STUART DEAN

WHITE PAPER

Curtain Wall Restoration Using Field Applied Fluororpolymer High Performance Coatings

EXECUTIVE SUMMARY

Stuart Dean has restored and protected many of our nations' most important buildings since the company formed in 1932. Over the years, we have developed unique resources and systems specifically to restore and preserve architectural metal clad structures. Today, Stuart Dean is the largest company in the world specializing in this field. This paper is an overview of our building façade related services offered to help you determine our capabilities.

OUR MISSION

Our mission is to prosper by building long-term relationships as we earn new business. We do this by helping people make important decisions that will prove wise and withstand the test of time. We understand that façade improvement projects can be very formidable to those concerned. This work is generally complex, with many dimensions encompassing both technical and business considerations. Thus, we've brought together a team of industry specialists dedicated exclusively to this challenging field.

SERVICES

Team Specialists

Stuart Dean's Façade Restoration **Special Services Group** consists of individuals with special skills and expertise required for this type of work. Their job is to respond to client needs inherent in these major projects. They work to tailor the various building facade services we offer to precisely meet established requirements.

Stuart Dean's Façade Enhancement and Preservation Services Include:

- Condition Surveys and Analysis
- Conceptual Budgets and Planning Reports
- Surface Treatments to Refinish, Restore and Preserve:
  - Anodized, painted and mill-finished aluminum
  - Factory applied finishes that are weathered, damaged, or outdated
  - Stainless Steel
  - Painted Steel
  - Porcelain Enamel Cladding
  - Bronze, Copper
  - High Performance Coatings, VOC compliant - any color - warranties
  - Clear Finishes – provides seal and corrosion protection and restores luster to weathered surfaces

We deliver these services employing the safest, gentlest means available that yield maximum performance and optimum value.

HIGH PERFORMANCE COATINGS

Stuart Dean is the leader in field-applied, high-performance PVDF/VDF coating systems. We pioneered the process of field painting monumental office structures using the highest performance coating technology available. Skilled technicians dramatically enhance the appearance of curtain walls and other architectural surfaces while greatly extending service life. We restore beauty to buildings lost from years of exposure to sunlight, wind, hot/cold cycles and rain. Moreover, we can modernize the appearance of older properties with bright new color schemes as we help retain and protect their future value.

Long Term Performance is Important: Stuart Dean Specifies Coraflon, by PPG Corporation

Until recently, enamel or urethane-type coatings have been used for façade renovation projects. Unfortunately, with prolonged exposed to the sun, moisture and thermal stress, these products do not hold up well for more than a few years. To make matters worse, such products are often formulated with high levels of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). Coating with high VOCs and HAPs limits application options, creates health and safety hazards for people, and harms the environment.

Today, Stuart Dean and the architectural community are embracing Coraflon as an outstanding replacement for products that have performed poorly in the field. Coraflon will last at least four times longer than enamel or urethane type coatings while it helps to protect the environment.

This coating's advanced PVDF fluoropolymer resin is the culmination of 30 years of technological research and development. This resin exploits the strength of the carbon-fluorine molecular bond, the strongest bond known in the chemical world. It provides unequaled stability for in-field applications to resist chalking, fading, ultraviolet degradation and salt spray corrosion. The system can be used over anodized aluminum, previously painted aluminum, steel and other compatible building substrates. A truly high performance coating, Coraflon is ideal for curtain wall or façade restoration and field repairs to architectural metal. Coraflon meets or exceeds the weathering characteristics of AAMA 2605-98 (specification for superior performing organic factory applied coatings) – just like Kynar 500® used in factory baked-on applications.

Coraflon is made with a low VOC formulation, making it compatible with today's environmental concerns. The coating is available in all colors to accommodate any color scheme.

Stuart Dean is proud to be the #1 approved applicator of this cutting-edge high performance coating.

STUART DEAN PLANNING

The success of a façade enhancement project relies heavily effective planning. As such, it's never too soon to begin to plan. Budget and scheduling considerations generally necessitate a one-to-two year time horizon from the concept stage to the time when work will commence. We work diligently with our clients to create well thought out plans. We focus on several major factors that require careful consideration and wise decisions to achieve optimum results. Below is a step-by-step outline of the process our clients have found to be effective in crafting the plan for a successful project.

Stuart Dean's Process for Project Analysis & Planning

I. Step One: Interview — Understanding the Client's Needs and Priorities
Establish Expectations, Requirements and Constraints

Including:

- Project Motive
- Ownership Outcome
- Business Issues (schedule/budget factors)
- Special Issues Related to Building Occupants

Process: To facilitate this step, we have developed a methodical client interview process. With it, we uncover information that must be included and anticipated in the planning process. Due to the depth and breadth of Stuart Dean's cumulative experience, our client projects benefit from the many lessons we've learned in the past. When this step is complete, we will share a deep understanding of the issues fundamental to the success handoff your project.

II. Step Two: Analysis — Understanding the Condition of the Building and its Substrates — Review Façade and Curtain Wall System General Condition
Observations and Photo Documentation at Ground and Roof Levels, Visual Analysis of the Cladding System Components

Including:

- Condition assessment of typical exposed façade construction materials including (as applicable) metal, masonry, natural stone, concrete, etc.
- Window and glazing system, weep system
- Water infiltration history and status
- Joint sealants at all typical locations including glazing
- Effectiveness of previous maintenance actions and schedules
- Review of considerations for existing HAZMATs (i.e.: lead, PCBs, asbestos)
- Work Access – considerations for house rig or temporary swing stages, building geometry and rigging

Process:
We explore and study the "skin" of the building and capture what we discover using digital photography, field measurements and detailed notes. We view the façade of the building in a holistic manner. By doing so, we determine the current functionality and condition of various building materials originally designed to provide a safe, durable and attractive building enclosure. We can conduct this assessment at various levels of intensity and detail relative to the desires of the client.

III. Step Three: Reporting — Provide Physical Assessment Information (Report the building's condition and its needs)

Reporting Observations on Existing Conditions from Step Two

Process:

We present a Condition Report to the client consisting of our physical assessment of the façade. Further, we explain how the treatment and inter-relationship of the cladding's components is essential to the overall form and function of a cost effective and successful project.

IV. Step Four: Scheduling — Provide Information and Considerations for Efficient Project Scheduling

Review Considerations Include:

- Potential Impact – tenant and building use consideration factors (ingress/egress restrictions, noise, odors, impact on retail tenants)
- Public health and safety, including overhead protection
- Environmental considerations
- Project and building security considerations
- Work sequence and scheduling, including seasonal/weather limitations and project duration

Process:

We run through conceptual scenarios that enable the client to consider how the work of the project will relate to the ongoing operation of the building. Consequently, the scope, work sequence and schedule become a functional matrix, fully mindful of the essential need to maintain the day-to-day activities of the building occupants with minimal discomfort. Moreover, we devise ways to organize the work execution so that the safety and well-being of both people and the environment will not be compromised.

V. Step Five: Review Options — Budget Factors — Propose an Action Plan

Enable the Client to Make Well-informed Decisions Considering Direct and Indirect Factors that Have Bearing Now and in Future Years

Including:

- Present analysis of surface treatment and protection options
- Propose options that optimize client needs and expectations
- Provide cost analysis and project budget information

Process:

Here we bundle together the information gained with the insights obtained through the previous steps. At this stage, we are well prepared to present data that is reliable and compatible with actual factors specific to the project — virtually eliminating uncertainty and possible confusion. The client gets vital information they can trust which is essential for them to make the best decisions possible.

Other Considerations

In most cases, initial testing is important to the success of these projects. We recommend that testing should be performed at or before the Step Two Stage of the process.

Such tests generally include:

1. Analysis of any existing paint or coatings that may be disturbed during the project (any lead within existing surfaces can have a major impact to the project).
2. Analysis of the existing joint sealant (sealants may be failing, some types contain PCBs).
3. Built-in rigging or suspension devices. Such items (if planned for use) need to have a current engineer's review and sign-off for compliance and project safety. Usually this requires load testing and inspection.
4. Mock-up panels are essential to make good decisions on the color and type of any new coating system before general application to the building. Such panels also enable the opportunity to determine production information vital to accurate cost analysis. Mock-ups should be done well in advance of the planned start of the work. Mock-ups performed a year in advance of the project have the advantage of showing how proposed products will appear and perform through a full seasonal/thermal cycle.

CURTAIN WALL RESTORATION PART I - SUMMARY

Stuart Dean is in business to help those who are serious about giving their building a new look and extended service life. We welcome the opportunity to demonstrate that we have the experience, personnel and business partners it takes to, "Do it right the first time and make it last." Our goal is to meet the client's needs and exceed their expectations with each project we undertake.

We hope you find this information useful. If you have any questions, please do not hesitate to let us know.

If you have a painted aluminum or steel curtain wall, you'll find more valuable information in Part II.

Part II:
Painted Architectural Aluminum and Steel Curtain Walls

EXECUTIVE SUMMARY

Highly durable fluoropolymer coatings have provided long-term beautification of metal building panels and components for over 40 years. Recent advances in fluoropolymer technology have brought newer and brighter colors and special effects. Derivatives of these new fluoropolymer finishes can now be site-applied and cured under ambient conditions. This allows building restorers to use existing building metal components, and to match new and old surfaces. Advances in colors and infrared reflective systems offer more variety and choices for the owner, architect, and specifier.

LEADER IN COATING SYSTEMS

Stuart Dean – the leader in field-applied, high-performance PVD coating systems

Stuart Dean pioneered the process of field painting monumental office structures using the highest performance coating technology available in industry. Skilled technicians dramatically enhance the appearance while greatly extending the service life of the modern curtain wall and other architectural surfaces.

The company is the best at restoring beauty lost from many years of sun, wind, hot/cold cycles and rain. Moreover, we can modernize the appearance of our customer's properties with bright new color schemes as we help retain and protect their value. Stuart Dean is an approved applicator for VOC compliant, high-performance, fluoropolymer coating, with excellent adhesion, resistance to chalking, fading, ultraviolet degradation and salt spray corrosion- available in all colors.

FLUOROPOLYMERS IN COATINGS: HISTORY

Some of the first fluoropolymers used as a protective layer for architectural applications were actually PVF (polyvinyl fluoride) films, for example, DuPont TEDLAR®. PVF was also supplied as a liquid coating in a pigmented solvent dispersion, however, the decomposition temperature was too near the "fusion temperature" of the PVF organosol to be practical on industrial coatings lines.

Fortunately, parallel work on PVDF (polyvinylidene fluoride offered a solution to the problem. DuPont held the first synthesis patent for PVDF in 1948. Pennwalt Chemicals acquired the rights in the 1950's and developed a commercial licensing program that allowed the first widespread commercial use of PVDF pigmented liquid coatings (sold under the trade name KYNAR® 500) in the mid1960's. In the mid 1980's, Elf Atochem (now Atofina) acquired Pennwalt.

The Federal Trade Commission mandated that Elf divest one of its PVDF production sites. Ausimont, USA (now Solvay Solexis) acquired it and became the second major supplier of the Pennwalt PVDF coatings technology (sold under the trade name HYLAR® 5000).

The first major entry into a "functional" or "thermoset" coatings-grade fluoropolymer was Asahi Glass in 1982 with a family of copolymers of fluoroethylene and alkyl vinyl ether (sold under the trade name LUMIFLON®). The coatings were recommended for architectural aluminum, coil, steel and masonry along with other applications. The polymer development continues today with waterbased and powder coating resin technology. There are a number of other resin/polymer suppliers too. This presentation will focus on the solvent-based liquid technologies that are in wide use today.

FLUOROPOLYMER COATINGS CHEMISTRY

Any liquid coating is composed of the following key ingredients:

1. Polymeric Binder
2. Pigment
3. Additives (flow, leveling, UVA, etc.)
4. Solvent or Water

The physical properties or the key performance features of the dry coating film such as exterior durability and chemical resistance are primarily derived from the polymeric binder and to some extent the pigments. The properties of polymeric binders are determined by their inherent chemical structure and their molecular weight.

Fluoropolymers like PVDF are very high molecular weight (MW) polymers. The polymeric films are thermoplastic and derive most of their properties from the high molecular weight PVDF. The KYNAR 500/HYLAR 5000™ technology is a 70% PVDF/30% acrylic organosol, in which the cured film is obtained by melt/fusing the acrylic/PVDF dispersion into a film. Aside from the excellent physical properties, one consequence of this material is the 25-40-gloss restriction. The gloss is limited by the refractive index difference between the high MW fluoropolymer and the acrylic in the film.

Coatings that use functional polymers like FEVE and functional CTFE copolymers are lower molecular weight solution polymers. They must be crosslinked (infinite molecular weight) to obtain hardness and chemical resistance. Because the functional polymer coatings are true solutions, high gloss and brighter colors are possible. The solution polymers also offer opportunities for higher volume solids and for lower temperature cure systems, and even air-dry systems, with a two-component finish.

The following table summarizes some of the major fluoropolymer types and sources.

Coating Types	Resin	Composition	Company
Baked (Thermoplastic) (Thermoset)	KYNAR500/HYLAR5000 Lumiflon/Fluoronate	PVDF FEVE/CTFE-functional copolymers	Atofina/Solvay Asahi DIC
Air Dry	KYNAR ADS LUMIFLON/FLUORONATE™	VDF/TFE/HFP FEVE/CTFE-functional copolymers	Atofina Asahi DIC

PIGMENTATION

Pigments are solid materials that are used to impart color, control gloss, improve performance, such as infrared reflectance or corrosion resistance, or simply occupy space in a paint film. In general, pigments in fluoropolymer coatings are used for color and appearance. Color stability of the fluoropolymer coating is to some extent dependent on the light fastness of the pigment chosen. It is desirable to use polymers that do not degrade, (lose gloss or chalk) and it is desirable to use pigments that do not change in color over time.

When selecting paint pigments, it is important to understand the conditions under which the coating will be used. The pigment must maintain its original color under the conditions to which the coating will be subjected. If the coating will be used outside, then the pigment must be capable of withstanding UV light and humidity. If the coating will be subjected to heat, either in-service temperature or during a bake or cure cycle, then the pigment must be heat resistant. The pigment must also be selected to be sufficiently chemical resistant, either toward solvents in the paint or chemicals to which it will be exposed.

Other important properties, such as color, opacity, tint strength, brightness, toxicity, and oil absorption are important factors that must be considered in selecting a pigment.

As a general rule inorganic oxide pigments are more durable (UV resistant) than organic pigments, but the organic pigments give a wider range of bright colors. Many different chemistries exist for organic pigments. The choice of pigment depends on the color desired and durability and performance needed.

Metallic pigments, such as aluminum, stainless, copper and bronze pigments, can impart special effects, chemical resistance and/or color to a coating. Aluminum flake is widely used in fluoropolymer coatings to impart a metallic look. Coloring pigments are often used in combination with the aluminum pigments.

Aluminum pigments are classified as leafing or non-leafing. Leafing aluminum flakes migrate to the surface of the coating forming a very reflective layer. Leafing aluminum pigments are used where high reflectivity and corrosion resistance are desired. Non-leafing aluminum flakes tend to disperse evenly throughout the paint film, not just on the surface. It is these non-leafing aluminum flakes, which are used in fluoropolymer coatings to give a metallic appearance and polychromatic effects (also known as “flop” or “travel”). Aluminum-containing coatings usually require a clear coat to maximize durability and prevent oxidation of the metal pigment.

Metal oxide-coated mica pigments are a form of nacreous or pearlescent pigments. Their color can vary from a white pearlescence to a variety of transparent colors. These products are made by depositing a layer of a metal oxide (titanium dioxide most commonly) on the transparent mica flake. These pearl pigments have a white pearl background. Colors can be produced by varying the metal oxide layer thickness and type. These pigments are made from a mineral and metal oxide so they are very durable. Mica pigments do not offer the same degree of "flop" or metallic look seen in aluminum pigmented systems, but their unique appearance combined with outstanding durability make them a good choice as a special effects pigments for fluoropolymers.

Pigments that reflect infrared energy are of particular interest for use in energy-saving coatings, especially for roofs. Pigments, which historically have been used in whites, light colors, and metallics, are inherently IR reflective. However, recent advances in dark colored pigments, have tremendously improved the reflectivity of coatings using these "reflective" pigments. In some dark colors, the reflectance values can triple with these new reflective pigments compared to matching colors made without using reflective pigments. The table below illustrates this comparison.

Color	Reflectance w/Standard Pigments	Reflectance w/IR Reflective Pigments
Off- White	61%	66%
Medium Green	34%	43%
Dark Bronze	8%	25.1%
Metallic	49%	53%

There are many benefits to using a highly reflective roof coating. Such coatings can reduce the roof temperature, thereby reducing building cooling requirements. Low roof temperatures can extend the life of the roof. More reflective roof coatings can reduce smog formation, and contribute less heat to the Urban Island effect. In many cases, building owners using reflective roof coatings may qualify for tax credits and rebates from Federal, State, and local governments. It is estimated that a 1% increase in coating reflectivity produces a 1°F reduction in surface temperature.

The EPA has established the Energy Star labeling program to encourage the use of energy efficient household items. Included in this program is the Energy Star Roof Products Labeling Program. To qualify, coatings must meet the following criteria, initially and after three years :

STEEP SLOPE ROOFS (greater than 2:12 inches)

- Initial Reflectance >/= 25%
- 3-Year Reflectance >/= 15%

LOW SLOPE ROOFS (2:12 inches or less)

- Initial Reflectance >/= 65%
- 3-Year Reflectance >/= 50%

AAMA STANDARDS

The American Architectural Manufacturers' Association, known as AAMA, has three voluntary performance based-specifications for coatings on aluminum extrusions and building panels. These are AAMA 2603, 2604, and 2605. AAMA 2605, entitled "Superior Performing Organic Coatings on Aluminum Extrusions and Panels," represents the most rigorous performance specifications. The specifications differ in requirements for documented coating performance after specified years of South Florida exposure. AAMA 2605 requires documented coating performance after exposure of the coating for 10 years in South Florida at an exposure angle of 45 degrees from the vertical facing south. AAMA 2604 requires five years South Florida exposure, and AAMA 2603 requires a one-year minimum South Florida exposure.

Accelerated weathering test methods are not included in the AAMA standards and cannot replace real-time weathering in Florida. Generally, fluoropolymer coatings are designed to meet the higher standards of AAMA 2604 and 2605.

Although color and gloss retention are the primary focus when highly durable fluoropolymer coatings are specified, AAMA specifications and performance requirements also include tests for film hardness, adhesion, as well as chemical, corrosion, impact and abrasion resistance. Resistance to chemicals such as mortar, detergents, window cleaners and acids are included in these standards. The requirements for the three AAMA specifications are presented in the table below.

Test	AAMA 2603	AAMA 2604	AAMA 2605
Dry Film Hardness	x	x	x
Dry Film Adhesion	x	x	x
Wet Film Adhesion	x	x	x
Boiling Water Resistance x	x	x	
Impact Resistance	x	x	x
Abrasion Resistance	x	x	x
Muriatic Acid Resistance	x	x	x
Mortar Resistance	x	x	x
Nitric Acid Resistance	x	x	x
Detergent Resistance	x	x	x
Window Cleaner Resistance	x	x	x
Humidity Resistance	1500 hrs	3000 hrs	4000 hrs
Salt Spray Resistance	1500 hrs	3000 hrs	4000 hrs
South Florida Weathering	1 Year	5 Years	10 Years
Color Retention	Slight fade	5ΔE Hunter	5ΔE Hunter
Chalk Resistance	Slight chalk	< No. 8	< No. 6/8
Gloss Retention	NA	30%	50%
Coating Erosion	NA	<10%	<10%

PRIMERS, PREPARATION AND APPLICATION

Primers, Surface Preparation, and Coating Application

Primers are typically required for bake and air-dry systems. In heat-cured coating systems, primers are required to provide adhesion and corrosion resistance to metallic substrates, such as aluminum and steel. Steel substrates include hot-dipped galvanized, GALVALUME and ZINCALUME substrates. The chemistry of the primer can be based on PVDF, epoxy, acrylic, or polyester polymers depending on substrate and performance requirements.

Air-dry systems are, in many cases, retrofitted to existing buildings. The primer chosen will depend on the substrate and existing paint system. Buildings may have older paint systems ranging from alkyds to factory-applied fluoropolymer coatings. Substrates can include anodized aluminum, porcelainized metals, and galvanized and carbon steel. Generally, two-component epoxy-based primers are used. This will be the case for most metal substrates. Because fluoropolymer coatings are chemical- and solvent-resistant, special primers are required if the existing paint system is a fluoropolymer. Surface preparation can range from thorough cleaning to extensive abrasion and sanding. In all cases, the manufacturer of the air-dry fluoropolymer must be consulted for primer and surface-preparation recommendations.

When corrosion resistance is a primary concern, primers must be capable of not only good adhesion to the substrate but corrosion protection as well. Highly corrosion-resistant zinc-rich primers, with epoxy mid-coats, can be used under fluoropolymers if superior corrosion protection of steel substrates is required.

Fluoropolymer coatings are typically applied by spray or roll-coat (coil) application techniques. Spray application techniques, electrostatic or conventional, are used for extrusions and retrofit using air-dry coatings. Roll coating is used to apply coatings to coil stock. It can be quite a challenge for coatings manufacturers and applicators to duplicate the color and special effects appearance on parts coated by different application methods.

APPLICATIONS AND CASE HISTORIES

Fluoropolymers are used when the highest level of exterior durability is demanded. The colors and special-effects appearance can be duplicated in other polymer technologies, such as polyurethanes, but the color and gloss retention of fluoropolymers is unmatched.

Fluoropolymer coatings have been used primarily on the exterior of commercial metal buildings. Coating costs have limited the use of these highly durable coatings, which can be up to 10 times the cost of other paint systems. With regard to total cost, this may only double the total painting cost when application and installation costs are included. If the use of fluoropolymer coatings can double or triple the repaint schedule, then the added cost of the fluoropolymer paint can be easily justified.

Fluoropolymer coatings have been used on 80-story skyscrapers, storefronts, movie theater facades, gasoline service station canopies and building panels, and road and traffic signs. They are used on building panels, walls, roofs, doors, window frames, handrails – practically any sound surface where long-term weather resistance is needed.