

COATINGS FOR ARCHITECTURAL METALS

A **Durability + Design**
Collection



the journal of architectural coatings





Coatings for Architectural Metals

A Durability + Design Collection

Copyright 2012
Technology Publishing Company
2100 Wharton Street, Suite 310
Pittsburgh, PA 15203

All Rights Reserved

This eBook may not be copied or redistributed
without the written permission of the publisher.



Contents

iv Introduction

COATINGS FOR BUILDING ENVELOPE METALS

- 1** **The Finish Line: Picking a Winning Chemistry for Architectural Aluminum**
by Tony Pupp, Linetec
- 6** **Curtain Walls—Exterior Metals: A Premium on Performance**
by Allen Zielnik, Atlas Material Testing Technology LLC
- 10** **Warning: Powder Coatings Zone**
by Walter R. Scarborough, Hall Building Information Group, LLC
- 15** **Anodization Analyzed**
by Tammy Schroeder, Linetec
- 21** **Getting More Mileage from the Metal Roof**
by Bob Brenk, Aldo Products Company, Inc.
- 25** **Ready for Prime Time: Low-VOC Fluoropolymer Coating Counted On to Generate Buzz in California and Other Venues Where ‘Green’ Takes Top Billing**
by Joe Maty, *D+D*
- 28** **Mega Makeover Delivers... More Than a Pretty Facade**
by Joe Maty, *D+D*

Contents

COATINGS FOR STRUCTURAL STEEL

31

Proving Their Mettle

by Jayson L. Helsel, KTA-Tator, Inc.

34

New Possibilities for Polyurethanes: Waterbornes on Metal

by Margaret Kendi, Pete Schmitt, and Raymond Stewart,
Bayer MaterialScience, LLC

39

High Performance, Low VOCs: Formulating Advances Deliver Waterborne Epoxies That Meet the Demands of the Day for Metal Coatings

by Daniel J. Weinmann, Ph.D., Hexion Specialty Chemicals

FIRE-RESISTIVE COATINGS FOR METAL

43

Fire-Resistive Coatings for Metal—Fire Drill: The Basics on Coatings that Protect

by Jayson Helsel, KTA-Tator, Inc.

46

Expansion Mechanism

by W. Casey West, StanChem, Inc., and Joe Maty, *D+D*

51

Premanufactured Intumescent Fire Protection: Aesthetics, Performance, Application Flexibility

by Bill Dempster, International Paint LLC



LUMIFLON's advanced FEVE fluorochemical technology and absolute clarity make possible the most beautifully brilliant colors in a gloss range exceeding anything else on the market today. LUMIFLON stands up to UV light degradation like nothing else, and its superior corrosion resistance and unique capabilities for field application make LUMIFLON the best and most practical resin there is for state-of-the-art fluoropolymer finishes. Protect your reputation. Specify LUMIFLON resin. **For more information, contact us at www.lumiflonusa.com or give us a call at 610-423-4300.**



when the standard's just not enough

Introduction

This eBook consists of articles from *Durability + Design (D+D)* and *The Journal of Architectural Coatings (JAC)* on good practice in selecting and using coatings for the protection of architectural metals.



*Photo courtesy of Tubelite Inc.
Cover photo courtesy of The Sherwin-Williams Company*

By Tony Pupp,
Linetec

*Editor's Note: This article appeared
in JAC in January/February 2007.*

**Matching the choice
of treatment to
service requirements
and environmental
conditions can
tip the odds of
successful results**

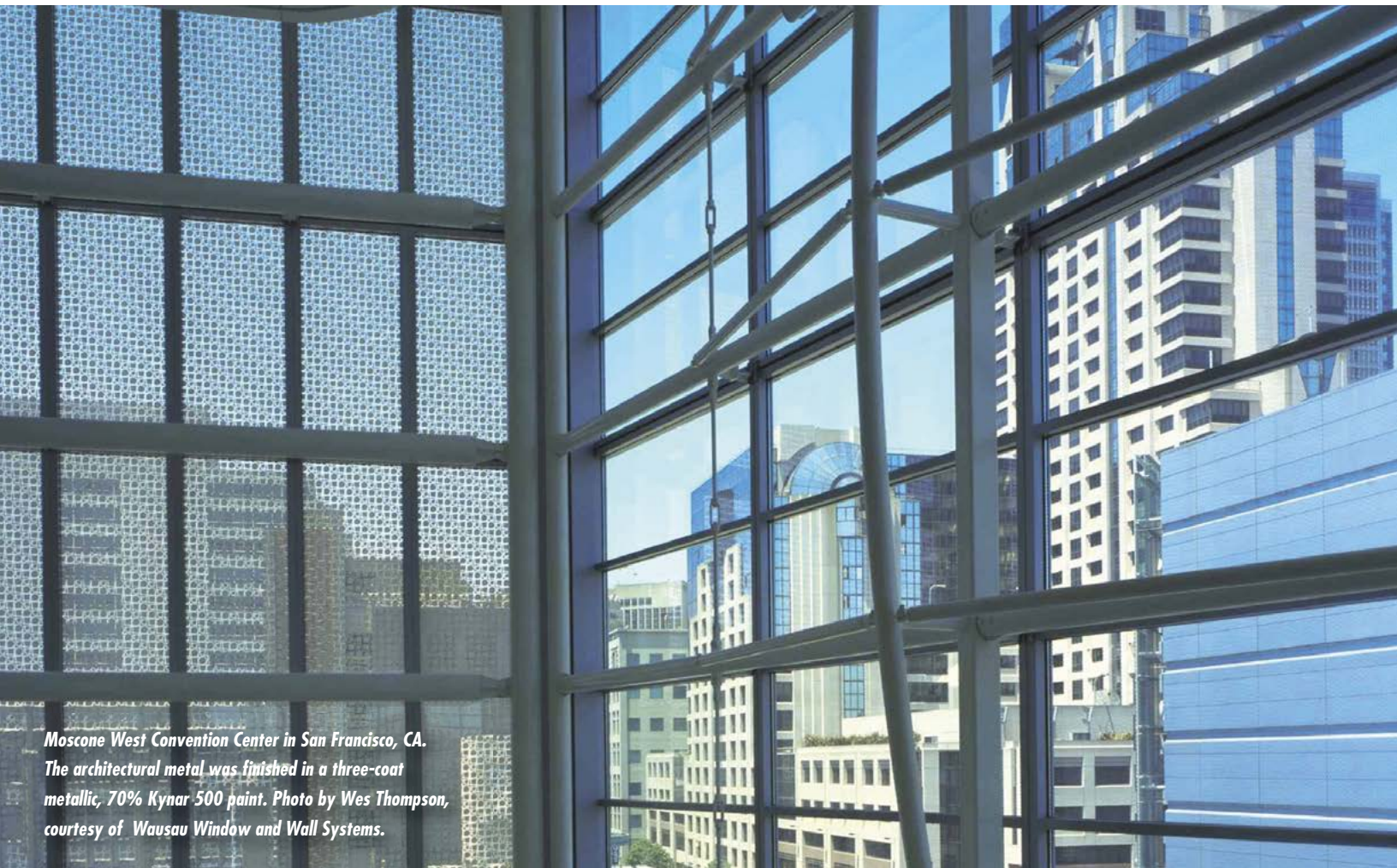
The Finish Line: Picking a Winning Chemistry for Architectural Aluminum

It certainly comes as no surprise to architects or facility managers that various environmental conditions can put building materials and surfaces to the test. If you are part of the team specifying these materials and surfaces, it helps to know which finishes will retain their appearance properties and will be easiest to maintain for the longest life span.

This guiding principle, needless to say, applies to exterior architectural aluminum. The finishing technologies and processes involved in this area of design and construction are extremely important.

In the architectural industry, the two types of factory-applied finishes for aluminum are anodize and paint. These finishing technologies require different application processes, and the resulting performance characteristics of the two technologies also differ. Both processes can deliver a long-lasting finish on building products. The finish choice of a particular project is generally based on a combination of personal taste and performance criteria.

Let's first consider anodizing.



*Moscone West Convention Center in San Francisco, CA.
The architectural metal was finished in a three-coat
metallic, 70% Kynar 500 paint. Photo by Wes Thompson,
courtesy of Wausau Window and Wall Systems.*



Grand Valley State University's Cook-Devos Center for Health Sciences in Grand Rapids, MI. The architectural metal was finished in a two-coat, 70% Kynar 500® paint. Photo by Wes Thompson, courtesy of Wausau Window and Wall Systems.

What is anodizing?

Anodizing is an electrochemical process that produces an oxide film on aluminum. This oxide film protects the aluminum substrate from deterioration. The coating produced is extremely durable, and the hardness of the surface is comparable to a sapphire—the second hardest substance on earth. This characteristic makes anodize an excellent choice for use in high-traffic areas where resistance properties are important.

The typical anodizing employed in the architectural industry is called “two-step electrolytic.” The actual anodizing and coloring of the aluminum occur in separate steps of the process.

The anodizing step takes place in a tank that contains a solution of sulfuric acid and water. The tank is charged with electrical current, and aluminum oxide is formed on the surface of the aluminum. After anodizing is complete, the parts can be immersed in an optional coloring tank, to achieve bronze or black tones instead of the standard clear or silver finish. In the coloring tank, the anodized aluminum is immersed in a bath containing an inorganic metal such as tin, cobalt or nickel, which are deposited in the anodic pores by means of electrolytic current. The amount of time the part is immersed will determine the color achieved. Darker colors are created by extending the immersion time and increasing metal deposition.

The colors typically seen on architectural products range from champagne to dark bronze and black. A recently introduced, propriety system for creating copper-colored anodize gives the look of rich, real copper, and is reported to resist stains from salt runoff, galvanic corrosion, and the formation of patina.

In order to ensure a long-lasting anodize finish on building products, the American Architectural Manufacturers Association's AAMA 611-98 specification should be referenced at the time of the order (see chart next page). This specification addresses finish mil thickness, color ranges, and performance of architectural anodize.

What is painting?

Painting is the application of a protective, decorative organic coating to the surface of a substrate. The range of color choices and specialty-type paints is seemingly boundless, and includes finishes with effects provided by metallic and mica content. Color and decorative aspects of the coating are generally based on personal preference. The end use of the architectural element, on the other hand, determines the level of protection required from a paint or coating. Paints vary in performance characteristics, including hardness, salt-spray resistance, and UV protection.

Architects should determine which performance specification is required, along with the paint color. In order to ensure the paint performance expected for a given application, three AAMA industry specifications should be referenced: AAMA 2603, 2604, and 2605. These three specifications apply to progressively stronger performance levels as indicated by South Florida outdoor exposure and laboratory accelerated testing results. The relevant performance properties and specified results are shown in the table on the next page.

The resin system is the primary determining factor in the specific characteristics and performance properties of paint. In the architectural industry, two primary resin systems are involved in prefinishing of metals: fluoropolymer-based (e.g., Kynar 500®/Hylar 5000®) and the “baked enamel” type, typically composed of acrylic or polyester resins.

A fluoropolymer system is typically used on exterior elements where UV protection, fade resistance, and protection against environmental conditions are important. This type of coating is usually seen on metal curtain-wall systems, windows, skylights, panel systems, storefronts, and doors. A baked enamel (acrylic/polyester) system is more commonly used on interior elements. These paints offer excellent hardness and abrasion resistance, but do not provide the same level of UV protection as fluoropolymer coatings.

AAMA Anodizing Specification 611-98

	Class I	Class II
End use	Exterior	Interior
	Exterior with regular maintenance	
Film thickness	0.7 mils	0.4 mils
Coating density	Best	Good
Salt-spray resistance	3,000 hours	1,000 hours
Color retention	5 years: Fade + 5 Delta E	5 years: Fade + 5 Delta E

Strengths and limitations of anodize

Strengths of Anodize

- Durability, abrasion resistance
- Metallic appearance
- Color stability

Limitations of Anodize

- Limited color choices
- Will not hide surface defects on aluminum
- Color will vary depending on aluminum alloy and trace elements in the aluminum
- Limited corrosion resistance in coastal settings

AAMA specifications for paint

Specification	2603	2604	2605
South Florida Weathering:			
Color Retention	1 year: "slight" fade	5 yrs: Fade = 5 Delta E	10 yrs: Fade = 5 Delta E
Chalk Resistance	1 year: "slight" chalk	5 yrs: Chalk = 8	10 yrs: Chalk = 8
Gloss Retention	No specification	5 yrs: 30% retention	10 yrs: 50% retention
Erosion Resistance	No specification	5 yrs: 10% loss	10 yrs: 10% loss
Dry Film Thickness	0.8 mils minimum	1.2 mils minimum	1.2 mils minimum
Pretreatment System	Chrome or Chrome Free	Chrome or Chrome Free	Chrome or Chrome Free
Accelerated Testing:			
Salt Spray	1,500 Hours	3,000 Hours	4,000 Hours
Humidity	1,500 Hours	3,000 Hours	4,000 Hours

Performance strengths and limitations of paint

Strengths of Paint

- Color retention (UV Resistance)
- Salt-spray resistance
- Many color choices
- Field touch-up/repainting capabilities
- Small-batch and custom color capabilities—fast and cost-effective

Limitations of Paint

- Fair hardness
- Cost of high-performance products
- Potential for inconsistent "metallic" paints

Weatherability: Fading and chalking

Resistance to fading and chalking rank as two key weatherability characteristics of paints and coatings used in exterior settings. Fade results when substances in the environment attack the pigment portion of the paint and cause color change.

Paints also exhibit varying degrees of resistance to chalking. Chalking is caused by the degradation of the resin system at the surface, due primarily to ultraviolet (UV) exposure. As the resin system breaks down, resin particles—along with embedded pigment particles—lose adhesion and take on a whitish appearance. Chalking is measured on a numerical scale—the higher the number, the better the chalk resistance.

In evaluating coatings for specific end-use situations, the following general guidelines can prove useful.

- Specification 2603—baked enamel paints (acrylic/polyester). Attributes include good hardness and economical cost. Limitations are relatively weak color and gloss retention and moderate chemical resistance. Recommended applications are interior surfaces.

- Specification 2604—an "intermediate" specification. A typical paint meeting this specification would be a 50% fluoropolymer product. Typical applications would be storefronts, doors, and other high-traffic areas where moderate cost is also a criterion. Finish attributes are good color and gloss retention, hardness, and abrasion resistance. Limitations include gloss-range capabilities of 25%-35% reflectance.

- Specification 2605—a "high-end" exterior specification, typically met by 70% fluoropolymer paints and coatings. These finishes exhibit outstanding resistance to humidity, color change, chalking, and gloss loss. Typical applications are high-profile, major architectural projects.

The application process

Several steps are involved in the prefinish paint-application process for metals. The first step is pretreatment, which involves cleaning and preparing a substrate, such as aluminum or steel, for paint finishing. A proper pretreatment enhances corrosion resistance and adhesion of paint to the metal surface. Without a proper pretreatment, delamination will likely happen in field service. This delamination normally occurs within the first year of installation of the finished element.

To prevent and warrant against this type of failure, the manufacturers of architectural paints require the paint applicator to employ an approved pretreatment system. Different pretreatments are available, but chrome-type pretreatments are widely recognized as being capable of ensuring a long-lasting coating on aluminum.

The second step in the process is the actual paint application. Before the paint is applied, aluminum products are placed on fixture racks. A paint applicator needs to know the areas of the surface that will be exposed when the product is installed in the field. This information is critical in determining how the material can be racked, so any rack marks are hidden on unexposed areas. The paint is typically applied electrostatically with either manual or automatic equipment.

Paint/Anodize Weathering Performance Comparison

	Paint Systems		Anodize Systems		
	Baked Enamel	50% Fluoropolymer	70% Fluoropolymer	Class I	Class II
Color & Gloss Retention	Poor	Good	Excellent	Excellent	N/A
Chalk Resistance	Poor	Good	Excellent	Excellent	N/A
Color Options	Extensive	Extensive	Extensive	Few	Few
Gloss Options	10-90	25-35	25-35	40 - 80	40 - 80
Hardness	Very Good	Good	Fair	Excellent	Very Good
Salt Spray Resistance	Poor	Fair	Good	Fair	Very Poor
Chemical Resistance	Fair	Good	Excellent	Good	Fair
Effect of Poor Substrate Quality	Moderate	Moderate	Moderate	Significant	Significant
Initial Cost	Low	Moderate	High	Low	Very Low

Paints are applied using automated “robots” or “bells.” As the parts move through the paint line, electric eyes direct the robots to adjust height and distance to target the paint spray on each piece of material. The bells spin at 10,000 rpm, atomizing the paint into small droplets, which are electrostatically attracted to the parts. This maximizes the amount of paint reaching the part and minimizes wasted paint.

Manual application of paint is necessary with certain material types. Manual spray is applied by highly trained painters. The painters ensure application to areas that automatic equipment does not adequately cover. Most finishers will use both types of equipment to provide the flexibility needed to paint a wide range of material shapes.

Many high-performance coatings are multi-coat systems that require a primer, color coat, and optional clear coat, depending on the color and paint type.

The last step in the application process is curing of the paint. Most paints used for architectural applications are heat cured at 350-450 F. Without proper cure, the paint will not perform in the field and may exhibit color or gloss problems. With the variation of material types, most paint applicators will place heat tape on parts before they go into a cure oven; heat tape shows the peak metal temperature reached in the cure oven.

Powder coatings

Powder coatings are also being marketed and used for building products, although they are relatively new to the U.S. architectural market. Some misunderstandings exist in regard to powder coatings, based on perceptions that these coatings are entirely different from liquid paint. In reality, comparable paints can be found in both powder and liquid versions. The key difference is method of application. Powder coatings are applied electrostatically in a manner similar to liquid paints. These coatings are applied as a powder to the charged metal surface. The powder particles are then subjected to heat and combine to form a film and cure.

Powder coatings contain no solvents when they are applied, so no VOCs (volatile organic compounds) are given off during or after application.

For specification of powder coatings, the same AAMA documents as apply to liquid-type coatings can be referenced (2603, 2604, and 2605).

Environmental considerations

To deal with VOCs given off by liquid paints, applicators that are cognizant of environmental and health considerations install pollution-control equipment—typically thermal oxidizers that destroy VOCs to prevent emissions into the atmosphere.

Architects and specifiers who make environmental considerations a top priority in the material-selection process will want to know how the finish applicator controls VOC emissions. Ideally, a 100% enclosed capture area should be used to contain emissions generated during application and cure, with VOCs routed to and destroyed by a thermal oxidizer. Also important is the handling of chrome waste (created in pretreatment) by a wastewater-recovery system. Hazardous waste disposal procedures must be followed for any residual waste material produced by the recovery system.



Stanford University Center for Clinical Science Research in Stanford, CA. The architectural metal was finished in a 70% Kynar 500 paint.

Photo courtesy of Wausau Window and Wall Systems.

Paint or anodize?

When the question before architects and specifiers involves finishing of metal building elements, key factors include performance requirements and appearance qualities. The chart on the next page summarizes, in general, these performance and appearance aspects of anodize and the major paint systems used for architectural metals.

Finishing up

In evaluating factory-applied finishing options for architectural aluminum, the architect and specifier will need to weigh performance and aesthetic considerations. Early communication and collaboration among architectural-product manufacturers, finishers, applicators, architects, and the entire building team will alleviate misunderstandings and deliver the desired appearance and durability for the project.

About the author



Tony Pupp is the national accounts manager for Linetec, an independent architectural finisher in the U.S. He earned a bachelor's degree in marketing from the University of Wisconsin and has 12 years of experience in paint and anodize finishing. Mr. Pupp shares his knowledge at national and local CSI meetings and frequently presents Linetec's AIA/CES programs to architectural firms. He also has contributed to such industry publications as *Glass Magazine*, *School Facilities*, and *U.S. Glass*. In addition to helping educate the design and construction communities, Mr. Pupp works closely with manufacturers and contractors, as well as his coworkers at Linetec's three finishing plants.

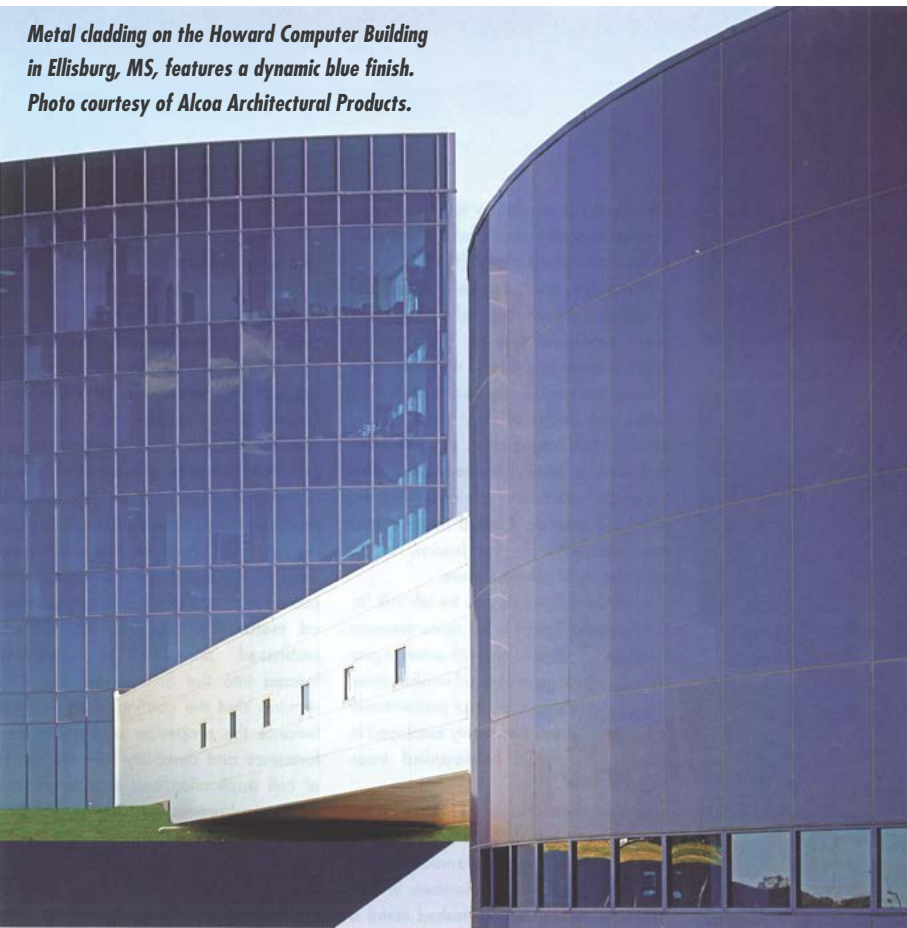
JAC

By Allen Zielnik,
Atlas Materials Testing Technology LLC

*Editor's note: This article appeared
in JAC in August/September 2007.*

*Long-term durability
and resistance
properties get top
billing in coatings for
metal curtain walls
and other architectural
elements*

*Metal cladding on the Howard Computer Building
in Ellisburg, MS, features a dynamic blue finish.
Photo courtesy of Alcoa Architectural Products.*



Curtain Walls—Exterior Metals: A Premium on Performance

Building design and construction underwent a fundamental shift in the first half of the 20th century. The exact timing of the transition in architectural design from traditional, external load-bearing walls—usually masonry—to today's dominant technology of relatively thin glass or metal panels, is as difficult to pinpoint as coming up with an exact definition of what constitutes a "curtain wall." Depending on your criteria—functionality, aesthetics, or product commercialization—agreement on this definition can prove elusive.

On paper, at any rate, the definition of a curtain wall can be stated as follows: *a vertical building enclosure which supports no load other than its own weight and the environmental forces acting on it.*

Several variations of curtain-wall construction details exist, such as "conventional stick" grid systems and the more seamless continuous-surface, semi-unitized, and unitized systems. These curtain-wall systems, however, are all essentially composed of panels made of glass, metal (usually aluminum, although steel is sometimes used), metal-composite sandwich panels, or nonmetallic cladding such as thin-stone veneer, EIFS (exterior insulation finish systems), pre-cast concrete panels, and others such as fiber-reinforced plastic (FRP).

In addition, coated metal is often used in spandrel panels that make up parts of some curtain-wall systems. These are the opaque areas in a curtain wall where the glazing material is required to hide insulation, the edges of floor slabs, ceiling details, HVAC equipment, etc. The spandrel panel is usually required to resemble the glazed vision area as viewed from the building's exterior. Coated metal is also used architecturally for fascias, soffits, canopies, and column covers.

While metal panels can be left mill finished (uncoated), it is far more common to surface these panels with either a protective clearcoat, a colored finish system, or both. In addition, surface pretreatment or priming is also commonly employed in both factory- and field-applied treatments.

Coated metal is used not merely for the curtain wall panels, but also for the exposed vertical and horizontal mullions that form the structural members in conventional stick systems. Finished metal is also used extensively in commercial prefabricated buildings, and its use in exposed-seam roofing is growing rapidly. Some of these standing-seam products are used as structural members to provide a span between roof purlins.

In this installment of "Passing the Test," our discussion will focus on coatings for metal curtain-wall elements—the types of coatings used, their performance characteristics, and how are they applied.

Common finishing materials and methods

A finish system as a whole consists of the recommended surface preparation, appropriate substrate primer, and one or two topcoats, depending on the product and application. In some cases, a clearcoat is applied over the topcoat for additional protection or for enhanced aesthetics such as high gloss.

Coated metal for new construction is invariably factory prefinished as stock product or custom fabrication. The two primary methods for factory coating of metal are coil coating and spray application. High-speed, automated coil coating accounts for the majority of factory-prefinished metal and produces a highly consistent product. Coil coating is an extremely versatile process and allows customized steps such as different pretreatments and primers and multiple coating “passes.” Both the top and bottom sides of the metal can be treated and coated in a continuous process. The coated metal can then be slit, texture-embossed, stamped, or otherwise formed into the finished product. This requires that the coatings manufacturer balance the properties of physical performance and durability with the needs of coil application and subsequent coil mechanical processing. Coil coating is a highly cost-effective process that keeps prices low, because the process facilitates coating of a significant volume of metal coil rather than individual parts.

Finished parts that cannot be coil-coated, such as formed panels or three-dimensional aluminum extrusions, can be coated using spray-application methods. Spray coating is also the primary field-applied refinish method for restoring weathered architectural metals.

A variety of factory-applied coating systems for architectural products is available. Most coil and extrusion coatings are liquid-applied materials that are then thermally cured (oven-baked) to a durable finish. Some progress has been made in applying dry powder coatings to metal coil, although this technology is still in the development stage. Also, ultraviolet (UV)-cure coatings are becoming available for coil. Both liquid-applied coatings and electrostatically applied powder coats are used for application to extrusions using spray methods.

Coating Chemistries

A variety of coatings chemistries are used for coil coatings, but due to long-term weathering durability requirements, the choices for architectural applications are more limited. The following are some commonly used coatings systems.

Polyesters, which are offered in a range of gloss and colors, are known to resist marring, staining, solvents, and corrosion, but generally do not possess a high degree of long-term durability and are rarely used for commercial exterior products. They are sometimes used for garage and entry doors and other applications where frequent maintenance repainting does not present an issue. Specialty grades of high-durability polyesters, however, do see use in architectural applications.

Silicone-modified polyesters constitute a hybrid technology that combines the properties of inorganic and organic chemistries, resulting in improved long-term durability. These coatings are often used for pre-engineered buildings.

Acrylics possess reasonably good durability properties, but can lack the “formability” capability required for coil-applied coatings.

Epoxies typically chalk in outdoor exposures and are normally limited to special high-corrosion/salt-air architectural environments.

Fluoropolymer coatings based on FEVE (fluorinated ethylene vinyl ether) and PVDF (polyvinylidene fluoride) resin technologies possess excellent color and gloss retention and lend themselves well to coil application. They are extensively used in metal roofing, metal cladding, and curtain-wall panels. These products include Asahi Glass Company’s well-known Lumiflon® resin technology. Coatings based on approximately 70% PVDF and 30% acrylic resin are used by a number of major architectural coatings manufacturers; the two primary producers are Arkema, which markets these resin products under the trade name Kynar 500®, and SolvaySolexis, which owns the Hylar 5000® brand. Some other coatings are based on 50% PVDF resin, and do not exhibit

equivalent performance when compared to the 70% PVDF materials; the uses of these coatings tend to be limited to earth tones due to reduced color-fade resistance compared to the 70%-content products.

Performance guidelines

The American Architectural Manufacturers Association (AAMA) has established a set of voluntary performance specifications to assist in the selection of a coating for a given application. A summary of the requirements appears in the table below.

Item	AAMA 2603	AAMA 2604	AAMA 2605
Coating Thickness	0.8 mils	1.2 mils	1.2 mils
Pre-Treatment	None Required	Multi-Stage Cleaning with Chemical Conversion Coating	Multi-Stage Cleaning with Chrome Phosphate Conversion Coating 40 mg./ft ² min.
Abrasion Resistance	No Requirements	Falling Sand Test - 20L/mil	Falling Sand Test - 50L/mil
Chemical Resistance	Muratic Acid/Mortar Resistance Test	Muratic Acid/Mortar Resistance/Nitric Acid Fumes Test	Muratic Acid/Mortar Resistance/Nitric Acid Fumes Test
Color Retention	1 Year South Florida	5 Years South Florida (Max. 5ΔE)	10 Years South Florida (Max. 5ΔE)
Gloss Retention	No Requirements	Minimum of 30% after 5 Years South Florida	Minimum 50% after 10 Years South Florida
Corrosion Resistance	1500 hr. Humidity/Salt Spray	3000 hr. Humidity/Salt Spray	4000 hr Humidity/Salt Spray
Chalking Resistance	No Requirements	No more than #8	No more than #8 (#6 for Whites)
Film Adhesion	Dry Adhesion/ Wet Adhesion	Dry Adhesion/Wet Adhesion Boiling Water Adhesion	Dry Adhesion/Wet Adhesion Boiling Water Adhesion
Erosion Resistance	No Requirements	Less than 10% after 5 Years South Florida	Less than 10 % after 10 Years South Florida

For exterior architectural applications such as curtain walls, compliance with AAMA 2604 or AAMA 2605 is recommended. Currently, only the 70% grade PVDF-based coatings meet the super-durable performance requirements of the AAMA 2605 standard; 50% PVDF grades typically conform to AAMA 2604.

It should be noted that the color-, gloss-, and erosion-resistance requirements of AAMA 2605 mandate at least 10 years of outdoor South Florida weathering exposure. This means that recently introduced coatings products may perform perfectly well but have not yet met the 10-year exposure requirement. Manufacturers will often provide interim test data based on laboratory artificial weathering while awaiting the 10-year results (see *Passing the Test: UV Resistance: Just the tip of the iceberg for testing of coatings durability*, JAC, April, 2005). The coating specifier may wish to consider these unrated products, but should evaluate the interim test data carefully.

The American Spray Coaters Association offers a standard—ASCA 96, *Voluntary Specification for Superior Performance of Organic Coatings on Architectural Aluminum Curtainwall, Extrusions and Miscellaneous Aluminum Components*—that essentially duplicates the AAMA 2605 specifications for key durability requirements.

Recoating considerations

Eventually, all coated architectural metal exterior surfaces may need to be refinished. A number of coatings products are available for field application to curtain walls and metal cladding. As with other coating-application tasks, a key to successful field application is substrate preparation. As much as 80% of coatings failure can be traced to improper surface preparation. The Society for Protective Coatings (SSPC) provides a set of guidelines for surface preparation of ferrous metals (SSPC-SP 1 through SP 15).

For previously coated surfaces, anything less than complete removal of the old coating may compromise performance and service life. It is recommended that a test patch of several square feet be painted and allowed to cure for a week, then tested for adhesion under ASTM D 3359, *Standard Test Method for Measuring Adhesion by Tape Test*. If the new coating system is incompatible with the existing coating, complete removal will likely be required (see *More Than A Pretty Façade*, JAC, April 2005).

Various field-applied coatings systems have been described in several issues of JAC. For metal curtain walls and metal cladding systems where the durability of factory-applied fluoropolymer-based coatings is needed, some coatings manufacturers such as PPG, have introduced low-VOC, air-dry fluoropolymer coatings for field application.

When choosing coatings for exterior metal architectural products, the architect or specifier can consider a variety of technologies. Voluntary performance specifications such as AAMA and ASCA can serve a useful purpose, but may limit selection to well-established products. For evaluation purposes, most manufacturers can provide additional, supplemental performance data. While high-performance coatings may cost more initially, this price premium may pay off in the long term in reduced maintenance requirements and longer service life. Thus, it may be worthwhile to conduct some type of life-cycle cost analysis that takes into account these long-term performance capabilities and, alternately, the consequences of using coatings that don't meet more stringent performance standards.

About the author



Allen Zielnik leads the technical consulting operation of Atlas Materials Testing LLC, where he serves as the director of strategic sales. In addition, Zielnik is a member of the American Chemical Society, the Society of Plastics Engineers, the Institute of Environmental Science, and the Federation of Societies for Coatings Technology (FSCT). He is an active member of several technical committees in ASTM International dealing with the weathering and durability of materials, and he frequently advises standards and trade groups on technical issues.

By **Walter R. Scarborough,**
HALL Building Information Group LLC

*Editor's note: This article appeared
in D+D in March/April 2011.*

*Design professionals
are advised to
proceed with caution
and extreme diligence,
due to differences in
performance of the
technology's various
chemistries*

Warning: Powder Coatings Zone

The mere mention of powder coatings elicits a wide variety of responses from the stakeholders of the design professions and construction industry. Some examples:

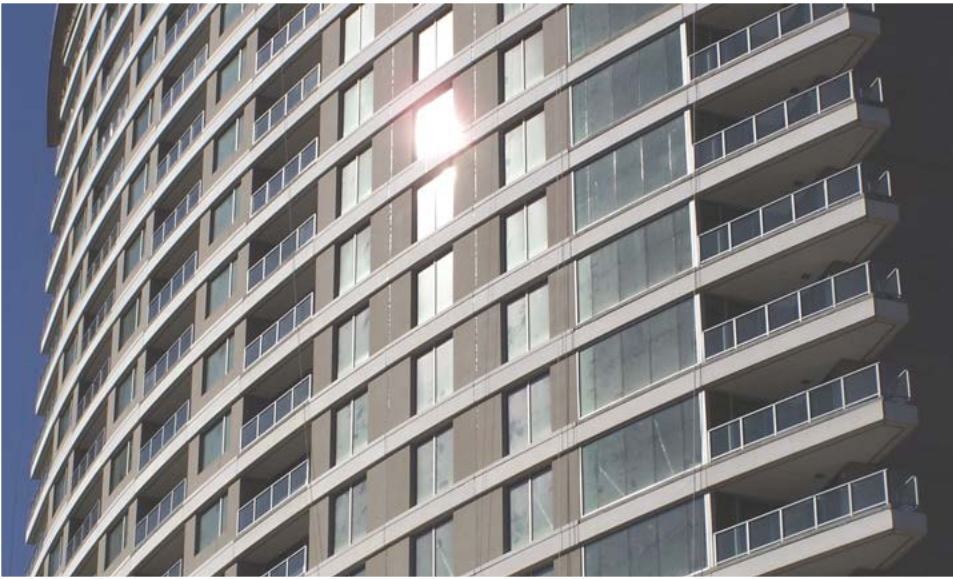
- to most owners, the mention of powder coatings probably means nothing because they are expecting the design professionals to make the right decisions about finishes;
- to the vast majority of architects and interior designers, the mention of powder coatings for one of their (they hope to be award-winning gifts to humankind) designs, conveys that warm fuzzy feeling we all seek, but for exterior coatings, this feeling could lull them into a false sense of security;
- to specifiers, the mention of powder coatings brings sighs because of the difficulty in getting the decision makers to commit to the desired color for the project (designers tend to put off making color decisions until construction is under way, which makes specifying a difficult task since the appropriate coating system is usually color dependent);
- to contractors ... well frankly, they don't really care because powder coatings are either a specifications issue or a subcontractor issue;
- to subcontractors, the accuracy of what is shown on the drawings and indicated in the specifications directly affects their livelihoods and reputations more than any other stakeholders because they have little control of the indicated and specified decisions for which they have to assume responsibility after construction; and finally
- to suppliers, they know exactly what powder coatings are and the conditions under which they should, or should not, be used;

however, like subcontractors they have little control of the decisions.

So, just like so many other aspects of the art and science of architecture, the body of knowledge of powder coating is never sought nor accessed by the design profession or the construction industry ... with the lone exception of specifiers. Many decision-makers have no desire to understand anything about paints and coatings except color. It is one of the great (well maybe not great, but significant) mysteries for decision-makers outside of the building-products industry to have little to no technical understanding about the products in which they create a design or produce construction drawings.



Photo courtesy of PPG Industries Inc.



The balcony guardrails of this new high-rise building in Dallas were coated with an AMAA 2605-compliant powder coating based on fluoropolymer resins. Photo courtesy of Quality Powder Coatings LP, Carrollton, Texas

The powder conundrum

At this point, one of two thoughts logically comes to your mind. Either (a) you think to yourself, "I did not know there was an entire family of formulation chemistries for paints and coatings that can be applied as powder coatings," or, (b) you think "I wish someone would explain to the paint and coatings industry that powder coating is a process and not a finish."

This article is written by an architect/specifier in the second group for the benefit of the decision makers and design professionals in the first group, and the main focus concerns coatings for the exterior of buildings. Unless the decision maker knows the differences, powder coating may be selected without knowing what the actual coating type and formulation chemistry will be and how it will perform in its environment.

So, here is the objective, and ulterior motive, for this article: Unlike other coating systems, the term

"powder coating" is the process by which a coating is applied to a surface; it is not a finish in the same sense that satin-gloss acrylic latex is a finish. Would we dare specify acrylic latex as "brush coating" or "roller coating" or "spray coating" as the finish we want applied to drywall, metals, concrete, etc., and expect the specification to be understood?

Following the same logic, powder coatings should not be included in manufacturer's product literature, nor should it be specified, without identifying the coating formulation chemistry.

Buyer beware

Before we move on, let's dispel the notion that a product manufacturer may be trying to take advantage of an unsuspecting, award-starved design professional by proposing the use of powder coatings for exterior applications. The idea of "buyer-beware" is common in our daily lives, and the same attitude should be used when specifying powder coatings for exterior applications.

It is the responsibility of the design professional to evaluate the products and materials selected for a design to determine if they are suitable for their final locations. Manufacturers sell products and materials, and unless the specification states otherwise, the manufacturer will provide the product or material as described in its product literature or on its website. So, accountability in this regard cannot and should not be sloughed off on the subcontractors, suppliers, applicators, or product manufacturers.

The essential problem with only indicating a finish to be "powder coated" on the drawings or in the specification is that it results in an incomplete specification. Neither the coating type nor the coating formulation chemistry is identified if this terminology is employed. Unless stated, which of the numerous chemistries is specified? By not specifying the paint or coating's resin chemistry, the finish that will be provided may or may not be suitable for the environment in which the product will be installed (example: epoxy as the exterior finish coat).

As all mothers at times find necessary, Mother Nature can be harsh in how she treats the built environment, dishing out rain, snow, ice, sleet, variable temperatures, termites, wind, humidity, moisture vapor, sunlight...not to mention dangerous conditions such as hail, hurricanes, lightning, floods, earthquakes, and tornados. Obviously no finish would be expected to withstand the most extreme weather events, but there is a reasonable expectation that a finish should be resistant to weather conditions that are normal for the project location. In northern climates, the cold might freeze a finish off, while in southern climates, the sunlight might do the job with heat and UV radiation.



Application of powder coating to aluminum trim. Photo courtesy of Quality Powder Coatings LP.

Thermosetting	Thermoplastic
Crosslinked polymer that cannot be remelted	Polymers that can be melted and remelted
Polyester-TGIC (triglycidyl isocyanurate)	Polyamides (Nylon)
Acrylic	Polyolefins
Polyurethane	Polyester
Epoxy	PVF3 Fluoropolymers
PVDF Fluoropolymers	

Powder coatings are polymers that are ground into a fine dust that can be divided into two basic types, as shown here.

Specialized equipment for cleaning, application, and baking (curing) is necessary for the application of powder coating, which requires the work to be performed in a manufacturer’s or applicator’s shop rather than at the building site. Powder coating is a very common finish approach for OEM (original manufacturer’s equipment) and many consumer products. Unlike liquid coatings, application of powder coating is a dry process, as described in the following.

- Surfaces to be coated are pretreated in much the same way as is done for conventional liquid coatings. They may be abrasive blasted or chemically cleaned to ensure the surface is free of oils, dust, mill scale, or other contaminants that might be detrimental to the finish.

- Sometimes, depending on the product, the surfaces may also be pretreated with a conversion or chemical coating, usually zinc or phosphate based, to improve the surface for powder adhesion.

- Surfaces are rinsed and dried.

- Pigment and resin powder particles are electrostatically charged and sprayed onto electrically grounded surfaces in a powder spray booth.

- Finally, the powder is heated to its melting point in a conventional curing oven or an infrared oven, or both, which results in a fused and smooth finish.

The advantages of powder-coated finishes include the following:

- Product application efficiency is 90% to 95% and the overspray is recoverable; three times more efficient than for liquids.

- One-coat applications are common (primer required for coastal settings); liquids usually require at least two coats, if not three or four.

- Volume solids are 100%—two to three times more than for liquids.

- Achieves a superior consistency and uniform finish without runs, drips, sags, or bubbles.

- Final coating is harder than with liquids.




In addition to the advantages listed above, additional environmental benefits include:

- lower curing temperatures and less time required than for liquids;

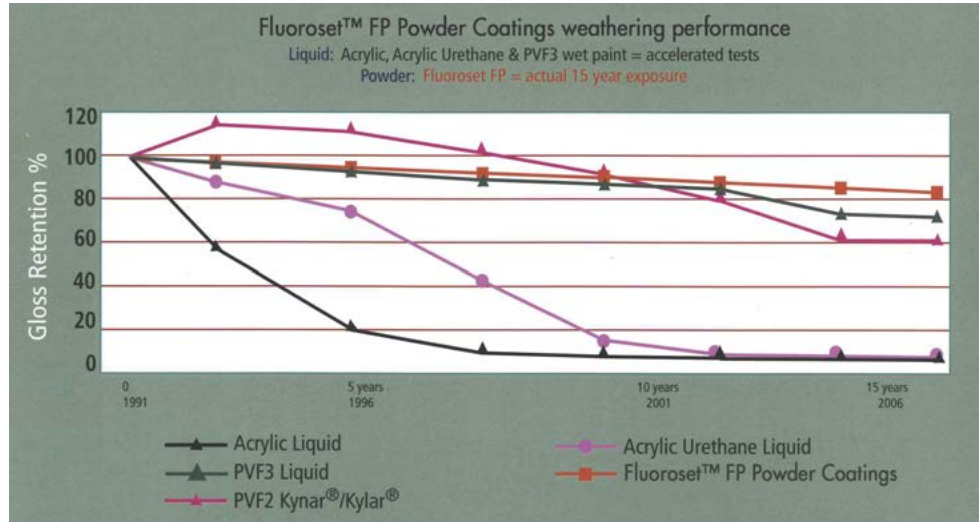
- compliance with environmental regulations;
- no solvents, no volatile organic compounds (VOCs);

- no hazardous waste; and

- not hazardous to applicators.

Performance Tests	AAMA 2603-02	AAMA 2604-02	AAMA 2605-05	
 Chemical	Muriatic Acid Resistance - 10%, 10 drops, 15 mins	No blistering, no visual change	No blistering, no visual change	
	Mortar Resistance - 24 hrs	No loss of film adhesion or visual change	No loss of film adhesion or visual change	
	Nitric Acid Resistance - 70% reagent grade, 30 mins	Not applicable	Color change Delta E < 5	Color change Delta E < 5
	Detergent Resistance - 3%, 72 hrs	No loss of adhesion	No loss of adhesion	No loss of adhesion
	Window Cleaner Resistance - 10 drops, 24 hrs	Not applicable	No blistering and no change in appearance	No blistering and no change in appearance
 Weather	Humidity Resistance	1500 hrs formation of blisters Size No.8	3000 hrs formation of blisters Size No.8	4000 hrs formation of blisters Size No.8
	Salt Spray Resistance	1500 hrs 1-2mm creepage, formation of blisters Size No.8	3000 hrs 1-2mm creepage, formation of blisters Size No.8	4000 hrs 1-2mm creepage, formation of blisters Size No.8
	Erosion Resistance	Not applicable	10% loss max	10% loss max
 UV Exposure	45° Florida Exposure	1 year	5 years	10 years
	Color Retention	Not applicable	Color change Delta E < 5	Color change Delta E < 5
	Chalk Resistance	Not applicable	No more than No.8 rating	No more than No.8 rating for colors and No.6 for whites
	Gloss Retention	Not applicable	Minimum 30%	Minimum 50%

Coatings used in exterior exposures should comply with one of the AAMA performance standards shown in the illustration. AAMA 2605 should be referenced for monumental and high-profile commercial projects in all environments (severe, mild or tropical). AAMA 2604 should be used for other project types and environments not named under the other two standards. AAMA 2603 should be used for residential applications of less than four floors in mild or tropical environments only. Chart courtesy of IFS Coatings Inc., Gainesville, Texas.



Product test results from a powder producer, IFS Coatings Inc., which charts the performance of the company's AAMA 2605 coating with four other competitive liquid coating types. Diagram courtesy of IFS Coatings Inc., Gainesville, Texas.

Powder coatings on exterior surfaces are common outside the U.S., and this has been the case for a couple of decades. For several reasons, however, the availability and use of powder coatings has been slow to develop in North America for exterior applications. These reasons include the following:

- Cost to produce and apply powder is more expensive and time-consuming than with liquids.
- Durability/weatherability is not quite as good as liquid coatings, especially in the southern portions of the U.S. due to the intensity of ultraviolet radiation.
- Major investment in sophisticated application and pollution-control equipment for liquid coatings has taken place, and until the cost of application of powder decreases or liquid coatings become more regulated for environmental reasons, powder coatings may continue to be slow to develop.

The critical importance of specifying the appropriate powder coating

As we've already established, it is critically important to specify the appropriate coating formulation chemistry for powder coatings intended for exterior applications. In the U.S., the most stringent performance standard for exterior finishes is American Architectural Manufacturers Association (AAMA) 2605, *Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels*. While there are several other AAMA performance standards for exterior finishes, AAMA 2605 requires coatings on metals that are more durable and have better color and gloss retention than any other standard.

The weathering portion of AAMA 2605 requires sample panels to be placed on a fence at a 45-degree angle and exposed to the climate of South Florida, which is considered to be the harshest location in which to test paints and coatings. After 10 years of exposure the samples are evaluated for color retention, chalk resistance, gloss retention, and resistance to erosion. Therefore, the most effective manner of specifying powder coatings for exterior applications is to reference one of the AAMA performance standards that is appropriate for the project and its location.

The physical properties that are important considerations for exterior applications are shown in the table on page 12.



It's all about the right chemistry

In closing, selecting and specifying powder coatings is as much about acquiring an understanding of paint and coating products that should *not* be specified for exterior applications as it is about an understanding of products that *can* be specified.

Design professionals are advised to exercise caution when specifying finishes for metals on the exterior of buildings. Clearly, this approach should be followed with powder coatings as much as with any other type of paint or coating, taking into account the performance characteristics of different powder-coating chemistries and relevant performance standards such as AAMA 2605. Otherwise, the design professional may be getting a call from an owner in five or six years—and it won't be an invitation to a round of golf.

About the author



Walter R. Scarborough, CSI, SCIP, AIA, is Dallas regional manager, HALL Building Information Group LLC, and a contributing editor of *Durability + Design*. He is a registered architect and specifier with more than 30 years of technical experience with many building types, including sports, healthcare, governmental, hospitality, entertainment, detention, banks, and commercial. HALL Building Information Group LLC, based in Charlotte, N.C., offers specifications consulting, manufacturing consulting, and peer reviews. Scarborough was formerly director of specifications for 10 years with one of the largest architectural firms in the world, and was with the firm for more than 22 years.

Scarborough is the revision author for the new *CSI Project Delivery Practice Guide*, co-author of the college textbook *Building Construction, Principles, Materials and Systems*, has written articles for a number of periodicals, has taught college courses about contracts and specifications, and has given numerous presentations at local, state, regional, and national conferences. He is active in the Construction Specifications Institute at the national and chapter levels, and is a past president of the Dallas CSI chapter and former member of the CSI Education Committee. He has CDT, CCS, and CCCA certifications from CSI, and received CSI's J. Norman Hunter Memorial Award in 2008. He also is an ARCOM MasterSpec Architectural Review Committee member. **D+D**

By **Tammy Schroeder,**
Linetec

*Editor's note: This article appeared in
JAC in October/November 2008.*

*Time-tested technology
delivers protection,
color, and aesthetic
appeal to aluminum
building elements*

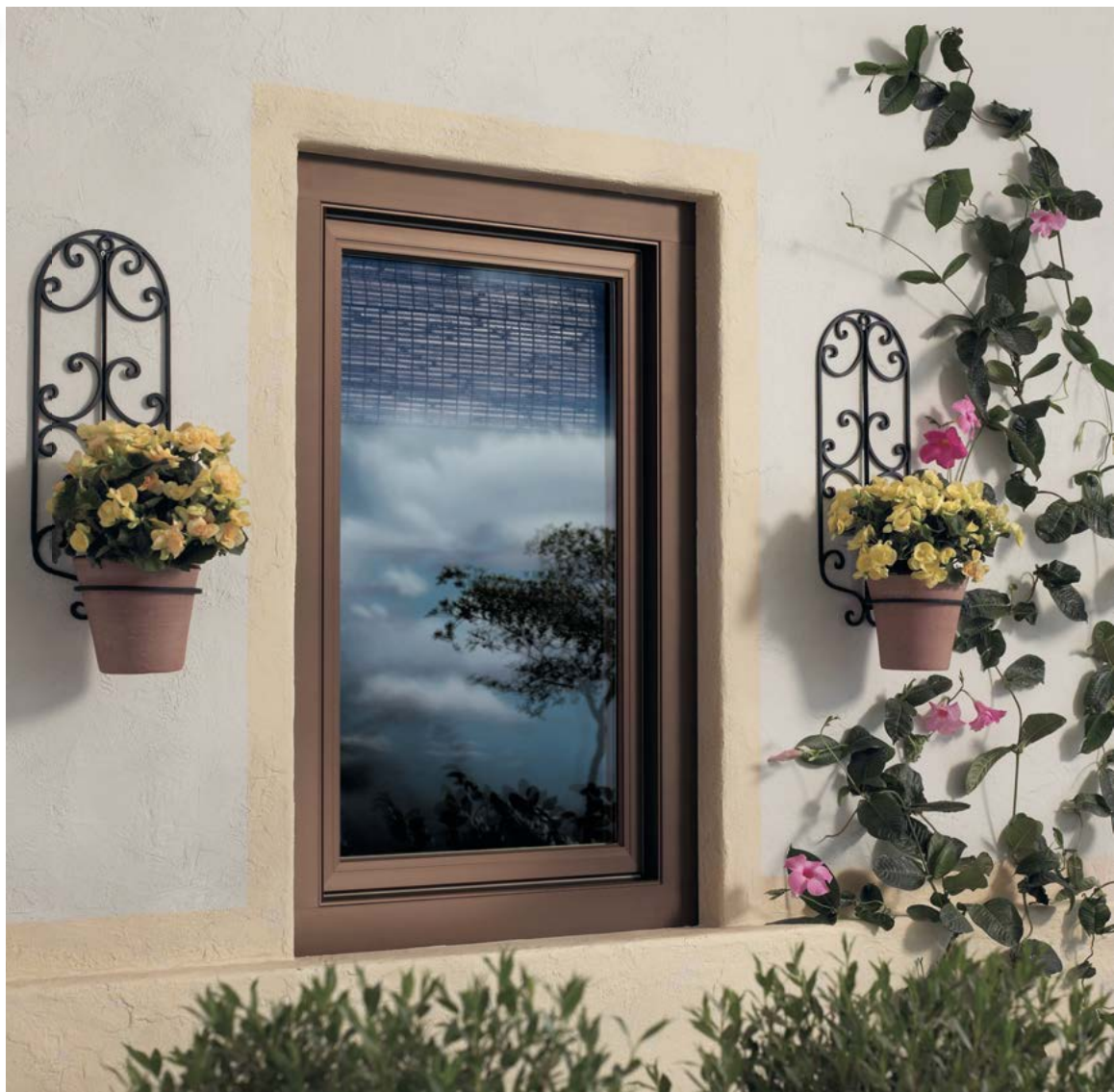
*The anodizing process enhances the protective and
aesthetic characteristics of aluminum with a transparent
color effect that accentuates the look of the base metal.
Copper anodize window unit; photo courtesy of Marvin
Window and Door.*

Anodize Analyzed

A versatile and durable technology, the process known as anodizing can boast of numerous applications, including architectural, recreational, commercial, and automotive. In building construction applications, anodized aluminum can be found throughout a structure's framing, in windows, doors, skylights, curtain walls, and entrances. Aluminum anodize also can be found on panel systems, roof coping, flat sheet, and brake metal, as well as ornamental work.

Anodized aluminum offers three, inherently desirable characteristics:

- protective chemical resistance to the environment, inside or out;
- transparency, which does not call attention to itself, but highlights the base metal; and
- application of various colors directly into the pores of the aluminum surface.



What is anodizing?

Anodizing successfully combines science with nature to create a high-performance metal finish. It is the process of electrochemically controlling, accelerating, and enhancing oxidation of the aluminum part, creating a durable, scratch-resistant coating on the aluminum.

The anodize process typically begins with the cleaning of the aluminum in a non-etching alkaline chemical. This removes all shop dirt, water, soluble oils, etc., which may have accumulated on the material during handling and/or manufacturing. After cleaning, the material is ready for caustic etching.

The caustic-etch process will produce a matte finish, and also minimizes minor surface imperfections such as light die lines and minor travel marks. Caustic etching will not eliminate all surface imperfections. A good rule to follow is that if the imperfection can be felt with a fingernail prior to anodizing, it likely will not be removed by caustic etching.

The material is then “desmutted” and rinsed to remove residuals left from the caustic etch. This is the final preparation stage prior to anodizing.

The sulfuric acid (Type II) anodizing process produces a protective and decorative oxide finish on aluminum. The aluminum oxide layer is made thicker by passing a DC current through a sulfuric-acid solution, with the aluminum part serving as the anode—the negative electrode. The current releases hydrogen at the cathode—the positive electrode—and oxygen at the surface of the aluminum anode, creating a buildup of aluminum oxide.

If the material requires coloring, it is moved to an electrolytic two-step coloring tank. Tin metal is electrochemically introduced into the anodic pores to produce bronze tones ranging from light champagne to black. A proprietary system for creating copper-colored anodize has been introduced that involves using actual copper to color the aluminum while isolating the copper in the coating. This unique process gives the look of rich, real copper, and is reported to resist stains from salt runoff, galvanic corrosion, and the formation of patina. After anodizing and coloring, the material is sealed in a mid-temperature hydrothermal seal and then given a final hot-water rinse. This final, important step ensures that the high-quality, anodized finish maintains its beauty for many years.

Anodizing per the American Architectural Manufacturers Association (AAMA) 611 specification is most common, although other specifications may be followed per job requirements. AAMA developed specifications to provide performance criteria and to aid in the selection of an anodized coating for a particular application. AAMA 611-98 is the Voluntary Specification for Anodized Architectural Aluminum.

Class I and Class II anodic coatings are designations created by the Aluminum Association for the purpose of codifying the AAMA 611 specification. A Class I coating has a mil thickness of 0.7 (18 microns) or greater. It is a high-performance anodic finish used primarily for exterior building products and other products that must withstand continuous outdoor exposure.

A Class II coating has a minimum mil thickness of 0.4 (10 microns). A Class II coating is a commercial anodic finish recommended for interior applications or light exterior applications receiving regularly scheduled cleaning and maintenance, such as storefronts.

For the best finishing performance, an architectural Class I anodize coating is strongly recommended (see table, p. 17). The thicker coating is less vulnerable to weathering and more resistant to corrosion and scratches.

With documented testing, some finishers offer warranties of five years on Class I Anodize. In some cases, with prior approval and a minimal upcharge, finishers may offer an extended warranty of up to 10 years. The anodizing warranty for Class I, (0.7 mil) clear, bronze, and black finishes generally warrant that the finish will not chip, crack, peel (adhesion), chalk, or experience color change and fading.



Anodizing offers an array of gloss and color alternatives, minimizes or eliminates color variations, and allows the aluminum to maintain its metallic appearance. Photo courtesy of Marvin Window and Door.



Commercial-building application of bronze anodize; photo courtesy of Tubelite Inc.

Class I and Class II coatings should not be confused with Type I, Type II, and Type III anodic coatings as described in the authoritative anodizing standard, MIL-A-8625. Type I anodize refers to chromic acid anodizing. Type II is normal, “clear” sulfuric-acid anodizing. Type III is “hard coat” using sulfuric-acid or mixed-chemistry electrolytes.

Table: Weathering Performance

	Class I	Class II
Color & Gloss Retention	Excellent	N/A
Chalk Resistance	Excellent	N/A
Color Options	Few	Few
Gloss Options	40 – 80	40 – 80
Hardness	Excellent	Very Good
Salt Spray Resistance	Fair	Very Poor
Chemical Resistance	Good	Fair
Effect of Poor Substrate Quality	Significant	Significant
Warranty	5 years	None
Initial Cost	Low	Very Low

Why use anodizing?

An anodized finish satisfies each of the following factors that must be considered when selecting a high-performance aluminum finish.

Durability. Anodize offers hardness and scratch resistance that surpasses paint. (The hardness of anodize is compared to that of a sapphire, the second-hardest substance next to the diamond.) The aluminum oxide created in the process becomes an integral part of the substrate and is much harder than the aluminum it replaces, producing a high level of wear and abrasion resistance. Because the anodic coating is an integral part of the substrate, it will not chip, peel, or flake over time.

Color stability. Exterior anodic coatings provide a high level of resistance to ultraviolet light do not chip or peel, and are easily reproducible.

Maintenance simplicity. Scars and wear from fabrication, handling, installation, frequent surface-dirt cleaning, and usage in service are virtually nonexistent. Rinsing with water, or mild soap and water cleaning, usually will restore an anodized surface to its original appearance. Mild abrasive cleaners can be used for more difficult deposits. Anodized surfaces, unlike stainless steel, will not show fingerprints.

Metallic appearance. Anodizing offers an increasing number of gloss and color alternatives and minimizes or eliminates color variations. Anodizing allows the aluminum to maintain its metallic appearance.

Lower cost, greater longevity. A lower initial finishing cost combines with lower maintenance costs for greater long-term value.

Health and safety. Anodizing is a safe process that is not harmful to human health. An anodized finish is chemically stable; will not decompose; is non-toxic; and is heat-resistant to the melting point of aluminum, 1221 F. Since the anodizing process replicates the naturally occurring oxide process, it is non-hazardous and produces no harmful or dangerous by-products.

A natural, green alternative. Anodize is a waterborne process and uses no volatile organic compounds (VOCs). Anodizing enhances aluminum and its environmental virtues by using the base metal—the aluminum alloy—to create a thin, extremely strong, and corrosion-resistant finish, thus preserving and extending the life of the aluminum product. Anodized aluminum is 100% recyclable; no intermediate processing is needed for anodized metal to re-enter the recycle chain.

Challenges, limitations to consider with anodize

A few challenges associated with an anodize finish include the following.

Limited palette. Architectural anodize finishes are limited to certain colors, including clear/silver, black, champagne, and traditional bronze tones.

Color variation. The color obtained in the anodize process is dependent on many factors such as alloy, temper, shape, etc. Therefore, it is impossible to produce a perfect color match.

Difficult touch-up. Anodize finishes are factory applied; any field repair touch-up must be done with a paint. A paint finish will never precisely match an anodize finish.

Low hide. Anodize is an integral part of the aluminum, therefore heavy die lines, dents, and dings on the aluminum part will show through the finish.

For best results...

Anodized finishes provide outstanding surface properties, including a high degree of resistance to abrasion, erosion, and ultraviolet-light degradation. These finishes are highly durable, deliver an exceptionally long life expectancy, and require only minimum maintenance.

Some basic guidelines to consider when preparing metal for an anodize finish are the following.

Be consistent. The easiest way to ensure consistency in aluminum parts is to work with one metal source/extruder per project.

Don't mix the metal. Mixed aluminum alloys or even tempers will not produce uniform results. For best results, 6063 alloys are recommended for extrusions and 5005 are recommended for sheet stock.

Bend and form before finishing. Anodic films are very hard. As a result, most post-production bending will lead to "crazing" of the film, which will give the appearance of a spider web. Crazing produces a series of small cracks in the finish.

Store properly. The aluminum should be stored in a dry and controlled environment. Moisture should not be allowed to build up between the pieces, as this will cause severe corrosion, known as white rust, which will not be removed in the finishing process. This is important not just to the fabricator; the finisher should also ensure proper climate control where aluminum is stored.

Avoid adhesives. Tape or adhesive on the aluminum may leave a residue that may not be removed in the anodize process.

Agree on specifications and expectations. In the architectural industry, the most widely recognized specification is AAMA 611-98. If specific parameters are required, it is important to furnish the finisher with the desired requirements to ensure the job is completed to the customer's expectation.

Watch for welds. Welded parts will show a different color on the weld than on the remainder of the part. The heat developed from the welding process can disturb the metallurgy on nearby metal and cause a localized discoloration after anodizing. The fabricator should ensure that the proper 5356 alloy welding wire and the lowest heat possible are used.

Prevent solution entrapment. Proper drainage holes are essential for drainage of solution, allowing entrapped gas to escape from the parts. Even the tightest of welded joints will cause anodize chemicals to seep out.

Talk about racking. The finisher needs to know where parts can be racked. There are a variety of ways for anodizers to rack parts, from welding material to spline bars, to a screw down-bolt system. In any case, contact marks are visible on the aluminum. It is important to define what is acceptable and what is unacceptable with regard to exposed surfaces and rack marks.

Handle with care. Good shipping practices are essential to a quality job. Prior to shipment to the finisher, the fabricator should package metal carefully to ensure the metal arrives dry and free of scratches and dents.

Quality in, quality out. Metal free from defects will produce a higher-quality finish. The fabricator should avoid sending the finisher metal with scratches, dings, heavy die lines, die pick-up, etc. These quality defects in the metal will show through the anodize process.



In building construction applications, anodized aluminum can be found throughout a structure's framing, in windows, doors, skylights, curtain walls, and entrances. Photo courtesy of Tubelite Inc.

Installation issues

To ensure a long-lasting anodize finish, the following issues should be considered during installation:

Dissimilar materials. Architectural designs often incorporate many different materials, making the potential for contact between dissimilar materials an important consideration. If questions occur regarding compatibility, the manufacturer of the aluminum products should be contacted.

Masonry work. The major source of damage to in-place aluminum components usually comes from the splashing, splattering, or run-down from adjacent or overhead masonry work. Acids used for cleaning operations also pose a serious problem. Any mortar, plaster, concrete, fire-proofing, sprays, paints, or other wet preparations that inadvertently splash on the aluminum must be immediately wiped clean before they dry, and the affected area washed liberally with water. Dried splatterings should be removed with wooden or plastic scrapers (not metal), which will not scratch the surface.

Chemical attack. Chemical attack occurs when acid or alkaline materials come in contact with aluminum finishes, especially an anodized finish. The most common occurrence is encountered when mortar or muriatic acid is

allowed to dwell, even for a short time, on a window or aluminum building component. Once the finish is visually affected, irreversible damage has occurred and the discolored item may need to be replaced.

Contact with strong cleaners. If strong cleaners are used to clean brickwork and masonry, they should be confined to the area being cleaned. Cleaners strong enough to dissolve mortar spots on brick will surely damage any aluminum finish and possibly the underlying metal. Accidental contact from these solutions should be flushed from the aluminum surface immediately with clean water.

Welding fluxes. Welding fluxes can cause damage to aluminum during installation, and should be immediately flushed from the surface with water if accidental contact is made. Care also should be taken to ensure that heat generated during welding does not affect the finish. Applying high temperature to anodize and painted coatings can permanently damage or discolor the finish.

Tar roofing. When tar roofing is applied, the roofing should be graveled on the same day to minimize staining from run-down. Failure to avoid contact with the aluminum will result in staining that is extremely difficult to remove.

Care of anodized aluminum following installation

It is crucial that aluminum work be carefully protected after the installation is complete and prior to the building's final acceptance. This protection is usually the general contractor's responsibility. Most damage to aluminum work will occur during this time.

Installed aluminum work is considered a "finished product," while the other building components are generally in a rough or unfinished state. Aluminum materials, therefore, must be well protected and shielded, since it is often impossible to satisfactorily repair damaged materials in the field. Even if possible, rework is costly and can lack the quality of the original work. Likewise, replacement is time consuming and expensive.

Cleaning procedures for aluminum should be initiated as soon as practical after completion of installation to remove construction soiling and accumulated environmental soiling and discolorations.

For light soils, the simplest procedure is to flush the surface with water using moderate pressure. If soil is still present after air-drying the surface, scrubbing with a brush or sponge and concurrent spraying with water should be tried. If soils still adhere, then a mild detergent cleaner should be used with brushing or sponging. Washing should be done with uniform pressure, first horizontally then vertically. After the washing, the surfaces must be thoroughly rinsed by spraying with clean water.

Certain precautions must be taken when cleaning anodized aluminum surfaces. Aluminum finishes must first be identified to select the appropriate cleaning method. Aggressive alkaline or acid cleaners must never be used. Cleaning hot, sun-heated surfaces should be avoided, since possible chemical reactions will be highly accelerated and cleaning non-uniformity could occur. Strong organic solvents, while not affecting anodized aluminum, may extract stain-producing chemicals from sealants and may affect the function of the sealants. Strong cleaners should not be used on window glass and other components where it is possible for the cleaner to come in contact with the aluminum. Excessive abrasive rubbing should not be used because it could damage the finish.

For added protection, wipe-on surface protectants are available and are estimated to provide protection for 12 to 24 months in the harshest environments. The benefits of such an application are two-fold: first, it protects the finish; and second, it makes subsequent maintenance easier. Subsequent maintenance may be reduced to simply flushing the surface with water, permitting it to dry, and wiping on a surface protectant every few years. In applying these protectants, it is important that the manufacturer's recommendations be carefully followed.

Working with an experienced finisher, the resulting beauty, versatility, and ease of maintenance of anodizing make it a highly recommended choice for architectural building applications where durable aluminum building components are sought.



About the author

Tammy Schroeder is the national marketing specialist for Linetec, an independent architectural finisher in the U.S. She has a decade of experience in paint and anodize finishing. In her current position, Schroeder develops and maintains Linetec's AIA/CES and other educational presentations.

By Bob Brenk,
Aldo Products Company Inc.

Editor's Note: This article appeared in JAC in March/April 2009. This is the first in a series of articles on the use of field-applied reflective roof coatings on different types of roof surfaces. The articles are being developed and published in cooperation with the Reflective Roof Coatings Institute (RRCI). More information on the institute is available on the website located at www.reflectivecoatings.org. The RRCI is located at 400 Admiral Blvd., Kansas City, MO 64106; phone: 816.221.1297.

Getting More Mileage From the Metal Roof

For decades, the construction of pre-engineered metal buildings has offered building owners and facility operators a quality building that meets existing budget and time constraints. Whether the building use is manufacturing, warehousing, professional office space, or some combination of functions, metal buildings have proven to be cost-effective from both the design and construction perspectives.

Metal roofing also finds use in other commercial building types, where it has earned a reputation for performance, durability, and aesthetic appeal.

Metal roofing comes in a variety of styles, each with its own identifying profile. In commercial applications, the most common metal roof styles are either concealed-fastener systems (batten seam, double-lock standing seam, and T-panels) or exposed fastener systems (R-panel and corrugated). Metal roof panels are treated at the factory with coatings products, including acrylic-polymer and fluorocarbon-based paints. These coatings serve as the first defense against the effects of weathering, which can include severe ultraviolet radiation in southern U.S. and tropical regions. These products also deliver aesthetic qualities and contribute to the durable nature of the metal roofing available in the current marketplace. Metal roof systems can offer advantages in terms of aesthetics, performance, and cost—advantages that include low maintenance and long lifecycle. Metal roof systems can last as much as two to four times longer than asphalt-based roof systems.

As with all roof systems, however, metal roofs don't last forever; service life is affected by a number of factors, including climate and geographic location of the building, the building function, the possible presence of airborne emissions and contaminants, and the quality of roof maintenance on the part of the owner. Not to be overlooked in the discussion of metal roof lifecycle is the role of proper original installation of the system.



Restoration with reflective coatings serves multiple objectives, including enhanced energy efficiency, sustainability, and economy

A constant with all metal roof systems is “thermal shock” or “thermal cycling.” Simply put, this phenomenon is defined as movement of the metal panels and other stress points in the system as the temperature of the metal fluctuates. This phenomenon sometimes becomes evident in the form of creaking sounds that can occur inside a metal building or warehouse. Thermal cycling or shock can occur seasonally during the year or as a diurnal (day/night) event, and can result in premature metal fatigue, degradation of fasteners and neoprene washers, and failure of seams. All of these factors can lead to unwanted water entry into the building.

At some point during its service life, any metal system will be in need of maintenance, restoration or, at the end of its service life, complete replacement. For an owner or facility manager, the most obvious symptom of the damaged or degraded roof in need of attention is repeated roof leakage during or shortly after rainfall. In many cases, application of an elastomeric coating serves as an excellent choice to restore the metal roof system to a leak-free state.

At the same time, the use of a white, reflective coating can slash the roof-surface temperature from a summer daytime high of 160 F to 175 F to no more than approximately 110 F, a 30% reduction. The building owner also can extend the service life of the roof, and ultimately reduce the energy costs within the building during peak cooling-demand hours. Many elastomeric-coating manufacturers can document these kinds of results with case studies and corresponding data.

Coatings choices

The owner, roofing professional, or specifier can evaluate a great number of high-quality products from manufacturers of elastomeric roof coatings for metal-roofing restoration projects. As limits on volatile organic compounds (VOCs) are lowered by federal and state government agencies, water-based acrylic coatings, primers, and sealants are being specified for many of these metal-roof restoration projects. Given the positive slope and limited ponding-water potential associated with most metal roofs, an acrylic coating in many cases represents an acceptable choice of coating materials.

Field-applied reflective roof coatings are also offered in a number of other chemistries, some of which are designed to provide specific performance properties, but the discussion here will be restricted to acrylics. These other coatings chemistries include asphaltic/bituminous, epoxy, fluoropolymer, polyurea, polyurethane, silicone, hybrid (combinations), and soy-based products. Acrylics account for the largest share of the field-applied roof-coatings market.

Acrylic elastomeric roof coatings are tested for specific performance and physical-property characteristics in accordance with ASTM D6083, Standard Specification for Liquid Applied Acrylic Coating Used in Roofing. In addition, the EPA Energy Star Program (www.energystar.gov) and the Cool Roof Rating Council (www.coolroofs.org) have established specific solar-reflectance and thermal-emittance criteria that products must meet for program acceptance.

The Cool Roof Rating Council maintains a “Rated Products Directory” that lists initial reflectance and emittance levels for hundreds of roof-coatings products. The directory can be accessed on the council’s website.



A roof-restoration coating system that includes a solar-reflective finish coat was applied to the metal roofs of the Mayfair Tennis & Racquet Clubs, Markham, Ontario. Top photo shows the coating application under way; the job is complete in photo above. The coating system—the ASTEC Metal Roof System—includes metal primer, acrylic waterproof membrane for seams and fasteners, and a white, solar-reflective, acrylic finish coat. Photos courtesy of ASTEC Re-Ply Roof Systems.

The restoration process

The first step in the metal-roof restoration process is typically a site visit by a roofing professional or coatings-manufacturer representative. This visual inspection will include an evaluation of:

- the integrity of metal panels with respect to oxidation (from rooftop and interior if possible);
- the condition of fasteners and panel overlap areas;
- the base of rooftop mechanical units and penetrations (vent pipes, etc.); and
- skylights, for breaches around their perimeters.

Additionally, it is essential to identify the type and composition of the factory finish originally applied to the roof to assure compatibility with the restoration coating system. For example, a Kynar® fluoropolymer factory finish may require a coating or primer of similar chemistry to achieve proper adhesion. Also important in this evaluation process is taking note of the slope of the roof.

These issues related to the condition of the roof, along with the time of year and project geographic location, will play a role in determining which elastomeric, reflective coating products are appropriate for application on any given project. For example, the relatively dry climate of the Southwest is not conducive to the use of a moisture-cure polyurethane sealers for fasteners, seams and penetrations.

Additionally, a water-borne coating used in a project scheduled for completion in the later months of the year in northern regions may be compromised during the curing process due to cold weather. In such a situation, it may be wise to identify and seal obvious leak areas and complete the entire project in the spring when weather permits.

Cleaning and preparation

The next step in the restoration process is surface cleaning and preparation. This part of the process is critical to project success, in that cleaning will yield the best surface possible for optimal coating adhesion and ultimately, performance as intended. Without proper adhesion, coating failure is simply a matter of time. If the roof is of the exposed-fastener type, all fasteners must be checked for integrity; if replacement is required, oversized fasteners are recommended. On many older roofs of this type, the neoprene washers have decayed over time, permitting the fasteners to back out, and making fastener replacement the only option.

Cleaning begins with a pressure wash, although the coating crew must exercise caution and not unnecessarily force water through any openings and into the building during this phase of the project.

Once the roof is cleaned, a primer is applied to all oxidized areas and a mastic material is used to seal all fasteners, panel gaps, any rooftop penetrations, and around the base of rooftop mechanical units. The primer may act as both a rust inhibitor and a bonding agent for the elastomeric coating. It is important not to leave a primer exposed for extended periods of time, as the surface “tack” that many primers exhibit as a bonding mechanism will pick up dirt if exposed for more than 24 hours. This excessive dirt and dust can also compromise the adhesion of an elastomeric coating.

The cleaning, priming, and sealing is critical in sealing all possible water-entry points in the roof system. Once these steps are completed, the roof is ready for application of two coats of an elastomeric coating. Actual coverage rates will vary by product, so all manufacturer requirements should be carefully reviewed by the project foreman.

Coating application

Some manufacturers supply the elastomeric coating in a light gray color for the basecoat and white for the topcoat. The gray basecoat will “film over” and set up quicker than white, allowing a film or skin to form slightly faster for protection purposes. In addition, the difference in color facilitates adequate coverage with the topcoat. This also helps ensure that the owner acquires the amount of product for which he has contracted, that the contractor uses all of the material specified, and that the coatings manufacturer’s recommendation on the needed dry film thickness (DFT, measured in mils) is achieved to fulfill warranty requirements. Typically, a cross-directional spray pattern is suggested by the coatings manufacturer to ensure uniform coverage rates.

Ideally, the topcoat is applied the day after the basecoat. Cure times for each coat are dependent on ambient temperature, relative humidity, and exposure to sunlight. Dry, sunny days offer the perfect scenario for any acrylic elastomeric to cure properly, maximizing the product's adhesive and cohesive properties. Imminent rainfall and surface moisture are the chief enemies of a coating crew. These conditions will seriously affect the cure of the product. Rainfall prior to coating cure may also result in erosion of the newly applied coating and runoff into the gutter system.

Once the application process is completed, a visit by the manufacturer's representative is usually required as part of the warranty procedure. A thorough inspection, including electronic metering of the DFT, is conducted. Any remedial work to meet the manufacturer's requirements is done at this point, prior to closing of the job file.

A restored roof, and much more

The resulting restored metal roof has given the building owner or facility manager more than just a repaired, leak-free roof. The surface temperature is greatly reduced during warm or hot weather, lessening the effect of thermal shock and stress to the roof and reducing the energy requirements of the facility. The roof also has been given a restored surface that is renewable and sustainable over time, and environmental impacts are reduced thanks to the avoidance of landfill disposal of roof tear-off waste. An added bonus achieved with this restoration approach is that little or no interruption to normal business functions is experienced, in contrast to a complete roof tear-off and replacement project.

About the author



Bob Brenk is an active principal and president of Aldo Products Company Inc., an elastomeric coatings and adhesives manufacturer based in Kannapolis, NC. He also is the 2008-09 president of the Reflective Roof Coatings Institute (RRCI), an association composed of reflective coatings manufacturers, specifiers, and associate members from across the U.S. Brenk and his wife Christine live in Concord, NC, with their children Eric, 17, and Andrea, 9.

By Joe Maty,
D+D

Editor's Note: This article appeared in Durability + Design, January/February 2011.

**Low-VOC
fluoropolymer coating
counted on to
generate buzz in
California and other
venues where 'Green'
takes top billing**

Ready for Prime Time

A recently developed high-performance coating based on fluoropolymer chemistry is beginning to make its mark on the West Coast due to a combination of aesthetic, performance, and environmental characteristics the technology is reported to deliver.

That's the message conveyed by coatings manufacturer Tnemec Company Inc. regarding the early commercial applications of its 1070 Fluoronar finishes. The Series 1070V Fluoronar gloss finish and Series 1071V Fluoronar semigloss formulation are described as complements to the company's existing line of high-performance fluoropolymer coatings products.

"This line of products enables the use of fluoropolymer in areas of the country where environmental regulations require low-VOC coating systems," Mark Thomas, Tnemec's vice president, marketing, said in an announcement on the introduction of the products.

Coatings based on fluoropolymer resins are known to deliver long-term weathering resistance and durability, with superior color and gloss retention in high-profile and monumental architectural applications. Research and development programs in recent years have focused extensively on the formulation of air-dry, field-applied fluoropolymer coatings with sharply lower VOC (volatile organic compound) content that can meet increasingly stringent air-quality regulations, particularly in California.

Tnemec says it's getting positive early reviews of its new, low-VOC Fluoronar coatings.

"Everybody seems to love the product, whether application is by spraying or brushing and rolling," says Dustin Kaatz, a Tnemec coatings consultant in Southern California. "It's not build-sensitive," he says, meaning the contractor enjoys a degree of latitude in applied film thickness without seeing an effect on aesthetic qualities.

Kaatz has served as Tnemec's representative for a number of early uses of the new low-VOC coatings, including high-profile "gateway" ornamental structures in North Hollywood and the Chinatown section of Los Angeles, and the Aon Tower, a high-rise office building in the city's central business district.

The company says its fluoropolymer coatings are high-solids products offering adequate and consistent film thicknesses and application capabilities by brush, roll, or spray. Available in more than 500 colors, the coatings are described as well suited for high-profile architectural applications, and in some cases can be used to restore aged fluoropolymer factory-applied coatings or in original equipment manufacturer (OEM) applications.

*Early commercial uses of the low-VOC fluoropolymer coatings include application to the Aon Center in Los Angeles (above left and right).
Photos courtesy of Tnemec.*



Opening acts present stern test of the technology

On the 62-story Aon Center, where the existing coating system on the building was starting to chip and flake, the gloss version of the coating was specified as the finish coat. The VOC content of less than 100 grams per liter meets South Coast Air Quality Management District (SCAQMD) regulations in the Los Angeles basin, the company says.

The project called for the two lowest levels and front entrance of the building to be recoated. The existing coating on the anodized aluminum façade was removed and the surface scarified with light sanding and then primed with Tnemec's Series L69 Hi-Build Epoxoline II, a low-VOC polyamidoamine epoxy. The fluoropolymer finish coat was applied by Duggan & Associates, a Los Angeles painting contractor.

Katz says the coating provides an attractive, hard, durable, and graffiti-resistant surface on the building's lower portion, where visibility is high and the exterior surface is subject to pedestrian contact and the effects of vehicle traffic. Eventually, the other 60 stories of the slender office tower, built in 1973, are to be repainted with the same coating system.

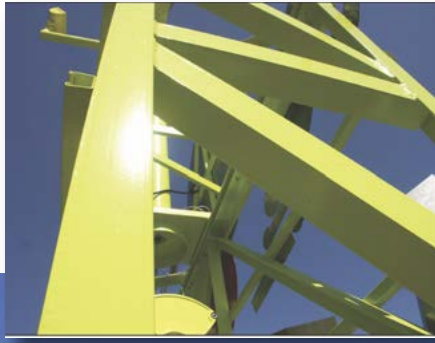
The system also was used on the North Hollywood Gateway, supported by a galvanized and stainless-steel truss structure and completed in 2009. Surface preparation played a pivotal role in the project, due to the challenge of achieving coating adhesion to the galvanized surface. The structure was prepared in accordance with SSPC-SP7/NACE No. 4 Brush-Off Blast Cleaning, and the epoxy primer was shop applied, followed by shop application of the high-gloss fluoropolymer coating.

The gateway design was the work of Los Angeles artist Peter Shire and conveys an entertainment-industry theme, portraying characters constructing movie sets, operating cameras, and designing costumes. Other elements include musical notes on a bar, balloons attached to a fence, and images connected to the area's residential community and airport.

The project was funded by the city of Los Angeles Community Development Agency. The architect was Tetra Design Inc., Los Angeles, and the shop coating applicator was Techno Coatings, Anaheim.

At another high-profile decorative structure—the Chinatown Gateway in Los Angeles—the epoxy primer/fluoropolymer topcoat was applied to restore an original acrylic polyurethane coating that had begun to fade in the high-UV environment. The original coating was found to be in sound condition based on adhesion testing done in accordance with ASTM 3359 and 6677, so the truss surface was scarified and the coatings applied. The work on the city-owned structure was carried out by the city's General Service department.

The gateway spans the entrance to the Chinatown section of Los Angeles, and depicts two dragons



Low-VOC fluoropolymer coatings adorn the "gateway" ornamental structures in North Hollywood and the Chinatown section of Los Angeles.





A detailed view of the North Hollywood gateway.

that symbolize luck, prosperity, and longevity. The project also was funded by the city's Community Development agency.

Kaatz says the gateway projects represent a stern test for the fluoropolymer coating's color-retention capabilities. On the Chinatown Gateway, the "Chilean Red" color requires a high pigment concentration, making the weathering capabilities of the fluoropolymer resin crucial.

The task: Meeting environmental, performance and applications objectives

Terry Wallace, Tnemec's vice president of sales, says the challenge facing the company in the development of the coatings included the task of meeting the VOC requirements of the South Coast Air Quality Management District.

"You've got to have the compatibilities with other coatings," Wallace says, referring to primers and intermediate coats based on zinc-rich or epoxy chemistries. Other objectives were user-friendly application and appearance characteristics, with

a degree of latitude in applied film thickness, and "the performance the industry has become accustomed to" in coatings based on fluoropolymer resins, he says.

"The goal was to meet the most stringent VOC regulations in the country. We knew this type of technology is proven to be sustainable, and we've been working on perfecting it for a number of years."

Wallace says the company's R&D program included extensive formulation work involving combinations of high-performance inorganic pigments, additives, and other components, with an array of accelerated and outdoor exposure testing.

In addition to the meeting the air-quality regulations in Southern California, Wallace says the coating also offers potential for use in projects meeting the certification requirements of the U.S. Green Building Council's LEED (Leadership in Energy and Environmental Design) rating system. He also points out that designers who make green and sustainable building a high priority are interested in standardization of product specification and use, no matter the geographic location.



About the author

Joe Maty is the editor in chief of *Durability and Design (D+D)* and *D+D News*, the daily newsletter of durabilityanddesign.com. He was also the editor of the *Journal of Architectural Coatings (JAC)*.

By Joe Maty,
D+D

Editor's Note: This article appeared in JAC in April 2005.

Promise of long-term exterior durability motivates choice of fluoropolymer finish for trio of aging office buildings near Washington, DC

Mega-Makeover Delivers... More than a Pretty Facade

Nobody said it would be easy, and it sure wasn't. For that matter, nobody said it would be cheap. But then, anyone who ever gave a passing thought to the notion that quality comes easy or cheap probably never rehabbed or repainted the exterior of a large office building with the expectation that the job would hold up for a good long stretch of years.

The Washington, DC-based Charles E. Smith Co. certainly rejected any idea of doing the job on the cheap when it came time to rejuvenate the aluminum-clad exteriors of the company's three "Skyline" office buildings at Bailey's Crossroads, near Arlington, VA.

In sizing up the project, the Smith company's objective was to keep the 1970s-vintage buildings relevant in an increasingly upscale suburban environment. The company realized it would require a hefty investment, said architect William Pegues, FCIC, of the Washington architectural firm Weihe Design Group (WDG), who served as project architect for the Skyline repaint jobs.

"Here were three big obelisks of dark chocolate brown, very dated in the quality of the coating," Pegues said in recalling the situation faced by the architects and the property owner.

Pegues said that at first glance, the turgid brown of the Skyline trio gave the impression that an original black color had chalked and dulled. The custom-tinted "Beaver Creek" shade chosen for the repainting—in the beige or tan color family—has made the buildings less of a misfit alongside their newer, brighter-hued neighbors.

"They wanted something that tended to blend with other colors," Pegues said of Charles E. Smith representatives. "They wanted them to blend in, be a little more contemporary" rather than "standing on end like dominoes."

Coatings supplier PPG Industries Inc., Pittsburgh, PA, and architect Pegues agreed on a coating combination headlined by a fluoropolymer resin-based topcoat—a top-of-the-line architectural-coat-

ing material that commands a steep price but comes with a promise of unparalleled long-term durability, gloss, and color retention.

Roger Mabe, PPG national sales and marketing manager, Building Restoration Products, said the company's sales pitch in cases such as Skyline emphasizes the long-term benefit when the talk gets around to price. "These kinds of projects aren't for the faint of heart," Mabe said in a frank assessment of the cost issue.



Photos courtesy of PPG Industries, Inc.

Mabe pegged the project cost for each of the buildings in the “seven-figures” range, with labor accounting for perhaps 80% of the total—a typical breakdown for professional coating work. He estimated that approximately 300 gallons of PPG’s “Megaflon” fluoropolymer topcoat was applied to each of the three structures, which combined consisted of 450,000 square feet of surface to be coated.

The fluoropolymer coating, since changed to the brand name “Corafalon,” sold for around \$275 per gallon at the time of the project.

The repainting of Skyline One was done in 2001, with Skyline Two and Three completed in late 2002.

A daunting prep and painting task

The restoration of the exteriors of the three buildings, each 15 stories high, began with the oldest of the structures, “Skyline One.” The original coating, a shop-applied fluoropolymer-based material of the Kynar-resin variety, had predictably lost its pizzazz after more than 20 years of exposure, and the aluminum cladding had been repainted every few years during the 1990s with a conventional alkyd resin-based enamel.

Clearly, a longer-term solution was needed to give the building—and eventually its younger siblings—an appearance mirroring changing architectural currents and the area’s subsequent commercial development. Project planning started in 2000 with the writing of the specifications for Skyline One, and preparation and application work spanned a five-month period in 2001.

Considerable discussion went into the development of a warranty agreement, a crucial part of the project for both property owner and coating supplier. In the negotiations, PPG agreed to issue a 10-year “material only” warranty covering adhesion, color retention and chalk resistance, and provided the building owner with a list of contractors that PPG believed possessed the capability to successfully do the job.

Universal Building Service, Germantown, MD, won the contract for Skyline One. John B. Conomos, Bridgeville, PA, secured the contracts for buildings Two and Three.

Preparation work for Skyline One started with “a hand-wipe,” or stripping, with the solvent acetone to remove the layers of repaint down to the original fluoropolymer coating or, in some places, down to bare aluminum. Use of mechanized sanding was scratched due to noise generation that would aggravate tenants. The stripping included the aluminum curtain-wall panels and the horizontal and vertical window extrusions.

The original fluoropolymer finish was in generally good shape, and the sanding yielded a roughening of the surface to provide “teeth” to facilitate adhesion of new coatings. The initial stripping and sanding was followed by another hand solvent wipe.

The Skyline office buildings at Bailey’s Crossroads in northern Virginia. Recoating of Building One, in foreground, is completed, with work under way on Buildings Two and Three.



Where the stripping and sanding exposed bare metal, a conventional acid-based wash primer was applied by brush and roller. All the surfaces were then painted with a recoatable epoxy primer, followed by the air-dry fluoropolymer topcoat. The application method on Skyline One was air-assisted electrostatic spray. Airless spray was used on Skyline Two and Three.

The restoration project also required removal of old window caulking in stages to prevent water leakage while the work was in progress. For this, a portion of the old caulking was removed, the painting was done, and then new caulking was applied. Painting over caulk would inevitably lead to coating failure due to the expansion and contraction of the caulk.

The caulk supplier—in this case Dow Corning—was sent a sample of the coating to match the topcoat shade. “If you go to these buildings and look at them, you can’t tell where the caulk joints start and where the paint starts, unless you get right up on it,” Mabe said.

Masking of windows also presented a challenge during the project, as plastic sheeting employed on Skyline One caused breakage of nearly 50 windows due to thermal expansion and contraction, the result of daytime-to-nighttime temperature swings. A strippable coating of the type used in spray-paint booths for shop-applied coating was used as masking on Buildings Two and Three, and the glass-breakage issue was largely neutralized.

The preparation and application processes for Skyline Two and Three were generally identical to the Skyline One project, with the notable exception that the initial solvent-stripping step was not required due to the relatively good shape of the existing coating surface.

Fluoropolymer technology: Color for the long haul

Mabe said Skyline marked PPG’s first exterior-restoration project using the Megaflon/Coraflon fluoropolymer coating technology, with the newer version offering a reformulated solvent mix to provide lower volatile organic compound (VOC) content. The coatings comply with an EPA rule that governs VOCs in architectural and industrial maintenance coatings in most of the country, he said.

PPG is at work on further reformulation that will result in VOC levels that will meet new, tougher restrictions in California and several Mid-Atlantic and northeastern states, Mabe said.

PPG has produced fluoropolymer-resin-based coatings for more than 40 years, but obtained the technology for air-dry systems with the acquisition of Keeler & Long in 1997, opening the door to field-application possibilities and restoration jobs such as Skyline.

The fluoropolymer resin technology employed by PPG was pioneered by Asahi Glass of Japan in the early 1980s, and coatings based on the technology have compiled an impressive track record of 20-years-plus service life in demanding settings such as bridge railings, PPG says.

A notable advance with new fluoropolymers, Mabe said, is the clarity of the resin and the resulting color strength and gloss capability of the coating. These attributes, combined with the well-documented UV resistance of fluoropolymers, deliver a field-applied finish quality on a par with the installation of all-new cladding carrying a shop-applied coating, Mabe asserts.

“That’s the real beauty of this. You’re going to restore the original fluoropolymer durability with a field-applied coating versus pulling the skin off the building and putting a new one up there. That’s probably 10 times more expensive than doing the field application.”

These advanced coatings systems are recommended for high-end architectural applications where UV resistance, color and gloss retention over the long haul are a priority. Use is not advised in highly corrosive or other extreme environments, where heavy-duty industrial maintenance coatings are specified.

“For the uses we’re recommending—primarily architectural metal—you’re not going to find a coating that is more aesthetically pleasing for a greater number of years,” Mabe said.

Skyline architect Pegues said the air-dry fluoropolymer technology answered the Skyline project’s need for an updated look that will last. “This was a great coating and a 10 year warranty,” he said. “I thought we got great results.”

Pegues and others involved in the project agree that while the Skyline trio may not warrant the title of Glitzville, it certainly can no longer be derided as Dullsville.

By Jayson L. Helsel, P.E.
KTA-Tator, Inc.

Editor's note: This article appeared in JAC in January/February 2009.

Proving Their Mettle

Exterior metals often call for the use of high-performance coatings that are counted on to maintain a consistently good appearance over time. These coatings may be used on structural steel, but are also frequently specified for sheet-metal substrates such as steel, galvanized steel, aluminum, and other metals.

Galvanized steel (a zinc layer on steel) is probably the most common sheet material, although a common variation is produced with a similar process with the application of a zinc-aluminum layer to the steel (GALVALUME™ under one brand name).

These sheet or “coil” materials are often used for siding or roofing. The term “coil” refers to the large coil that is formed when the sheet metal is rolled up. Coatings are applied to the metal in highly automated coil-coating operations in factory settings.

The high-performance coatings to be discussed here are often shop- or factory-applied, particularly with regard to coil material, but such coatings are also applied in the field. Regardless of application, it is important that the applicator (e.g., field painting contractor or metal-fabrication shop) are experienced in applying the particular coating. In addition, the coating manufacturer may approve or certify the applicator.

**Advances in
technology
expand the choices
of high-performance
finishes for metallic
substrates**



For many years, aliphatic polyurethane coatings have served as a workhorse high-performance exterior finish. While polyurethanes still play an important role—particularly in the industrial coatings market—other high-performance coatings such as polyaspartics, polysiloxanes, and fluoropolymers are frequently specified. Details for each of these coating types are discussed below.

Polyurethanes

Polyurethane coatings cure by chemical reaction and are most often applied as two-component products, with the two parts—resin and curing agent—combined at the time of application. The cured film is hard and dense, and is typically applied at 3 to 5 mils dry film thickness (DFT). Polyurethane coatings are characterized by excellent chemical resistance, and aliphatic polyurethane formulations exhibit good resistance to weathering.

Polyurethanes are also offered in single-component products that cure by reaction with moisture in the surrounding atmosphere. These “moisture-cure urethanes” (MCUs) offer many of the same high performance characteristics of two-component urethanes in a single-pack product. They are generally more user-friendly than two-part coatings, can be more surface tolerant, and can be applied in a wider range of temperatures; significantly, much cooler application temperatures can be tolerated.

Polyurethane coating systems will usually include a primer, possibly an intermediate coat, and the finish coat. When the system is used on blast-cleaned steel substrates, a zinc-rich primer and epoxy intermediate coat are typically specified. When the coating is being applied to galvanized sheet material or aluminum, the system includes an epoxy primer and the polyurethane finish. For galvanized or aluminum surfaces, special attention must be paid to the surface-preparation requirements recommended by the coating manufacturer (e.g. chemical etching and/or specialized primers).

Polyaspartics

Polyaspartic coatings are modified polyureas with application and performance properties similar to polyurethanes. One difference from polyurethanes is an increased application thickness, typically 6 to 9 mils DFT. This increased thickness may allow use of a two-coat system when applied to blast-cleaned steel; in this case the system would include a zinc-rich primer and the polyaspartic finish, with no intermediate coat.

If the system is used on galvanized or aluminum surfaces, an epoxy primer is usually applied, followed by the finish coat. As is always the case, surface-preparation methods and primers recommended by the coating manufacturer should be employed.

Polysiloxanes

Polysiloxanes are silicon-based coatings that offer a high degree of thermal stability and heat resistance as compared to typical organic compounds. These properties give polysiloxanes excellent weathering characteristics.

Polysiloxanes are applied at a relatively high application thickness—generally in the 3-to-7-mils DFT range. As with polyaspartics, the increased film thickness may allow for use of a two-coat system (zinc primer and finish coat) on blast-cleaned steel rather than a three-coat system. An epoxy primer is the norm for galvanized and aluminum surfaces, again with the coating manufacturer’s recommendations for primer and surface preparation being a guide.

Fluoropolymers

Fluoropolymer coatings are generally regarded as being unmatched in terms of weathering resistance. These coatings, however, carry a higher cost and exhibit less tolerance for application error than the other types of coatings reviewed here. Fluoropolymer coatings are based on polyvinylidene fluoride (PVDF) or fluorinated ethylene vinyl ether (FEVE), which give the coating film a high degree of mechanical hardness, abrasion resistance, chemical resistance, thermal stability, and resistance to weathering.



A high-performance polyurethane coating based on polyaspartic ester technology was applied to the steel beams of the National Museum of the Marine Corps, Quantico, VA. Photo courtesy of The Sherwin-Williams Company.

Factory finishes that require cure by heating (baking) are often based on PVDF, while field-applied coatings are typically formulated with FEVE resins.

Fluoropolymer coatings are most often applied to sheet materials such as galvanized steel and aluminum, usually in factory settings. Fluoropolymer coatings are thin-film materials with a DFT in the range of 1 mil, depending on the particular coating and color. A typical fluoropolymer coating system includes a thin primer layer (0.5 mils DFT or less), and may also include a clear coat for certain colors. Primers are specified by the coating manufacturer for use in combination with the finish coat; primers may be epoxies or products also based on fluoropolymer resins. When properly applied as specified by the coating manufacturer, fluoropolymer coatings can be warranted for 20 to 30 years by the coating manufacturer or metal-product installer.

Industry standards

While few industry standards exist with regard to high-performance coatings, guidance for performance of polyurethane coatings is provided by SSPC in Paint Specification No. 36 for "Two-Component Weatherable Aliphatic Polyurethane Topcoats." The Paint 36 standard specifies three levels of performance as measured by accelerated weathering requirements, with "Level 3" representing the highest-performing coatings.

These performance requirements essentially address color and gloss retention as measured with specialized instruments. Although the standard is written for polyurethane coatings and does include compositional requirements, the performance requirements could be applied to other coating types.

Other industry references on the performance of these types of coatings are published by the American Architectural Manufacturers Association (AAMA); these specifications address requirements for coatings on aluminum extrusions and panels. Of the many specifications published by AAMA, those with applicability here are:

- AAMA 2603, "Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels";
- AAMA 2604, "Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels"; and
- AAMA 2605, "Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels"

The specifications include performance requirements for properties such as color uniformity, gloss, dry-film hardness and adhesion, impact resistance, chemical resistance, and corrosion resistance. Of these standards, AAMA 2603 is the least rigorous, while AAMA 2605 spells out the most demanding performance requirements.

Gaining an understanding of the various types of high-performance coatings and the relevant manufacturer requirements for applications represents an important first step in specifying their use. Additionally, the use of applicable industry standards can contribute to efforts to ensure specification and application of coatings that deliver optimum performance levels.

About the author

Jayson Helsel, a senior coatings consultant with KTA-Tator, manages failure investigations and coating projects and is involved with coating surveys and inspection of industrial structures. He holds an MS in chemical engineering from the University of Michigan, is a registered professional engineer, and a NACE Coatings Inspection Technician.



**Margaret Kendi,
Pete Schmitt, and
Raymond Stewart,
Bayer MaterialScience LLC**

*Editor's Note: This article appeared
on durabilityanddesign.com
in February 2011.*

New Possibilities for Polyurethanes: Waterbornes on Metal

Material-science advancements in one-component (1K) water-borne urethane coatings have led to increased interest among formulators and users regarding their suitability for architectural direct-to-metal applications.

Some of the potential applications for this type of product would be outdoor metal elements, including railings, support structures, facades, window and door frames, outdoor furniture, signs, and mailboxes.

Yet, the process of selecting the proper water-borne coating for direct-to-metal applications is complicated by necessary surface treatment, application requirements, cost of the coating, and desired performance properties. Another challenge is calculating the time and resources necessary for a successful coating application. The latter step is made more complex by the potentially time-consuming and less environmentally friendly aspects of traditional direct-to-metal coating applications.

Common direct-to-metal applications utilizing solvent-borne coatings employ epoxy or alkyd products as primers, often followed by application of a topcoat to achieve the desirable finish properties. The topcoat can be a 1K or 2K water-borne or solvent-borne coating. This two-step process, however, adds to the time required for coating-system application. Additionally, the unwanted odors of solvent-borne coatings can reduce productivity during the application process. Meeting increasingly strict environmental regulations is also a concern.

By comparison, 1K water-borne urethane coatings offer a one-coat solution that provides an excellent starting point to meet the various performance and environmental requirements of today's metal markets. In addition to being environmentally friendly, these low-volatile-organic-compound (VOC) resins feature a number of other beneficial properties including low energy requirements



Polyurethane coatings offer high-performance appearance and protective properties in a variety of architectural metal applications. Notable examples include the new Yankee Stadium, shown during construction in New York (left), and Ludwig Mies van der Rohe's S.R. Crown Hall at the Illinois Institute of Technology in Chicago, a National Historic Landmark (right). Photos courtesy of Tnemec Company Inc.

(ambient cure or force dry), corrosion protection, early water resistance, ease of application (can be applied by spraying, dipping, flowcoating, brush, or roller), and ease of field repair. Typical applications include large construction vehicles, mass transportation such as trains, manufacturing and industrial equipment, and the architectural uses mentioned previously.

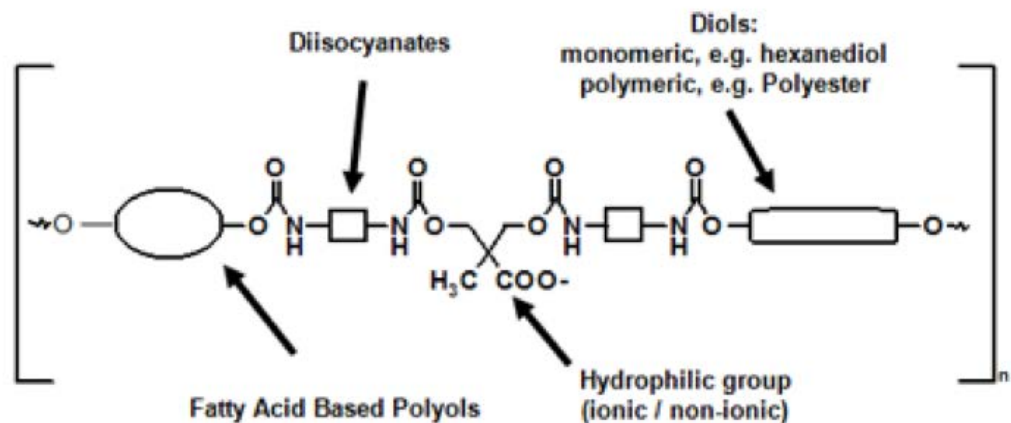
The 1K water-borne coatings also can be used by do-it-yourselfers for weekend projects to repair handrails, exterior furniture, doors and window frames, and for other common household metal applications.

Testing

A group of Bayer MaterialScience LLC scientists conducted a series of demanding tests to better understand how a one-coat, 1K water-borne urethane direct-to-metal coating responds under typical field conditions versus traditional coatings that require multiple coats.

The study compared different formulations of a 1K water-borne urethane coating based on polyurethane dispersions for ambient or low-temperature cure with the benchmark formula, a commercially available latex emulsion coating. Formulations for the commercially available coatings were based on coatings purchased at a home improvement store.

This drawing shows the chemical structure of the oxidatively-curable polyurethane dispersion utilized in the one-coat 1K water-borne system.



The specific coatings tested were the following.

1. A single-coat system based on an oxidatively curing polyurethane dispersion, (Formulation A1 and A2). This formulation is the 1K water-borne urethane direct-to-metal coating and features the following attributes:
 - Water-borne alkyd-modified polyurethane
 - Contains a small amount of cosolvent, allowing for an extremely low-VOC formulation (<150 g/l)
 - Provides excellent corrosion resistance and exterior durability in a single-coat application
 - Provides excellent adhesion to various substrates
 - Application by spray, brush or roll
 - Dry time: depends on the film thickness and the means of application.
2. A commercial water-borne acrylic latex direct-to-metal gloss enamel (Formulation B), which features the following attributes:
 - Recommended as both a primer and a finish coat
 - VOC of 206 g/L
 - Uses are application to ferrous and non-ferrous metals, interior and exterior surfaces
 - Application by spray, brush or roll
 - Dry time: one hour; recoat: eight hours
 - Passes MPI #153 for interior light-industrial coatings.
3. Commercial solvent-borne alkyd topcoat (Formulation C) features the following attributes:
 - Recommended: use of primer for improved adhesion
 - Oil-modified alkyd with excellent rust prevention when applied directly to metal
 - VOC of 450 g/L
 - Offers excellent coverage, chip resistance and color retention

- Application: spray, brush or roll
 - Drying time: two to four hours; recoat: 24 hours; based on brush application.
4. Commercial solvent-borne alkyd primer and topcoat (Formulation D)
- Recommended use of primer
 - VOC of 450 g/L
 - Application: spray, brush or roll
 - Dry time: two to four hours; recoat: 24 hours, based on brush application.

All coating formulations were applied to various substrates, including cold-rolled steel, zinc phosphate-treated steel, iron phosphate-treated steel, milled aluminum, and chromium-treated aluminum. The coatings were then tested for the following properties:

- Adhesion, using ASTM D3359 after one day and seven days
(For this test, the samples cured for a week and then a crosshatch test scratch was done to create grooves in the surface. Tape was then applied to see if coatings released from the surface.)
- Cleveland Condenser humidity resistance using ASTM D4585
(For this test, the panels were placed in the cabinet at 100 F at 100% humidity. A crosshatch test scratch was performed and tested with tape.)
- Salt-fog corrosion resistance using ASTM B117-97
(For this test, scratched test panels were placed in the cabinet and sprayed with salt water on a regiment cycle of exposure testing over a period of 500 hours or six weeks.)

Results

The study confirmed that 1K water-borne coatings worked as well or better than commercially available coatings in direct-to-metal applications. Specifically, the adhesion chart below shows that the 1K WB coating (Formulation A1 and A2) scored the highest marks across the material types for adhesion after a seven-day application.

Adhesion, seven days after application on various substrates

	Steel	B952	B1000	Al Mill	Al Cr treated
A1 - Resin Alpha (EMEA control)	5	5	5	5	5
A2 - Resin Alpha (NAFTA control)	4	3	4	4	3
B - Commercial Acrylic (rolled on)	3	5	5	4	5
C - Commercial Alkyd SB (rolled on)	3	1	4	1	1
D - Commercial Alkyd SB as primer and topcoat (rolled on)	1	1	1	1	2

Scale: 5-Excellent, 4-Very good, 3-Good, 2-Moderate, 1-Poor

The Cleveland Condenser humidity resistance test identified similar results. Specifically, that the 1K WB formulation provided adhesion that was equal to superior to other commercially available coatings.

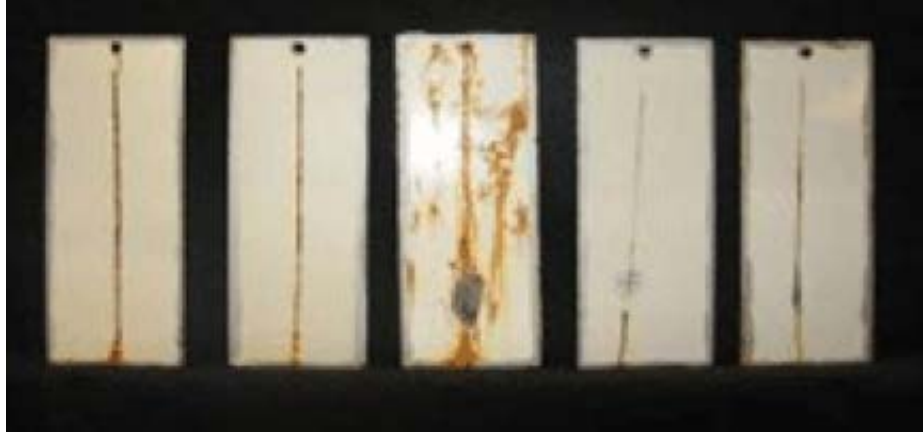
Adhesion, Cleveland Condenser on various substrates

	Steel	B952	B1000	Al Mill	Al Cr treated
A1 - Resin Alpha (EMEA control)	5	5	5	5	5
A2 - Resin Alpha (NAFTA control)	5	5	4	4	4
B - Commercial Acrylic (rolled on)	5	5	5	5	5
C - Commercial Alkyd SB (rolled on)	1	NA	2	NA	NA
D - Commercial Alkyd SB as primer and topcoat (rolled on)	NA	NA	NA	NA	NA

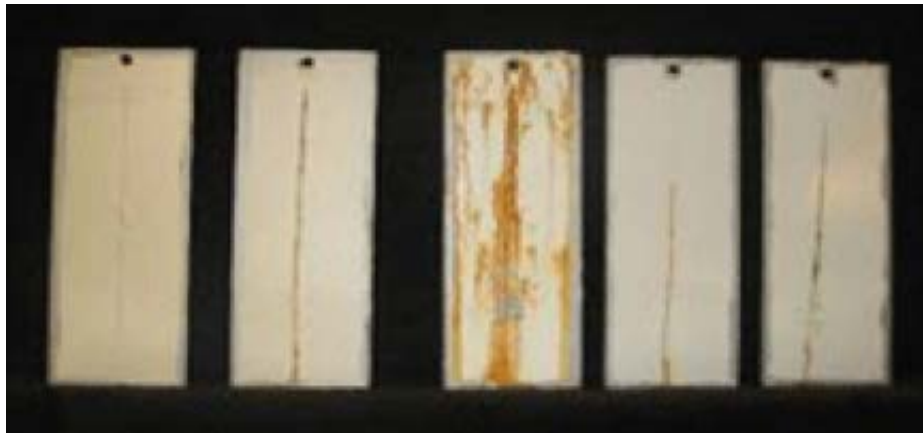
Scale: 5-Excellent, 4-Very good, 3-Good, 2-Moderate, 1-Poor

NA—Due to poor adhesion performance at room temperature the samples were not analyzed at elevated temperature and humidity.

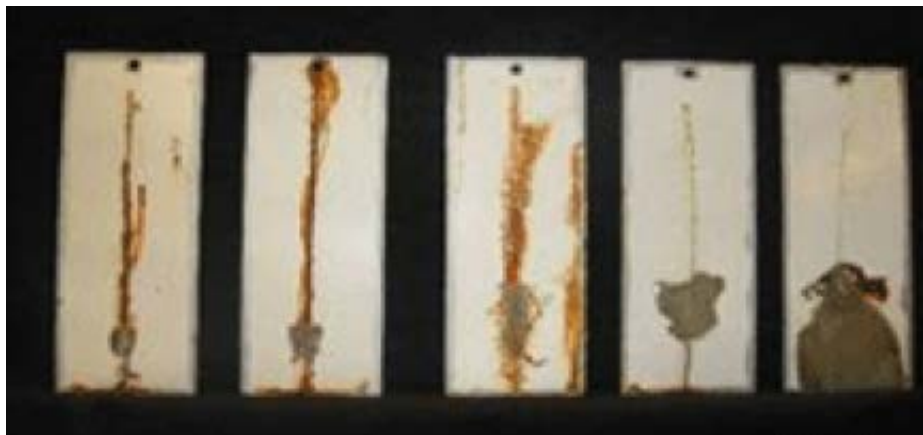
The Salt-Fog testing—one of the highest testing standards—reveals a more visual example of how 1K water-borne coatings surpass the properties of existing commercially available coatings as detailed in the following images. Note that due to poor performance results of system B, the panels were removed from the salt spray at 300 hours. All other systems were exposed for 500 hours.



This image shows the results of the Salt-Fog test as applied to zinc phosphate-treated steel. Formulations from left to right are: 1K water-borne (Formulations A1 and A2); commercial water-borne acrylic latex direct to metal gloss enamel (Formulation B); commercial solvent-borne alkyd topcoat (Formulation C); commercial solvent-borne alkyd primer and topcoat (Formulation D).



This image shows the results of the Salt-Fog test as applied to iron phosphate-treated steel. Formulations from left to right are: 1K water-borne (Formulations A1 and A2); commercial water-borne acrylic latex direct-to-metal gloss enamel (Formulation B); commercial solvent-borne alkyd topcoat (Formulation C); commercial solvent-borne alkyd primer and topcoat (Formulation D).



This image shows the results of the Salt-Fog test as applied to cold-rolled steel. Formulations from left to right are: 1K water-borne (Formulations A1 and A2); commercial water-borne acrylic latex direct-to-metal gloss enamel (Formulation B); commercial solvent-borne alkyd topcoat (Formulation C); commercial solvent-borne alkyd primer and topcoat (Formulation D).

Summary

The study found that a single coat of the water-borne polyurethane dispersion is as effective or superior to multiple coats of the commercially available coatings. This is evident in the high quality of corrosion resistance found with the 1K water-borne polyurethane as displayed in salt-fog exposure testing.

The study also showed that it's possible to accomplish with one coat of the 1K water-borne polyurethane what traditionally took two layers to accomplish with other commercially available direct-to-metal coatings.

A 1K water-borne polyurethane coating for direct-to-metal application also provides adhesion to various types of metal substrates, is easily applied, resists water spots early, contains lower VOC levels (compared with commercially available direct-to-metal coatings) and is cured with lower energy requirements. Typical applications could include protection and durability of exterior surfaces such as handrails, furniture, roof vents, frames for doors and windows, and interior surfaces such as pipes and structural steel supports.

As formulators and applicators search for advanced coatings that offer time-saving, eco-friendly solutions with properties equal to or better than traditional solvent-borne coatings, 1K water-borne coatings provide a viable coatings option for direct-to-metal applications.

While this study provides compelling reasons to consider the use of 1K water-borne urethane coatings based on polyurethane dispersions to replace commercially available coatings, scientists will continue to pursue material advancements that meet existing market needs and anticipate future needs.

About the authors



Margaret Kendi joined Bayer Corp. in 2000 in the analytical department, and has held various positions in the company's Coatings, Adhesives and Specialties group. Her work with Bayer MaterialScience LLC has included a focus on synthesis of new raw materials, screening of materials for their efficacy, and determining the properties of various coating systems. A current focus is evaluation of one-component water-borne coatings on various substrates, including wood, plastics and metal. She previously worked for Rohm and Haas Company's agricultural-chemicals business, and has a B.S. degree in chemistry from Penn State University.



Raymond Stewart is a senior scientist with Bayer MaterialScience LLC's CAS Business Development Group. His current area of specialty is coatings applications, including one-component water-borne polyurethane resin technologies. He also has held various technical positions with four major coatings manufacturers during a 30-year career in the industry. He is a member of the American Chemistry Society and American Coatings Association, and past president of the Pittsburgh Society for Coatings Technology, where he maintains an active involvement.



Pete Schmitt is a senior technology manager in the Coatings, Adhesives and Specialties group at Bayer MaterialScience LLC, specializing in water-borne resins. He has more than 30 years of experience in the coatings industry, including work in laboratory development, pilot-plant scale up, production support, product stewardship, R&D management, and technical marketing. Most of his experience is in the area of aqueous polyurethane dispersions. He has B.S. degree in chemistry from West Liberty State College and a masters degree in colloids, polymers and surfaces from Carnegie Mellon University. He also holds 10 U.S. patents.

D+D

By Daniel J. Weinmann, Ph.D.,
Hexion Specialty Chemicals

Editor's Note: This article appeared on durabilityanddesign.com in August 2010.

High Performance, Low VOCs: Formulating Advances Deliver Water-borne Epoxies that Meet the Demands of the Day for Metal Coatings

Consumer concerns and current trends in regulation make it clear: environmental compliance is the order of the day. As such, the coatings manufacturers and users share a keen interest in continued development of water-based, low-VOC solutions.

Many people in the industry, however, continue to believe it's impossible to make water-borne epoxy coatings that perform on metal as well as solvent-based epoxies.

For the first 25 years in the history of waterborne epoxy development, this was true. Such coatings worked well on non-metallic substrates such as concrete flooring, or masonry. The formulation of water-based light-duty epoxy metal primers was possible, but a water-borne epoxy primer with the excellent corrosion resistance of a solvent-based epoxy did not exist.

The reasons were twofold. A water-borne epoxy is formed by combining an epoxy resin with an amine curing agent. In early systems, the amine components dissolved readily in water, but the epoxy resins were hydrophobic—not easily combined with water. Hydrophilic surfactants were used to disperse the epoxy resins in water. Combining the epoxy resin dispersion with an amine solution often yielded a coating with marginal corrosion resistance.

Furthermore, minimal compatibility of the resin and curing-agent components impeded coalescence, yielding incomplete film formation. Clearly, the challenge was to improve coalescence by making the epoxy and curing agent more compatible, and also to make the final coating more hydrophobic.



Epoxy coatings are used in a number of high-performance applications, including use as metal primers in demanding industrial and architectural settings and as concrete floor coatings. Proper formulation methods are critical to achieving the needed application and performance results in water-borne epoxy coatings. Photos courtesy of Hexion Specialty Chemicals

Advancing the science

Well, here's the good news: the latest (Type 5) epoxy systems eliminate these problems. A proprietary, non-ionic surfactant is pre-reacted into the epoxy resin. The same surfactant is also pre-reacted into a hydrophobic amine adduct curing agent, creating an amine dispersion whose backbone is closely related to that of the epoxy resin.

The result? A hydrophobic binder system with greatly improved film formation. Coatings made with this type of water-borne epoxy resin technology are highly corrosion resistant, as shown by the 2,000-hour salt spray study (Figure 1).

This figure compares the performance of a traditional solvent-borne coating based on a solid epoxy resin, cured with a polyamide (left) next to that of a Type 5 water-borne epoxy primer (right). Both coatings were applied to cold rolled steel at 3 mils dry film, and cured for seven days at room temperature.

Other application and performance benefits include:

- no induction time required (mix and use);
- visible end of pot life (strong viscosity increase after 4-6 hrs);
- fast dry at standard temperatures and humidity levels below 80% (dry-through in 4-6 hrs); and
- rapid overcoatability (suitable for wet-on-wet applications).

This is the level of performance that water-borne epoxies should deliver. But there's one other important issue to discuss. Some coatings chemists are under the impression that formulating water-borne epoxy coatings can be done using the same "tools" that they use to formulate other water-borne resin coatings. They use the same methods, proportions and additives as when formulating water-borne latex paint, for example. Unfortunately, the result can be as successful as opening a brownie mix and then following the instructions from a box of macaroni and cheese.

The chemistry of water-borne epoxies is fundamentally different from that of latex emulsions. As such, the tools required to formulate these coatings are fairly unique and very specific. Standard latex emulsions are acrylic polymers that are stabilized by the use of ionic surfactants (typically anionic). Many additives designed for water-borne coatings (i.e., acrylics or polyesters) also use ionic surfactants. Epoxies are not compatible with ionic species so water-borne epoxy systems use non-ionic surfactants to stabilize the resin particles.

Unfortunately, using additives that contain ionic dispersants is a common pitfall that leads to significant issues when formulating water-borne epoxy coatings. Such issues include paint instability due to premature epoxy reaction, reduced shelf life of the paint due to solid settling of pigments or phase separation of the liquid paint components.

When starting to formulate high-performance water-borne epoxy coatings, meticulous adherence to a known starting formula is imperative, at least until acceptable performance has been demonstrated in the lab. Annoying as it may be to wait to receive a particular additive, if the supplier's suggested formula calls for defoaming agent X-40, the formulator should not use defoaming agent Y or defoaming agent X-39, or even X-40B, for that matter.

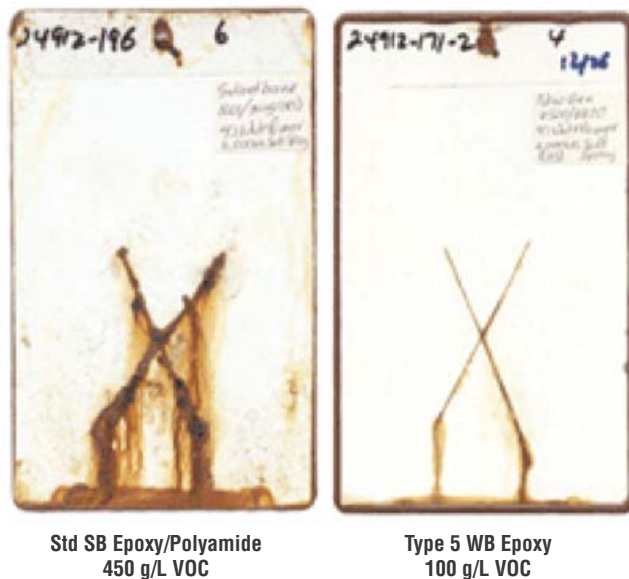


Figure 1



Epoxy coatings are used in a number of high-performance applications, including use as metal primers in demanding industrial and architectural settings and as concrete floor coatings. Proper formulation methods are critical to achieving the needed application and performance results in water-borne epoxy coatings.



Epoxy coatings are used in a number of high-performance applications, including use as metal primers in demanding industrial and architectural settings and as concrete floor coatings. Proper formulation methods are critical to achieving the needed application and performance results in water-borne epoxy coatings.

Adhering to a supplier's exact instructions can actually help speed development of a new water-borne formulation. Resin suppliers typically invest months (sometimes, even up to a year) to develop starting formulations that demonstrate the superior performance of their resins. The starting formula provides important details, and formulation know-how, regarding specific grades, use level, and order of addition. All of these variables are critical to a water-borne epoxy coating's final performance.

Once the starting formulation demonstrates that the resin, curing agent and formulation meet the market requirements, then the chemist should add his unique knowledge to make the water-borne coating better, cheaper or faster. Unfortunately, on more than one occasion, superior epoxy resin systems have been thrown out because of well-meaning but sometimes, ill-informed selection of substitute ingredients during the initial screening stage of a project.

Formulation keys

Some of the most important considerations in the formulation of water-borne epoxy coatings are highlighted here. For an exhaustive treatment of the topic, see the references at the end of this article.

Wetting or dispersing agents

Dispersing agents are generally required to coat the pigment and keep it from soaking up oil. If insufficiently passivated, the pigment can absorb epoxy surfactants and/or cosolvents, compromising dispersion stability and gloss.

Latex formulations often include anionic dispersants. In water-borne epoxy systems, however, ionic dispersants can cause gel formation, low gloss, reduced hardness, poor water resistance, and storage-stability issues. Therefore, non-ionic dispersants are strongly recommended.

Adhesion promoters

Silane adhesion promoters improve substrate wetting and adhesion, the speed of hardness development, and the corrosion resistance of metal primers. The chemical structure of the silane matters. Among epoxy silanes, triethoxy silanes or diethoxymethyl silanes give the best shelf stability. Amino silanes contribute to yellowing. Methoxy silanes hydrolyze to form homopolymers with poor adhesion.

Typical use levels for the epoxy silanes range from 0.5% to 3% by weight of epoxy resin dispersion. Higher use levels can cause orange peel in the coating, particularly in low-VOC primers. For smoother, glossier films with maximum film performance, the silane should be incorporated into the epoxy component during pigment grind.

Thickening agents and thixotropes

These additives improve component stability by preventing settling, and imparting sag resistance. Many commercial additives are designed for latex coatings and as such, they contain amines that will react with the epoxy groups of water-borne epoxy coatings, causing extreme viscosity build, gel formation, coagulation, and pigment kick-out. The following types of materials can be used:

- Modified hydroxyethylcellulose
- Fumed silicas
- Attapulgite clays
- Modified bentonite clays

The supplier's starting formulation should be referred to for specific grades and use levels.

Defoamers

Defoamers suppress foam generation during manufacture, filling, tinting, and paint application. As a starting point, 0.5% by volume may be used, with a portion put into the grind, and the remainder put into the let-down. It must be established that the defoamer will work throughout the product's desired shelf life, and that pigment flocculation, poor color acceptance, poor inter-coat adhesion, surface defects such as cratering or fish eyes, and water sensitivity do not occur. Effective defoamers are usually based on silicone or oils. Again, the supplier's starting formulation should be referred to for specific grades and use levels.

Anticorrosion pigments

The key to finding a good corrosion-inhibitive pigment is to choose one with a proper balance of solubility for the resin system. Excessive solubility leads to the rapid loss of corrosion resistance after good early performance. Insolubility shows up as poor early resistance that eventually levels off. Excellent results can be obtained when calcium phosphate and a proprietary organic corrosion inhibitor (e.g., a proprietary polymeric amine salt in ethanol) are combined. To be avoided are ionic species such as zinc phosphites, zinc borates and zinc phospho-oxide complexes.

Flash-rust inhibitors

Nitrite salts (preferably calcium or potassium salts) may be added to the epoxy and/or curing-agent component to inhibit flash rusting. Sodium nitrite should be avoided due to its inherent water solubility and resultant poor corrosion resistance. Lead naphthenate, tertiary amines, chromates, and dichromates should not be used; they are incompatible or ineffective.

The flash-rust resistance of a specific formulation depends on the solids content of that coating. If water is added to reduce viscosity, the likelihood of flash rusting increases. This tendency may be countered by adding more flash-rust additive. A thorough screen of each formulation modified by the flash-rust additive should be conducted to ensure that acceptable water and corrosion resistance remain.

Formulating methods make all the difference

Using currently available water-borne epoxy resins and curing agents, high-performance water-borne epoxy coatings with low VOC levels can be formulated that match, or exceed, the performance of solvent-based coatings. To achieve a high level of performance, the components and additives used must be carefully studied and selected. Formulating techniques that are specific to water-borne epoxy technology must be employed to achieve the desired performance levels.

For more information, see "Formulating High Performance Waterborne Epoxy Coatings" and "New Starting Formulations" at www.hexion.com/epoxywaterborne.

About the Author

Daniel J. Weinmann, Ph.D., is a market development manager for epoxy specialties at Hexion Specialty Chemicals in Houston, Texas. His primary focus is supporting the coatings industry. Weinmann earned his B.S. in chemistry from the University of Oklahoma and his Ph.D. from the University of North Dakota in Grand Forks. He is the co-author of two U.S. patents, has published numerous technical articles, and is a frequent speaker on high-solids, solvent-free and water-borne epoxy coatings technology. He is a member of the American Coatings Association and SSPC: The Society for Protective Coatings.

D+D



By Jayson Helsel,
KTA-Tator, Inc.

*Editor's Note: This article appeared
in JAC in August/September 2009.*

**Attention to
specification
and application
details make
all the difference
with use of
intumescent
materials**

Fire Drill: The Basics on Coatings that Protect

The term “fire-resistive coatings” generally refers to intumescent coatings, which are designed to passively protect certain types of substrate materials from reaching combustion temperatures. Intumescent coatings function by charring and “swelling” upon exposure to high temperatures, as occurs in the event of fire. The charred coating then acts as an insulating layer to slow heat transfer to the substrate.

An intumescent coating’s performance is rated in terms of hours, which indicates how long the coating can adequately protect the substrate.

In the U.S., Underwriters Laboratories (UL) is the recognized authority that evaluates and approves intumescent coatings for a certain classification and fire rating. It is important to recognize that there are different types of fire-resistance classifications. For most architectural applications, classification is required in accordance with ANSI/UL 263, “Fire Tests of Building Construction and Materials.” Fire ratings under UL 263 are expressed in hours and are applicable to floor-ceilings, roof-ceilings, beams, columns, walls, and partitions.

Another, more stringent classification is ANSI/UL 1709, “Rapid Rise Fire Tests of Protection Materials for Structural Steel.” This classification provides fire-resistance designs for protecting structural members subject to petrochemical-exposure fires, such as those affecting a refinery or offshore oil platform. Although UL 1709 classification has not generally been required for typical architectural applications, this could be a future requirement for structures such as skyscrapers. Again, building codes will set forth the particular requirements for fire-resistive coatings.

Intumescent fire-resistive coatings are applied to structural steel in a variety of buildings. An intumescent coating was applied to the exterior steel supporting the multi-story control room of this air traffic control tower. Photos courtesy of Stanchem Inc.





A solvent-borne vinyl mastic intumescent coating was applied to the exterior structural steel of this air traffic control tower.



Acrylic intumescent coatings are commonly used for interior structural-steel applications.

UL approvals for a coating under both UL 263 and 1709 include important details, such as the type and size of member (e.g. beam, column, angle, etc.), the required coating thickness, and any primer and/or exterior finish required as part of the system. Failure to comply with the design requirements would likely void the UL approval for the coating, and more importantly, could jeopardize the coating's fire-protection properties. City building codes will dictate the requirements for fire-resistant coatings and may require that coatings are specifically approved or listed in an approved materials list compiled by the city.

The fire-protective materials portfolio

It should be noted that intumescent coatings are part of a broader group of materials known as Sprayed Fire-Resistive Materials (SFRMs). The majority of SFRMs are cementitious- or gypsum-based materials, whereas intumescent coatings are more similar to conventional liquid-applied coatings. Cementitious-based SFRMs are generally field applied to structural steel at a greater thickness than intumescent coatings to achieve the required fire rating.

A separate UL classification also defines "fire-retardant" coatings, which should not be confused with intumescent coatings. To be classified under this category, the coating must reduce the flame spread over the combustible surface by at least 50%. The types of surface materials rated include wood, cellulose tile and board, and oriented strand board (OSB). In addition to requirements for intumescent coatings on structural members, fire-retardant coatings may also be required by building codes for interior spaces such as wall and ceiling surfaces.

Intumescent coating types and systems

Two generic coating types typically comprise intumescent coatings—single-component acrylic/vinyl/polyvinyl acetate coatings, and high-build epoxy coatings. Single-component acrylic-based coatings are applied in several coats, with the number of coats dependent on the thickness necessary for the coating to provide the required fire rating. Since multiple coats are required, the time frame for a complete application may span several days, based on the recoat time between coats.

After application is completed, additional time may be needed to allow for full curing of the intumescent coating layers before application of any required exterior finish coat. Finish coats are normally required, since the intumescent coating alone may not be suitable for prolonged exterior exposure. Typical finish coats include 100% acrylic and urethane coatings.

Epoxy intumescent coatings are generally high-solids materials applied by plural-component spray equipment in one or two coats. Plural spray application is a specialized technique that usually requires the use of applicators licensed or approved by the coating manufacturer. The coatings cure rapidly and are often ready for finish-coat application (if required) within a day or two. Epoxy coatings may also require mesh reinforcement, which is installed between applications of the coating. Finish coats consisting of urethane or polysiloxane coatings are generally required for satisfactory weathering performance in exterior exposures.

The overall time frame for complete application of epoxy intumescent systems is typically two to four days as compared to several days or a number of weeks for single-component intumescent coating systems.

A primer may also be required as part of the intumescent coating system; this would be dictated by the design approval for the intumescent. It is critical that the type of primer selected and the applied dry film thickness meet the approved design requirements. Coatings manufacturers typically approve a variety of primers that can be used as part of the intumescent system, including primers based on alkyd, acrylic, and zinc-rich chemistries.

Coating appearance and application issues

The finished appearance of an intumescent coating system should also be taken into consideration in selecting the materials for a project. Intumescent applications, regardless of the type of coating, usually result in a rougher surface texture, which can be influenced by the application method. For example, spray application followed by back rolling may make the surface smoother. The finish coat applied to the system can also affect the final appearance.

Projects requiring intumescent coating systems may include commercial buildings, rail stations, airports, stadiums, and others. Again, building codes will dictate where intumescent coatings are required. Typical applications involve structural-steel components that are exposed as part of a facility's design.

Specification of an appropriate intumescent coating system prior to the start of projects can prove crucial to success. For structural steel, primers are often shop-applied prior to erection at a building site. As previously noted, a primer approved for use with the intumescent system must be used. Equally important is application of primer at the thickness specified for the system.

The intumescent coating may be shop or field applied, but is more commonly applied in the field after erection of the steel. As previously discussed, the proper thickness of the intumescent coating is critical for providing the required fire rating. Once application begins, monitoring the proper curing of the coatings is an important step, particularly for single-component coatings that are applied in several coats.

One common method (as specified by the coatings manufacturer) of assessing cure is determining the hardness of the coating as measured by a Durometer tester. "Shore D" hardness is the typical test for coatings, and measures the resistance of the coating film to indentation by the Durometer instrument over a 0-to-100 scale. If the indenter completely penetrates the sample, a reading of 0 is obtained, and if no penetration occurs, a reading of 100 results. The required hardness value will vary by the type of coating and is specified by the manufacturer.

Another suggested step for intumescent projects is applying the entire system to a smaller test area to evaluate the application process. In addition to ensuring proper application and thickness of all coats, the finished appearance can also be evaluated to determine if any adjustments (e.g. back rolling) should be made before full scale application.

Attention to all details required for specification and application of an intumescent-coating system should lead to a successful project outcome. **JAC**



The proper thickness of the intumescent coating is critical for providing the required fire rating.



Intumescent coatings are widely used on exposed structural-steel elements, above left, but also are applied to wood substrates such as the beams and deck shown above right.

**By W. Casey West,
StanChem, Inc.
and Joe Maty,
JAC**

Editor's Note: This article appeared in JAC in May 2009.

Combination of aesthetics, performance, and cost effectiveness broadens the horizons for use of intumescent fire-protective coatings

Intumescent coatings were applied to structural steel as part of the renovation of an historic train-station garage in Philadelphia, converted to retail use. Photos courtesy of Albi Mfg., a division of StanChem Inc.

Expansion Mechanism

You might call intumescent coatings a hot commodity. After all, these coatings deliver a valuable package of effective fire-protective capabilities and attractive aesthetics for various structural materials and surfaces. This combination has helped fuel growth in the specification and use of intumescent coatings, particularly for applications such as exposed structural building elements.

In a fire event, intumescent coatings films expand rapidly, absorbing heat while this expansion occurs, deflecting heat away from the substrate, and insulating the substrate by developing a char layer. In this way, the coating protects the substrate, delaying failure of structural building elements and contributing to building safety.

These coatings were first commercialized in the 1960s and, in addition to fire-protective and aesthetic qualities, the growth in their use can be attributed to economics. Early versions of intumescent coatings were applied in rather thick films, resulting in a high cost per square foot both in terms of the material used and labor required. Improvements in the technology have reduced film thicknesses, making the coatings more cost effective.





Transit station in Boston, where an intumescent fire-protective coating was applied to the structural steel.

Fire-protective coatings: The basics

Fire-protective coatings are classified as fire retardant or fire resistant. These terms frequently cause confusion, which can be clarified by following the general rule that “fire retardant” means the product is tested to the ASTM E-84 method, which addresses flame spread and smoke development. The term “fire resistant,” on the other hand, refers to a much more stringent test standard, ASTM E-119, which involves testing for one to four hours of protection. These materials are also often tested by Underwriters Laboratories with the test method UL 263; this method incorporates the ASTM E-119 standard.

Fire-retardant coatings are divided into three classes, with • Class A being the most stringent, based on performance levels in testing conducted in accordance with ASTM Standard E-84. These are:

- Class A—0-25 flame spread/0-50 smoke development;
- Class B—26-75 flame spread/ 50-125 smoke development; and
- Class C—76-200 flame spread/126-200 smoke development.

Fire-resistive coatings also are rated under ASTM E-119, based on the number of hours of protection provided, from one to four hours.

In addition to intumescent coatings, fire-protective materials used in architectural applications include fire-rated drywall; sprayed fire-resistive materials (SFRMs) such as low-density cementitious, gypsum, and mineral-fiber materials; mineral fiber board; and calcium silicate board. Intumescent coatings are often preferred in situations where aesthetics are a priority and where properties such as durability and abrasion resistance are important.

Fire-retardant intumescent coatings look and apply like paints, at coverage rates ranging from 100 to 225 square feet per gallon. SFRMs, on the other hand, are applied in thick, irregularly textured layers and are used on structural steel that is usually concealed within wall assemblies.

This article will focus on the use of intumescent coatings. The discussion here will be devoted primarily to the use of these coatings on non-metallic substrates, particularly on wood.

Intumescent coatings: Types and applications

Intumescent fire-protective coatings represent an important specialty, or niche, market in the architectural-coatings marketplace, and are manufactured by a number of companies. Generally speaking, the chemistry of intumescent-coatings formulations is similar among the various manufacturers, although these manufacturers have developed proprietary products with nuances and subtleties that differentiate them from their counterparts.

These intumescent coatings are offered in water-borne and solvent-borne formulations. The waterbornes are primarily used in interior applications, while solventbornes are used for both building exteriors and interiors. Also offered for certain specialized applications are 100% solids, two-component catalyzed epoxy systems.

As is the case with some conventional architectural paints and coatings, water-borne intumescent-coatings formulations typically are composed of vinyl-acrylic or acrylic resins, pigments for hide, and additives that provide application and performance properties such as flow, leveling, and UV resistance.

But intumescent coatings formulations also contain specialized ingredients that interact to cause the coating film to expand and create the insulating carbonaceous char:

- an acid source such as ammonium polyphosphate;
- a carbon source that reacts with the acid to form the carbonaceous char; and
- a blowing agent such as melamine.

Solvent-borne intumescent coatings formulations are quite similar to the waterbornes, but an organic solvent replaces water as the “carrier,” and resin chemistries can also differ from water-borne formulations. These coatings are commonly preferred for exterior applications, due to durability and weathering-resistance properties in exterior settings. As with water-borne interior intumescent coatings, solventbornes provide a decorative, paint-like finish preferred for architectural settings.

Typical coating systems

For interior applications, intumescent coatings systems typically would include a primer recommended for the given substrate, followed by the intumescent fire-protective coating, and in some cases a topcoat for protective or decorative purposes.

For exteriors, such systems typically include a primer, fire-protective intumescent coating, and in many cases a protective topcoat. Some manufacturers, however, offer systems that do not require a topcoat.

Wood applications

Typical applications of intumescent fire-resistive coatings for wood are diverse, and can include:

- historic restorations and renovations—mill and warehouse conversions, loft conversions, historic theater renovations, historic home restorations, and others;
- new construction—condominiums, nursing homes, schools, multi-family residential buildings, and others; and
- noncompliant construction—noncompliant drywall, one-hour rated separation walls, and fire-rating upgrades to existing lath and plaster walls and embossed tin ceilings.

Key considerations in selection and use

Important considerations when specifying and selecting fire-protective coatings for wood are surface-burning characteristics of the substrate, dimensions of the structural member, hourly requirements under the relevant building codes, and assembly construction details. Also important is the coating product's suitability for the given environment.

Fire testing conducted by Underwriters Laboratories (UL) should be referenced to determine what level of fire protection is provided by a fire-retardant or fire-resistant coating. UL conducts tests that replicate both interior and exterior environments for these coatings, and classifies intumescent coatings for three different environmental exposures:

- interior conditioned spaces, where the coating cannot be applied until the HVAC systems are operational;
- interior general purpose, which can be applied in any interior settings; and
- exterior.

Laboratories other than UL also conduct fire testing globally. Some of these include Intertek plc, Southwest Research Institute, Bodycote Warringtonfire, UL of Canada, Western Fire Center Inc. (WFCi), and Factory Mutual.

The development of fire test standards progresses as the laboratory testing facilities continue to advance their procedures and as codes become more stringent. Innovations at the fire test labs are helping to drive refinements in test standards, which then can be used to strengthen building codes.

It is interesting to note that UL is viewed as the bible in the world of intumescent paints and coatings and is clearly recognized globally for its UL Mark. Some smaller laboratories, however, have carried out extensive work on the fire protection of wood substrates. A notable example is Western Fire Center Inc. (WFCi), located in Kelso, WA. This lab has done important work that has advanced the understanding and analysis of the reaction of wood substrates under fire conditions. For the manufacturer, this contributes to better understanding of the necessary attributes of an intumescent coating.

Local building-code requirements must also be investigated in determining the proper application or installation of fire-protective materials. These codes vary to some extent, but generally affect buildings that serve uses such as educational, commercial, multifamily residential, health care, and institutional, along with some commercial buildings.

Finally, finish appearance, particularly texture, must figure into any coating-product selection. As mentioned previously, the need for a topcoat over the intumescent coating is often determined by color preference in addition to protection.



Fire-protective materials are often specified in existing buildings where adaptation or renovation for a new or different use is planned. Above: intumescent fire-resistive coating applied to a wooden floor/ceiling assembly as part of a restoration program in an historic building.



Intumescent coatings applied to wood structural elements in an historic manufacturing building converted into residential condominiums.

Fire protection of historic structures

Fire-protective materials for wood and other non-metallic building elements are often specified and used in existing buildings where adaptation or renovation for a new or different use is planned. In these cases, measures to provide fire protection are required to bring the building into compliance with current buildings codes.

Fire-protective coatings are applied to various elements of existing and historic buildings, including structural wood columns and beams. These coatings are also applied to steel, terra cotta block, cement block, concrete slab, brick, tin ceilings, and other elements.

While fire testing of materials and assemblies figures prominently in the specification and use of intumescent coatings, this testing only provides a certain amount of data, which then must be interpolated and engineered to fit a range of very specific construction practices for new and existing buildings. Two primary means for accomplishing this are generally accepted by the uniform building codes. The first is a publication developed by HUD, titled “Fire Ratings of Archaic Materials and Assemblies,” and the second is the Component Assembly Method (CAM). The HUD resource and calculations of the CAM of an assembly can be employed together or separately.

The HUD publication provides fire-resistance data on specific archaic building materials, measured in minutes without any fire protection provided. The data was developed by the National Institute of Science and Technology (NIST).

Building-code authorities broadly recognize the Component Assembly Method, which allows a fire-protection engineer to calculate the total unprotected fire resistance of a built-up assembly consisting of different components by adding each component’s individual fire-resistant property expressed in terms of minutes of fire resistance.

This allows determination of the necessary film thickness of intumescent paint needed to protect the full assembly for the specified rating. Essentially, if the assembly’s components added up to 90 minutes of fire resistance and the code called for a two-hour rating, it can be determined and recommended that an appropriate film thickness is needed to provide the added 30 minutes of protection.

Real-world challenges

Although the HUD and CAM methods are both represented in current building codes, they are not universally accepted at the local building-code level. Building codes dictate the required fire-resistance rating for buildings, based on size, location, proximity to other buildings, occupancy, and use. These codes range from a flame-spread classification (Class A, B, or C) as tested per ASTM E-84 to a four-hour fire-resistance requirement (for structural steel) per ASTM E119.

Building codes, however, do not provide specific construction details, which can and do vary on construction projects. This level of detail is left to the local JHA, or jurisdiction having authority. Typically this would be a local building official, city plan officer, or local fire marshal. This scenario, however, often represents an obstacle to the use and acceptance of an intumescent coating as providing the required fire protection to the project-specific substrate or assembly. This situation is most often attributable to a lack of knowledge of product technology, fire testing, and fire-protection engineering; concerns about long-term, in-place performance; and doubts about the possible subsequent recoating of the intumescent paint with non-fire-resistant paints.

Since intumescent coatings have built a track record originating more than 50 years ago, a number of manufacturers are able to provide evidence that addresses concerns about long-term, in-place performance of materials. Many examples of intumescent-coatings installations dating back to the early 1960s can be cited as confirmation of this long-term performance capability.

UL, recognizing the need to effectively test the long-term, in-place performance of intumescent coatings, many years ago initiated a test program to simulate exterior and interior environmental conditions and their effect on these coatings. These programs help document the successful performance of intumescent coatings in accelerated exposure testing that simulates interior and exterior environmental conditions.

Given this information, intumescent-coatings manufacturers are convinced that questions about the long-term efficacy of the coatings can be addressed with a program of education of local building officials, supported with fire-test data and results. Also seen as playing important roles in establishing and disseminating such information and data are the expertise of fire-protection engineers, and documentation of real, long-term in-place performance.

Future prospects for fire-protective coatings

Taking a look into the future of the fire-protective coatings industry and the role played by coatings specifiers and users, it would appear likely that a continued increase in the use of intumescent coatings will take place. This is due in part to increased product awareness, greater attention to life-safety concerns, strengthening of building codes, and the desire of architects, specifiers, and building owners to exploit materials and technologies that provide an important safety function while contributing to the objective of attractive aesthetics.

For fire-protective coatings manufacturers, this trend of expanded use will make it imperative that full-scale fire-testing programs be expanded to better demonstrate product performance on wood and other building materials. The scope of this work should be broadened to encompass new building materials and those subject to more widespread use in construction.

In addition, manufacturers will be challenged to devote additional time and resources to the evaluation of emerging technologies such as nanoclay materials and environmentally friendly, low-VOC formulations as part of ongoing programs to advance the science of fire-protective coatings.



About the Author

W. Casey West is chairman of StanChem Inc., based in East Berlin, CT. StanChem is the parent company of Albi Mfg., a manufacturer of a range of fire-protective materials for use in the construction industry and other markets. He has been involved in the fire-protective materials industry for 25 years. He has held positions in field sales, sales management, and at the executive level. He is co-owner of StanChem.

JAC

By Bill Dempster,
International Paint LLC

*Editor's Note: This article appeared on
durabilityanddesign.com in July 2010.*

Premanufactured Intumescent Fire Protection: Aesthetics, Performance, Application Flexibility

The recent development of premanufactured intumescent fire protection for architectural applications can deliver a number of important advantages, including the aesthetic qualities of thin-film fire-protective materials, flexibility in on-site application, and fire-protective performance that is equivalent to spray-applied epoxy intumescent coatings.

This technology offers improved mechanical durability and an aesthetically pleasing finish while achieving a fire-protection rating up to two hours, with simple installation techniques that can be used in new construction, maintenance, and building retrofits with little disruption on the job site. The visual result is an ultra-smooth finish with no "orange peel" effect.

Introduction

The use of passive fireproofing plays an integral role in protecting structural steel in commercial and industrial structures around the globe. Traditional types of passive fireproofing materials, such as cementitious, sprayed mineral fiber, rigid board and, more recently, intumescent thin-film paints are routinely applied at the job site following the construction of the structural frame.

Intumescent fire protection has become the industry norm for protecting exposed structural-steel elements. These are predominantly water- or solvent-borne acrylic materials that are spray applied and provide an orange peel-type finish following the contour of the underlying steel.

The drawbacks with acrylic-based intumescent materials are low film build per pass, extended dry times, poor constructability and durability. Epoxy mastic intumescent materials have crossed over from industrial applications to provide improved constructability, faster application, elevated mechanical durability, and the option of shop or field application.

The challenge, however, has been managing the architectural expectations with an acceptable decorative spray finish. Perceptions are that only a rough, textured finish is achievable, when in fact due to the epoxy chemistry, the finish is limited only by the architect's imagination.

Epoxy chemistry

Epoxy intumescent fireproofing consists of two components that, when mixed in the proper ratio, result in a crosslinked polymer that irreversibly cures to a rigid and strong material. A unique feature of epoxies is that they are malleable in the viscous state prior to curing, and can be molded into their final form. Spray-applied epoxy intumescent fireproofing can be troweled, back-rolled with various roller naps, or stamped during the gel stage of curing, which locks in the desired finish and effect. Once fully cured, the hard epoxy surface can also be sanded smooth to achieve an automotive body-type finish. This is the premise on which premanufactured architectural fire protection is based.



Installation of pre-manufactured epoxy intumescent fire protection

The manufacturing process

The process for molding and shaping the epoxy intumescent material takes place in a climate-controlled factory. Epoxy material is mixed and dispensed into reusable release forms using the same plural-component equipment as spray application. Precise thickness of the fire protection is maintained throughout the entire cast section, resulting in a uniform finish profile. The cured epoxy castings are inspected for shape, thickness, and uniformity with imperfections repaired prior to shipping.

Installation

The inherent robustness of the epoxy castings permits installation of the fire-protection elements during any point in the construction schedule, from initial steel erection to just prior to occupancy. Additionally, in a retrofit or upgrade application, the installation can take place during off hours, thus offering limited or no disruption to the commercial operations.

The installation process is summarized below.

- Ensure the steel substrate is prepared in accordance with manufacturer's recommendations.
- Inspect the pre-manufactured fire-protection sections for correct sizing and shape.
- Apply a layer of epoxy intumescent adhesive on the inside face of the pre-manufactured shells using a notched trowel.
- Place the coated pair of pre-manufactured pieces against the structural steel section, ensuring proper alignment, and clamp in place.
- Repeat the steps along the length of the structural steel section.
- Fill gaps and joints with the same epoxy intumescent material as the castings. Holding clamps can be removed during the joint-filling process. Remove excess epoxy intumescent material from the joints and edges.
- Allow the epoxy intumescent adhesive material to cure, lightly sand, and apply the specified topcoat material.

The on-site application can occur simultaneously with other construction trades, with no bulky equipment, tarp protection, or supplemental engineering controls required. Rapid installation is achieved by trained craftsmen with an eye for decorative perfection. There are no unsightly design joints or mechanical attachments that could detract from the desired smooth and seamless effect.

Construction damage or normal wear is easily repaired using the same epoxy intumescent material as the casting. Local damage areas are prepared, filled with the epoxy intumescent material, sanded smooth, and top coated while in place. In most cases, the damaged casting section does not require replacement.



Completed installation of circular hollow structural columns



Completed installation of square hollow steel column

Advantages of premanufactured architectural fire protection

Pre-manufactured architectural fire protection essentially combines the best qualities of factory-produced epoxy intumescent material with site-applied intumescent materials, such as those based on acrylic chemistry. These attributes include the following.

- A reproducible, seamless architectural finish, and maintenance of the same fire protection and in-place performance as spray-applied epoxy intumescent fire protection.
- Minimized visual variation of the applied intumescent, ensuring that the visuals the architect is seeking are achieved. With circular hollow columns, a smooth, symmetrical finish is achieved, while on square or rectangular hollow columns, a smooth, sharp, angular corner finish is achieved.
- Less application complexity, permitting flexible site installation on new construction and retrofit projects.
- Lower installed cost due to a significant reduction in manufacturing, installation and finishing times.

In summary, this recently developed premanufactured architectural fire-protection technology combines the aesthetic capabilities of intumescent coatings with a high degree of fire protection of the structural steel. The in-place performance characteristics of the premanufactured option are equivalent to spray-applied epoxy intumescent fire protection, but with a reproducible decorative finish that meets the aesthetic requirements of the project architect.

About the author



Bill Dempster is the HVI market manager for International Paint LLC, responsible for advancing the use of intumescent fireproofing and high-performance coatings in the commercial market segment. He has more than 25 years of experience in the protective coatings industry, specializing in fire protection. Prior to joining International Paint, he held various technical and marketing positions with W.R. Grace & Company and the Tyco Corrosion Protection Group. Dempster is a member of CSI, SSPC, and NACE, and is a past ASTM task group chairman for fireproofing standards. He has published more than 30 technical articles, holds one patent, and is a certified CIP Level II Coatings Inspector. He has a bachelor's degree in environmental sciences from Bemidji State University.

D+D

