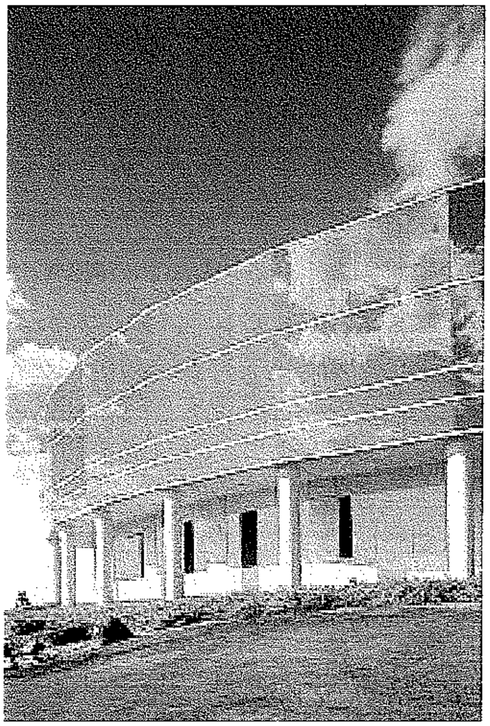
a lifetime *performer*

Fluoropolymer Coatings Resist the Effects of Aging



Consider shining-blue spandrel panels on an 80-story high-rise, or three tiers of green and gold bleachers at a high-school stadium, or a vibrant blue *brise soleil* at a day care center. These are critical components of architects' designs. Decades after construction, the finishes on these components should ideally be just as pure as when the projects were completed - colors and gloss levels should be minimally altered and surfaces unblemished despite constant exposure to the sun, wind and airborne contaminants.

By Ann C. Sullivan

To achieve such superior protection, architects have learned to specify polyvinylidene fluoride (PVDF) fluoropolymer coatings but they may not have given much thought to the technology behind these high-performance metal coatings.

The formulation of special grades of PVDF fluoropolymer coatings is the culmination of a 30-year period of technological development. It's a story about chemistry: fluoropolymers exploit the strength of the carbon-fluorine bond, the strongest bond known in the chemical world, to achieve unmatched stability.

Moreover, it's a story about business. A critical component of architectural fluoropolymer coatings a special PVDF resin grade was once available from only one United States source. A 1990 federal antitrust decision eliminated the inevitable difficulties of a one-source market

Healthy competition raises the performance bar, which benefits all coatings manufacturers, specifiers and applicators who depend on specially formulated PVDF resin to deliver the highest grade of architectural finishes. PVDF fluoropolymer coatings have also earned a reputation for exceptional durability and low maintenance. They can withstand the abuses of heat, humidity and airborne contaminants, and come through with flying colors - literally. Colorfastness and gloss retention are assured because PVDF fluoropolymers do not absorb ultraviolet (UV) light from the sunlight spectrum.

Demand has risen steadily as word of PVDF spread among specifiers. Today the North American PVDF fluoropolymer coatings market is growing at an estimated 7% annually. One of the fastest growing segments is the architectural -coatings market.

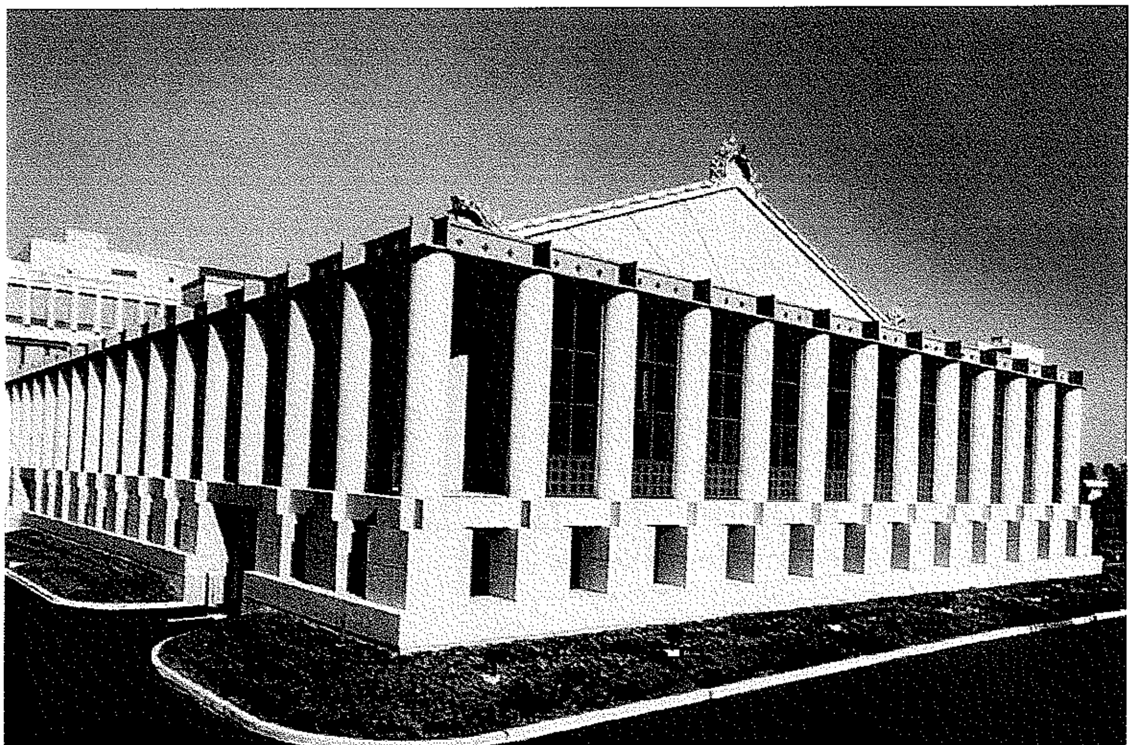
PVDF fluoropolymer coatings have made their way into industrial, residential, institutional and commercial projects including power plants dormitories and shopping malls. Appropriate substrates include metal materials such as aluminum aluminized steel, galvanized steel and stainless steel and nonmetal surfaces such as glass. Applications have grown to include ornamental metal, expansion-joint cover assemblies, roof and wall panels sheet-metal roofing entrances and storefronts, metal windows, curtain-wall components, and column covers. Structural items, including louvers sunscreens and skylight frames are regularly finished with PVDF fluoropolymer coatings.

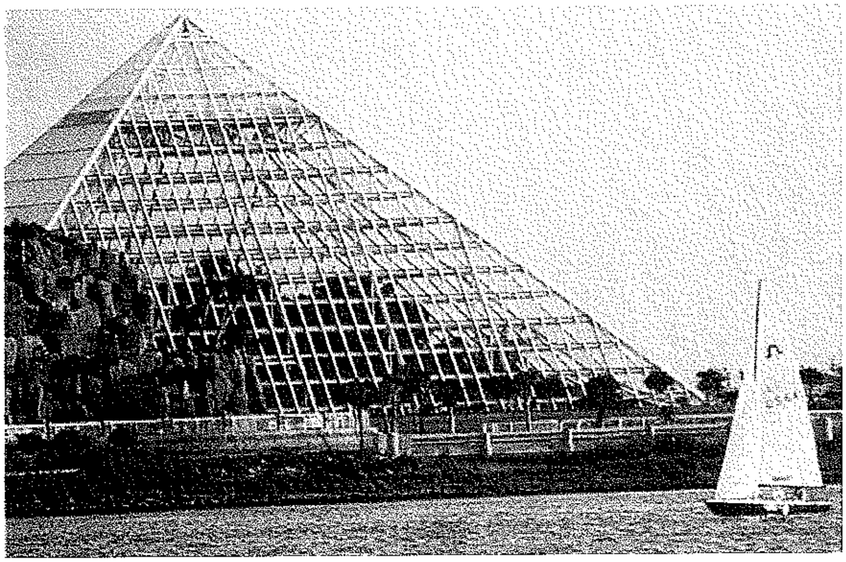
PVDF fluoropolymer coatings like most paint, consist of three main ingredients: pigment for color; resin which binds the pigment to the substrate; and a solvent, which allows for liquid application During baking, the solvent evaporates and the resin molecules surround the pigment molecules and bind them to the substrate.

There are several different kinds of fluoropolymer coatings. All fluoropolymer resins have a strong carbon-fluorine bond which accounts for the fluoropolymer's stability

PVDF resin goes a step further. It has a special molecular structure that makes it particularly inert, resistant and stable. it combines the strength of the carbon-fluorine bond with a carbon-hydrogen bond.

As a result these special PVDF fluoropolymers are tough, thermoplastic dispersions that have the characteristic stability of fluoropolymers when exposed to harsh thermal, chemical and UV conditions. In addition, alternating CH2 and CF2 groups along the polymer chain create a polarity that affects the solubility and electrical properties of PVDF resin. A unique capacity for selective solubility gives PVDF resin an advantage when it comes to the preparation of corrosion-resistant coatings. In addition, fluoropolymers provide excellent color and gloss retention.





Architectural coatings manufacturers depend on these advantages. They rely on PVDF resin for superior stability and environmental performance to combat the perils of acid rain, pollution, salt spray and airborne particles all of which can contribute to a resin's break-down. When a nonfluoropolymer-coating resin fails particles on the surface of the finish will lose adhesion and chalk. in addition if the resin at the surface of the finish degrades and loosens the pigment particles that are embedded in the resin will detach resulting in a noticeable paint failure.

PVDF resin, with its long track record of superior gloss and color retention, provides architectural coatings with the most consistent protection from the elements. Such resilience, stability and colorfastness weren't achieved overnight; the formulation of today s PVDF resin-based coatings follows 30 years of continued architectural coatings research and development.

PVDF Predecessors

Unprecedented construction activity following World War 11 led to widespread installation of prefabricated metal building components including curtain walls aluminum siding, and metal panels and roofs These applications raised new questions about how to preserve and enhance metal finishes, since conventional methods of wood protection were unsuitable.

Between 1946 and 1965 manufacturers struggled to find compounds that would protect metal substrates from prolonged exposure to the elements and preserve their appearance. With each iteration, coatings developers adopted new and increasingly higher standards for gloss and color ranges, colorfastness, UV resistance flexibility, application techniques, and cost-effectiveness Today s PVDF resin-based coatings evolved from and surpassed, in terms of performance their predecessors, which include acrylics, plastisols, porcelain enamel, siliconized polyester and PVC film

Among the early metal coatings were alkyds. These one-coat finishes were first applied to interior aluminum blinds and residential siding. However problems with flexibility and chalking shortened their life span Flexibility improved with solution vinyls, which were introduced in the early 1950s. Difficult application and poor resistance to cleaning agents ended their tenure.

In the early 1960s, one-coat thermoset acrylics appeared in the residential siding and pre-engineered metal buildings market until increasing incidences of corrosion mandated two-coat applications. Coatings developers spent the remainder of the decade working on a variety of alternatives, which include organosols polyesters and plastisols.

Organosols, or polyvinyl-chloride dispersions, were easy to handle and featured good flexibility, but were hindered by limited color and gloss range. Polyesters for residential siding and metal buildings were cost effective compared to acrylics but they demonstrated unacceptable costs suffered from low production speeds, poor UV performance, and limited color and gloss ranges

Color and gloss retention received a boost from silicon polyesters but not without compromise. When silicon levels were reduced for the sake of color and gloss the lower amount of silicon hindered the coating's flexibility and quality suffered.

It wasn't until 1965 that coatings developers formulated the first PVDF fluoropolymer-based coatings. Very inert and capable of excellent color and gloss retention, PVDF fluoropolymer coatings set new standards for environmental performance.

A highly impermeable, thermoplastic dispersion, PVDF coatings cure physically by fusion. In other words, the resin melts under heat and flows uniformly to form a paint film PVDF resin-based coatings are characterized by consistently high pigment dispersability, adhesion and flexibility - qualities that have served the building industry well for 30 years and counting.

The U.S. Fluoropolymer Market

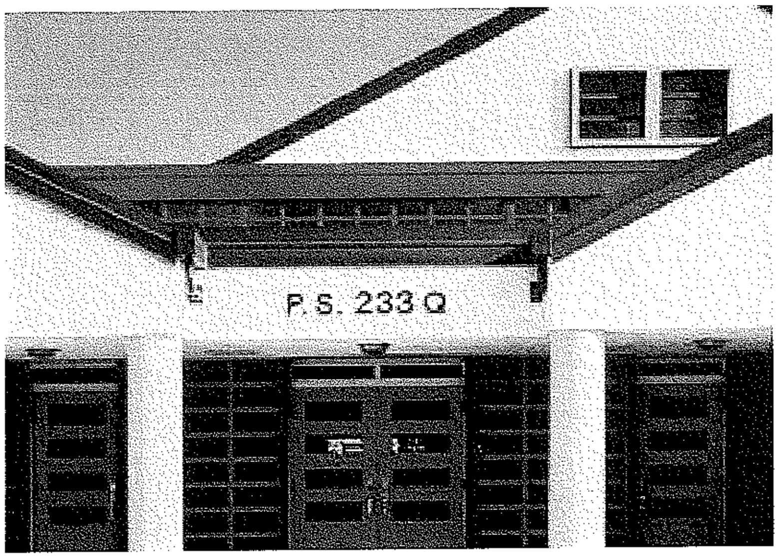
PVDF resins are supplied to licensed coatings manufacturers worldwide who use the resin to produce their own proprietary PVDF resin-based finishes. Prior to 1990, these specialty resins were available from only one U.S. supplier, the Pennwalt Corp. In 1990 Ausimont USA purchased a Kynar 500® PVDF plant and secured an exclusive perpetual license to the original Pennwalt technology. Ausimont then began producing PVDF resins under their new tradenames Hylar® and Hylar 5000®. Hylar 5000 PVDF resins employ the same technology and superior attributes consistent under the original Pennwalt Kynar 500technology: chemically inert. impervious to environmental and chemical assault. resistant to UV radiation gloss and color stable, and nonchalking.

Now available from more than one U.S. source special PVDF coating resins have reached a broader audience. The expanded market has raised architects' and specifiers' awareness. and resulted in greater demand for PVDF resin-based coatings. Architectural applications. in particular have raised PVDF demand

Specifying Hylar 5000 PVDF

The American Architectural Manufacturers Association (AAMA) describes test procedures and requirements to help architects and specifiers provide and maintain high-performance architectural coatings. The primary guide is AAMA 605.2 Voluntary specification for high performance organic coatings on architectural aluminum extrusions and panels. Film integrity exterior weatherability and general appearance are covered by this AAMA specification. Specifically, detailed procedures and reporting methods judge color uniformity; specular gloss; dry-film hardness; film adhesion; impact, abrasion chemical and corrosion resistance; weathering; and sealant compatibility

Additional specification guidelines covering the performance of PVDF resin-based fluoropolymers



are available from the Architectural Spray Coaters Association (ASCA). The ACSA 96 *Voluntary supplemental specification for use with* AAMA *605.2 to ensure the high standards of quality recommended by* AAMA *and* ASCA covers procedures for processing, testing and packaging. This specification describes the basis metal, surface appearance, touch-up, film thickness, metal preparation sampling and testing procedures

Ann C. Sullivan is a freelance journalist who earned a degree in architecture and served as technology editor for Architecture magazine.

Attachment # 7

New AAMA Paint Specifications

	AAMA 2603 (same as AAMA 603)	AAMA 2604 (similar to AAMA 605)	AAMA 2605 (new specification)
South Florida Weathering:			
Color Retention	1 yr - "slight" fade	5 yrs - Fade = 5 Delta E	10 yrs - Fade = 5 Delta E
Chalk Resistance	1 yr - "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 - 30mg/sq ft
Accelerated Testing:			
Salt Spray	1,500 hours	3,000 hours	4,000 hours
Humidity	1,500 hours	3,000 hours	4,000 hours

The Valspar Corporation

A COMPARISON OF

AAMA SPECIFICATIONS FOR COATING ARCHITECTURAL ALUMINUM PRODUCTS

The ARCHITECTURAL ALUMINUM MANUFACTURERS ASSOCIATION ("AAMA") is the governing body that develops specifications for organic coatings that are applied to architectural aluminum buildings products, specifically:

1. AAMA 2603-98 " PIGMENTED ORGANIC COATINGS ON ALUMINUM EXTRUSIONS AND PANELS".
2. AAMA 2604-98 "HIGH PERFORMANCE ORGANIC COATINGS ON ALUMINUM EXTRUSIONS AND PANELS".
3. AAMA 2605-98 " SUPERIOR PERFORMING ORGANIC COATINGS ON ALUMINUM EXTRUSIONS AND PANELS"

AAMA 2603 supercedes the old AAMA 603-8 specification, which essentially covers the "lower end" single coat, finishes that are applied to residential building products such as windows, door, soffit and rain carrying hardware. Coatings covered by this specification would include thermosetting acrylics and high solids polyester (liquid and powder coatings).

AAMA 2604 supercedes the original AAMA 605-2-92 specification covering the higher performing coatings such as aliphatic urethanes, siliconized polyesters and PVDF powder coatings.

AAMA 2605 is a new ten-year superior performing specification with increased performance compared to AAMA 605.2-92. Significant upgrades have been made in the areas of ten-year weathering performance, abrasion, salt spray and humidity resistance.

The conversion of the original AAMA 605.2-92 "High Performance" specification to the new intermediate AAMA 2604-98 specification has however caused some confusion with regard to certain process and performance criteria between the new AAMA 2604 and AAMA 2605 specs and is also causing similar confusion with certain aspects of warranty coverage

Some of these significant areas are addressed in this memo or exemplified in the attachments.

Perhaps the most significant issue is that of the chemical pretreatment of the mill finish aluminum that precedes the coating process. This is **the most critical** first stage of any high performance coating system, and while an **AMORPHOUS CHROMIUM PHOSPHATE CONVERSION COATING** is mandated for AAMA 2605-98, the non-chrome pretreatments are allowed in AAMA 2604-98. Chrome phosphate is the time tested and proven pretreatment and is not only specified **exclusively** in AA 2605-98 but is the only product that is specified for the most rigid Military specification **MIL-C-81706** for aluminum on military aircraft and equipment. The selection of the appropriate pretreatment is especially important for products exposed in areas of high salt concentration such as prevails in ocean front locations, and the attached pictorials (Attachment # 5) show some of the many premature paint failures that have occurred along the Florida coastline that have not employed chromium phosphate pretreatment.

The next important stage of the high performance coating process is the application of an inhibited primer coating (typically Strontium Chromate) prior to applying the color coat. A primer is not a specified requirement for AAMA 2605-98, but is mandated by all the manufacters of the liquid Kynar 500 fluoropolymer coatings, which **are the only coatings that currently meet the AAMA 2605-98 specification.** The primer provides an additional level of corrosion resistance, is an excellent paint anchor and acts as a physical blocker of UV and intrusive airborne contaminants to the substrate. Powder coatings that meet the AAMA 2604 specification do not require the use of a primer.

In areas of high salt concentration or industrial atmospheres, the Kynar 500 manufacturers (and Windsor) recommend the application of a clear topcoat. The pure polyvinyledene fluoride topcoat protects the underlying color pigments from the elements that cause chalk and fade. The lubricity of the coating also encourages abrasive elements to skid off rather than dig in and enhances Kynar's self-cleaning attributes. This non-stick characteristic is also extremely stain and graffiti resistant. A comparison of the powder (AA 2604-98 spec) and liquid Kynar (AA2605-98) coating film characteristics is shown in Attachment # 6.

AAMA specification 2605-98 extends the time period for the very important Humidity and Accelerated Salt Spray Resistance testing from 3000 to 4000 hours and also doubles the South Florida Exposure (Weathering) requirement from five (5) to ten (10) years to meet new higher standards with regard to color and gloss retention, and resistance to chalking. Once again, **liquid Kynar 500 finishes are currently the only high performance coatings that meet these new rigid AAMA 2605-98 standards.**

The comparison of AAMA 2604 –98 (the highest specification to which the superior powder coatings qualify) compared to AAMA 2605-98 (the highest standard in the industry to which only liquid Kynar 500 fluoropolymers qualify) are summarized in Attachment. #7.

SPECIFICATION FOR KYNAR XL (3 COAT)

1. General :Finishing designations prefixed by AAMA conform to testing and performance standards established by the Architectural Aluminum Manufacturers Association. Coatings for this specification shall be compliant with the performance standards set forth in AAMA Specifications 2605 -98 " Superior Performing Organic Coatings on Aluminum Extrusions and Panels".

2. Finish designations prefixed by "AA" conform to the system established by the Aluminum Association for designating aluminum finishes.

3. Chemical Pretreatment (AA- C12C42R1X) : Aluminum railings shall be cleaned with inhibited chemicals and the surface chemically converted to amorphous chromium phosphate to conform to ASTM - D 1730, Type B, Method 5, prior to coating. Conversion coating weight must exceed 40 milligrams / square foot. No substitutions for amorphous chromium phosphate (conversion coat) shall be permitted.

4. High Performance Organic Coating: Apply manufactures standard three (3) coat thermocured system comprising :(a) a specially formulated inhibited primer with chromate pigmentation, (b) the fluoropolymer color coat, and, (c) the clear (XL) fluoropolymer top coat. Both the color coat and clear top coat shall be formulated to contain not less than 70% polyvinylidene fluoride resin by weight. Provide coating that has been field tested under normal range of weathering conditions for a minimum of ten (10) years without significant peel, flake, chip, crack or check in finish and without chalking in excess of a No 8 rating for colors based on ASTM - D 4214, Test Method A (Method D-659) and without fading in excess of 5 NBS units.

5. Testing: Aluminum test samples representative of actual aluminum extrusions and alloys utilized in railing system (or other specified aluminum building products) shall be pretretreated and painted with production materials and submitted to coatings manufacturer for the full battery of tests to ensure compliance with AAMA Specification 2605-98 . Test results must be made available to architect /engineer /owner upon request.

6. Applicators: Coating applicator shall be approved by coatings manufacturer and qualified with current (annual) "Blanket Warranty" approval status. Verification of current status must be made available to architect /engineer /owner upon request.

7. Approved Applicators : Windsor Metal Finishing or equivalent.

WARRANTY CONSIDERATIONS

KYNAR 500 (LIQUID) COATINGS versus HYLAR 5000 (POWDER) COATINGS

Powder coatings that are formulated with Hylar 5000 PVDF resin are frequently described by powder coating applicators and their (railing) customers as being the equivalent of Kynar 500 PVDF liquid coatings. These comparisons imply the products are equal as regards the specifications they meet and the similarity in their respective warranty coverage. This is a misconception and the following commentary addresses some of the significant (albeit sometimes subtle) differences between the warranty coverage's, especially as they relate to AAMA Specifications.

Perhaps the most convincing evidence that the products are clearly not equivalent is shown in Attachment #1 which is a letter from Atofina Chemicals Inc. (the exclusive manufacturers of the Kynar 500 resin) to the writer addressing that issue. The powder product Atofina is referring to is the Series 2000 PVDF coating that is formulated by Crosslink Powder Coatings Inc. who are located in Clearwater, Florida. Although the letter does not get into specific detail, several of the more important issues arise around some "powder" literature that implies the product meets or exceeds the AAMA 2605-98 specification, ***which it does not*** for at least the following reasons:

1. Pretreatment: Warranty requests for a Hylar 5000 (Crosslink, Series 2000) powder product require that the aluminum product must be cleaned and pretreated in accordance with AAMA 2604-98 **AND** AAMA 2605-98. Not only is this redundant as AA 2605-98 would cover both specifications, but AA 2604-98 does not mandate the use of amorphous chromium phosphate pretreatment, which is in contrast to AAMA 2605-98. Of the several hundred powder coaters in Florida, none are known to the writer (or our pretreatment chemicals supplier) who apply the amorphous chromium phosphate pretreatment that is required in 2605-98. ***This includes the two approved Hylar 5000 applicators who both use non-chrome*** pretreatment systems. As Crosslink's warranty work request is quite specific about pretreatment methods ie. **AND 2605-98** (printed top case and bold), the question of the validity of warranty coverage arises in the event of a paint failure that did not use chrome phosphate pretreatment. (See Attachment #2). Similarly, the specifications required in the warranty document to verify pretreatment coating weight refer exclusively to chrome pretreatment and not chrome substitutes. (See Attachment #3)

2. Performance Standards: The expressed objective of the new AAMA 2605-98 specification is ***"a new ten-year superior performing specification with increased performance to AAMA 605.2-92. Significant upgrades have been made in the areas of 10 year weathering performance, abrasion resistance, salt spray and humidity "***. As such, AAMA 2605-98 specifically requires 10 year South Florida exposure testing to meet the specification requirements for Color Retention (7.9.1.2.), Chalk Resistance (7.9.1.3),Gloss Retention (7.9.1.4.) and Resistance to Erosion (7.9.1.5). Crosslink Powder Coatings Inc. the formulator of Series 2000 PVDF powder coatings that utilize the Hylar 5000 resin was founded in 1995, so by definition does not have any product history that meets these very important performance requirements of the AAMA 2605.98 spec.

3. Maintenance Requirements. Other areas where there are significant differences between the powder and liquid PVDF systems are concerned with the maintenance programs that are required to maintain warranty coverage. The 2000 Series powder warranty requires

"Regular cleanings must be performed. Documentation of such cleanings must be submitted to CPCI (Crosslink) in writing at the scheduled intervals" !! (Attachment #4) No such stringent conditions are required for liquid Kynar 500 coatings PPG (Windsor's liquid Kynar 500 supplier) simply recommends that in areas of high salt concentration the product be systematically rinsed with fresh water to avoid the accumulation of concentrated salt deposits. ***No record keeping or written notification is required.***

The Series 2000 warranty further stipulates that ***"When cleaning, rub cloth in a circular motion"***. !!! (Attachment #5) No such limitations are required by PPG. Not only is this an impractical way to clean a railing but all PPG requires is a common sense approach with a garden hose.

Finally, when performing the required cleaning of the Series 2000 powder coating ***" Use only 100% soft cotton cloth, mild soap and clean water when washing the coated extrusion. Do not use organic or inorganic solvents to clean the coated extrusion"*** !!! No such limitations are imposed by PPG. In the event a building owner elects to clean a Kynar coated aluminum product, a comprehensive list of organic and inorganic industrial and commercial cleaning chemicals that are compatible with Kynar 500 coatings are shown on PPG's web site at :

"www.ppg.com/car_indcoat/if_cleaning.htm."

Note: Whether non-compliance to Crosslink's very stringent (and sometimes ambiguous) maintenance requirements would abrogate the warranty coverage in the event of a paint failure clearly ***poses a significant potential threat***, and ***the burden of responsibility certainly appears to be on the building owner,*** not the powder coating manufacturer or applicator PPG's warranty terms by contrast are reasonably practical, and the liquid Kynar 500 system does have the significant additional insurance provided by chrome phosphate pretreatment, a strontium pigmented primer and the clear XL polyvinyledine fluoride (PVDF) top coat.

If you need any additional information, or any of the referenced topics require elucidation please do not hesitate to call me at 1-800-272-2689.

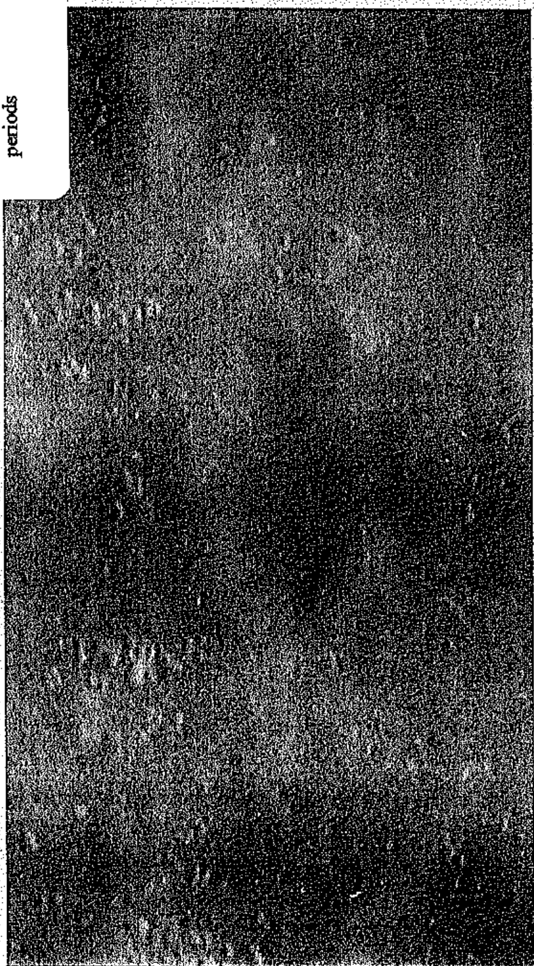
Respectfully submitted,

Malcolm Brant.
President. Windsor Metal Finishing.

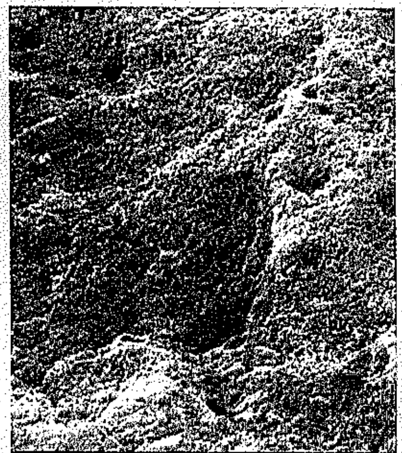
All organic coatings are porous to some degree and this pictorial @ 1000 X magnification compares various architectural coating that have been exposed in South Florida for different time periods

45° SOUTH FLORIDA EXPOSURE STUDY

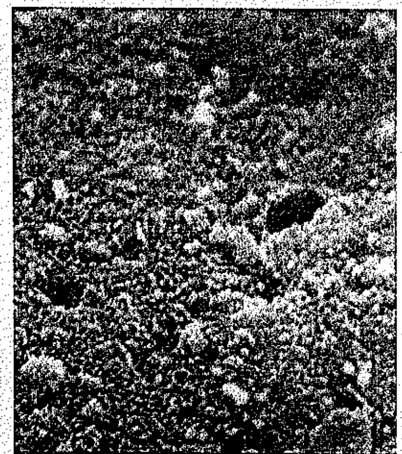
PHOTOMICROGRAPHS • ENLARGED 1000X



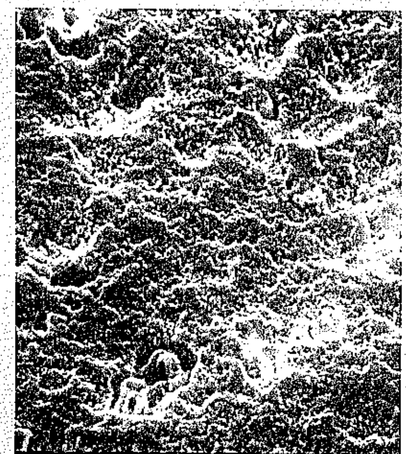
CONTROL PANEL – UNEXPOSED



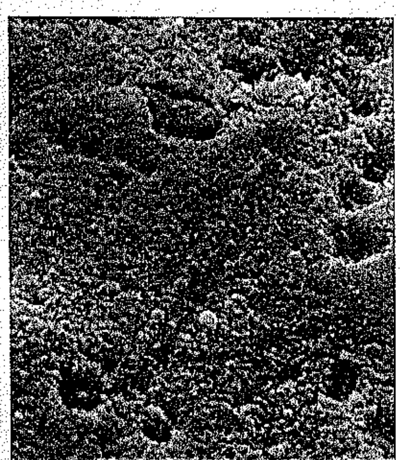
TGIC POWDER - EXPOSED 2.5 YEARS



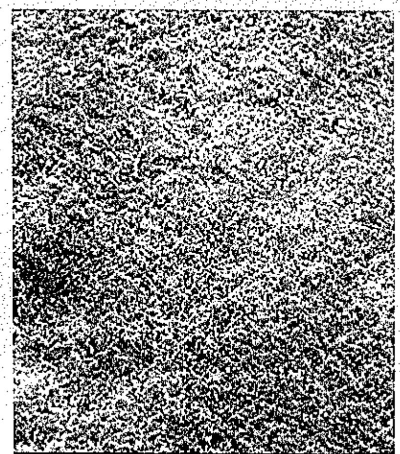
ACRYLIC - EXPOSED 4 YEARS



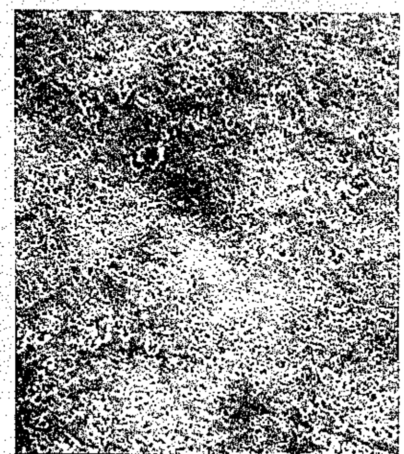
POLYESTER - EXPOSED 6.5 YEARS



SILICONE POLYESTER - EXP. 9 YEARS



50% FLUOROPOLYMER* - EXP. 10 YEARS



70% FLUOROPOLYMER* - EXP. 10 YEARS

* Kynar® or Hylar™
**Kynar 500® or Hylar 5000™

The Valspar Corporation

These actual South Florida weathering tests compare TGIC powder at 2 1/2 yaers compared with Kynar 500 @ 13 years exposure.

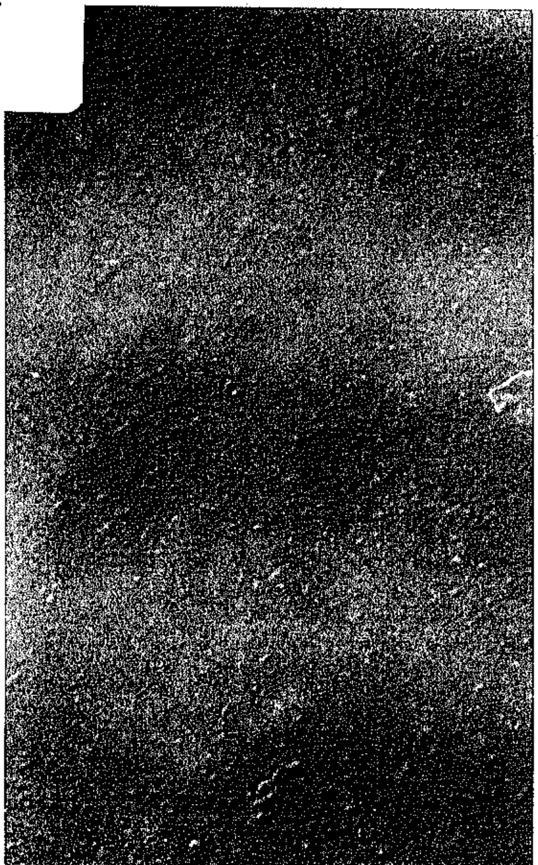
45° SOUTH FLORIDA EXPOSURE STUDY

PHOTOMICROGRAPHS • ENLARGED 1000X

TGIC POWDER

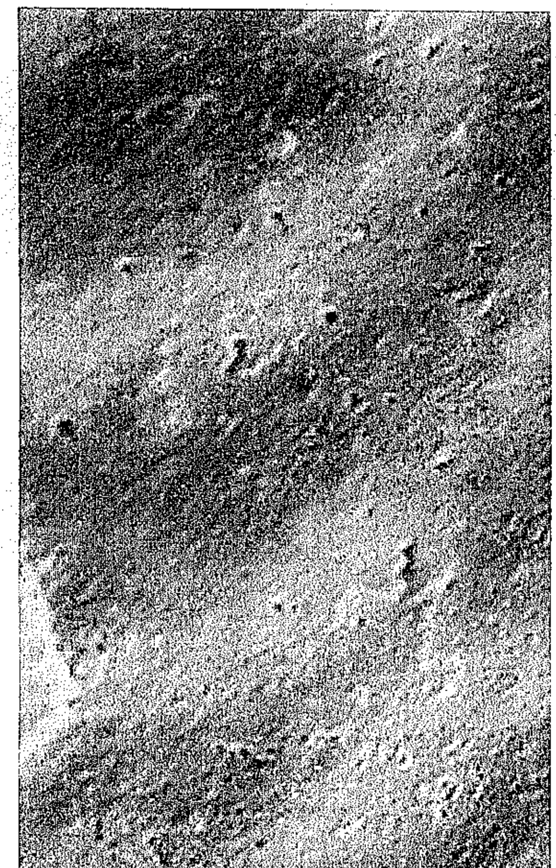
FLUROPON®

WITH KYNAR 500®



CONTROL PANEL – UNEXPOSED

EXPOSED PANEL – 2 1/2 YEARS

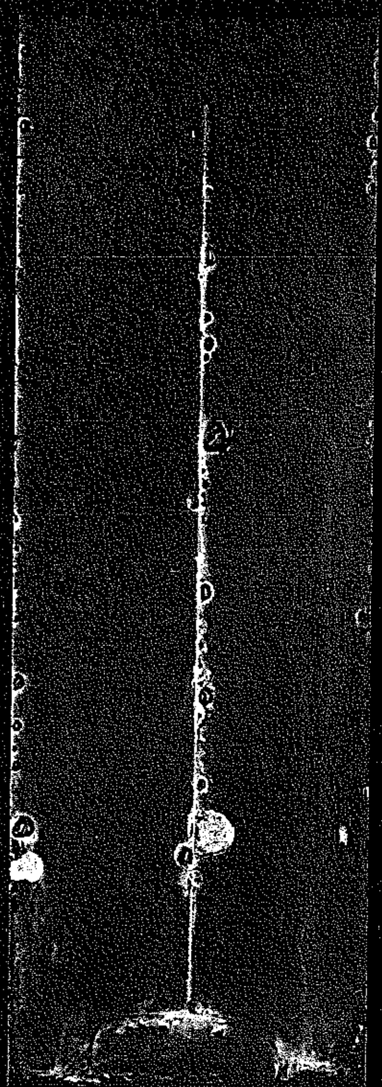


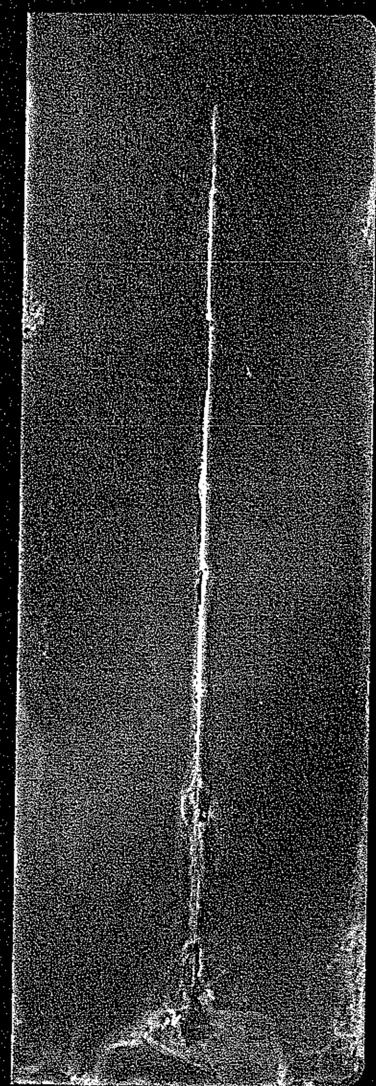
EXPOSED PANEL – 13 YEARS

The Valspar Corporation

This test confirms the additional protection provided by a primer. Both samples were pretreated with chrome but sample on right received primer coat. Both samples were subject to 4000 hours corrosion test

1-Coat Versus Primer/Topcoat System 4,100 Hours Salt Spray (5%)





Competitive System
Topcoat Only
(No Primer)

Duranar®
Primer/Topcoat