Fire Safety With Specialty Coatings

Suppliers of Fire Resistant/Retardant Coatings
Carboline (division of RPM)
International Paint Protective Coatings (Akzo Nobel)
Albi Manufacturing, a Division of StanChem, Inc.
Isolatek International
PPG
Flamemaster Corp.
Fire Research
Sherwin Williams
The Muralo Company
Thermal Product Research (TPR2)
Flame Control Coatings, LLC
NoFire Technologies, Inc.
Vimasco Corporation
Hy-Tech
Sherwin Williams

Source: Kusumgar, Nerlfi & Growney

Fire protection has been recognized as a crucial part of public and commercial building design for decades. Following the collapse of the World Trade Center towers on September 11, 2001, increased attention has been focused on the need to ensure that adequate fire protection is incorporated and maintained in buildings where large numbers of people might be present. Fire resistant coatings are a relatively new option available to architects. They can help lengthen the time that structural materials can maintain their integrity under fire conditions.

Fireproofing is recognized to play a crucial role in establishing building safety and generally refers to the protection of the structural steel and other supporting members in a building. Traditional fireproofing materials include concrete encasement, gypsum wallboard and coatings categorized as Spray Applied Fire Resistive Materials (SFRMs) that are typically composed of ingredients such as mineral wool, cement and gypsum and can very in density. Intumescent fire resistive coatings are newer fireproofing materials. They are paint-like coatings that are applied to structural steel members at a final thickness of from 0.03 to 0.50 inches.

All of these fire proofing materials are designed to provide an insulating barrier between a fire and the structural steel. The barrier prevents the high temperatures within a fire from affecting the structural performance of the steel members. Because the intumescent coatings have paint-like properties, they are receiving increasing attention from architects and designers.

Fire Retardant vs. Fire Resistant

There are actually two types of coatings on the market that are designed for use on different substrates and that respond very differently when exposed to fire.

Fire retardant paints are applied to combustible materials (wood, plastic, foam) and are designed to reduce the rate of flame spread. Typically they are based on silicone, casein or vinyl resins. They look like paints and are formulated to be applied like paints (brush, roller or spray). They do burn, can generate smoke, do not have high temperature resistance and would vaporize under test conditions designed for fire resistant coatings.

The standard ASTM test for flame retardant paints is ASTM E84, which lasts for several minutes. The test evaluates flame spread and smoke development. Coatings that are meant to protect combustible substances

are tested over Douglas Fir and are classified as either Class A (Flame Spread under 25, Smoke below 450), Class B (Flame Spread between 26 and 75, Smoke below 450), or Class C (Flame Spread between 76 and 200, Smoke below 450). These figures are indices when compared to Red oak (Flame Spread =100) and Cement board (Flame Spread =0).

Many fire retardant coatings are only rated for the ability to 'not contribute' to a fire, i.e. they will not become a fuel source. Others do provide some resistance in keeping the fire from getting to the substrate. Most create a soft char that will not keep plastics from melting and dripping into a fire. Some do not do a good job at keeping rapid heat transfer through metal. Smoke management is another, even more critical (and difficult to address) requirement. The smoke generation due to substrate/coating interaction will be different for different fire retardant paint/substrate combinations and must also be designed into a robust coating system.

Fire resistant coatings provide insulation to the substrate. Intumescent fire resistant coatings work by expanding their volume from 15 to 30 times and generating an ash-like char layer that erodes as fire exposure continues. Expansion then occurs again, with the number of times the process repeats itself dependent upon the thickness of the coating. The shape of the structural steel will affect expansion and char formation.

These coatings are given fire ratings (1, 2 and 3) depending on the length of time for which they can provide this protection. Adhesion, char integrity and char growth are critical. The standard test for these materials for a cellulosic fire is ASTM E119 (UL 263, NFPA 251, UBC 7-1), which involves placement of the coated part in a furnace for as many as 3-4 hours. UL 1709 is the test used when it is necessary to simulate a hydrocarbon fire, which can reach very high temperatures very quickly (2000ºC within 5 minutes).

Fire resistant coatings are much thicker than fire retardant coatings and are either sprayed or troweled on. The rheology of these formulations is designed so that the coating hangs at high film builds.

Building Codes and Appropriate Applications

Fire protection requirements are established in various building codes. There is no uniformity in these codes. Within the U.S. they are established by individual towns and states. Federal government buildings and military structures have yet different requirements. Outside of the U.S., codes vary from country to country as well.

"This lack of cohesiveness in building codes is a problem for the industry," notes Rick Jones, Vice President of The ChemQuest Group, Inc., a Cincinnati based coatings consulting firm. "A consistent set of fire proofing requirements would make it possible for coatings manufacturers to better focus their R&D efforts on achieving specific physical characteristics for given building scenarios."

The codes address what types of materials should be used for what substrates and in what sections of buildings. Expected occupancy, height of the building, and other factors are considered when assigning the fire proofing requirements. Intumescent fire resistant coatings are generally required where ever exposed structural steel is present. Typical examples include lobbies of hotels and high rise condominiums, convention centers, atriums, and remodeled warehouses and docks.

Most often, many different types and levels of fireproofing will be required for any one project because there will be different types and levels of substrates and exposure. "Different substrates require the use of different kinds of coatings," stresses Bob Zielinski, Technical Sales and Marketing Director for Flame Control Coatings, LLC.

For combustible surfaces like wood and plastic, the coating needs to be able to reduce the surface burning characteristics of the underlying substrate. For substrates like metal, masonry and drywall which are effectively non-combustible in nature, the coatings need to either not increase the combustibility of the

substrate or it needs to insulate the substrate from the heat and extend the amount of time before the substrate starts to lose its physical properties. With substrates like foam, the coating must be formulated to withstand the inherent base properties of the substrate (like having some flexibility) so that the coating will not fracture or leave parts of the substrate unprotected.

Different types of exposure include vibration (elevator shafts or mechanical equipment), air currents, humidity in non-air conditions spaces, concealed locations, and exposed structures are some examples.

Intumescent coatings in general are much more expensive than light weight cementitious fireproofing alternatives. As a result, these cement-based products are typically used for any structural surfaces that will be concealed in a building. They are available in varying densities for different applications. According to Paul Greigger, who is responsible for product development and testing of passive fire protection (PFP) coatings at PPG, cementitious material does have water pick-up issue and will degrade (flake off), resulting in loss of adhesion. In addition, the material must be applied on site and often the building must be sealed before the process can take place.

For exposed structural steel, however, the fire resistant coatings are a more attractive alternative because they provide a textured paint-like appearance and are more aesthetically appealing. "Even though these intumescent coatings are more expensive than traditional fire proofing materials, they broaden the architect's options for artistic expression," states Jim Rippe, title? with Carboline. He adds that for some industries – computer chip manufacturing, for example – where a dust-free environment is critical, fire resistant coatings are much more appropriate than cementitious materials.

Testing and Application

Coatings must be tested on specific structures to determine the appropriate thickness. Most testing is conducted at Underwriter's Laboratory, and each test is designed for a specific application. The architect's design is utilized to generate thickness requirements which are dictated by building codes. The general contractor then places bids out for the actual fire proofing work, which is completed by a certified contractor.

Surface preparation and application are critical for achieving the desired performance of these coatings. Primers are generally required prior to application of the intumescent fire resistant coating to structural steel. In some cases, topcoats are also necessary to provide a protective barrier (most often on interior coatings). Testing is conducted on the complete system, and only approved primer and topcoat formulations are then approved for use.

Because application technique can affect adhesion, it can ultimately affect the performance of the coating. To maintain control of this important aspect of the protection process, most manufacturers require that contractors wishing to apply fire proofing coating products receive specific training and certification.

Developments in Testing Standards and Codes

There are numerous standards that have been issued by independent and government agencies and laboratories in the U.S., such as ASTM, UL, ANSI, NFPA, UBC and the US Dept of Defense. Additionally, there are many international standards such as IMO, ISO and MPI. "These standards are very detailed and specify performance criteria including; flame spread, resistance to ignition, rate of heat release, total heat release, smoke generation, toxic products of combustion, VOC, adhesion, resistance to water, salt water, chemicals and gases, resistance to UV, durability, resistance to mold and bacteria, safety to the environment, and many others," says Sam Gottfried, title?, with NoFire Technologies.

Despite the existence of so many standards, after the 9-11 tragedy, several groups conducted evaluations and initiated programs to develop more extensive standards for fire proofing materials including intumescent coatings.

In May 2002, the Federal Emergency Management Agency (FEMA) published the "*World Trade Center Building Performance Study: Data Collection, Preliminary Observations, and Recommendation"* report that stated that "Fireproofing needs to adhere under impact and fire conditions that deform steel members, so that the coatings remain on the steel and provide the intended protection."

UL is still evaluating a durability testing methodology (UL2431: "*Durability of Spray Applied Fire Resistive Materials*") that includes evaluation of coating performance after the coated part has been exposed to various environmental conditions (accelerated aging, elevated humidity, carbon dioxide an sulfur dioxide exposure, salt spray, freezing , simulated rain, etc.). "The idea is to address the issue of adhesion of these specialty coatings, because adhesion is absolutely critical to proper performance," comments PPG product development and testing specialist Timothy Figore.

There is still, however, a lack of agreement among the players in the market as to what standards should include. "The market is still not sophisticated enough to develop a consensus as to what the physical performance guidelines should be," asserts Bijou Ganguly, Product Manager of Isolatek's Industrial Division.

The International Code Council (ICC) recently approved (May 2007) the first comprehensive set of building code changes based on recommendations from the Commerce Department's National Institute of Standards and Technology (NIST). The recommendations were based on the findings of NIST's three-year investigation of the collapses of New York City's World Trade Center (WTC) towers on Sept. 11, 2001. The changes will be incorporated into the 2007 supplement to the ICC's International Building Code (IBC), a model code used as the basis for building regulations promulgated and enforced by U.S. state and local jurisdictions. Those jurisdictions have the option of incorporating some or all of the code's provisions but generally adopt most provisions.

Several of the provisions refer to fire protective materials, both SFRMs and intumescent coatings. Specific items include increased bond strength of fireproofing materials (3-7 times); field installation, inspection and maintenance requirements and higher fire ratings.

Formulations

The key ingredients of fire suppressant coatings vary depending on the type of coating. In addition to the resin or binder, ablative coatings, or sacrificial coatings designed to reduce the rate of burn, usually contain fire retardant chemicals such as aluminum trihydrate or antimony oxide. Intumescent coatings contain the resin and approximately 15 other ingredients. The three key active components are the promoter or catalyst (typically a phosphate salt such as ammonium polyphosphate), a char former (often pentaerythritol) and a blowing agent (usually a melamine derivative).

Fire retardant coatings contain only a fraction of the amount of some of the ingredients found in fire resistant coatings. "It is difficult to maintain traditional paint characteristics when adding larger quantities of flame retardant chemicals into a formulation," notes Ganguly. "In particular, if too much retardant, generally a phosphate, is used, blending and spraying equipment can become clogged." The use of activated carbon particles is being investigated, but this material is a challenge to keep in suspension.

In general, intumescent coatings differ in how the fire retardant chemical is formulated to create char growth. "All of the ingredients are important because they interact with one another to achieve the desired overall performance.

For fire resistant coatings, selecting the appropriate resin for a given formulation and application is critical. "The resin is directly related to adhesion ability and therefore to durability," says Rippe. "In addition, different resins react at different temperatures, and the right resin must be chosen so that the right char is produced at the right time."

There are two main types of resins used in these intumescent coatings – vinyl acrylics and epoxies. Waterborne (latex) vinyl acrylic formulations are typically used for interior applications. Because the ingredients have some water solubility, the water resistance and general exterior durability of these formulations is affected. Solvent based vinyl resins and 100% solids epoxies find use in external applications where weathering can occur. Epoxies in particular are finding use in offshore oil platforms and petrochemical facilities where there is a potential for hydrocarbon fires and weathering can be a significant issue.

Formulations of each type of coating may also vary according to the substrate on which they are intended to be used. "Changing of formulations for different substrates may or may not be required and is determined by performance," comments W. Casey West, owner of Albi Manufacturing, a Division of StanChem Inc. "Some coatings are designed to work on multiple substrates, while others may require changes."

The challenge today is to create higher performing flame retardant and resistant coatings that behave more and more like traditional paint with regard to appearance and application. "There are three main properties that need to be addressed," states Don Le, product manager with PPG. "Fire suppressant coatings must be cost effective, provide the expected level of performance with regard to fire protection and durability, and be easy to apply. All three of these characteristics need to be optimized."

Currently the market is looking for interior fire protective coatings that are single component products that can be applied with a bush, roller, or can be sprayed on, and that have the appearance of regular paint. Newer latex paints are coming closer to meeting these expectations. Exterior formulations, however, tend to be much thicker and often are two component formulations that provide a more textured appearance. Intensive research efforts within the industry are focused on developing exterior formulations that are more paint-like yet retain the performance characteristics of current products. Developing coatings that have the durability of epoxies but the cost of cementitious materials is another area targeted by coatings manufacturers.

Regulatory Issues

Regulations covering volatile organic compounds do apply to fire protection coatings, but they have not up to this point affected the ability of coatings manufacturers to formulate solvent based coatings. "The regulations are performance driven and are not affecting our ability to develop new formulations," says Rippe. Jones adds that the VOC regulations are based on best available technology and recognize that the performance of the coatings is critical safety issue. Even so, it can be expected that VOC limits will be lowered as technology becomes available to provide the necessary level of fire protection at lower VOC levels.

Many manufacturers are shifting to water based formulations already and are working to overcome some difficulties presented by the use of water as the carrier. "It can be a challenge to incorporate the amount of flame retardants necessary to achieve desired ratings into water based (or very low VOC) systems and still maintain the physical properties required for the coating," notes Zielinski.

For PPG, a greater challenge in developing new formulations of fire protective coatings relates to the numerous different registration lists that currently must be complied with. The U.S., Canada, Europe, Japan, Korea, China and the Philippines all have specific regulatory requirements regarding raw materials. "When developing new formulations, it is a real challenge to ensure that all materials meet the various requirements of these lists from different countries and regions of the world," explains Greigger.

Market Dynamics

In the U.S., the market for fire retardant and fire resistant coatings (as defined by ASTM tests E84 and E119) has reached 1.5-2 million gallons and has a value of $60 million, according to consulting firm Kusumgar, Nerlfi and Growney A modest annual growth rate of 5% reflects a growing interest in these types of coatings for fire proofing.

While these coatings have always been recognized as important, the circumstances surrounding the 9-11 terrorist attached brought protective fire coatings back into the forefront and raised their profile on a broader front. “We are seeing the development of coatings for blast mitigation in addition to force mitigation (wind and seismic disturbances), and the use of fire proofing coatings parallels this activity,” says Jones. “The polyureas used for blast mitigation offer different functionality, of course, but the drivers behind the growth and development of these materials are carrying over to protective coatings as well.”

An overall trend toward increased multi-functionality in coatings should also have a positive effect on the fire suppressant coatings sector. “The market is demanding additional functionality above and beyond aesthetic appeal and protective properties,” Jones explains. Examples include cool roof, self-cleaning and biocidal coatings. “It is not a big leap to suggest that that fire protection capability will eventually be incorporated into a broader set of coatings.” Of course, ultimately more expanded use will be determined y economics – whether or not the technology can be achieved at an appropriate price point.

This trend should benefit both fire retardant and fire resistant coating suppliers. There are many fire retardant paint manufacturers because the barriers to entry in this segment of the market are minimal. A recent trend in the U.S has been the emergence of greater numbers of products being introduced through the Internet that have not been properly tested, according to Zielinski. “Only education of the building officials to properly evaluate the qualifications of the products being proposed for a particular building will make sure that the intent of the building codes are properly enforced,” he notes.

Entry into the fire resistant coatings market, however, is not easy. According to West, the technology for producing fire resistant coatings is not easy to develop or duplicate. In addition, the products must be fire tested at a high cost. Therefore, it is difficult for companies, especially those in low cost regions of the world, to enter the market and be competitive.

Emerging markets such as China, India and Eastern Europe actually present a great opportunity for producers of fire proofing coatings. All of the leading producers in the U.S. and Europe have a presence in at least one or two of these regions, either through licensing agreements, partnerships/alliances, or joint ventures. “As parts of the world increase in sophistication and population density, fire regulations in those areas will become more stringent,” Zielinski comments. “If a company is a major player in this sector of the coatings market, they need to have a presence in these developing markets,” Rippe asserts.

Changing building codes in these developing regions will provide additional mechanisms for growth. In many of these emerging markets, building codes are not advanced and often are simplified. “As building codes in these emerging regions become more similar to those established in the U.S. and Europe, there will be a great opportunity to provide fire protective coatings,” West states.

Building codes are also changing in the U.S. Fire ratings are increasing for taller buildings, and lower smoke tolerances are being set for interior coatings. “We see the codes aggressively changing,” says Richard Barone, VP-Marketing for TPR2. “Everything from NYC having fire retardant electroluminescence coatings in all stairwells to mining operations requiring significantly more robust protection of mine seals and equipment to professional racing mandating fire safety on par with space shuttle needs.”

Use of a wider array of substrates may also provide opportunities. Fire retardant polyurethane foam coatings are an emerging market. For us,” says Barone. “Projections show that spray polyurethane foam insulation is going to grow by leaps & bounds over the next several years. The problem with PU spray foam insulation is flammability & smoke. Therefore, fire protective coatings are ideal for this substrate.”

The replacement of standard building materials, including steel, with strong lightweight, but combustible materials, such as composites, is another example of a material requires use of a fire suppressant coating, according to Gottfried. These new applications require additional performance features beyond fire protection.

There is also a growing awareness of the availability of fire retardant and resistant coatings. "These materials are becoming a more viable option. They can impart real fire protection," Rippe underscores. According to Barone, many companies and industries are defining their own internal, more aggressive standards.

Even though they are significantly more expensive than other alternatives, the use of intumescent coatings can result in space savings that equate to overall cost savings in some projects. In addition, they provide the architect with more freedom in terms of design. "The demand for fire protective coatings in the past has been confined to the protection of structural steel. These coatings are an expensive, but more attractive alternative to the standard 'cementitious' fire protection for structural steel," adds Gottfried.

Product Highlights

Albi Manufactures 4 fire resistive coatings that are sold under the Albi Clad trade name. The product range includes an interior, waterborne UL listed product, an exterior solvent based coating, an interior water based coating specifically designed for wood, defective construction identified on site, and historical renovation projects, and a compressed mineral fiberboard fire proofing material. Its Albi Clad FP product designed for wood (and foam) is the newest product and was developed in response to growing demand for 1 and 2 hour rated protective coatings for these substrates, according to West.

The company also offers an extensive line of fire retardant coatings sold under the Albi Cote trade name. Many are designed for plastic and other unique substrates. Two of its biggest products include a water based, Class A rated coating and a fire inert topcoat that doesn't burn and is mostly used over the Class A rated product.

Albi has its own fire test facility with two furnaces and has developed laboratories specifically for its fire protective coatings business. "We are always working on new products and reinvesting in the company, in terms of human resources, lab equipment and space, and plant expansions," asserts West.

Carboline offers seven true coatings for structural steel protection. Three products are sold under the – NULLIFIRE trade name. Two are solvent based and one is waterborne. Its THERMOSORB solvent based coating is designed for commercial applications, while its A/D FIREFILM coatings are water based products. THERMO-LAG 3000 is an epoxy based coating for exterior commercial and petrochemical applications. THERMO-LAG 220 is a waterborne fire retardant paint for interior use.

Over the past two years, Carboline has acquired two companies with the goal of expanding its product line. AD Fire Protection Systems was purchased two years ago and added the water based FIREFILM products as well as a line of light weight cementitious materials. The acquisition of Nu-Chem in November 2006 added the TERMO-LAG and THERMOSORB products. "We are committed to this industry and will continue to grow both organically and through acquisitions where they are appropriate," Rippe states.

Flame Control Coatings offers a line of fire retardant paints. Recently the company launched its #50-50 Foam Kote product which serves as an approved 'ignition burner' for Spray Polyurethane Foam insulation (SPF). "As far as we are aware, our product is one of only two to pass the required tests," says Zielinski. Flame Control has also expanded its plant and staff and is looking at several acquisitions.

There are three fire resistive coatings sold by Isolatek as CAFCO SprayFilm® Thin Film Intumescent Systems. The SprayFilm coating can be color coated to the surroundings and allow steel to be left exposed to view while providing the required fire resistive rating. Its CAFCO® TOP COTE is a water based, permeable surface coating designed to provide multiple degrees of flexibility and abrasion resistance.

TOP-COTE forms a tough yet aesthetically pleasing and bright appearance, and is ideal for indirect weather exposures and high wear applications, according to Ganguly.

"We are a long term participant in this market and have invested in good people to ensure long term success," he adds. "We also put significant effort into our R&D activities and are always working to develop new products. Our manufacturing takes place at third party compounders, but we have extensive control over the purchase of all materials incorporated into our products."

NoFire's product line includes intumescent coatings, fire retardant wraps, and fire retardant systems for nuclear, military, maritime, residential, commercial, industrial and transportation applications. "The primary goal of the company is to increase fire performance and efficiency, allowing for thinner, more economic coatings for commercial and industrial applications where cost is a determining factor," says Gottfried. Recently the company introduced the third generation of its NoFire A-18 line of products for military, marine and residential applications. NoFire LP is designed for residential and small business applications and provides all the features of the standard products at a more attractive price.

The NoFire product is a liquid fire retardant for use as a coating material, similar to paint, on many different kinds of substances to render them fire and heat resistant. The product can be manufactured in various liquid forms, specifically adapted for the particular substrate, application and degree of protection required; or as a coated textile product, typically a woven fiberglass material, coated with the NoFire liquid product.

According to Gottfried, beginning in the fall of 2007, the company will be launching new products specifically designed to meet commercial and industrial requirements for high speed manufacturing applications that will also provide far higher fire protection than currently available. NoFire is also currently in discussions for partnerships, including additional facilities.

PPG offers two intumescent fire resistant coatings. Its Pittchar® XP coating is a 100% solids, 2-component epoxy based product that can be sprayed on using plural component spray equipment. Cleanup of the equipment simply involves rinsing with hot water. The company is currently developing the next generation of this epoxy coating.

SteelGuard™ is a vinyl, solvent based thin film widely used in Europe. PPG recently applied for UL approval in the U.S. and other waterborne (latex) versions that provide thinner films are currently undergoing additional UL testing.

"We are dedicated to growing this business," asserts Le. In September, 2006, PPG formed its Protective and Marine Coatings business by merging its high performance coatings unit with the recently acquired Ameron and Champion brands. With the acquisitions the company now has manufacturing and R&D capabilities in both the U.S. and Europe.

TPR^2 has coatings that have been tested over and passed on metal, framing wood, PU insulative foam, plywood, PE plastic, PVC plastic, and other customer specific substrates. "Our non flammable coatings overcome resin behavior in a variety of proprietary and patented ways," Barone states. "As a 'green'-oriented company, TPR^2 focuses on how available components and raw materials can be formulated in the most environmentally friendly AND performance effective way."

R&D efforts have led to the development of several new products. Late in 2007, the company plans to launch a new flame retardant for steel. This new product will be followed up In 2008 with a bio-based coating that is designed to be sprayed on houses in the path of wildfires that can be power washed off after the fire passes through the area. In addition, TPR^2 is currently looking to expand on the West Coast.

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