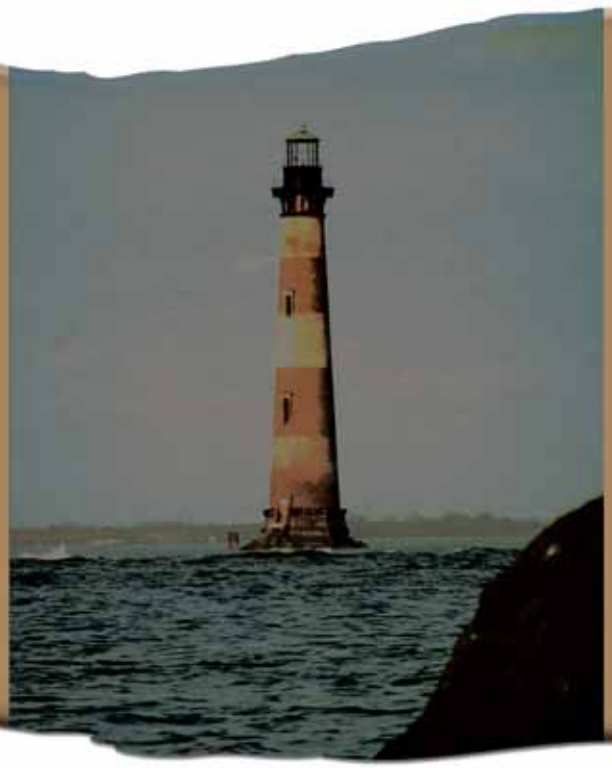
CONSIDERATIONS FOR COASTAL COATINGS

PART I OF III



By Joseph "Cris" Crissinger, CCS, CCCA

This article will be presented in three parts. Part I provides an analysis of types of paints and coatings. In Part II, surface preparation and application will be discussed. Part III will examine suggested painting/coating systems for coastal environments.

INTRODUCTION

The current mass migration to the coast is producing a boom in the construction industry. Most of this construction will need some type of paint or coating on the exterior. In addition to the suggested coating systems for various exterior materials, alternative corrosion-resistant materials are also mentioned in this article. The types of paint or coatings, surfaces being painted, ambient conditions, and application methods appropriate for coastal environments are the focus of the article.

Modern paints are thin film coverings that are typically applied at 3 mils (0.003 inches) or less dry film thickness (DFT) per coat and are used for routine painting. Coatings are heavier film coverings that are usually applied at greater than 3 mils DFT and are generally associated with high-performance coating systems. Since coastal environments require high-performance materials, the term "coating" will be used predominately in reference to those materials. While the same types of coating failures – delaminating, cracking, blistering, alligatoring, crazing, etc. can occur inland, these failures tend to occur sooner, at a faster rate, and at a more severe level on the coast.

Theoretically, the U.S. Navy should represent the ultimate in experience regarding protective coatings in a coastal environment. I recall Mary Kay's Side Painters from my Navy days back in the 1950s. (I do not believe this Mary Kay is related to the cosmetic company, although both are involved in cosmetics of some sort.) Mary Kay worked out of Hong Kong, and her group would paint a ship from the top of the mast to water line for payment in food scraps from the crew's mess hall and for various and sundry trash, scrap, and other disposable

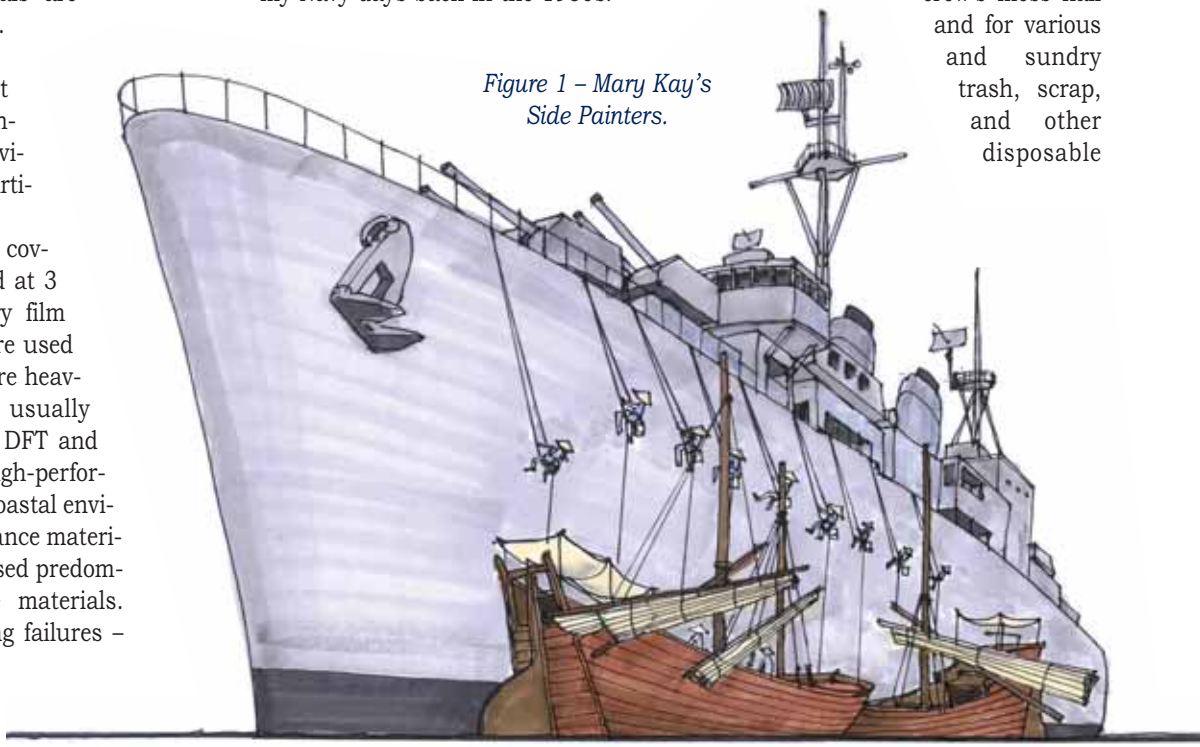


Figure 1 – Mary Kay's Side Painters.

When it comes to protection from environmental elements (especially coastal conditions), one of the best methods is to use corrosion-resistant material.

items (see *Figure 1*). This painting was not exactly high tech. There was little or no surface preparation, and the Navy furnished the oil-based paint. Often, dirt, rust, and salt particles were painted over. The painters used mostly pads of gauze, since rollers and brushes were a novelty to them. Surface crafts were painted gray to blend with the horizon. I served in submarines (diesel and nuclear), which were painted black to blend with the ocean depths. The side painters wanted to paint our sub, but subs did not carry paint because it was flammable, and the painters did not have black paint. The ships that did get painted probably looked fine until they reached homeport or encountered heavy seas.

Using lead paint was the extent of the high technology then. Of course, this was before the Navy became aware of or responded to the hazards associated with lead paint. Now, the lead paint taboos have been replaced with modern high solids and low Volatile Organic Compound (VOC) coatings that include epoxy, polyurethane, and high-performance acrylic. More than 20 years ago, the propellers of Coast Guard icebreakers were coated with a 100 percent solid polyurethane that repelled the build-up of shell life while resisting contact with ice. Epoxy works especially well in resisting the acidic conditions that are produced when the soot from "blowing the boilers" mixes with ambient moisture.

Before a coating can do its thing, it has to stick and stay stuck. Anything less is failure. The three most important factors that should be considered to ensure success are:

- Coating selection
- Surface preparation
- Application of materials

These three aspects complement one another. Of the three, the specifier or designer has the most control over the selection of materials. Although surface preparation and application parameters can be specified, they are useless unless they are strictly enforced. Enforcement through inspections or rejection after the fact comes at a cost. However, this cost can reap rewards to the owner through improved aesthetics, and more importantly, performance.

Routine maintenance after application is a factor also, but is not the direct responsibility of the designer. However, the owner's maintenance program should be given some consideration. As time passes, finishes do require periodic maintenance (spot priming, touch up, cleaning, etc.) to prolong their useful life. The need for such maintenance will only increase over time. All coating systems will require maintenance, and some will require it sooner, more often, and more intensely than others. Routine and scheduled maintenance is even more of a factor in coastal environments. If it is suspected that the owner is maintenance challenged, then corrosion-resistant materials or very high performance coatings should be used.

PART ONE - SELECTING A COATING

No single protective coatings system is a panacea for all situations. When I was first learning construction specifications and protective coatings in particular, I contacted a painting representative from a major manufacturer for assistance on a paper mill project. After the representative had made a recommendation, I proudly presented it to my supervisor and mentor, Bob Gaddis, for review. I then learned that this particular product representative thought that an organic zinc primer and high-build epoxy polyamide was the solution for all coating situations and would probably use it to paint a baby's crib.

Well, Mr. Gaddis liked to conduct experiments, and he used sodium hydroxide to create the caustic conditions similar to what was expected to be experienced at the project site. Carbon steel was coated with the recommended system and then exposed to the simulated conditions. To my astonishment, the system soon took on the initial appearance of a failing coating – blistering, discoloration, and puckering. Mr. Gaddis was an excellent teacher and mentor, and the lessons learned from that experience have stuck with me for over a quarter of a century.



Figure 2 – Stainless steel railing corrosion. (Photo courtesy of TMR Stainless.)

Protective coatings are the first barrier that the ambient conditions (weather, chemical fumes, or splashes, etc.) encounter in their quest to reach a substrate. In the world of real estate, the key phrase is - Location! Location! Location! In protective coatings, the phrase is - Preparation! Preparation! Preparation!

When it comes to protection from environmental elements (especially coastal conditions), one of the best methods is to use corrosion-resistant materials, such as stainless steel, galvanized steel, Galvalume, terne metal, aluminum, bronze, copper, fiberglass-reinforced plastic (FRP), and simulated wood.

However, this approach may not always be practical, especially when tight budgets are a factor or the latest color in vogue is desired. When this is the case, coating systems must be considered.

As a note of caution, not all stainless steel is suitable for the coast. Type 304 and 306 are probably the most common stainless alloys, but they tend to pit and discolor and generally do not perform as well in coastal environments as other alloys such as type 316 or 416. Use the correct product for the correct condition. When stainless steel is used within 300 feet of the coast, then a more corrosion-resistant alloy than type 304 or 306, such as type 316 or 416, should be used, and it should have a smooth finish and receive frequent rinsing with fresh water. *Figure 2* shows a Type 304 stainless steel railing that was exposed to continuous salt spray.

Paper mills can create a very corrosive environment, even with current emission standards. There are situations where the exterior ambient conditions inland can be as corrosively aggressive as a coastal location. Thus, the materials and protective coatings used on exterior materials of a mill in Potlatch, Idaho, could be the same as for a paper mill in Georgetown, South Carolina. However, a school or hospital in Miami Beach, Florida, should have a more corrosive and UV-resistant exterior coating system than a school or hospital in Tulsa, Oklahoma.

Many of the protective coating concerns such as UV, wind, various forms of moisture, etc., that apply to coastal conditions apply to other locations. Developing protective coating systems for a normal environment can be difficult. However, a coastal environment has other elements tossed into the equation. These elements include, but are not limited to, moisture, wind, salt, and, in our southern latitudes, heat and ultraviolet (UV) light. The coastal areas in northern latitudes also get a dose of freeze-thaw conditions and freezing rain.

To compound the equation even more, some manufacturing facilities are located along the coast; and, even while remaining within EPA guidelines, some of these facilities can discharge some really rough chemicals into the atmosphere. Thus, ambient conditions resemble a witch's brew. The descriptions under the following conditions are not all-inclusive and are intended to give the reader a starting point for analysis.

Prevailing winds

Prevailing winds can affect one elevation of a structure more than another elevation of the same building by carrying and depositing damp, salty air or corrosive particles. Evaluate the site to determine if this is a factor. If it is, preparations must be made either to coat the areas exposed to prevailing winds (*Figure 3*) or to use a more corrosion-resistant coating. The best practice is to treat all exposures as if they were subjected to the worst conditions. With today's color technology, it is usually possible to match the color of different generic coatings.

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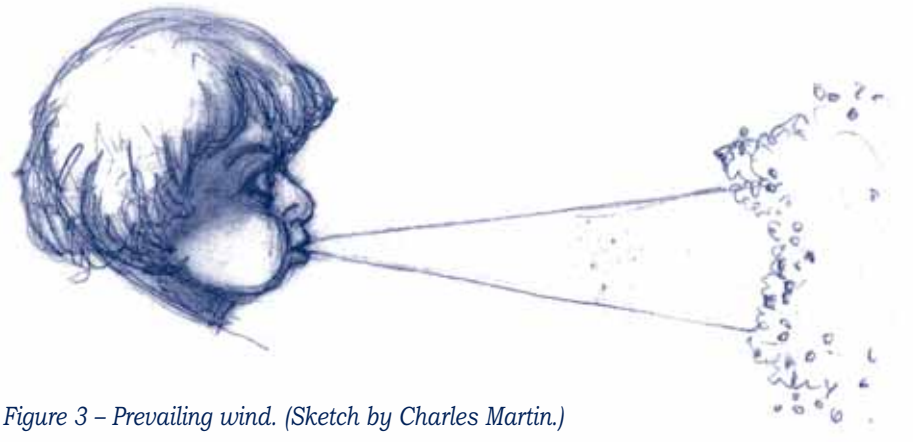


Figure 3 – Prevailing wind. (Sketch by Charles Martin.)

Material to be coated

Some materials respond better to one type of coating than to another. For instance, oil-base paints are not normally recommended for direct application to cementitious substrates because saponification can develop from the reaction of the oil in the paint with the free lime in cementitious substrates. Saponification is the same reaction that occurred when Grandma mixed lye with fat to make soap. Painting carbon steel with some of the water-base paint can cause rust bloom as the water in the latex paint reacts with the steel.

Some water-base paint can be applied directly to steel, but this should be verified with the coating manufacturer. Steel is usually susceptible to corrosive attack from both acidic conditions (pH less than 7) and caustic conditions (pH more than 7).

However, cementitious products such as concrete tend to resist attack from caustic conditions, but not from acidic conditions.

In most situations, epoxy coatings would not be a good choice for wood

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Figure 4A – Mild efflorescence on brick.



Figure 4B – Efflorescence on brick.

because wood can experience significant dimensional changes during moisture fluctuations, and epoxy is too hard and not resilient enough to accommodate the wood's movement.

Cementitious materials can pose special problems because they are reservoirs for moisture, and the more porous the material, the larger the reservoir. This is a difficult problem in any region, but it is especially acute in coastal regions where there is an abundance of moisture and because the moisture often contains salt particles.

Plugging up the voids in the masonry with a filler reduces the size of the reservoir. However, the filler should be breathable to allow moisture to escape. This is especially true if the building design does not provide for drainage, such as solid masonry construction. Cavity walls that are properly weeped and vented usually provide adequate drying.

When it comes to moisture movement, think high to low (high temperature to low temperature; high humidity to low humidity; and high point to low point). Moisture tends to move from points of high temperature to points of low temperature. The greater the temperature difference between

the high and low areas, or the more moisture that is held in the cementitious material, the greater the force behind the moisture movement. This force is analogous to vapor pressure. If a painted surface stops this moisture movement, something has to give, and it is usually the coating in the form of some type of delamination.

A coating can stop water from entering (water resistant) and still allow the substrate to breathe (breathable). Typically, acrylics are very good at this, while alkyds, epoxies, and polyurethanes are not. Some epoxy coatings are modified to allow breathing. These coatings offer the water resistance of epoxy to repel wind-driven rain, plus the color stability and breathable properties of acrylic.

Cementitious materials, including the mortars, usually contain free salts that are picked up by moisture movement. When moisture reaches the surface, it can deposit the free salt that can attack an improper primer or filler. Whether the white stains are hidden by a coating or are visible as white streaks, it is called efflorescence as shown in *Figures 4A* and *4B*. Since it is dependent on moisture, efflorescence may be more abundant along the coast. An alkaline-resistant primer should be used to resist the salt deposits. Additionally, oil-base primers should not be applied directly over cementitious substrates because they can lead to saponification.

Wood can be a difficult substrate to coat because it is a very dynamic material and can react significantly to moisture changes. What do we find in abundance on the coast? Moisture! Thus, coatings used on wood should retain their flexibility.

Both oil and acrylic coatings perform satisfactorily on the coast because they tend to remain somewhat flexible, while epoxy and polyurethane are significantly harder and tend to crack from the wood's movement.

Moisture is a natural enemy of wood, and many professionals believe that water-based coatings should not be used as a primer in direct contact with wood, especially in exterior applications. Actually, this is a common opinion shared by many historic preservationists. Using oil-based primers is a safe practice; however, some of the national coatings manufacturers produce water-based, 100% acrylic coatings that can be safely applied directly to wood. Verify before using. Since the coatings that work best on wood (such as polyurethane) are not the coatings that are associated with long-term, high performance, maintenance painting will usually start sooner and be more vigorous. This can present a problem for a church that has a steeple so high that only angels can reach the top. In this case, simulated wood trim might be in order. This might not satisfy a purist, but when it is so high, only the carpenter will know. These materials have a strong resemblance to wood, and some manufacturers will warrant simulated wood against the usual shortcomings of wood, such as warping, bowing, buckling, cracking, splitting, failure to accept field-applied finishes, failure to bond, and dimensional instability.

Surface temperatures

Surface temperatures are critical during and after application. If surfaces are too hot during application, the coating can flash off before a bond occurs. If surfaces become too hot after application, delamination can occur. Product data sheets usually list surface temperature for application and for service.

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Proximity to the coast

Corrosive properties of air become more aggressive closer to the coast. Salt deposits from sea breezes and fog are some of the bullies on the corrosive block, and they can be tough characters to deal with for all but the very high performance protective coatings. (See *Figure 6.*)

Immersion, splash, or spillage

Although more characteristic of an industrial environment where protective coatings are exposed to corrosive chemicals, coatings in a marine environment can be exposed to immersion, splash, and spillage. For instance, the base of a handrail installed along a coastal or harbor pier may experience immersion conditions produced by high waves that are brought on by strong winds, fast boats, high tides, etc. However, the cross bars of the same handrail may experience splash or spillage conditions. While a coating suitable for splash and spillage may not be suitable for immersion conditions, it would be very prudent to select a product suitable for the most extreme conditions expected. Product data sheets usually mention performance in these conditions.



Figure 5 – Lighthouse with discolored paint.

Types of chemicals and their concentration

Chemical-resistance charts for various coatings list not only chemicals the coatings resist, but also their concentrations. These charts should be referenced for all conditions, especially for coastal and industrial environments.

What kinds of conditions can be expected along the coast? While exterior environments everywhere tend to share most of the listed conditions periodically, coastal locations can frequently experience all of them. Additionally, coastal locations in southeastern latitudes can significantly amplify the effects of these conditions.

- Fog
- Rain
- Heat
- Wind
- Pollution
- Humidity
- Salt spray
- Ultraviolet light
- Sea gull feces (mixed with water, produces an acid mixture that can devour galvanizing)
- Heavy condensation
- Snow, sleet, and freezing rain

At seaports, raw materials may be stored in bulk storage. The types of materials being stored must be considered since they can be in direct contact with a substrate. For instance, sugar is sometimes stored in bulk form in large buildings that are ventilated only by ambient air. Thus, interior temperatures and humidity can approach those of the exterior. When mixed with moisture, raw sugar can severely damage unprotected concrete, especially in damp conditions produced by humidity and condensation. Therefore, coatings resistive to sugar, such as epoxy, should be considered. Always refer to the manufacturer's chemical resistance charts for the coating being considered.

WHILE A COATING SUITABLE FOR SPLASH AND SPILLAGE MAY NOT BE SUITABLE FOR IMMERSION CONDITIONS, IT WOULD BE VERY PRUDENT TO SELECT A PRODUCT SUITABLE FOR THE MOST EXTREME CONDITIONS EXPECTED.

SHOP-APPLIED PRIMERS

The value of a good shop primer should not be overlooked because it will be the only protection for the metal before it receives the finish coats at the jobsite. It makes no sense for the metal to arrive on site with rust and corrosion already starting. It will start soon enough along the coast, so why give it a head start (*Photo 6*)?

When carbon steel is to be shop-primed prior to delivery, the shop primer should be specified. Ideally, the shop primer should be by the same manufacturer as the field-applied coatings. This will help to ensure coordination and compatibility between the shop primers and the field-applied coatings and can narrow responsibility and eliminate finger pointing if there is a failure. Also, knowing the shop primer can be beneficial in selecting the field-applied touch-up

primer. Usually, steel fabricators purchase shop primer in huge quantities, often by the tank car, and the quality of these primers can range from excellent to poor. Some fabricators may be operating on a very tight profit margin or may have bid a project too closely. When this happens, there is temptation to use an unsuitable primer that is just good enough to protect the steel until it gets out of the shop before rust blooms pop up.

Fabricators also like fast-drying primers so that the steel can be handled as quickly as possible. However, a characteristic of many fast-drying coatings – especially primers – is they can flash off before establishing a bond. This is especially true when they are applied by an inexperienced applicator. Premature



Figure 6 – Shop primer failure.

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flash-off is a guarantee of primer delamination and, with that, failure of any topcoat sticking to the primer. I have seen shop primers delaminate while the steel is being handled in the shop and before it is ever loaded on the truck. Some of the most important characteristics of an ideal shop primer include, but are not limited to:

- Fast drying
- Good wet-out
- Strong adhesion
- High abrasion resistance
- Fast moisture resistance
- Excellent corrosion resistance
- Compatibility with expected topcoats

Since a shop primer provides the only protection until the topcoats are applied, it must be able to offer protection as soon as possible and continue to provide that protection until the finish coats are applied. Unfortunately, coatings do not offer full protection from routine handling and the environment until they are fully cured. Uncured coatings are usually more permeable than cured coatings. Consequently, slow curing primers could leave steel vulnerable to a corrosive atmosphere. The time required to reach the various states of curing can vary and is normally listed in the product data sheets and on the container. The time to reach full cure can run from approximately a week or less for alkyd, epoxies, and polyurethanes, and up to 30 days for acrylics. However, for shop-applied primers, the critical time is from application until the primed item can be handled. The following terms are often used to describe the various states of curing for primers and finish coats:

- **Tack Free:** Dust will not stick to coating.
- **Dry to Touch:** Touching with a finger, using weight of hand, will not leave a fingerprint.
- **Dry to Handle:** Can be carefully handled or staged on dunnage without damaging the primer.
- **Dry to Recoat:** A topcoat can be applied without volatiles being trapped between the coats.
- **Full Cure:** Full bond strength and hardness have been reached and maximum protection is provided. The painted item should not be put into service before full cure.

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Zinc-rich primers are usually considered to be the ultimate in primers, especially inorganic zinc primers. Because of inorganic zinc's sacrificial properties that rival those of hot-dipped galvanizing, inorganic zinc can exceed the performance of organic zinc and epoxy primers when left exposed to weather. If the primers are coated, then systems consisting of inorganic zinc, organic zinc, or epoxy primers will perform similarly as long as the finish coats remain intact. If the finish coat is breached, then the inorganic zinc has the advantage. Organic zinc primers are more forgiving in their application. They can be top-coated sooner, and they can be touched up with organic zinc. Inorganic zincs can be fussy to apply; they cannot be touched up with inorganic zinc until they have aged. Like galvanized steel, they usually must be aged prior to top-coating.

Until recent years, a wash vinyl was the preferred primer for galvanized steel. However, technology has produced multipurpose or universal primers that are very effective. Additionally, some finish coats such as epoxies and 100 percent acrylics are self-priming over galvanized steel.

Typically, shop primers come in red (actually, a terra cotta color) and white, with an occasional gray tossed in for variety. Zinc-rich primers can come in a green tint. White has the advantage of contrasting surface dirt, rust bloom, thin spots, holidays, and, to a lesser extent, irregular surface preparation. Conversely, everything seems to blend in with red. The common and critical defects highlighted by a white primer must be addressed in the field prior to applying a finish, especially in coastal or corrosive environments.

SHOP-APPLIED FINISHES

When considering protective coating, whether for a coastal environment or elsewhere, attention usually focuses on the conventional liquid coatings that are applied in the shop or field. Other than these conventional coatings, two other coatings are anodized aluminum and powder coating.

Most finishes, from alkyd to epoxy, can be applied in the fabricator's shop, as long as their application does not interfere with production. Tonnage is the name of the game. When a complete system is applied in the shop, it may be a good idea to make the steel erector responsible for all costs associated with repairing shop-applied finishes that are damaged during erection. This

tends to encourage better handling and erecting procedures. Three very common shop-applied finishes that deserve special notation are anodized aluminum, Fluoropolymer (sometimes referred to as Kynar®), and powder coating.

Anodized Aluminum Finishes

By itself, aluminum offers reasonably good resistance to weather and corrosion, but it forms a white powder soon after exposure to oxygen and will eventually form pits when exposed to weather. When aluminum is exposed to oxygen, aluminum oxide forms on the surfaces to provide a protective coating that prevents further corrosion as long as the oxide is intact. This process is different than the oxide (rust) that forms on steel that allows it to continue to rust. However, the oxide that forms on aluminum is relatively thin and is loosely bonded to the aluminum. Anodizing is an electrochemical process that enhances the naturally occurring oxide by making it thicker, tougher, and harder. Anodizing also improves adhesion. Actually, the hardness of anodized aluminum rivals that of a diamond.

The oxide that occurs on the surface is a form of coating. Since it is an oxide of the metal, it is also a part of the metal. Additionally, since anodizing improves the naturally occurring oxidation, anodizing can be considered a coating. It is also a part of the aluminum and is not a hazardous or harmful byproduct, and does not discharge hazardous or harmful byproducts.

Key advantages of anodizing are corrosion and abrasion resistance, long-term durability, aesthetics, and environmental friendliness. Aluminum coils, extrusions, and roll forms can be anodized. Unlike conventional coatings that offer a very wide range of colors and gloss levels, anodized aluminum is normally available in somewhat limited colors that include clear, black, bronze, dark bronze, champagne, and white. There are some fabricators that can provide a much wider range of colors.

Standard AAMA 607.1 is frequently used to specify clear anodized aluminum and AAMA 608.1 for colored anodized aluminum. The two common classes for anodized architectural metals are Class 1 and Class 2. The primary difference between the two classes is thickness, which is determined by the amount of time the aluminum is in the treatment baths. Class 1 is minimum 0.018 mm or thicker and Class 2 is minimum 0.010 mm thick, and these thicknesses apply to both clear and colored anodizing.

- Anodized aluminum finishes can be difficult-to-impossible to touch up. These finishes can be used on most aluminum surfaces, including extrusions used for storefront framing and sheet metal used for roofing and wall panels.

Both classes of anodized aluminum can perform in coastal climates, but a Class 1 will provide the best performance. Class 2 would be suitable for rural and urban areas and areas not subject to abrasion or wear and exposure to corrosive elements.

Fluoropolymer Finishes (Kynar®)

Kynar® finishes are used mostly for coil-coated metals, such as galvanized steel, Galvalume, and aluminum and can be used on extruded aluminum. These finishes come in 50 percent Kynar® resin and 70 percent Kynar® resin, but nothing less than 70 percent should be considered. Kynar® systems also come in two-coat and three-coat systems, with the third coat being clear. Both systems perform well; however, the three-coat system has the edge for overall performance, especially for gloss and color retention. Kynar® finishes are also difficult to match and touch up. Kynar® is ideal for thin sheet metal used for roofing and siding, etc., because, contrary to popular belief, it is relatively soft, which allows it to expand and contract with the metal. Most manufacturers of Kynar® finishes offer long-term (up to 20 years and more) finish warranties.

There are new generations of fluoropolymers that can be both shop-applied and field-applied, are easy to touch up, seem to perform as well as previous generations, and have finish warranties that often include the touch ups.

THE VALUE OF A GOOD SHOP PRIMER SHOULD NOT BE OVERLOOKED BECAUSE IT WILL BE THE ONLY PROTECTION FOR THE METAL BEFORE IT RECEIVES THE FINISH COATS AT THE JOB SITE.

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POWDER COATINGS

Powder coatings are significantly different from conventional coatings. Conventional, wet-type, shop-applied coatings consist of solids (including the resins, binders, and pigments) that are suspended in a solvent. These coatings are applied in liquid form by spray, brush, or roller. After the solvent evaporates, the solids are left behind to form the protective coating.

A powder coating is applied while in the dry, solid state. Two common types of powder used for powder coatings are thermoplastic and thermosetting. Thermoplastic powder can be re-melted and cooled repeatedly after initially setting. A thermosetting powder cannot be re-melted after initial setting.

Two common methods of application are dipping and spraying. During dipping, the component is either lowered into a tank filled with powder coating that is fluidized and usually electrostatically charged. The electrostatic charge ensures better adhesion between the powder and the component. During spraying, an electrostatically charged powder is sprayed on a component. Like dipping, the dry powder electrically bonds to the component. After dipping or spraying, the components are moved to an oven where the powder melts to form a continuous and uniform protective coating.

The powders are available in different generic formulations to meet specific applications, such as corrosion, abrasion, and impact resistance; electrical insulation properties, etc. A wide selection of colors is available. The complete, continuous, and uniform application plus the corrosion resistance of powder coatings make them suitable for a coastal environment.

COMING IN PART II:

SURFACE PREPARATION AND APPLICATION

Joseph "Cris" Crissinger, CCS, CCCA



Cris Crissinger has completed the NACE course of instruction in Protective Coatings and Corrosion Control and is a Construction Materials Specifier with 22 years of experience. As a partner with McMillan Smith and Partners Architects in Spartanburg, Greenville, and Charleston, SC, he evaluates new products and develops all written construction specifications for the firm. His responsibilities also include facility assessment, field investigations, and the coordination of internal training programs. Mr. Crissinger is a Certified Construction Specifier, a Certified Construction Contracts Administrator, and a member of the Construction Specifications Institute, the Building Performance Committee of ASTM, and the Design and Construction Division of the American Society for Quality. He is the winner of the 2006 Horowitz Award for his contributions to *Interface* journal.