Duplex systems employing painting or powder coating over hot-dip galvanized steel blend long-term protection with desired aesthetics. Here is some practical advice on successfully specifying and getting the most out of a duplex system.

steelwise

BEST OF BOTH WORLDS

BY ALANA HOCHSTEIN

AS EVIDENT THROUGH its use in attractive structures and artful sculptures, hot-dip galvanized steel provides specifiers with a natural and metallic look with long-term corrosion protection in aggressive environments.

However, there are instances where the metallic or natural matte gray appearance is not compatible with an architect's overall design, or color is needed to either provide branding or blend in with the surroundings. But how to accomplish this without sacrificing the corrosion protection capabilities of galvanized steel? Via duplex systems, where a layer or layers of painting or powder coating are added over the galvanized steel, thus achieving the desired aesthetics or branding while still providing the corrosion protection and service life required to make a lasting impression.

Synergistic Effect

Here's how it works. When implementing hot-dip galvanizing and paint or powder coating in a duplex system, the two coatings work together to increase overall longevity and provide a more sophisticated level of corrosion resistance known as the synergistic effect. This involves the exterior layer of paint or powder coating providing barrier protection to slow down the rate at which the underlying zinc is consumed. Then, once the exterior layer has been breached or weathered, the hot-dip galvanized coating beneath is still available to provide cathodic and additional barrier protection. Additionally, the hot-dip galvanized coating prevents under film corrosion of the paint or powder coating system, which increases the longevity of the top coat and extends paint maintenance cycles at least 50% in comparison to the same paint system applied over bare steel.

As a result, the overall product is afforded maintenance-free corrosion protection for 1.5 to 2.3 times the sum of the paint life and hot-dip galvanizing life. In other words, if you apply a hot-dip galvanized coating expected to last 50 years and a paint system expected to last 10 years, the duplex system would provide 90 to 138 years of maintenance-free corrosion protection. Or, if routine maintenance is performed on the paint or powder coating system, the overall coating system will last indefinitely. When discussing the synergistic effect, the value for the multiplication factor (1.5 to 2.3) is selected based on the corrosivity of the environment. A minimum value of 1.5 is intended for the most aggressive environments with high pollution, salt or humidity, while 2.3 is the maximum value for mild and rural environments. (If needed, the American Galvanizers Association—AGA—can be contacted for help in estimating this value.)

Cost Efficiency

The synergistic effect allows for great economic advantages over the life cycle of a duplex project. While the initial cost of a duplex system is high due to the application of two corrosion protection systems, the synergistic effect will result in increased time between paint maintenance cycles, and therefore a total life-cycle cost that is less expensive than if the same paint system were to be applied over bare steel.

To analyze the initial and life-cycle cost of a duplex system in comparison to more than 30 other corrosion protection systems, the AGA has developed a Life-Cycle Cost Calculator (available at **lccc.galvanizeit.org**). Based on published cost date and calcu-

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Specifying a duplex system for the steel components of the Salvador Dali Museum in St. Petersburg, Fla., located in a highly corrosive coastal environment, allowed a color selection that would blend with the facility while the galvanized structural tubing beneath ensured the pieces would be protected inside and out. The museum features a framework of duplexed steel tubing that was painted to minimize distraction from the 75-ft geodesic glass bubble known as the "enigma."

lated in accordance with ASTM A1068, *Standard Practice for Life-Cycle Cost Analysis of Corrosion Protection Systems on Iron and Steel Products*, this calculator allows users to input the details of a project and compare the initial and life-cycle costs side by side.

Example Project

Let's consider an example project, with the following parameters:

- 50,000 ft sq. ft
- Typical mix of structural pieces, simple <50 ft
- 60 Year Service Life
- C3 – Moderately Industrial Environment
- 3% inflation; 4% interest

According to the output of this example project, derived from the Calculator, in Tables 1 and 2, the initial cost of a duplex system is 71% more than paint initially, but the delayed paint maintenance cycles for the example duplex system as exhibited in Table 2 results in a life-cycle cost savings of 45% in comparison to the paint system over black steel. Therefore, specifying a duplex system for corrosion protection can pay for itself while providing value and aesthetic appeal throughout the design life.

Table 1: Economic Comparison Case Study

Coating System	Initial Cost $/ft2	Total Initial Cost	Life-Cycle Cost
Black Steel: SSPC SP-10 automated surface prep, Epoxy/Polyurethane	$3.14	$157,050	$1,210,500
Duplex System: SSPC SP-16 surface prep, HDG/ Epoxy/ Polyurethane	$5.28	$263,950	$658,000

Table 2: Maintenance Comparison Case Study

Maintenance Activity	Epoxy/Polyurethane	Duplex System: HDG/Epoxy/ Polyurethane
Touch-Up Repaint	Years 11, 31, 51	Years 22, 51
Maintenance Repaint	Years 14, 34, 54	Years 29, 58
Full Repaint	Years 20, 40	N/A

Specifying a Duplex System

Specifying a duplex system can be relatively simple if the steps for surface preparation are followed, as prescribed in the relevant specifications. Different specifications are required for the application of the hot-dip galvanized coating, surface preparation of the coating and then application of the paint or powder coating. The primary specification for batch hot-dip galvanizing of structural steel including plate, beams, tubing, piping and various fabrications is ASTM A123: *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*. For batch hot-dip galvanizing of any nuts, bolts or other fasteners, ASTM A153: *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*, should be specified to ensure parts are centrifuged or otherwise handled to remove excess coating which could affect their intended use.

Next, there are additional supporting specifications to assist in preparation of the hot-dip galvanized surface. ASTM D6386: *Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting* provides detail on recommended methods to prepare hot-dip galvanized surfaces for painting. Instructions are included for smoothing, cleaning and profiling the surface. Depending on the identified initial condition of the hot-dip galvanized surface as defined by the specification, some of these preparation practices may be optional.

For preparing the hot-dip galvanized surface for powder coating, a separate specification ASTM D7803: *Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Powder Coating* details similar practices for surface smoothing, cleaning, and profiling the hot-dip galvanized surface based on the identified initial surface condition. However, D7803 also provides instructions for a heat treatment of the parts after surface preparation to prevent outgassing of the galvanized coating during the baking step in the powder coating curing process.

Referenced within both D6386 and D7803 is a specification for sweep blasting to profile the hot-dip galvanized surface: SSPC SP16: *Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel*. This abrasive blast cleaning standard is the most common method for profiling of the hot-

Franklin Park Conservatory and Botanical Gardens in Columbus, Ohio, houses a seasonal butterfly exhibit, a Chihuly exhibit and an extensive plant collection. The varieties of temperatures, humidity levels, and herbicides involved make this conservatory a candidate for extreme corrosion, but the duplexed structural steel has held up beyond the expectations of the owner over its 20-year existence.

Reaching high into the Vancouver sky, the windowed walls of the Woodwards Building "W" Tower are laced with duplexed columns of intricately etched decorative panels depicting tangled branches.

Photo Courtesy of AGA

dip galvanized surface without damaging the coating. If an abrasive blast cleaning is desired but SSPC SP16 is not specified, a painter unfamiliar with hot-dip galvanized surfaces may instead use methods intended for cleaning bare steel, which can directly result in peeling or excessive removal of the hot-dip galvanized coating.

Finally, it is the responsibility of the architect or engineer to specify the paint or powder coating system based on the intended use of the part, the application method, environmental concerns and the desired aesthetics. There are many available options from paint manufacturers that are designed to work well over hot-dip galvanized surfaces. It is possible to consult a paint manufacturer for the proper paint selection, or reference SSPC Guide 19: *Selection of Protective Coatings For Use Over Galvanized Substrates*. SSPC Guide 19 is a resource available to owners and specifiers looking to select an appropriate coating system for a duplex system exposed to corrosive environments. Coating selection is based on evaluation of the environment, condition of the hot-dip galvanized steel and surface preparation. After coating selection and preparation of the hot-dip galvanized surface, the paint or powder coating should always be mixed, applied and cured in accordance with the manufacturer's instructions.

Clarifying Roles and Responsibilities

Some hot-dip galvanizers market and sell their own duplex systems while others partner with a paint shop to provide an all-in-one duplex coating service. However, it is more common to see the hot-dip galvanizing and painting/powder coating bid as two separate contracts. When this occurs, clarifying the roles and responsibilities of each party (galvanizer and paint applicator) is critical to the success of a duplex system and avoiding any schedule delays.

The first topic to be clarified is the acceptability of any post-treatments performed by the galvanizer. Many galvanizers apply post treatments or perform water quenching of the galvanized articles to prevent the formation of wet storage stain or accelerate cooling. The use of post-treatments will alter the surface chemistry of the coating. Some post-treatments such as phosphatizing will produce surfaces acceptable for painting,

while others like chromating will result in a surface that is difficult to top coat. Although water quenching does not change the surface, the quench bath typically contains small amounts of oil, grease or galvanizing flux which can interfere with paint adhesion. It is the responsibility of the owner or paint applicator to inform the galvanizer ahead of time that the part is to be duplexed. Once informed, the galvanizer is responsible for ensuring quenching and chromating are not performed.

Another need for clarification arises in the preparation of the hot-dip galvanized surface. Some surface conditions present on hot-dip galvanized coatings such as roughness, small dross inclusions, and zinc runs do not affect the corrosion protection and are typically acceptable under ASTM A123. However, these same surface conditions will negatively affect adhesion of the paint/powder coating, and are therefore not acceptable. Instructions for smoothing the surface

Hot-dip galvanizing and duplex systems are specified for all refurbishment projects at Boston's Fenway Park to reduce maintenance costs without compromising aesthetics and the stadium's well-known shade of green.

Photo Courtesy of AGA

Located in the heart of Boston's Chinatown, the Chinatown Park project has a great deal of public exposure, an element that made quality and craftsmanship important components in the choice to specify a duplex system. As a landmark project representing a major neighborhood in Boston, a duplex system was specified to provide the longevity and appearance required.

Photo Courtesy of AGA

The specification of hot-dip galvanizing and duplex systems was integral to the Denver Zoo's Toyota Elephant Passage becoming the first zoo exhibit in the country to attain LEED Platinum Certification, the highest level awarded by the U.S. Green Building Council. The system allowed the coated elements to achieve unmatched durability while blending into the surroundings.

are contained within the surface preparation standards ASTM D6386 and D7803, but these specifications do not clarify whether surface smoothing is to be performed by the galvanizer or the paint/powder coating applicator. As a result, when two parties are involved, this critical surface preparation step can sometimes be left out due to poor communication, resulting in a lumpy coating or poor adhesion. To prevent these issues, ASTM A123 and D6386 were revised in 2017 to clarify that once the galvanizer and painter are mutually aware the article is to be duplexed, the responsibility for surface smoothing shall be mutually determined by the galvanizer and the purchaser. There are plans to include similar language within ASTM D7803 upon its revision in 2019.

Although not contained within any surface preparation standard, it is also recommended to clarify the acceptability and responsibility for any repairs to the hot-dip galvanized coating. Repairs may be performed either at the galvanizing plant or when under customer ownership. Three methods are acceptable for the repair of all hot-dip galvanized coatings: zinc metallizing, zinc solder and zinc-rich paint. No clarification is required for the use of zinc-spray metallizing or zinc solder for repair of the HDG coatings to be duplexed. However, if zinc rich paint it used, re-coat time windows and compatibility with the paint or powder/coating system should be evaluated by the specifier. Depending on the logistics involved to transport articles between the galvanizer and painter, it may be desired to have the painter perform any repairs using zinc-rich paint in order to meet suitable recoat time windows.

Any further surface preparation required for painting or powder coating hot-dip galvanized steel such as cleaning, profiling, and outgassing are the responsibility of the paint or powder coating applicator. These preparation steps should be performed as required for each surface condition listed within ASTM D6386 or D7803 (newly galvanized, partially weathered or fully weathered). If the surface is incorrectly identified or if the painter receives a different surface condition than expected, there exists a potential for insufficient cleaning of the hot-dip galvanized surface, resulting in poor adhesion of the paint. Where the initial surface condition of the galvanized surface is unknown, the preparation steps for a partially weathered surface should be used.

Duplex systems offer the best of both worlds by offering durable corrosion protection and a wide variety of aesthetic finishes. Furthermore, the synergistic effect between the hot-dip galvanized surface and the paint or powder coating system allow for longer maintenance cycles and significant cost savings over the life cycle of the project. However, proper specification and clear communication regarding the roles and responsibilities involved is critical to reap these benefits. The above recommendations will allow you to ensure you achieve a durable and stunning duplex coating that will benefit many generations. ■