Chemical flame retardants have been used since the time of the Romans, who reportedly used solutions of alum and vinegar to prevent warships and siege towers from catching fire. The search for and use of fire-protective materials, chemicals and coatings continues to this day. While some of the chemicals used over the years have since proven harmful to health or the environment, today’s products, particularly the non-halogenated flame retardants, are considered essential for helping to protect lives.

Especially in large public buildings, building codes increasingly require fire-retardant coatings, particularly intumescents. They can significantly reduce flame spread and toxic smoke generation while extending the performance of steel reinforcements in a fire situation, to allow additional egress time and emergency first response. While early products may have had some appearance issues such as orange peel, modern intumescent coatings, which insulate the underlying materials from temperature rises by forming a solid-phase char, have significantly advanced in both fire performance and aesthetics.

Advances in intumescent coatings systems mean that today’s modern architectural design and color palette are no longer limited by fireproofing requirements.

Parsing Fire-Retardant vs. Fire-Resistant Coatings

Two classes of fire-protective products are in use today, and the distinction is worth noting:

- A fire retardant is a chemical that endows a treated material with the ability to slow the spread of flames, particularly vertical fire spread, and to delay flashover, thus allowing more time for evacuation and firefighting.
- A fire resistant is a material that is inherently resistant to fire penetration; they are commonly used in wall and ceiling assemblies.

Both are considered passive fire protection and are usually used in combination with active protection, such as sprinkler systems. In either case, the primary purpose is to prevent the passage and spread of smoke and flame.
from one area of the building to another and to allow building occupants a safe escape. Secondarily, they prevent or reduce the amount of damage to the building and neighboring structures, and they reduce the risk of structural collapse to give more time for emergency response.

Fire retardants can act by any of several methods. First, they can act chemically to interfere with the free radical reactions that occur during combustion or, as intumescents do, to insulate the underlying materials from temperature rises by forming a solid-phase char. Secondly, they can act physically to lower the temperature through heat-releasing (endothermic) reactions, or to slow the fire spread by diluting the oxygen with non-combustible gases. Lastly, they can provide an impervious surface layer to keep oxygen from reaching a flammable substrate.

Many classes of chemicals are used as fire protectives, but the prime considerations are the properties. If one were to make a “top 10” list of desirable fire-protective coatings properties (or, in this case, a “top 9” list), it might include the following:

- Provide long-term thermal and ignition protection from heat and flame;
- Have a low flame spread rate;
- Produce little or reduced amounts of smoke and toxic gases;
- Be durable under normal environmental exposures;
- Have good wear resistance and maintainability;
- Have and retain good aesthetic properties (for exposed surfaces);
- Be easy to apply, maintain and repair;
- Be low in VOCs and odor; and
- Be cost-effective.

Protecting Steelwork with SFRMs

Most modern office, multi-unit residential and large construction projects, such as airport terminals, convention centers, public buildings and sports venues, use steel frame construction. Structural steel weakens when exposed to temperatures 750 to 1,100 F (400 to 600 C). Therefore it is important to protect the steel to help prevent or delay structural collapse.

This steel framework typically is concealed behind walls and ceilings, where good appearance is not a factor. Designers often protect this framework during construction by covering it with an economical fire-resistant cementitious or similar
intumescent ingredients. The binder also must provide the desired gloss level and flow-leveling to resist orange peel appearance.

Low- or zero-VOC waterborne acrylic systems comprise a large segment of the market, although polyurethane, two-component epoxy and other products are available. The epoxies are sometimes perceived as better than water-based products in terms of aesthetics and durability. Intumescent coatings do need a high film build, and many products require two coatings; the water-based products will have a longer dry time for installation. As the proper film thickness is critical for functionality, certified installers often must perform field application or the application must be inspected for compliance. The application method is product-specific, with most intumescents being air- or airless-spray-applied, although some can be rolled on. These products are generally too thick for application by brush.

Intumescent coatings generally can be applied during construction, but the manufacturer will dictate specific temperature and moisture windows for application and cure. Waterborne products, in particular, also must be protected in-can at the job site from freezing temperatures and have tighter application windows than solvent-based products. In Europe it is more common to factory-coat the structural mem-

material, known as a spray-applied fire-resistant material (SFRM).

SFRMs typically include ingredients such as mineral wool, cement and gypsum. These are viscous products that are spray-applied at least a half-inch thick. This coating helps insulate the steel, delaying temperature rise and the resulting structural weakness. One drawback is that these coatings are sensitive to damage during construction.

Protecting Exposed Surfaces with Intumescents

Modern architectural design, however, often includes large expanses of exposed steel where a thick, lumpy and unattractive cementitious material is not aesthetically acceptable. In many cases, the exposed steel is itself a major decorative design element. In these cases a “thick film” intumescent coating, first commercialized in the 1960s, is the go-to solution. Protection of structural steel remains the largest market for thin-film intumescents. They are also used for rising commercial, multifamily and residential markets that include combustible building components like structural insulated panels, spray foam insulation, engineered wood framing and architectural woodwork.

Thin-film intumescents, when exposed to fire, swell to 30 to 100 times their original volume and form an insulating protective surface char, much like the char from toasting a marshmallow over a campfire. The final applied thickness typically ranges from 0.03 to 0.50 inches.

Intumescent coatings generally require three components: a source of carbon, a blowing agent and an acid catalyst. The resulting char is a low-density cellular insulating structure with low thermal conductivity.

Binder chemistry formulation is especially critical with intumescent coatings. In addition to the usual coating functions, the binder must contribute to the formation of a uniform char structure, since the molten binder helps trap gases emitted by the decomposing blowing agents. That helps to provide an even expansion of the char. The binder must help resist abrasion and damage during construction and in-service use by providing the necessary hardness, and provide any necessary protection from UV and moisture, which can damage the

On contact with flames, here 1,000 F to 1,200 F (538 C to 649 C), a water-based intumescent paint forms a dense, protective layer, or “char.” Photo courtesy of Paul Pisarski of Flame Control Coatings.

A measuring tape shows the approximate thickness of a protective char from a thin-film intumescent where it has been scraped away from a wood substrate following a burn test. Photo courtesy of No-Burn Inc.
Most outdoor products require the use of a weather-resistant topcoat. For interior spaces that may be exposed to high levels of daylighting, the light-fastness of pigmented products and the UV stability of the binder may be additional considerations when selecting the intumescent or topcoat product. The intumescent should usually be considered as a system rather than a discrete layer or product.

Classifying Fire-Protective Coatings

Finally, a few notes about fire-resistance classifications.

A fire-resistive rating, determined under the Standard Methods of Fire Tests of Building Construction and Materials standard (NFPA No. 251, ASTM E119, UL No. 263), may be referenced for rated or non-rated construction determined suitable for fire exposure. It

Thin-film intumescent coatings form an insulating protective char when exposed to heat. Here, a steel test panel coated with a thin-film intumescent is shown before exposure to fire (front), and a similar coated panel shown after (back). Photo courtesy of Shield Industries Inc.
applies to walls, partitions, floors, roofs or other building materials.

Wall and floor construction can be classified as three-hour, two-hour, one-hour or non-rated construction. The International Building Code (IBC) and International Residential Code address these requirements, as applicable.

Intumescents on steel beams must meet ASTM E2226. The standard assigns hourly ratings of one, one-and-a-half, two, three and four to complete assemblies of structural materials for buildings, including walls, floors, ceilings and roofs. Hourly ratings, however, are not real-time hours in an actual fire, but performance in a controlled test. Note that the ratings are not given to any single component such as an intumescent coating but only to a complete building assembly such as walls, floors and ceilings.

For coatings on cellulosic materials such as wood, ANSI/UL263/ASTM E119 is used to evaluate materials for use in protecting modern commercial structures. This test reaches 1,000 F (537 C) after five minutes and gradually reaches a temperature of 2,000 F (1,093 C) after a period of up to four hours.

Flame spread ratings/classes are based on the ASTM E-84/UL 723/NFPA No. 255 Test for Surface Burning Characteristics of Building Materials. This test measures the relative rate at which flame spreads over a given surface and the degree of smoke development and toxicity; it applies only to a single component such as a paint film.

ASTM E-84 is often called the Steiner tunnel test, because the test chamber is a nominal 25-foot-long by 20-inch-wide dimension. A gas burner is lit at one end of the chamber and a draft applied to facilitate flame spread along the test specimen. Instruments measure the relative amount of smoke generated during the 10-minute burn. The distance of flame spread is measured and a flame spread index (FSI) calculated by comparing the test specimen to a reference fiber-cement board (rated 0) and a red oak standard (rated 100). For example, an FSI of 25 indicates the test specimen performed approximately 25 percent of the red oak standard; a smoke index is similarly calculated.

Fire-resistant or -retardant materials are classified A, B or C under ASTM E-84 and are qualified on the basis of surface-burning characteristics (flame spread) and smoke generation. For interior finish material, which may include thin-film intumescents and fire-
FireGuard® E-84 Intumescent Coating

INNOVATIVE TECHNOLOGY

FireGuard® E-84
Flame Resistant Coating/Primer
Wood • Sheetrock • Plywood • Steel • Oriented Strand Board (OSB)

- Stops Flame Spread & Reduces Fire Penetration
- Contains & Minimizes Fires Even at High Temperatures

Class A/ASTM E-84, ASTM E-2768 Rated in Surface Burn Testing
Achieves Up to a 2-Hour Fire Rating on Walls & Ceilings (ASTM E-119)
Easy to Apply: Spray/Brush/Roller
Water-Based • Easy Cleanup • Environmentally Friendly • Non-toxic

VOC Level: <0.3% (weight/weight)

- Fire Resistant Coating
- Tested, Listed & Certified
- Contains Fires to Point of Origin

View Burn Demonstration!

When Dealing With Fire, Every Second Counts!

Questions? 800-332-6327
http://shieldindustries.com/fireguard_wp/fireguard/fireguard-e-84/

Shield Industries, Inc.
retardant coatings, National Fire Protection Association No. 101 Chapter 10, NFPA 703 and IBC Chapter 8 reference the aforementioned standards for surface-burning characteristics. Based on the results of ASTM E-84 testing, NFPA 101 and the IBC Chapter 8 list flame spread and smoke development classifications, the most important being —

Class A or I: flame spread 0–25
Class B or II: flame spread 26–75
Class C or III: flame spread 76–200

NFPA and IBC primarily apply these classifications to interior wall and ceiling finish materials, and this rating system is commonly used in product specifications. Again, it applies only to a specific component such as a paint film, wall covering or some other single piece of material.

Related NFPA 268 Standard Test Method for Determining Ignitability of Exterior Wall Assemblies Using a Radiant Heat Energy Source is used to assess the potential for fire in one building to ignite an adjacent structure. NFPA 285 is an “intermediate scale” test developed to assess the fire performance of EIFS (exterior insulation...
MAKE IT LAST 1,000 YEARS

Okay, maybe that’s not realistic. But SSPC Training and Certification programs for Contractors, Architects and Inspectors can help you to improve the quality of your projects - from specification to paint application - leading to beautiful, long-lasting, structures.

**SSPC QP 9**
Certification for contractors who apply Architectural Paints and Coatings

**Concrete Coating Inspector Program (CCI)**
Teaches proper methods to inspect surface preparation and installation of protective coatings on concrete

**Floor Coatings Basics (C10)**
Teaches proper application and repair of coatings over a concrete surface

SSPC has over 40 training and certification programs for the coatings professional, more than 100 performance-based standards, and 10 corporate certification programs for contractors and companies — all designed to give you an edge on your next project. Since 1950, SSPC has been the leading resource for information, training, and certification for protective coatings.

For more information visit www.sspc.org or contact us at info@sspc.org | 877.281.7772

Circle No. 18 on Reader Service Card
UL 1709 Rapid Rise Fire Tests of Protection Materials for Structural Steel measures the resistance of protective materials to rapid-temperature-rise fires. The test method covers both full- and small-scale fire exposures. The full-scale exposure is intended to evaluate the thermal resistance of protective material applied to structural members and the ability of the protective material to withstand the fire exposure. The small-scale fire exposure is used to evaluate the ability of protective materials to withstand various environmental conditions.

UL 2431 Durability of Spray-Applied Fire Resistive Materials measures the ability of fire-resistive materials, thin-film intumescents and fire-retardant coatings to retain their fire-resistive properties after exposure to various conditioning environments. These include air erosion; a combination of wet, freeze and dry cycling; humidity; impact resistance; industrial atmosphere; salt spray; temperature stability; ultraviolet light; and vibration. The fire-resistive performance is determined by measuring temperatures of steel tubes protected by the materials.

In addition to the standards and classifications described above, evaluation agencies such as IAPMO’s Uniform Evaluation Service and the International Code Council Evaluation Service publish criteria and evaluation reports referencing applicable standards of ASTM, NFPA, UL, FM Global and other fire and non-fire standards. The purpose is to evaluate the ability of non-prescriptive building materials to meet the intent of the model building codes.

Finding the Right Product for the Job

Dozens of companies supply fire-protective coatings in a range of chemistries. For an updated listing of suppliers and products, access D+D’s Coatings and Materials Buying Guide at durabilityanddesign.com/bg and select the fire-resistive coatings category.

About the Author

Allen Zielnik is senior consultant-weathering science in Atlas Material Testing Technology LLC’s global Consulting Solutions group, where he specializes in the weather durability testing of materials and products. A frequent speaker at various worldwide technical symposia, he is the author of more than 120 publications and conference presentations. He has degrees in electronics engineering and analytical chemistry, and since 1994, he has been involved with natural and accelerated weathering technology and solar simulation with Atlas Material Testing Technology.
You’ll save both with a subscription to *Durability + Design*

Providing state-of-the-art technical information and news for the architectural coatings and building materials industries.

Absolutely **FREE**

Subscribe today

**www.durabilityanddesign.com/subscribe**

**Available in print and digital formats**