) in their buildings and are coating the members with thin-film intumescents in order to expose the steel. (When using conventional cementitious coatings and gypsum wallboard or t-bar ceiling enclosures, all of the steel and fire-protective materials are generally concealed.)

Intumescent coatings are also used in "clean-room" environments, because unlike most cementitious coatings, they do not "dust" or give off particles into the atmosphere. Other uses for intumescents include tight spaces and areas along window walls, as the films are 1⁄16 in. to 1⁄8 in. thick compared to 1 in. to 1½ in. for gypsum-based materials.

A typical coating system that includes an intumescent material might consist of the following:

- ✓ Shop-applied primer (modified alkyd, organic zinc, or inorganic zinc-based) in the 4 mils dry-film thickness range.

Projects such as New York's Hayden Planetarium, with its unique design and large amount of exposed steel, make attractive fireproofing a necessity. Photo: Polshek Partnership Architects

- ✓ An intumescent base coat of 22 to 465 mils, depending on substrate shape, assembly design, and hourly fire rating requirement.
- ✓ A top coat (optional in interior applications) of penetrating epoxy sealer (2 mils) followed by high-build polyurethane (3-5 mils).

Primers for intumescent materials are usually modified alkyds and epoxies. Typically, proper application of the primer is more important than which primer material is used. A poor-quality primer applied properly will likely do a better job than a great primer material applied improperly. (Primers are important to the adhesion of intumescent materials but are usually not required for cementitious materials unless the application setting is an aggressive environment.)

Top coats may vary widely depending on the type and use of the intumescent coating. It is always advisable to research the suitability of the proposed top coat with the intumescent coating manufacturer. It is also advisable to use materials from only one manufacturer to assure continuity of the system. However, it is important to note that many coating manufacturers do not manufacture primers or top coats.

Application Methods

Intumescent coatings can be applied in the field by airless spray following erection of the steel. If a coating is shop-applied, instructions for special care in the erection and transportation of the steel should be noted in the job specifications, and touch-up or re-application can be performed in the field as needed. The applicator's pump should be a large, industrial type—40:1 or 53:1 or even 56:1. Top coats also should be spray-applied with a similar process, but may be brush- or roller-applied if necessary.

Successful application of intumescent materials is dependent on good painting practices and adherence to standard quality control and quality assurance methods. These considerations include but are certainly not limited to:

- ✓ A well-written specification that takes into account intended use, exposure, and the suitability of material selection
- ✓ Provisions for using only "factory trained", certified, and qualified contractors and application personnel
- ✓ Verification of the substrate and assurance of the suitability and quality of the primer
- ✓ Use of proper equipment
- ✓ Consideration of environmental conditions, as in too wet, too humid, too cold, and at times, too hot
- ✓ Reference to applicable quality control documents such as Manual 12-B of the Association of the Wall and Ceiling Industries International and SSPC PA-2.

Intumescent mastic materials are supplied in water-borne, solvent-borne, and epoxy versions. As with SFRMs, intumescents are classified as interior conditioned space, general-purpose, and exterior use products. (These are important distinctions, as most interior-grade materials fail miserably in exterior environments.)

A simple way to distinguish the three grades is to think of interior conditioned space in terms of "air conditioned", while general-purpose refers to interior non-air conditioned space and exterior use refers to an outdoor setting such as a parking garage or awning exposed to the weather.

Testing Requirements

Coatings are tested and approved by several laboratories, but generally speaking, Underwriters Laboratories (UL) is the standard in the industry. UL provides the protocol and testing requirements and actually performs the fire testing at the UL facility in Northbrook, Ill. It also annually publishes a compilation of all the currently approved systems, assemblies, and designs in its *UL Fire-Resistance Directory* (2008).

In evaluating fire-protective materials, UL conducts three levels of laboratory environmental testing. The most demanding test is for exterior materials, and the procedure involves material weathering, humidity, carbon- and sulfur-dioxide air mixture, UV, and salt spray. Two levels of testing for interior materials involve weathering and high humidity, with general-purpose materials required to last longer under the test conditions.

Cementitious and intumescent coatings are both listed in the *UL Fire Resistance Directory* and classified as beams and columns and assemblies of structural steel and floor and roof designs. The directory also includes many types of construction, such as gypsum walls and concrete floor and composite roof systems, and the fire resistance of various assemblies as measured in hours. Architects and engineers use the designs listed in the directory to help them in meeting the hourly rating required by the prevailing building code.

While high-performance coatings are tested in various chemical exposures, fire-protective materials are tested in accordance with ASTM E119 and UL 1709. The E119 test applies to general building materials placed under a "time temperature" fire test, where the materials are cooked over a few hours as the heat in the oven temperature increases. The UL 1709 test is a "rapid rise" test where the sample item is immediately exposed to a full 2,000 °F to replicate an industrial fire where the fuel would primarily be petrochemicals.

Most intumescent coatings are tested and approved under the ASTM E119 test, as they are usually applied to structural steel on commercial buildings. In some cases intumescent coatings are approved for use in chemical or industrial applications such as refineries.

Weight and Mass of Steel

The terms *W/D ratio* and *A/P ratio* (weight over heated perimeter [for W-shapes] and area over heated perimeter [for hollow sections]) refer to formulas where the area and exposed perimeter of the steel is measured to determine a value. With all fire-protective materials, the size and the weight of the structural steel to be protected may be a factor in determining the thickness of the material needed to achieve the required fire rating. This is particularly important with intumescent coatings applied to HSS.

In many cases UL has published a listing of the applicable steel members by size, with the corresponding dry film thickness (DFT) of the fire-protective material. Steel members having greater mass or weight per foot versus the exposed perimeter area (measured in square inches) are likely to require a lesser thickness of material coverage, and those with less weight with the same surface area will usually require more material to provide the same hourly rating.

Inspection Guidelines

The Association of the Wall and Ceiling Industries International (AWCI) publishes inspection manuals that are widely accepted as the basic criteria for the inspection of both cementitious and intumescent coatings.

An important guide here is Technical Manual 12-A, *Standard Practice for the Testing and Inspection of Field Applied Spray Fire-Resistive Materials; an Annotated Guide*. This is the initial guide specific to cementitious materials.

AWCI also publishes Technical Manual 12-B, *Standard Practice for the Testing and Inspection of Intumescent Fire-Resistive Materials; an Annotated Guide*. This guide is specific to intumescent coatings.

Both guides are similar in nature to SSPC PA-2 and include protocols for measurement of thicknesses, the number of readings required, and other procedures. Other inspection criteria and guidelines in the manuals address general information; surface conditions such as the substrate and primer; site conditions including environmental conditions; and actual inspection procedures including design criteria and an inspection form.

Exposed Equals Intumescent

Designers can choose from many different types of SFRMs and intumescent fire-resistant materials for different applications. But in exposed structural steel applications, thin-film intumescent mastic materials are becoming an increasingly popular choice thanks to their combination of fire-protective capabilities and utility in not only showcasing the steel, but also maintaining its attractiveness. MSC

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