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PVDF Architectural Coatings

Technical Paper

PVDF resin-based architectural coatings provide high-performance durability for metal building products. These resin systems are available for both liquid and powder coatings. PVDF resin-based coatings are combined with the hardness of acrylic to deliver durable, superior-performance coating systems that withstand the test of weather and time.

Tested under extreme conditions, these coatings are proven to resist humidity, fading, chalking, abrasions and most chemicals, while retaining the intended color, gloss and appearance. Across North America, building owners, architects, contractors, product manufacturers and finishers have relied on PVDF coatings for 50 years.

Known Names

PVDF is the abbreviation for polyvinylidene difluoride. PVDF is a fluoropolymer resin. Coatings containing fluoropolymer resins are produced by many manufacturers and branded with a variety of trademarked names. Unfortunately, it can be confusing for those outside of the coatings industry to differentiate between the resin manufacturers and the coating manufacturers.

Although architectural coatings from different coating manufacturers contain similar PVDF resins, the performance of the coating systems can vary widely. This is due to the proprietary formulations of each coating manufacturer. Hylar® by Solvay Solexis and Kynar® by Arkema Inc. are the two brands of PVDF resins most widely recognized in the U.S. They offer equivalent performance per industry standards for weathering. Every coating manufacturer's unique coating formulation includes resins, pigments, solvents and additives. These are detailed in a separate section later in this paper.

Aria Resort & Casino, Las Vegas, NV

For 50 years, The Valspar Corporation has manufactured Fluropon® brand 70% PVDF architectural coating systems. Continuous improvements at Valspar have contributed to Fluropon's longevity, as well as resulted in additional branded PVDF coatings. Valspar's PVDF coatings are recognized for their enhanced application properties, dependable color consistency, and special formulations such as energy-efficient solar-reflective coatings and color-changing coatings.

Valspar's 3-Part Specification Guide "05 05 13 Shop-Applied Coatings for Metal" provides in-depth specification information for architects.

End-Use Expectations

From the roof to front door, PVDF resin-based coatings protect and enhance numerous architectural metal products.

End-uses include:

Metal roofing and wall panel systems
Framing for curtainwall, windows, skylights and entrance systems
Louvers and grills, soffits, fascia, mullions, column covers and more

These exterior metal products are manufactured from steel and aluminum coils, or from aluminum extrusions. Coil and extrusion product guide specifications for shop-applied, exterior coating systems are available from PVDF coating manufacturers. These specifications should follow the Construction Specifications Institute (CSI) 3-Part Format and reference standards. Applicator and end-user expectations are influenced further by PVDF resin manufacturers that have earned a reputation for resin systems with weathering performance perceived as superior to all others.

To ensure PVDF coatings perform and appear as intended and expected, regardless of the manufacturer, architectural metal products typically are specified with reference to the project requirements and voluntary industry standards.

- ***American Architectural Manufacturers Association (AAMA)*** standards are considered the most stringent for coatings applied to aluminum extrusions, panels and substrates. The AAMA also publishes standards for hot-dip galvanized and zinc-aluminum coated steel substrates.
- Additional guidance is provided through test procedures of ***ASTM International***, formerly known as the American Society for Testing and Materials (ASTM). More information on these standards and test procedures is included later in this paper.

Coil and Extrusion Coatings

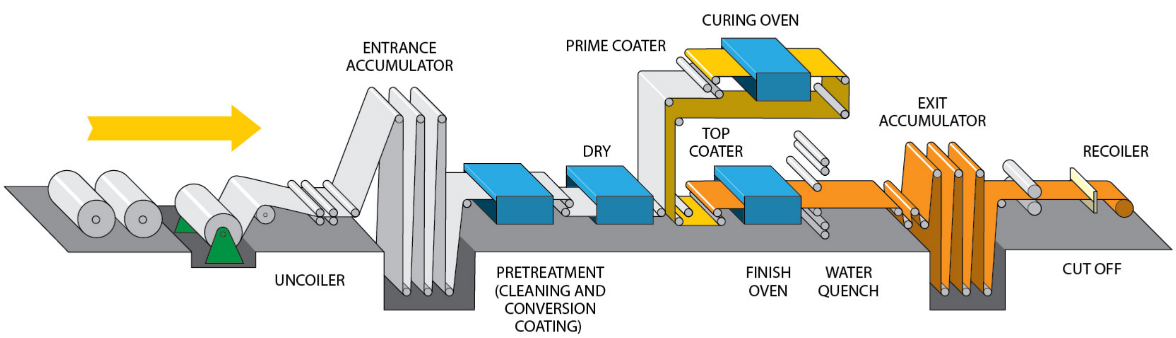
PVDF resin-based coatings are available for both coil and extrusion applications.

Coil Coatings

Coil-coated, or pre-painted, architectural building products start out as flat sheets and are formed into shapes such as roof panels, wall panels, gutters and pre-manufactured metal buildings. Substrates may include pre-treated hot-dip galvanized steel (HDG), (Galvalume®) and pre-treated aluminum.

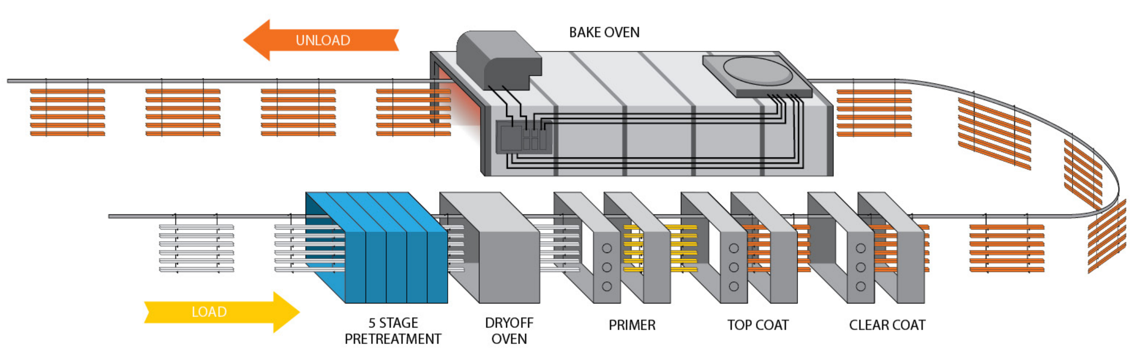
The National Coil Coating Association's website explains:

"Coil coating is a continuous, automated process for coating metal before fabrication into end products. The metal coil is positioned at the beginning of the coating line, and in one continuous process, the coil is unwound, pre-cleaned, pre-treated, pre-primed and pre-painted before being recoiled on the other end and packaged for shipment."



Extrusion Coatings

While coil coating is applied to the metal prior to it being shaped into architectural building products, the aluminum extrusion process creates the metal products first — before a finish is applied. The shape of the die determines the shape of the extrusion. Using aluminum billet and a powerful hydraulic press, extruders can produce almost any shape imaginable. Fenestration products are among the most common examples of extruded aluminum, such as framing for windows, curtainwall, storefront and entrance systems.



PVDF Coating Composition

To meet the industry's highest performance standards for architectural metal products, 70% PVDF resin-based coatings are recommended. The remaining 30% of the binder is composed of acrylic. Pigments, solvents and additives are also included in the formulated liquid product. For PVDF powder coatings, the solvent is omitted.

The raw materials of these coatings are:

RESINS	PIGMENTS	SOLVENTS*	ADDITIVES
Serve as the binder that forms the paint film and are the principal components that determine the durability of the coating, its appearance and its performance.	Provide the color and influence the coating's durability.	Maintain the liquid state and influence the ease of application, but are not used in powder coatings.	Affect the flow, cure rate and surface appearance, and also influence the liquidity and application.

*Are not used in powder coatings.

Resins (Binder)

Coatings are often named for their resin type or blend, such as 70% PVDF and 30% acrylic blend. For coatings other than PVDF, common resin names are epoxy, polyester and urethane.

Resins bind the coating to the substrate. They determine many coating properties, including weather resistance, physical properties, chemical resistance, color fade, chalk, and gloss retention. With 70% PVDF coatings, the resin typically results in a medium- to low-gloss finish. Degradation of the resin system by ultraviolet (UV) exposure or hydrolysis results in chalking — a visible whitish, powdery substance. As the resin system degrades, the coating surface gets rougher as pigment particles in the film become exposed. Combining the PVDF resin system with acrylic provides an added hardness and adhesive quality to the overall coating system. The acrylic must be selected carefully for compatibility with the PVDF and for premium UV resistance.

Pigments

Pigments provide the coating with color, while hiding the primer and substrate. Depending on their chemistry, pigments impart color to PVDF coatings by absorbing and reflecting visible light. The majority of the time, color is the most important design element to an architectural coating. Not only does pigment color give a design beautiful aesthetic properties, but it also influences the coating's durability and can enhance its mechanical strength.

For enhanced performance considerations, specialty pigments can impart additional solar-reflective, energy-saving properties for PVDF coatings. For both aesthetic and performance criteria, it is essential to choose the right pigments. An important basis for the selection is an effective outdoor exposure program.

The Exploration Tower at Port Canaveral in Port Canaveral, Florida, features Valspar's 70% PVDF Kameleon™ coating, which shifts in color when viewed from different angles.

The three types of pigments used in architectural coatings are:

- ***Inorganic, which generally are ceramic or mixed-metal oxide pigments***

  Inorganic pigments are sourced from minerals that either have been mined and refined, such as red oxide, or have been synthesized at high temperatures, similar to firing ceramics. The coloration imparted by these pigments tends toward the earth tones of gray, brown, and muted reds and yellows.

  With few exceptions, inorganic pigments maintain their color for many years and even decades. One of the exceptions can be titanium dioxide (TiO_2), which is commonly used for white colors. When mixed with other pigments, TiO_2 must be given careful consideration to ensure the intended performance.

- ***Organic, which are manufactured using petroleum-based (carbon) chemistry***

  Organic pigments can achieve bright, bold colors, but their carbon-based chemical structures typically degrade more quickly than inorganic pigments. These pigments are more easily affected by sunlight, moisture and temperature changes (thermal cycling).

- ***Metalescent, which are fine flakes of aluminum or pigmented mica***

  Metalescent pigments are composed of tiny metal flakes of aluminum, natural mica or synthetic mica-like material. They can produce coatings that shine and sparkle as a result of the size and shape of the metal flakes. Some coatings with metalescent pigments also change color depending on the viewing angle and light conditions.

Solvents and Additives

Solvents thin the consistency of the mixture so that it can be properly applied. During the curing process, solvents evaporate, while the resin system adheres to the substrate. Experienced coating manufacturers are able to balance the solvent formulation to achieve the desired consistency for different customers' unique applications needs.

Specific to the application, additives are used for processing pigments within the film, for flow and smoothness, for regulating the rate of the cure, and for enhancing the coating's hardness, gloss, mar resistance and other performance attributes.

PVDF Coating Application

PVDF resin-based liquid coating systems include 1) a primer, which imparts corrosion resistance to the substrate and determines adhesion quality and 2) a topcoat, which determines the color. These are described as two-coat systems. For PVDF two-coat powder coating systems, a liquid primer precedes the PVDF powder topcoat to meet the AAMA 2605 corrosion requirements. Three-coat systems also include a clear coat, which can add protective attributes to better resist corrosion reactions.

The way in which a 70% PVDF coating is formulated differs depending on how the paint is applied. This may result in slight appearance differences on the finished product in a coil application compared with a spray application. There should be little difference in exterior performance between a coil-applied and a spray-applied PVDF coating from the same supplier.

Specifying 70% PVDF Coatings

With respect to 70% PVDF coatings, AAMA 2605-13, "Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels," is the most widely referenced. It not only pertains to spray-applied coatings for extrusions, but also includes an appendix addressing coil coatings for aluminum substrates.

The appendix included in the current AAMA 2605-13 standard replaced the previous document, AAMA 620-02, "Voluntary Specifications for High Performance Organic Coatings on Coil Coated Architectural Aluminum Substrates."

For coil coating steel substrates, the standard remains AAMA 621-02, "Voluntary Specifications for High Performance Organic Coatings on Coil Coated Architectural Hot Dipped Galvanized (HDG) and Zinc-Aluminum Coated Steel Substrates."

Other commonly referenced AAMA standards for liquid finishes are:

- ***AAMA 2603-13***, "Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels," addresses acrylic and most high-solid polyester resins, which deliver a lower level of performance than 70% PVDF coatings
- ***AAMA 2604-13***, "Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels," addresses 50% PVDF-based resins, and also reflects their lower level of performance compared to 70% PVDF coatings

  As with AAMA 2605-13, these two standards also include an appendix that describes differences in test procedures and performance requirements for organic coatings, applied on a coil coating line, to aluminum architectural products.

Liquid finishes that meet AAMA 2605-13 are ideally suited for long-life external use on monumental high-rise structures and pre-engineered buildings' exterior architectural aluminum products. The AAMA's rigorous 2605-13 testing performance standards for Superior Coatings include more than 2,000 hours of prohesion (cyclic corrosion) exposure, 4,000 hours of humidity resistance, and a variety of physical property and chemical resistance testing. AAMA standards also require that the coating maintains specified standards of film integrity, color retention, chalk resistance and gloss retention after enduring outdoor weathering exposure in South Florida for a period of 10 years.

As most industry standards are written to provide a base-level guideline, they are regularly reviewed and updated. Building products manufacturers also provide coating specifications for their products and include language in their products' warranties that address their finishes. Coatings manufacturers are sometimes asked to surpass existing industry standards, such as AAMA 2605-13.

Key Performance Considerations

Chalk and Fade Resistance

The right combination of resins and pigments is essential to ensure protection against chalk and fade. No matter how well a coating is made, certain colors are more affected by the outside environment than others, especially bright colors like yellows, oranges and reds. When selecting a color, ultraviolet (UV) exposure and intended end-use should be taken into consideration.

PVDF coatings have the best UV resistance of any polymer used in coatings today. The carbon-fluorine bond is one of the strongest chemical bonds known. The bond gives PVDF resin-based coatings their stubborn resistance to chalking and erosion, as well as to harsh airborne industrial and atmospheric pollutants.

Chalking is caused by degradation of the resin system at the surface of the finish, due primarily to exposure to UV wavelengths. As the PVDF resin system breaks down, resin particles take on a white appearance and imbedded pigment particles lose their adhesion to the film, resulting in a whitish, powdery substance. The acrylic resin can influence the chalking characteristics of PVDF coatings.

ASTM D4214-07, "Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films," outlines several test methods for collecting the chalk sample and provides a photographic comparison chart of numbered images. The range goes from 10 to 1, with 10 showing the least chalk and 1 showing the presence of extreme chalking. After 10 years of exposure testing, AAMA 2605-13 requires the finish to exhibit no more than a 6 rating for whites and an 8 rating for colors.

While the high-performance resins work to prevent chalking, pigments are important to guard against fading. Fading occurs when substances in the environment attack the pigment of the paint and cause the color to change. Fade is caused by a breakdown of the pigment itself, measured in Delta E (DE) variations. Color fade in the paint system often manifests itself as a lightening of the color, but not all pigments become lighter over time — some darken.

Organic pigments, like the resins of a coating system, are susceptible to degradation by UV and hydrolysis. The inorganic, mixed metal oxide pigments are stable to those mechanisms. The effects of gloss retention, chalk and fade are all related to the degradation of the acrylic portion of the resin by those two primary degradation mechanisms. As the resin degrades, the surface gets rougher, which lowers the gloss of the coating and begins to expose the pigment particles. As resin degradation continues, those pigment particles, once held firmly in the binder, become loose. Loosened pigment particles, along with the degraded resin byproducts, become powders and are easily washed off the surface or removed by touch (chalking). With mixed metal oxide pigments, it is not pigment degradation that results in color fade, but rather the removal of pigment from the coating surface via chalking.

Film Integrity and Adhesion Quality

Blistering, peeling and cracking are all indications that the film integrity of a 70% PVDF coating has degraded. This is caused by heat, moisture or a combination of both, in conjunction with other factors in the total substrate-coating system. Improper drying or curing of the coated material can cause surface blistering. Improper application, spreading paint too thin, or poor surface preparation can also lead to undesirable performance and longevity.

Properly cleaning and pretreating the substrate is necessary for the adhesion performance of the entire coating system and for the corrosion protection of the substrate. Analogous to a foundation under a building: if the pretreatment is weak, the coating above it will not be stable to stresses imposed by the environment. A quality coating manufacturer will invest in full system evaluations, including cleaners, pretreatments and substrates, to help its customers make informed decisions and avoid risks associated with weak substrate-pretreatment combinations. Adhesion of PVDF coatings also depends on a high-quality primer that adheres to the substrate, creates a strong bond with the PVDF topcoat, and resists the stresses of forming (for coil coatings) and of weathering. Similar to pretreatments, primers will also vary by supplier.

Another important aspect of film integrity is erosion rate — the rate at which coating degrades and "washes away" in the elements. The erosion rates of PVDF coatings are relatively small and support a very long coating life. There are PVDF coatings on Valspar's test fence in Fort Myers, Florida, that have more than 40 years of exposure time.

Both a coating system's performance quality and the robustness of its application are dependent on the quality of the raw materials, beyond the PVDF resin, that coatings manufacturers use, the consistency in their manufacturing process, and the reproducible procedures and test methods they employ. In other words, when a coating is manufactured, there should be a high degree of confidence that it will perform as intended.

Architects, owners and applicators have a reasonable expectation that the product has formulating stability such that it does not significantly change when the product leaves the coating manufacturer. The minimal amount of change that may occur once it leaves the facility is due to the quality of the raw materials and the formula of the coating system.

Valspar's 70% PVDF Fluropon® Coating versus Competitor A: Gallery Blue Natural Weather Expsoure, Ft. Myers, FL, 9+ Years Exposure

Although the coatings may differ in color, a single coating manufacturer provides consistency from one formula to another. Supporting consistent results and quality, the most reliable coatings manufacturers also make their own acrylic resins. Furthermore, the reputation and technical capabilities of the coating manufacturer play important roles in the quality of the final product. Any paint manufacturer, theoretically, can make a 70% PVDF coating, but 30% of the binder, pigmentation, and the solvents and additives are determined by the knowledge and expertise of the paint manufacturer. Companies with a strong and lengthy weathering test program (outdoor exposure history) and a commitment to quality products will ensure that only high-durability pigments and resins are used, and that the product performs up to end-user expectations.

Green Building Considerations

Beyond voluntary industry standards and project-specific requirements, manufacturers and applicators of PVDF coatings must comply with all laws and regulations where their facilities are located and where the buildings with the installed, finished products are located. In the U.S., the Environmental Protection Agency (EPA) monitors chemicals used in PVDF coatings and resins, and recommends safe and health-minded practices.

Focusing on the health and wellness of building occupants, the Green Building Initiative, the International Living Futures Institute, and the U.S. Green Building Council's LEED® Rating Systems are some of the organizations with established guidelines that pertain to architectural coatings. The International Code Council's International Green Construction Code also provides minimum requirements for increasing the environmental and health performance of buildings.

Certain pigments can be included in PVDF coatings to reflect non-visible infrared (IR) wavelengths. IR is largely responsible for unwanted solar heat gain that makes building occupants uncomfortably warm. The greater the amount of solar energy reflected from the roof surface, the less energy the building will need to cool down. Pigments specified for IR reflection and used in exterior coatings can contribute to lower utility bills, such as in specialized coatings for "cool" roofs.

Cool Roof Rating Council (CRRC) established a methodology and system of quality control for roofing manufacturers to report reflectance and emittance data in roofing products. Roofing manufacturers can label various roof surface products with radiative property values rated under a strict program administered by the CRRC. Reflective roofing products are also listed on the ENERGY STAR® qualified products list. Products that earn the Energy Star label use less energy and prevent greenhouse gas emissions by meeting strict energy efficiency guidelines.

Not only do 70% PVDF resin-based coatings contribute to architectural projects' sustainability goals, they offer durability to lower maintenance and lengthen lifecycles. These benefits further complement PVDF's strengths in retaining the intended color, gloss and appearance.

However, it is important to remember that, while 70% PVDF architectural coatings are created with similar quality resin systems, the remaining 30% of the formulation can vary in longevity and performance depending on the coating manufacturer.

Choose a coating manufacturer that provides careful raw material selection, robust application properties, dependable color consistency, innovative technical leadership, clear specifications and responsive customer service, as well as the willingness to share its expertise and educational resources.

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if it matters, we're on it.®

To learn more about PVDF resin-based coatings offered by The Valspar Corporation,
please visit www.valsparinspireme.com.